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(Draft)

Technical Report of

ISO/IEC JTC1/SC6

Future Network :

Problem Statement and Requirements

This Technical Report (TR), entitled “Future Network : Problem Statement and Requirements” is the product of ISO/IEC JTC1/SC6.

This TR is being developed by the contributions from a lot of SDOs, organizations, individual experts such as ITU-T SG13 Q21/SG13, and Future Network on Focus Group (FG-FN), as well as ISO/IEC JTC1/SC6.

Especially, the joint work with ITU-T Q.21/SG13 will be preferred.

This TR discusses 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 research on Future Network.

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Table of Contents

[Editor's Note] ToC will be added.

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Introduction

This TR discusses 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 research on Future Network.

[Editor's Note] ITU-T Q.21/SG13 joint work description will be added, if required

[Editor's Note] Further contributions are invited.

1 Scope

This Technical Report (TR) discusses the description, rationale and general concepts of Future Network (FN) to understand the reason why the concept of Future Network is proposed at this moment and what's the scope of research on Future Network.

[Editor's Note] Further contributions are invited.

2 Motivation of Future Network

2.1 Needs to research and standardize the Future Network [1,2,3]

The current Internet becomes essential communication infrastructure, not only for information and communications but also for social critical infrastructures such as e-government, energy/traffic controls, finance, learning, health, etc.

Even though the current Internet is such an essential infrastructure, we see that there are many concerns on the following aspects on current Internet, including IP based networks: scalability, ubiquity, security, robustness, mobility, heterogeneity, Quality of Service (QoS), re-configurability, context-awareness, manageability, data-centric, economics, etc. Also, the advancement of mass storages, high speed computing devices and ultra broadband transport technologies (e.g. peta/exa/zeta bps) enables many emerging devices such as sensors, tiny devices, vehicles, etc. The resultant new shape of ICT architecture and huge number of new services cannot be well supported with current IP technologies.

Therefore we need to study and standardize the Future Network (FN) which overcome the limitations of current IP, and enable new plentiful services. 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.

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. 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 the reason why the Future Network research effort is called as “Clean-Slate Design for the New Internet’s Architecture”. 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.

[Editor’s Note] Further contributions are invited.

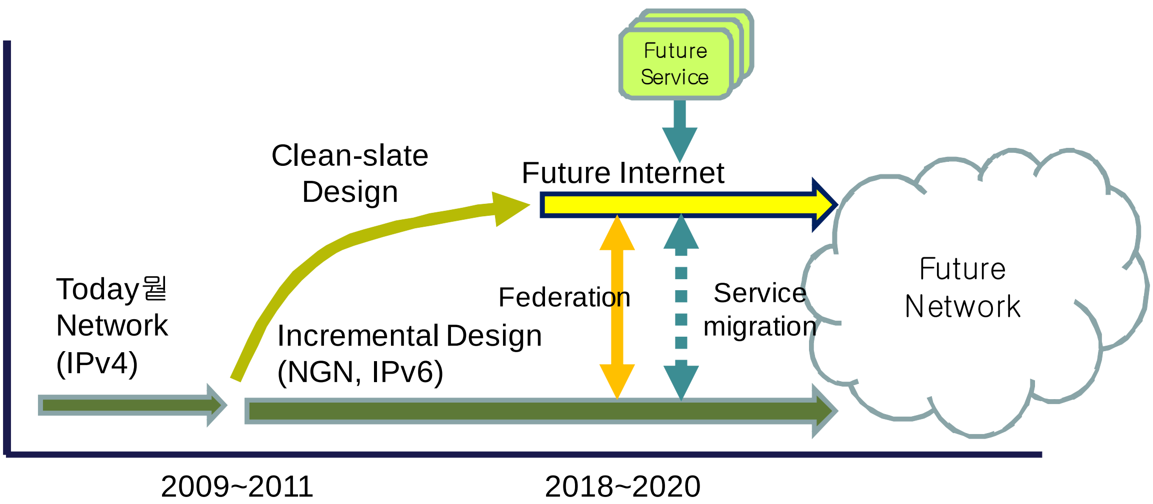
2.2 Value and Vision of Future Network

The business model of Future Network (FN) aims for profit sharing among network providers, service providers, application providers and end users by building cooperative eco-systems between them [1].

