International Cooperation in the Introduction and Promotion of Next Generation Mobile Networks

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Standardization activities of the next generation mobile networks, which will succeed W-CDMA, CDMA2000 and other third-generation systems, are proceeding in parallel in multiple standards organizations such as 3GPP, 3GPP2, and IEEE. In promoting new technologies, the wide range of cooperation among not only operators but also vendors, standards organizations, research labs and other concerned organizations is essential. The NGMN Initiative was set up for this reason, led by operators, and has begun to collect requirements, evaluate standard technology, study development scenarios, and preserve interoperability in order to build a framework for the smooth introduction and promotion of the next generation mobile networks. We report on trends in the standardization of next generation mobile network technologies and the present situation of international cooperation in the NGMN Initiative.

1. Introduction

Looking back on the history of mobile phone progress, different systems have been used in Japan, Europe, and the U.S. in the first-generation analog mobile phones, and the second-generation digital mobile phones. When Japanese users travel abroad, they can use the same phone number as they use in Japan by renting a mobile terminal that is suitable for their travel destination from the mobile phone company. As mobile phones proliferate throughout the world, it becomes more convenient to use one's own terminal abroad, so there is a high demand for being able to use Japanese mobile terminals anywhere in the world. The above are the reason why the need for an international standard for the third-generation system is growing. NTT DoCoMo was the world's first operator of the third-generation system W-CDMA in 2001. The third-generation system has many more additional functions and options than did the second-generation PDC/Global System for Mobile communications (GSM), and it is necessary to decide which functions to select to realize a single service from the standard specifications. Furthermore, the specifications are sometimes open to different interpretations, and this ambiguity makes it difficult to decide with full confidence on an implementation. For those reasons, operators in Europe and the U.S. as well as in Japan have been forced to spend much time on unifying the interpretation of the specifications and achieving interoperability.

In the progress of W-CDMA, High-Speed Downlink Packet Access (HSDPA) services have already begun. Standardization of High-Speed Uplink Packet Access (HSUPA) has also been completed, and introduction of the mobile networks that is being referred to as the next "3.9-generation" is com-

ing into view. The Next Generation Mobile Networks (NGMN) Initiative [1] has emerged from that background, and leading operators in Europe, the U.S. and Asia are cooperating on the introduction and promotion of the next generation after HSPA (HSDPA, HSUPA) and EVolution Data Only/Optimized (EVDO)[*1] systems. Standardization of the next generation mobile network technologies are being vigorously conducted by multiple organizations such as 3rd Generation Partnership Project (3GPP), 3GPP2 and Institute of Electrical and Electronics Engineers (IEEE).

The relations among the standards organizations and the NGMN Initiative are shown in **Figure 1**. The standards organizations make requirement specifications and technical specifications, but as a step prior to that, it is necessary to collect requirements from potential market demand when deciding on what standard specifications should be set. Furthermore, after the completion of the technical specifications, interoperability of standard-based services will be achieved through interoperability tests and actual-environment trials. The NGMN Initiative complements the activities of standards organizations, playing its part before and after specification-making activities. While the activities of the NGMN Initiative support standardization, the NGMN Initiative is not itself a standards organization.

Chapter 2 below describes the situation of standardization activity of next generation mobile network technologies. Chapter 3 explains the background of establishment, current activities and the organization of the NGMN Initiative. Chapter 4 describes the LTE/SAE Trial Initiative (LSTI)[*2] activities. This Initiative conducts the trials, with the cooperation of the NGMN Initiative, of the radio access network and core network systems for which the 3GPP Long Term Evolution (LTE)[*3] and System Architecture Evolution (SAE)[*4] are the respective standard specifications. In the conclusion, we summarize how we will proceed in the future and NTT DoCoMo's challenges.

