Sommario: Vengono presentati la visione del NICT ed i cinque obiettivi della ricerca e sviluppo (R&D) della rete di nuova generazione (NWGN). Il NWGN è basato su nuovi concetti di design che guardano al di là della rete di nuova generazione (NGN) e di Internet. Il NWGN manterrà la sostenibilità della nostra civiltà prospera e contribuirà a risolvere i vari problemi sociali, utilizzando le tecnologie dell’informazione e della comunicazione. Sulla base di questa visione, 19 punti che riguardano le questioni sociali e le prospettive sociali vengono analizzati, e le esigenze funzionali del NWGN vengono estratte. I requisiti vengono raffinati e classificati in cinque obiettivi di rete che devono essere sviluppati per realizzare la visione di insieme.

Abstract: the National Institute of Information and Communications Technology (NICT) vision and five network targets of research and development (R&D) of the new generation network (NWGN) are presented. The NWGN is based on new design concepts that look beyond the next generation network (NGN) and the Internet. The NWGN will maintain the sustainability of our prosperous civilization and help resolve various social issues and problems by using information and communication technologies. Based on this vision, 19 items concerning social issues and future social outlook are analyzed, and the functional requirements of the NWGN are extracted. The requirements are refined and categorized into five network targets that must be developed for realizing the vision.

I. Introduction

The remarkable advances in telecommunications technology in recent years have brought about a new information revolution that ranks alongside the industrial revolution. Today, the Internet is an essential part of our social infrastructure not only in the business world but also in our everyday lives. The Internet, however, is facing a critical crisis. The original Internet itself was invented in the late 1960\textquotesingle{s}. The original usage of the Internet is a kind of communication tool for closed research community and it is used as a communication link among computers. Now a day, around 1,000,000,000 hosts are connected to the Internet and the number of the hosts is still increasing. The Internet architecture is extended to accommodate unsaturated user\textquotesingle{s} demand, but thin veneer of expansion of the Internet has come off, and the Internet finds it difficult to respond to newly emerging social demands. [1] said that the Internet is broken and a new type of routing architecture called flow based routing must be introduced into the new network system. Therefore, a new network that can overcome the several drawbacks of the Internet is required.

There are many activities for designing post Internet or future networks on the globe [2][3]. The NeW-generation network (NWGN), Japanese project belonging above activities, is based on new design concepts looking further beyond the next-generation network (NGN) and the Internet. In short, it aims to fundamentally solve difficult issues and limits in an improved and extended Internet, by a clean slate approach designing unconstrained by existing technologies. Research and development (R&D) of the NWGN is now done as a Japanese national project. The concept of NWGN is shown in Figure1.

The NWGN will emerge in 2015 to 2020. As for another activity, International Telecommunication Union (ITU) established a special discussion group called Focus Group on Future Networks (FG-FN) in the middle of 2009. One of FG-FN objectives is to collect and identify visions of future networks, based on new
technologies [4]. Four objects of Future Networks are shown in the latest draft of its output document “Draft Deliverable on “Future Networks : Design Goals and Promising Technologies” [5]. They are 1) Environment awareness, 2) Service awareness, 3) Data awareness, and 4) Social-economic awareness respectively. Recently NSF (National Science Foundation) announced that NSF has decided to fund four future Internet architecture research projects [6]. They are candidates of future internet architecture but the future network is still unrevealed.

The National Institute of Information and Communications Technology (NICT) launched the strategic headquarters of NWGN R&D on October 1, 2007, to strategically promote the R&D of the NWGN. The aims of the strategic headquarters include (1) planning the medium- and long-term R&D strategy for the NWGN, (2) playing a leading/guiding role in international cooperation and competition, and (3) promoting R&D human resources related to Information and Communication Technology (ICT) with a long-term/global perspective.

As for the medium to long term R&D strategy, NICT published NWGN vision and five network targets. The vision is derived from discussions about what and how to ICT contributes to create future delightful society. The five network targets represent functional requirement network images. They are “Value Creation Network,” “Trustable Network,” “Ambient/Ubiquitous Network,” “Self-* Network,” and “Sustainable Network.” It should be noted here that our technological strategy is not “seeds-oriented” but “needs-oriented.”