It can be accomplished by openness and accommodating various requirements of each party.

Figure 1 illustrates vision and roadmap of Future Networks.

[Editor's Note] Further contributions are invited.



[Figure 1] Vision and Roadmap of Future Network

3 Definition, General Concept and Terminologies

In this section, definition, general concept, and terminologies of Future Network are described.

3.1 Definition

- Future Network (FN) : A network which is able to provide revolutionary services, capabilities, and facilities that are hard to provide using existing network technologies [1].

[Editor's Note] Further contributions are invited.

3.2 General Concept

General concept of Future Network (FN) could be clarified and listed as follows :

- The FN is the network of the future which is made on Clean-slate Design.
- It should provide futuristic functionalities beyond the limitations of the current network including Internet (IP).
- Revolutionary approach should be considered for the FN.
- The FN should not dependent on the current technologies and solutions.
- FN provides mechanisms that benefit every participant as much as they contribute.
- The backward compatibility may or may not be required.
-

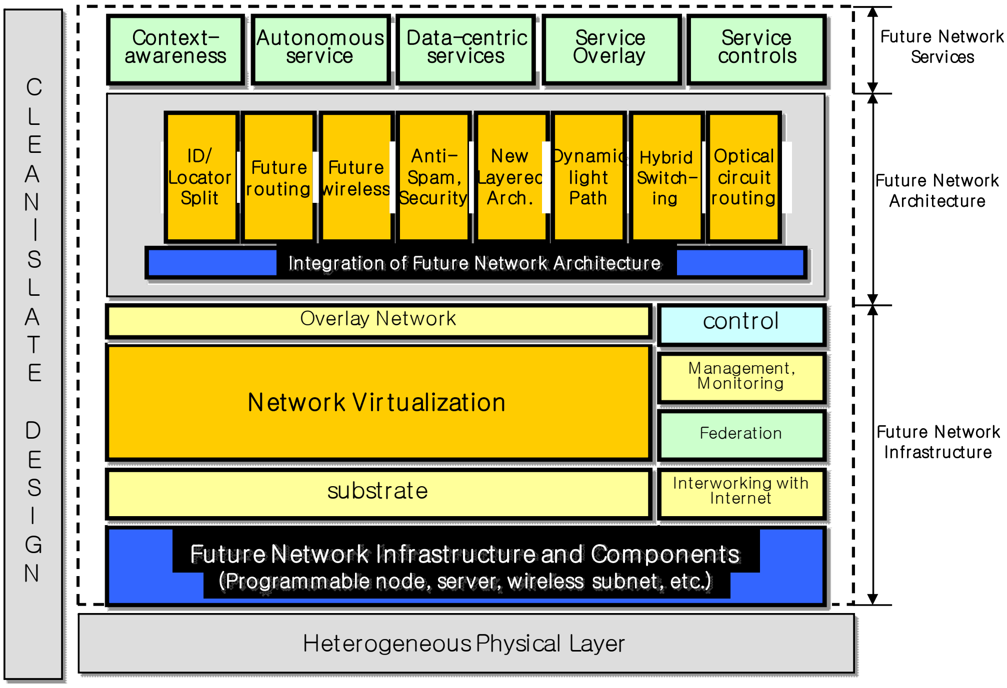
Note : *Clean-slate approach was understood as a design principle, not deployment aspect.*

The futuristic functionalities could be :

- Network virtualization
- Programmable networks
- New layered functions (e.g., cross-layer communications),
- Autonomous management and manintenance
- New control and management functions for network resource sharing and islolation
- Context-awareness services
- Data-centric or content-centric services
- Media distribution
- Customizable QoS/QoE

Future 2 illustrates a basic concept of Future Network for research and standardization.

[Editor's Note] Further contributions are invited.