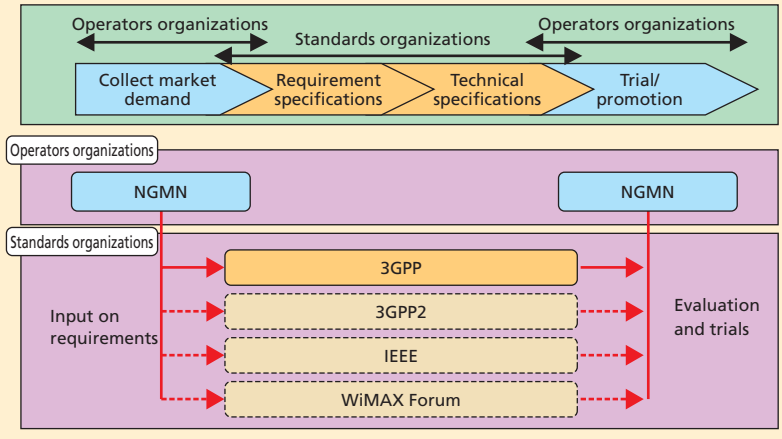

Figure 1 Positioning of the standards organizations

2. Next Generation Mobile Network Technology Trends in Standardization

The main standards organizations concerned with the next generation mobile networks and a comparison of their basic standard specifications are shown in **Table 1**[2][3]. Since 1998, standardization for the Third-Generation (3G) mobile communication system has been conducted by 3GPP and 3GPP2. The Worldwide Interoperability for Microwave Access (WiMAX) Forum[*5] has also been deciding on specifications for Mobile WiMAX. In the following sections, we describe recent trends in the activities of these important standards organizations.

2.1 3GPP Trends

The scope of 3GPP activities is to

*1 **HSPA/EVDO**: HSPA is a name formed from the combination of HSDPA and HSUPA. HSDPA and HSUPA are respectively high-speed packet transfer systems for the downlink and uplink based on W-CDMA and standardized by 3GPP. EVDO (formally named CDMA2000 1xEV-DO) is a high-speed packet transfer system for the downlink and uplink based on cdma2000 and standardized by 3GPP2.

*2 **LSTI**: An industrial organization that promotes the 3GPP LTE and SAE standards for interoperability. Vendors and operators cooperate to confirm the interpretation of standard specifications, decide on test items, and test interoperability.

Table 1 Comparison of next generation mobile network basic specifications

System		IEEE 802.16e (Mobile WiMAX)	3GPP2 UMB	3GPP LTE (E-UTRAN/E-UTRA) (under development)
Multiplexing		OFDMA	OFDMA CDMA※1	OFDMA SC-FDMA
Duplexing		FDD/TDD	FDD	FDD/TDD
Frequency band (Hz)		1.25~20 MHz	1.25~20 MHz	1.4~20 MHz
Data services (bit/s)	Sector Maximum data rate (downlink)	Wave1: 20.16 Mbit/s (10 MHz, Up/down ratio2:1TDD) Wave2: 40.32 Mbit/s (10 MHz, Up/down ratio2:1TDD)	152 Mbit/s (20 MHz) 288 Mbit/s (20 MHz)	326 Mbit/s (20 MHz)
	Sector Maximum data rate (uplink)	Wave1: 5.04 Mbit/s (10 MHz, Up/down ratio2:1TDD) Wave2: 10.08 Mbit/s (10 MHz, Up/down ratio2:1TDD)	151 Mbit/s (20 MHz)	86 Mbit/s (20 MHz)

FDD: Frequency Division Duplex
TDD: Time Division Duplex
SC-FDMA: Single-Carrier Frequency Division Multiple Access
※1 Part of the uplink control signal uses the CDMA base.

set specifications for the 3G mobile communication system based on the evolved GSM core network and the Radio Access Network (RAN) that supports it. After setting the initial specifications in 1999 (Release 99), 3GPP has been working on revised specifications in response to market needs and technological progress. The main current activity is study of the long-term evolution of the 3G mobile communication system under the working name of LTE. Most of radio interface specifications were completed by LTE in September 2007, and the Release 8 specifications are the objective for the next term. The radio technology specifications are called Evolved Universal Terrestrial Radio Access Network (E-UTRAN)/Evolved UTRA (E-UTRA)(Table 1). LTE is studying the incorporation of Orthogonal Frequency Division Multiple Access (OFDMA)[*6], Multiple Input Multiple Output (MIMO)[*7] and other such new technologies to achieve a further dramatic improvement in data transmission rate. The objective is to improve spectral efficiency by a factor of 3 or 4 relative to the Release 6 specifications, which improved reception performance with high-speed technology for the downlink (HSDPA).

Concerning the core network that accommodates E-UTRAN, too, SAE has continued with study of the network development series of standardization that had previously been investigated by 3GPP. The technical specifications are called the Evolved Packet Core (EPC), and the setting of the standard specifications for Release 8 is in progress. Under the premise of an all-IP network in which all services will be implemented with IP, EPC is targeting an architecture that can accommodate heterogeneous radio access.