General technological strategies and road maps are established using an incremental approach that is an extension of today’s technology. However, our technological strategy is directly derived from the vision and considers how to realize the vision using ICT. The results obtained from the investigations are presented in this paper.

The rest of this paper is organized as following matter: NWGN vision and technology requirement for NWGN is described in Section 2, and the five network targets are shown in Section 3. Finally, Section 4 summarizes this paper.

2. NICT Vision for the NWGN

2.1 The Vision

The NWGN aims to maintain the sustainability of our prosperous civilization by looking beyond the NGN and resolving various social issues and problems by using ICTs. Further, by unfolding the potential ability of individuals and the society, the network aims to realize an affluent life of higher quality. Furthermore, by accepting human diversity, the network aims to lay the cornerstones for information and communication, which perpetually develops the human society.

To achieve these aims, we need to (1) construct a vision or a concept, (2) define the goals and values of the NWGN, (3) share consciousness of issues concerning future social problems, and (4) create a new image of the future society. To create such an image, we need to understand the roles and directions of each individual researcher or organization, and as a result, contribute to achieving a sustainable and rich human society and
world, bearing fruit as a significant activity.

The three values required to form the NWGN are as follows.

(1) Solving Emerging Social Issues (Minimizing the Negatives)

Serious issues such as energy shortage and aging demographics have left people increasingly concerned about their future safety and well-being. ICT should contribute to resolving these serious issues. The NWGN aims to help resolve challenging issues such as energy shortage, aging demographics, and natural disasters, that is, to minimize the negatives of society at both the domestic and global levels.

(2) Creating New Values (Maximizing the Potential)

If humankind is to have a bright future, it is essential that new values be created by improving industrial productivity and the quality of life and by empowering the latent potential of humans and society. Of course, this requires an environment wherein the driving principle of the economic society will not be comprised with increased focus on information and a radically new social information infrastructure. The NWGN aims to explore the world's potential abilities in this broad sense.

(3) Contributing to Inclusion

As globalization progresses, excessive development results in disparities that manifest themselves in the forms of regional disputes and confrontations, urbanization and depopulation, clashes between different generations, and the technology gap between the “haves” and the “have-nots.” Future societies are expected to permit the coexistence of cultural, geographical, and individual diversities in order to help the global culture to develop in new ways. In other words, there is a need to allow diverse situations in people's lives and social economies and on various scales from region to region. The NWGN aims to support the construction of an inclusive society wherein such diversity is respected and cooperation is promoted.

In the process of deriving concrete network images that realize the vision, the technological requirements of the NWGN were first derived from emerging social issues (social perspective), issues related to achieving a future knowledge society (future perspective), and respect for diversity and cooperation (inclusion perspective). Figure 2 lists 19 items investigated in this process.

According to the requirements obtained, they were classified into network technologies. Since these items vary in size from small to large, there is a wide range of technology requirements of the NWGN. Due to space limitations, the result of this process cannot be described in this paper. Please refer to [7].

3. NWGN Five Targets

As described in the former section, social issues and social outlook covering 19 items were analyzed, and the technology requirements of the NWGN were extracted. At the same time, we investigated technology requirements of the network; however, this could not be achieved using the expansion of the existing Internet technology or the NGN technology. As a result, more than 100 technology requirements for the NWGN were extracted and were classified into several abstract categories. The classification was carried
out by considering the links between the network and all the entities on the earth, relation between the earth and the sustainable society, trust between people and the networking society, and support relationships. As a result, it was consolidated into five network images, as shown in Figure 3.

These network images are network targets that show the NWGN the ways in which the vision can be realized. As for these five network targets, each technology development element is made conditional on being a technology requirement that contributes to resolving social issues and to the future social outlook. Hereafter, an overview of each target is described.

- **A: Value Creation Network**
  
  The aim of this network is to bring new service innovation in the network, growing beyond services simply offering connections. The issues concern the creation of a new value chain for offering services from the standpoint of users and the coexistence of diversifying user needs with sharing of functions for service execution. Moreover, in the future, it will contribute to the productivity of services by collecting and accumulating related information that flows through the network, combining business and human knowledge, aiming at building a platform that generates new services that were previously unavailable.