[Figure 2] Basic Concept of Future Network

[Note] The definitions of Internet and NGN:

- Internet: A collection of interconnected networks using the Internet Protocol which allows them to function as a single, large virtual network[4].
- The Internet: a global system of interconnected computer networks that interchange data by packet switching using the standardized Internet Protocol Suite (TCP/IP). It is a "network of networks" that consists of millions of private and public, academic, business, and government networks of local to global scope that are linked by copper wires, fiber-optic cables, wireless connections, and other technologies [5].
- Next Generation Network (NGN): A packet-based network able to provide telecommunication services and able to make use of multiple broadband, QoS-enabled transport technologies and in which service-related functions are independent from underlying transport-related technologies. It enables unfettered access for users to networks and to competing service providers and/or services of their choice. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users [6].

3.3 Terminologies

- Clean-slate design : clean-slate design means that a system (network) is re-designed from scratch. It should be based on long-term, revolutionary approach. In Clean-slate Design, the backward compatibility may or may not be required [7].
- Network virtualization : the purpose of network virtualization is to de-ossify the Today's Internet. It could realize virtual network with programmable network elements and support the architecture of

multiple architectures. Different virtual networks can provide alternate end-to-end packet delivery systems and may use different protocols and packet formats [8].

- Cross-layer communication : cross-layer communications creates new interfaces between layers, redefine the layer boundaries, design protocol at a layer based on the details of how another layer is designed, joint tuning of parameters across layers, or create complete new abstraction.
- Autonomous service : It enables users or services in motion to configure autonomously and to mange networks.
- Context-awareness : It enables applications or services to adapt their behaviour based on their physical environment.
- Data-centric/content-centric : It supports contents-based applications and services.
- Service overlay: It investigates the dynamic construction of service-based overlay networks and their control and maintenance.
- Customizable QoS/QoE: It supports preference setting and service composition/re-composition accordingly
-

[Editor’s Note] Further contributions are invited.

4. Problem Statement [8, 9]

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 today's 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 today's Internet architecture. The problem is known to be caused by current Identifier-Locator integration architecture 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.

[Editor's Note] Further contributions are invited.

4.1.2 Insecurity

One of the main problems on the today's 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.

[Editor's Note] Further contributions are invited.

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.

[Editor's Note] Further contributions are invited.

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.

[Editor's Note] Further contributions are invited.

4.1.5 Heterogeneous Physical Layers, Applications and Architecture

IP architecture was known as “a narrow waist” of today’s Internet hourglass. 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.

[Editor’s Note] Further contributions are invited.

4.1.6 Network Management

The original Internet lacks in management plane. Instant and easy management for users is highly required, as the Future Internet 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.

[Editor’s Note] Further contributions are invited.

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.

[Editor’s Note] Further contributions are invited.

4.1.8 Opportunistic 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, etc.) do not confirm to this design philosophy.

[Editor’s Note] Further contributions are invited.

4.1.9 Fast Long-Distance Communications

Current Internet is based on the philosophy of ‘end-to-end’ packet forwarding scheme i.e., best-effort network, so that a point of bottleneck causes a delay. When the distance becomes longer, the probability of bottleneck-appearance becomes higher.

[Editor’s Note] Further contributions are invited.

4.1.10 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 today’s Internet can be traced to a failure of engineering. The today’s Internet lacks explicit economic primitives.

[Editor's Note] Further contributions are invited.

4.2 Problems with Original Internet Design Principles

4.2.1 Packet Switching

Today's Internet 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.

[Editor's Note] Further contributions are invited.

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.

[Editor's Note] Further contributions are invited.

4.2.3 Layering

Layering was one of important characteristics of today's Internet 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.

[Editor's Note] Further contributions are invited.

5 New Design Goals and General Requirements [10,11]

In this section, new design goals and general requirements for the Future Network are described.

5.1 Scalability

Scalability issue is emerging as the cultural demands for networking toward the future is growing continuously. 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)

[Editor's Note] Further contributions are invited.

5.2 Naming and Addressing Scheme

As one of the aims of FN is data/content-centric networking, naming and addressing schemes based on the data/contents are required.

[Editor's Note] Further contributions are invited.

5.3 Identification

As one of the aims of FN is data/content-centric networking, identification schemes based on the data/contents are required.

[Editor's Note] Further contributions are invited.