2.2 3GPP2

The objective of 3GPP2, as same as 3GPP, is the long-term evolution of the 3G mobile communication system. It is conducting standardization for the Ultra Mobile Broadband (UMB) (Table1). The initial specifications were completed in June 2007. Concerning the core network, also, network specifications for the all-IP are being decided.

2.3 IEEE 802.16/WiMAX Forum

IEEE 802.16[*8] initially set the WiMAX specifications for fixed wireless access in 2004, and later added the IEEE 802.16e specifications that allow mobility management. Specifications for a system in which upper layer functions were added to the IEEE 802.16e specifications were set by the WiMAX Forum as Mobile WiMAX (Table 1). Those specifications involve many options, as well as the specifications of 3GPP and others, creating an issue for interoperability. For that reason, the WiMAX Forum defined a profile of the IEEE 802.16e specifications as Wave1. Wave2 further adds MIMO,

*3 **LTE**: The working name for a high-speed radio access system that extends the third-generation mobile communication system being studied by 3GPP. The specifications by LTE are referred to as E-UTRAN and E-UTRA.

*4 **SAE**: The working name for the evolved GSM core network development series that the 3GPP is studying. It targets accommodation of E-UTRAN and is premised on all services being implemented over IP. The specifications studied by SAE are referred to as the EPC.

*5 **WiMAX Forum**: An industrial organization that promotes development of the IEEE 802.16 standard and tests the interoperability of devices that conform to the IEEE 802.16 specifications. WiMAX is the popular name for IEEE 802.16.

Quality of Service (QoS), and IPv6.

3. International Cooperation of Operators in Promoting the Next Generation Mobile Networks

3.1 Establishment of NGMN Initiative and Its Objectives

In the promotion of widespread use of the next generation mobile networks, cooperation among all the members in the ecosystem such as infrastructure vendors, mobile terminal vendors, industrial forums, research labs, mobile operators and other concerned organizations is indispensable in addition to the creation of international standards by standards organizations. Therefore, activities for gathering basic requirements, performance targets, network deployment and transition scenarios as a shared vision, and creating new partnerships among members have begun. The leading operators in Europe, the U.S. and Asia have taken the initiative in this activity, and have produced a White Paper that summarizes the basic requirements of the next generation mobile networks. Next, NGMN Ltd. was established in the U.K in September 2006 to introduce and promote the next generation mobile networks that meets the requirements described in the White Paper. The seven founding members were China Mobile Communications Corporation, Orange S.A., Royal KPN NV, Sprint International Holding, Inc., T-Mobile International AG & Co KG, Vodafone Group Services Limited, and NTT DoCoMo, Inc.

In parallel with the establishment of the NGMN Initiative, several workshops were held to broaden the objectives of the activities; the System Architecture Workshop (July 2006 and March 2007), the Chipsets Vendor Workshop (November 2006), the Self-organizing Networks Workshop (May 2007), and the Terminals Workshop (June 2007). Such activities have increased the number of operators and vendors that endorse the NGMN Initiative and want to participate. There are currently 33 participating organizations, including 13 operators, 18 vendors, and two research labs. The NGMN Initiative partners are shown in **Figure 2**. The objectives of the NGMN Initiative activities are described in the January 2007 NGMN White Paper as follows.

The objective of the NGMN Initiative activities is to provide a platform for innovation by moving towards an integrated network for each individual mobile network operator for the seamless introduction of mobile broadband services. The newly introduced next generation mobile networks will coexist with the existing network, and allow a smooth transition.

To achieve that objective, the NGMN Initiative produces "Recommendations" to give direction to the activities of vendors and standards organizations and to give guidance toward providing a network of good cost effectiveness to succeed HSPA/EVDO.

Number	Class	Company
1	Member	Royal KPN NV
2	Member	China Mobile Communications Corporation
3	Member	AT&T Inc.
4	Member	T-Mobile International AG & Co KG
5	Member	Vodafone Group Services Limited
6	Member	Sprint Nextel Corp.
7	Member	NTT DoCoMo, Inc.
8	Member	Orange S.A.
9	Member	Telefónica S.A.
10	Member	Alltel Corp.
11	Member	SK Telecom Company Ltd.
12	Member	Telecom Italia S.p.A.
13	Member	Telus Corp.