  There are two scenarios for implementing this value creation network as follows:

  (a) As the network becomes the platform to create new values, first the network itself modularizes this service function and the network must promote openness along with meeting various user needs (Step 1). Furthermore, the visualization of the service process offered through the network is achieved (Step 2). Finally, it aims at building a network platform which combines dormant knowledge of people (step 3).

  (b) It is also necessary to bring innovation involving the users of these functions, not for only network functions. The information transmission environment of the user is arranged (Step 1); Reliability is judged by information collection and analysis technology (Step 2); The network aims at enabling provision of information having new value originating in each individual which cannot be offered by existing media, and acting as the platform for an information and communications environment that creates this new value (Step 3).

  There are two sub-targets in this target (1) service creation network and (2) media creation network. The former aims to make the network itself the platform for services innovation and the latter aims at becoming an information and communication platform for the network to bring about new media innovation.

- **B: Trustable Network**
  
  The network is absolutely essential in all the social activities of individuals and organizations,
and the stability and trustworthiness of the network are important in maintaining continuous network functions. Here, achievement of new infrastructure to trust the society-wide network becomes an issue: Advanced failure tolerance and prompt recovery from failure, guarantee for services that provide stable operations in case of human error or cyber attack, and a network usage environment in which safety and trust are secured.

In fact, the presence of threats typified by cyber attacks is unavoidable, in addition to failures, including human errors, associated with its larger scale. Although such vulnerabilities are expected, it is important to develop a sustainable and stable network. In a networked living environment and a society-wide network environment, users demand (1) improvement in the reliability of various services and (2) a network usage environment with both high level stability and user-friendliness for privacy protection.

Towards achieving a trustable network which handles these points, the following two broad issues can be raised.

I. Social infrastructure for trustable network.

Uniform dependable network technology is sought, to offer continual and stable network functions from the user terminal to network infrastructure online service. While one assumes vulnerabilities such as cyber attacks and human errors, functions are required which achieve stable network operation, including advanced failure tolerance and prompt recovery from failure. In addition to such survivability of the network itself, it is also very important to prepare social infrastructure to provide survivability for people during disaster emergencies.

II. Trustable network for human and society

A service usage environment is demanded in which reliability is assured to network entities such as individual and enterprise transaction counterparties, when the network is extended to include a social environment such as online public services and banking operations. New trust infrastructure technologies are required which focus on the coming ubiquitous environment: advanced security infrastructure technology, personal authentication technology, privacy protection technology, identity management technology, service reliability technology, etc.

• C. Ambient/Ubiquitous Network

Issues concerning the environment, food, and ageing can be considered social problems that are closely related to the society and are foreseen at the time of the NWGN. In such an environment, to achieve a life supporting society in which humans can lead decent, high-quality lives, the support of ICT is required with respect to all living situations. There has been internationalization of distribution and progress in international cooperation, especially with respect to environment- and food-related issues. Thus, it is believed that cross-border food distribution management, environmental monitoring, traffic accident prevention using networks, remote health care for senior citizens, and support for humans by network robots, can be achieved if it becomes possible to perceive, pursue, and collect and process necessary sensor information generated by humans, things, and living environments on a broad global scale. Further, NWGN should help resolve the abovementioned social issues. Achieving the above requires a global environmental sensing system, that is, a global sensor/actuator cloud infrastructure to universally connect and manage sensor actuators in the living environment, and middleware that can adaptively and flexibly handle data in the cloud infrastructure. A network will be achieved that supports a living environment in which sensor information generated by the living environment that includes all existing people and things can be sensed and tracked, and if necessary collected and processed and the judgment then transmitted to drive the actuator. The aim is to establish a management technology to realize a global sensor actuator cloud and scalable large-scale sensor actuator cloud for universally connecting the sensor actuators existing in the living environment, and to establish sensor actuator middleware that can process highly flexible data. Two main issues in achieving a living environment supporting network are given below.