5.4 Transport/Switching Mechanisms

[Editor's Note] Further contributions are invited.

5.5 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.

[Editor's Note] Further contributions are invited.

5.6 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 Internet.

[Editor's Note] Further contributions are invited.

5.6.1 Context-awareness

Mobility in the Future Network is expected to support context-awareness. Section 5.13 describes details on context-awareness. Although location is a primary capability, location-awareness does not necessarily capture things of interest that are mobile or changing.

[Editor's Note] Further contributions are invited.

5.6.2 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.

[Editor's Note] Further contributions are invited.

5.6.3 Heterogeneity

Mobility in the Future Network is expected to support heterogeneity. Section 5.7 describes details on heterogeneity.

[Editor's Note] Further contributions are invited.

5.7 Quality of Service

The Future Network should support quality of service (QoS) from user and/or application perspectives. In addition, QoS in the Future Internet is expected to support context-awareness described in section 5.13.

[Editor's Note] Further contributions are invited.

5.8 Heterogeneity and Network Virtualization

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.

[Editor's Note] Further contributions are invited.

5.8.1 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.

[Editor's Note] Further contributions are invited.

5.8.2 Device Heterogeneity

The Future Network should support new devices such as sensors, RFIDs, etc.

[Editor's Note] Further contributions are invited.

5.8.3 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 Internet architecture.

[Editor's Note] Further contributions are invited.

5.8.4 Network Virtualization

The Future Network should support network virtualization. The purpose of network virtualization is to de-ossify the Today's Internet. It could realize virtual network with programmable network elements and support the architecture of multiple architectures. Different virtual networks can provide alternate end-to-end packet delivery systems and may use different protocols and packet formats. The requirements of network virtualization implementation are a) multiple network architecture support, b) common control and distributed management, c) resource federation, d) programmability support, and e) domain federation. In this principle, for example, a new future service provider who doesn't have its own physical infrastructure just chooses a new particular architecture and to construct an overlay supporting the architecture that the new service provider needs to do. The new future service provider then distributes softwares or codes that let anyone, anywhere, access its overlay [13]. Also, all the resources within the infrastructure could be uniquely defined and shared.

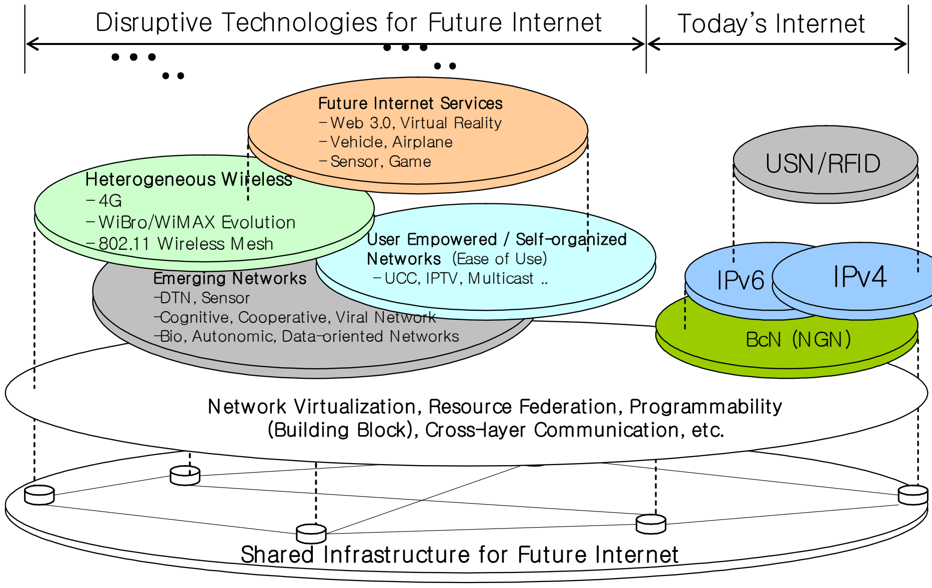
Network virtualization provides a common means to accommodate the new heterogeneous architectures and facilitate architecture revolution. Benefits from network virtualization are listed below : the conceptual benefits from network virtualization are illustrated in Figure 3.