Number	Class	Company
1	Advisor	University of Surrey
2	Advisor	RH TW Aachen - UMIC

Number	Class	Company
1	Sponsor	Airvana Inc.
2	Sponsor	Huawei Technologies Company Ltd.
3	Sponsor	Samsung Electronics Company Ltd.
4	Sponsor	Starent Networks Corp.
5	Sponsor	ZTE USA Inc.
6	Sponsor	LG Electronics Inc.
7	Sponsor	NEC Corp.
8	Sponsor	Alcatel Lucent S.A.
9	Sponsor	Cisco Systems Inc.
10	Sponsor	Ericsson AB
11	Sponsor	Intel Corp.
12	Sponsor	Motorola Inc.
13	Sponsor	Nokia Corporation
14	Sponsor	Nokia Siemens Networks GmbH & Co. KG
15	Sponsor	Nortel Networks Inc.
16	Sponsor	Texas Instrument Inc.
17	Sponsor	Qualcomm Inc.
18	Sponsor	Datang Mobile

Figure 2 NGMN partners

*6 **OFDMA**: A radio access system that employs orthogonal frequency division multiplexing (OFDM). OFDM achieves high-quality transmission that is highly robust against multipath interference (interference from delayed signals) by parallel transmission of a high data rate broadband signal using multiple low data rate carrier signals.

*7 **MIMO**: A technology for increasing data transmission speeds through the use of multiple antennas.

*8 **IEEE 802.16**: A high-speed radio data transmission standard that is being studied by the IEEE 802.16 committee for high-speed radio Metropolitan Area Network (MAN).

Although the White Paper identifies common requirements, the NGMN Initiative does not engage in the selection of a particular technology. The role of the NGMN Initiative is to evaluate the candidate technologies made by the international standards organizations described in Chapter 2 for whether or not they satisfy the requirements, and to ensure that individual operators can use the evaluation results to select technology that meets the demands of their respective markets.

3.2 NGMN Requirements

The White Paper selects 11 keywords that serve as keys to the requirements and sets priorities (**Figure 3**)[4]. These keywords relate mainly to the technical requirements, but they include some system requirements, such as the total cost of ownership.

The NGMN road map is shown in **Figure 4**[4]. The White Paper describes only the 3GPP road map for development from GSM. In the GSM/Universal Mobile Telecommunications System (UMTS) development series, NGMN goes on to evolve from GSM to 3G (W-CDMA), from 3G (W-CDMA) to 3G+HSDPA, and from 3G+HSDPA to 3G+HSDPA+HSUPA. The transfer speed requirement of the NGMN wireless link is from 40 Mbit/s to 100 Mbit/s or more, so LTE satisfies it in the GSM/UMTS development series. The milestones to the start of commercial service are shown in **Figure 5**[4]. The schedule for the NGMN set by the White Paper is as given below, and the trials that we describe later in this article will also proceed along these milestones.

- 2008:Standards completed
- 2009:Systems available for operator trials
- 2010:Commercial service possible on a country and operator specific basis