I. Global-scale sensor/actuator cloud

Establish a configuration, control and management technology for global sensors/actuators/
cloud that can sense and track information generated by all existing people, things and living environments, and drive actuators.

II. Real-world information processing platform

Establish a middleware infrastructure technology for environment adaptable sensors and actuators that can flexibly sense, track, collect and process data, restore data and drive actuators in response to changing conditions and various demands.

• D: Self-* Network

This network is used for data transfer like Web and e-mail and to transfer sensor data and streaming data like audio and video. There is also rapid progress in the diversification of services, such as offering applications and platforms through the network, called PaaS (Platform as a Service). On the other hand, although the accompanying conditions required for services are also diversifying, they are not satisfactory, and drastic problems are foreseen. A network that can be used freely by everyone and that responds flexibly to conditions requesting services shall be achieved. “*” in the target’s name is a wild card character. It is substituted by “management”, “configuration”, or “organizing”.

In order to achieve a network society focusing on persons and services which are freed from network restrictions, a new generation network which has the following three main functions shall be achieved.

I. Network for diversity

In order to operate so that the network can respond to various types of services at the same time, it responds to various demand conditions of the usage purpose of the network, and a network shall be achieved which can operate multiple types of networks at the same time.

II. Network unification

In order to fulfill various conditions which network services demand, optical/ electronic, wireless/ wired, and path/ packet integration networks shall be achieved in which services can be enjoyed in the best environment without considering the network.

III. “OMOTENASHI” (hospitable) network

In order to enable network services that everyone can easily enjoy unburdened, a user friendly, simple and easily used network shall be achieved.

• E: Sustainable Network

Information and communication systems such as cellular phones, Internet, e-mail, and search engines have already become indispensable infrastructure for the modern society. These information and communication systems were achieved through the synergistic effects of breakthrough innovative technologies, especially extra-large capacity (high data rate) communication technology typified by optical fibers, Internet technology, mobile telecommunication technology typified by cellular phones, and computer technology such as CPUs and memory. On the other hand, with the rapid innovation and spread of these technologies, this field is now facing many problems that can be termed as limitations of the earth (resource), and these problems are being considered constraints for the further development of telecommunications. Therefore the NWGN must be earth friendly and it is necessary to find methods for solving the global problems that surround such information and communication networks and to achieve sustainability of the networking society and make further developments. Two leading issues are given below.

I. Energy Problems

The power consumption of ICT already accounts for around 5.8% of Japan’s total power consumption, and is expected to rise even further. This trend results from the increase in telecommunication traffic, due to the increase in users and the amount of power used by each user. There has been a sharp increase in this telecommunication traffic in recent years, and recent surveys have forecast that the new generation network will reach 1000 to 100,000 times the current level in 15 years. Therefore, even greater increases in power consumption are inevitable if the present communication network technology is used as is.

If we consider recent international trends in energy problems (CO2 gas emission reduction), drastic measures in information and communications networking are essential to tackle energy
problems, in order to achieve continuous progress in telecommunication and increase the number of users including in developing countries.

II. Frequency resource problems

Radio frequency resources are on the verge of hitting their limits, due to the rapid increase in the population using wireless communications typified by cellular phones, and faster communication speeds. Considering user demand for enhanced communication speeds, and the demand for wireless communication capacity following new usages such as ubiquitous communications and sensor networks, etc., it is essential to find solutions in new generation networks with great technology breakthroughs for exhausted radio frequency resources.

4. Conclusion

This paper presented NICT NWGN vision and five network targets. It is a technological strategy; aims to define the innovative network required after 10 to 20 years and propose the execution of its research and development. However, execution of this strategy requires planning and execution of strategies other than technological strategy, ex. testbed strategy, technology transfer strategy, R&D funding strategy, etc.. Therefore, we have already started such planning. Especially in R&D on network technologies for the new generation, both deskwork investigations and testbed demonstrations are necessary. NICT has already started R&D along with this strategy with special focus on Self.- Network and designed new testbed for NWGN called JGN-X. The NWGN or Future Networks, however, is still unrevealed.
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References