(1) Building up a single shared infrastructure for Future Network : network virtualization can play a central role to build up a shared common infrastructure for Future Network. The functionalities to support the network virtualization could become the architecture's core functionalities. So, in this assumption, a lot of different networks can be built on a single shared infrastructure for future experiments.

(2) Deploying unconventional network architectures : New heterogeneous architectures as well as today's Internet architecture can co-exist on top of a shared infrastructure. Also, different virtual networks may provide alternate end-to-end packet delivery systems and may use different protocols and packet formats. Network virtualization has the flexibility to support a broad range of experiments, services and users. It can support various clean slate-based and disruptive technologies experiments.

(3) Deploying new emerging technologies : To deploy new emerging technologies and services such as IPv6, mobile IPTV, wireless mesh (e.g., IEEE 802.11s), etc. each networks should be isolated and distinct path for new services. Meta-Architecture can easily support these kinds of new technologies and services.

(4) The Advent of new generation service provider : In this network virtualization scenario, a new generation service provider will appear for Future Network services. A new generation service provider chooses a particular new architecture, then constructs a virtual network supporting architecture [11]. The new generation service provider could easily support new architecture natively.



[Figure 3] Network virtualization concept

5.9 Customizability

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

[Editor's Note] Further contributions are invited.

5.9.1 Context-Awareness

The Future Network shall be aware of context. Three important aspects of context are: where you are; with whom you are; and what resources you are nearby. For example, 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.

[Editor's Note] Further contributions are invited.

5.9.2 Re-configurability and Service Discovery

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

[Editor's Note] Further contributions are invited.

5.9.3 Content-Centric Services

The Future Network shall support content-centric services. For example, numbering shall be supported in a content-centric manner.

[Editor's Note] Further contributions are invited.

5.10 Media Distribution

[Editor's Note] Further contributions are invited.

5.11 New Layered Architecture

Basically, layering was one of important characteristics of Today's Internet technologies, but recently, it is also reported that it has sometimes inevitable inefficiencies. Therefore, Future Network may provide cross-layer communication functions. To achieve this, first thing is to exploit the dependency between protocol layers to obtain performance gains and then create new interfaces between layers, redefine the layer boundaries, design protocol at a layer based on the details of how another layer is designed, joint tuning of parameters across layers, or create complete new abstraction. The purpose of cross-layer communications is to provide a way direct communication between protocols at nonadjacent layers or sharing variables between layers. We adopt this principle only within mobile, wireless, sensor sub-networks, since there is a trade-off between optimization and complexity (abstraction). Thus, measurement and monitoring should be given in advanced. Also, it is designed to support at any layer (e.g., physical layer to application layer) and implemented through network virtualization to support flexibility and programmability.

[Editor's Note] Further contributions are invited.

5.12 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.

[Editor's Note] Further contributions are invited.

5.12.1 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.

[Editor's Note] Further contributions are invited.

5.12.2 Autonomy

Autonomic management might be provided to future mobile networks: self-protecting, self-healing, self-configuring, self-optimizing, etc.

[Editor's Note] Further contributions are invited.

5.13. 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.

[Editor's Note] Further contributions are invited.

5.14 Infrastructure and Integration Architecture

[Editor's Note] Further contributions are invited.

6 Services and Applications in Future Networks

In the section, the following future services are envisioned and considered as benchmark services to achieve to build the Future Network.

Though the listed services are shown as examples (not normative), they imply essential, societal and infrastructural services, and require considerable network resources that current Internet technology cannot support.

Research projects	Envisioned future services	References
GENI [15] (Global Environment for Network Innovations)	− Ubiquitous health care − Participatory urban sensing − Dealing with personal data − Tele-presence	GENI Research Plan GDD-06-28 Version 4.5 of April 23, 2007
NwGN [16] (New Generation Network Architecture)	− Essential services: medical care, transportation, emergency services	AKARI Conceptual Design April 2007, AKARI Project
EU FP-7 [17] (European Union Framework Program-7)	− Personal service creation − Future home − Future of traffic − Virtual reality − Productivity tools	The future Internet: the operator's vision,' Eurescom P1657, EDIN 0546-1657, 2007.11

Distinguished from the traditional CT (communication technology) or IT (information technology) services, the services of the future should be reconsidered with broader concept since the future network will encompass wide range of heterogeneous networks [18]:

- The problem of scope, functionality, capability, granularity, time, scale, intelligence, roles, people and their stuff, and "at your service"

Future Network (or future) services can be stated as:

- the services which emerge in the year 2010 ~ 2030

  : FN services emerge with short/mid/long term time line.