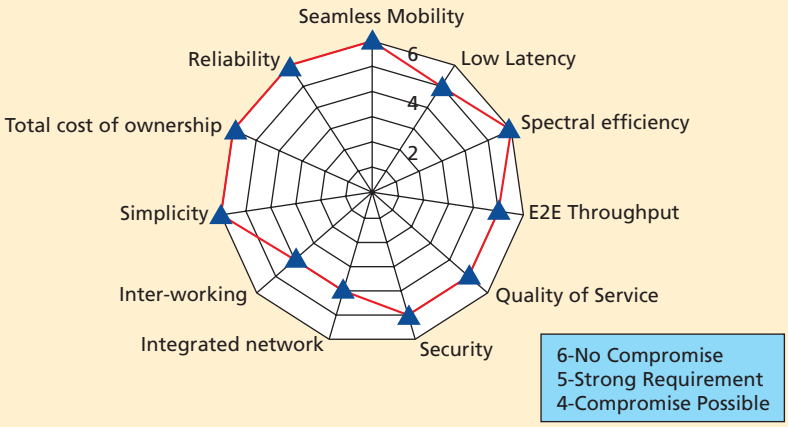

Figure 3 Priority

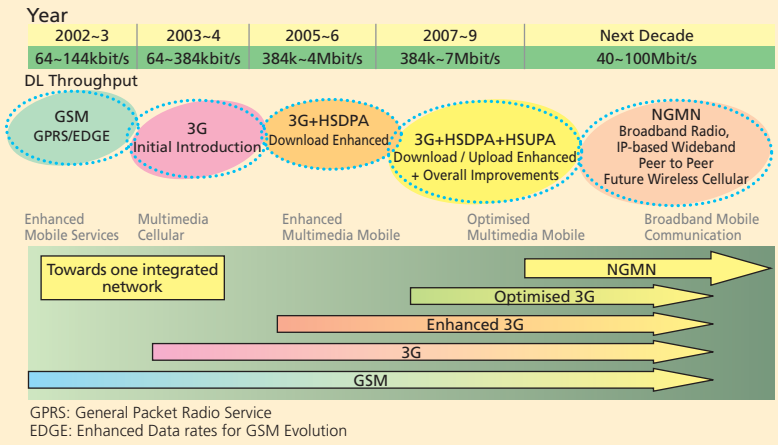

Figure 4 NGMN roadmap

The NGMN requirements have five parts, which are the Common Recommendations, Radio Access Network Recommendations, Core Network

Recommendations, Terminal Recommendations, and Service Creation & Delivery in NGMN. The Common Recommendations comprise the 18 items shown in **Table 2**.

3.3 Organization and Activities of the NGMN Initiative

The organization of the NGMN Initiative is shown in **Figure 6**. There are three membership classes. The Member class includes mobile operators, their parent companies, or their subsidiaries. Only one company from one corporate group can participate in the Member class. There is also a Participant class, which is subdivided into a Sponsor class and an Advisor class. Vendors should join the Sponsor class, and universities, research labs and other non-profit organizations can join the Advisor class. The NGMN Board is selected from the Member class. In the first two years since establishment, the seven founding member companies have served as the board members. The Operating Committee comprises participants from all of the Member companies and is charged with the day-to-day operations under Board governance. The Chair of the Operating Committee, which is titled the Operating Officer, does not serve under dispatch from an operator, but is a full-time position with the NGMN

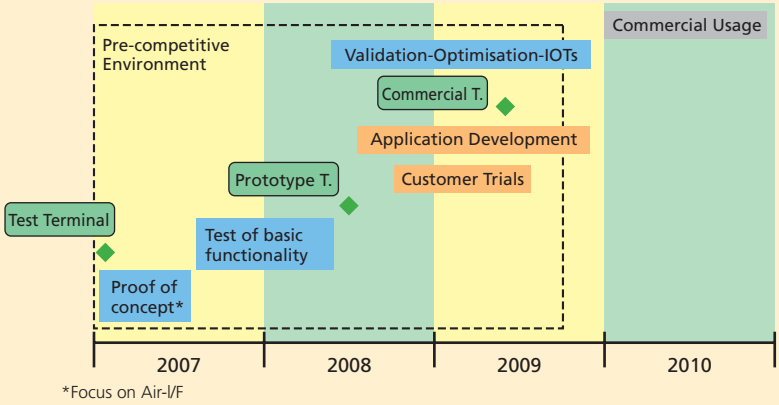

Figure 5 NGMN trials and milestones

Table 2 Common recommendations of the NGMN White Paper

Recommendations on techniques	• Simplified system and protocol structure for low latency • Optimized QoS architecture • Efficient always-on support • Seamless mobility • Network selection characteristics • Support of broadcast and multicast • Self-organizing networks • Security • Reliability support • Support for location determination
Recommendations on system management	• Carrier-grade Operation and Management (O&M) systems for commercial launch • Unified network management
Recommendations on ease of introduction	• Service continuity • NGMN migration path • Transparency of IPR licensing cost • Open and standardized interfaces • Implementation in embedded systems
Recommendations on regulation	• Compliance

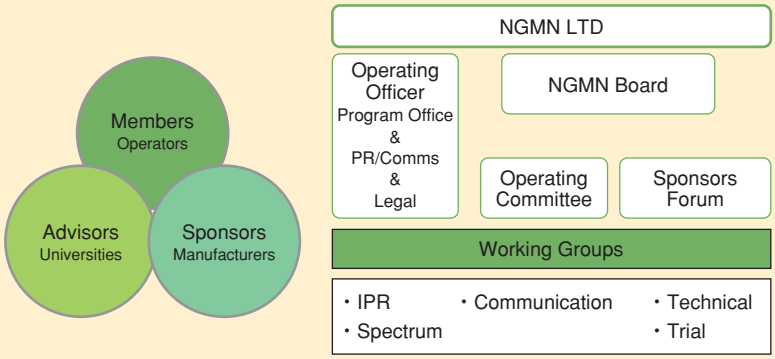

Figure 6 NGMN organization

Initiative. The Operating Officer is also a member of the Board, but his or her voting rights are limited to issues relating to the operations of the NGMN Initiative.