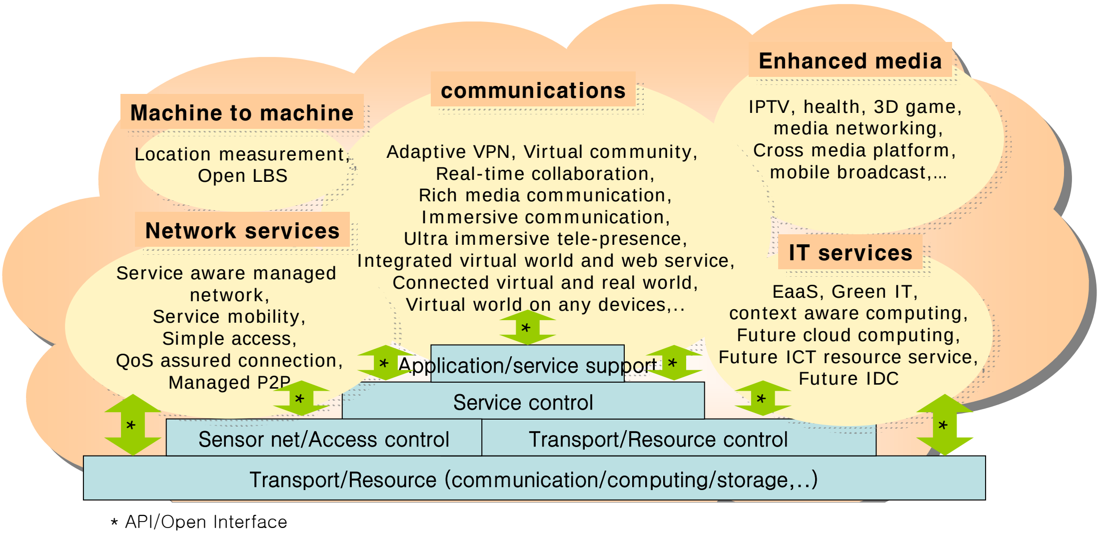
- the services which are provided and inter-work on top of both clean slate based new networks and/or existing networks

  : Since services are inherently transport /access network independent, it may span across the exiting and clean slate based infrastructures.

- the services whose features are both user centric (I-Centric) and network centric (Net-Centric)

  : The purpose of future services is to satisfy and provide best convenience for end users with optimal usage of network resources.

And it would cover the IT, Telecom, Media and Cloud computing areas, which can be provided on any layers of network (Figure 4): for example, future ICT resource services may be provided directly on transport and resource layers, or may be provided on transport/resource control layer in case with quality controls. Likewise, immersive communication services may be provided on application/service support layer, or service control layer according to provider's own service policy and capabilities. Capabilities of each network layer may be accessed with open standardized interfaces.



[Figure 4] Services Concept of Future Networks

The key features the Future Network services should support include:

- Context awareness
- Dynamic adaptiveness
- Self organization and Self-configuration
- Self-detection and self-healing
- Distributed control
- Mass data control
- etc

[Editor's Note] Further contributions are invited.

7. Milestone for Standardization on Future Network

[Editor's Note] Further contributions are invited.

8. Conclusions

[Editor's Note] Further contributions are invited.

Annex A : Gap Analysis

This Annex A 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 [19,20].

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	Future Network
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 management
	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	Limited	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".

[Editor's Note] Further contributions are invited.

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 cannot 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	Future Network
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 locatord
	Security	IPsec for IPv6	Not clear yet
	Mobility	MIPv6	Cross-layer design based mobility management
	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

[Editor's Note] Further contributions are invited.

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