To achieve its mission, the NGMN Initiative has also set up the following five Working Groups (WG).

- Technical WG

  This group works out the details of the NGMN requirements and creates joint contributions for 3GPP and other such standards organizations. This group also defines criteria for evaluation of the next generation mobile network technologies decided by the standards organizations with respect to satisfaction of the NGMN requirements.
- Spectrum WG

  This group identifies the frequency-related requirements that are common to the NGMN Initiative members. It publishes its results as the Spectrum White Paper.
- IPR WG

  This group works to increase the transparency of the Intellectual Property Rights (IPR)[*9] framework of the mobile communication industry so that licensing conditions can be anticipated before the introduction of a new system. The transparency of IPR is one of the key contributions of the NGMN Initiative and it is important for the success of the industry. The White Paper describes requirements concerning IPR.
- Trial WG

  This group evaluates the candidate technologies set by the standards organizations whether they satisfy the NGMN requirements. The Trial WG performs evaluations in cooperation with the LSTI described in Chapter 4 and other such Trial Initiatives.
- Communication WG

  This group handles the NGMN Initiative press releases and gathers external feedback to invigorate communication among the members of the next generation mobile network ecosystem (operators, vendors, standards organizations, research labs, etc.).

4. LTE/SAE Trial Initiative

There are multiple candidate technologies that correspond to the NGMN requirements, but the NGMN Initiative does not select particular technologies. Furthermore, interest in a given technology varies among the members, so the trials of individual technologies are conducted by organizations outside the NGMN Initiative. The NGMN Trial WG serves as a window of cooperation with the trial Initiatives, requesting technical evaluation based on the evaluation criteria produced by the Technical WG and compiling the results.

The establishment of LSTI was announced in May 2007. LSTI will conduct trials of the radio access system and network system based on the 3GPP LTE and SAE standard specifications. The eight founding members are Alcatel Lucent S. A., Ericsson AB, France Telecom S. A., Nokia Corporation, Nokia Siemens Networks GmbH & Co. KG, Nortel Networks Inc., T-Mobile International AG & Co. KG, and Vodafone Group Services Limited. NTT DoCoMo participated in LSTI formally in July 2007. LSTI starts the test of radio access network, core network, and mobile terminal, and targets to launch the commercial service in 2009 or 2010 based on the LTE and SAE specifications.

5. Conclusion

We have described the situation of standardization related to next generation mobile networks, and the activities of the NGMN Initiative and LSTI, which support the introduction and promotion of the next generation mobile networks.

While it has been about a year since the NGMN Initiative began for-

*9 **IPR**: Rights given to the creating persons to protect intangible assets such as inventions, ideas, and expressions and so on that are the results of human creative activities. Examples include patents, utility model patents, design rights, trademarks, and copyright (This article is concerned mainly with patent rights.).

mal activities, the Initiative has already published the White Paper and the Spectrum White Paper, and has shared ideas and a road map among the partners in the ecosystem (vendors, operators, standards organizations, etc.). As the next step, it is necessary to put the ideas into concrete form and have a consistent interpretation of the specifications, and to ensure interoperability through trials with the objective of providing services that follow the road map. Concerning the standard specifications set by the 3GPP LTE and SAE, the LSTI has already enlisted leading vendors and operators and has begun activities, so it is important to share roles with the NGMN Initiative and proceed with the confirmation and promotion of the technologies in parallel.

NTT DoCoMo regards the standard specifications set by LTE and SAE as the next generation of mobile networks, and is contributing to the development of standardization and the widespread adoption of the specifications standardized by LTE and SAE as a founding member of the NGMN Initiative. In addition, the request for proposals for LTE started in July 2006 and development of LTE has begun under the name Super 3G[*10]. In July 2007, Super3G verification experiments began, and after participation in LSTI, we plan to use the results as feedback in contributing to the realization of international interoperability.

REFERENCES

[1] http://www.ngmn.org/
[2] 3GPP2: C30-20070514-038
[3] 3GPP: TR25.912 ver. 7.2.0
[4] Next Generation Mobile Networks Beyond HSPA & EVDO, A White Paper, http: //www. ngmn. org/doc/NGMN_Release_WP30. pdf

*10 **Super 3G**: A high-speed radio access system that extends the third-generation mobile communication system. NTT DoCoMo proposed this concept in 2004, and it is being studied by 3GPP as E-UTRAN/E-UTRA.