Standardization Activities for Next-Generation Mobile Communications Systems

● Akishige Noda

The 3rd Generation Partnership Project (3GPP) founded in 1998 by standardization organizations in Japan, Europe, North America, China, and South Korea released a set of specifications called Release 8 in December 2008. This release formally specified Long Term Evolution (LTE) technology and presented the evolved packet system (EPS), a new architecture covering the radio access and core networks. By supporting only packet communications and achieving more flexible frequency spectrum usage, LTE enables mobile communications at even higher bit rates and wider bandwidths. The explosive increase in new terminals like smartphones, however, is dramatically increasing the amount of data that the network must handle, making it necessary to further expand system capacity. To address these new issues, standardization activities for the Heterogeneous Network (HetNet) system and other new systems have begun, centered on 3GPP. This article describes standardization trends for next-generation mobile communications systems and Fujitsu's contributions to standardization activities.

1. Introduction

The development of the third-generation mobile communications systems is well underway. It follows first-generation systems based on analog technology and second-generation systems based on digital technology and will provide higher transmission speeds to users worldwide. This development effort began when standardization organizations in Japan, Europe, North America, China, and South Korea launched the 3rd Generation Partnership Project (3GPP) with the aim of developing a third-generation mobile communications system called International Mobile Telecommunications (IMT)-2000, a standard system that could be used by mobile communications operators and vendors around the world. Fujitsu has participated in 3GPP activities from the beginning and has actively contributed to the standardization of communications specifications for third-generation radio access systems: Wideband Code Division Multiple Access (W-CDMA), High-Speed Packet Access (HSPA), Long Term Evolution (LTE)/system architecture evolution (SAE), etc.

This article describes standardization activities centered on 3GPP for third-generation mobile communications systems.

2. 3GPP

The 3GPP was launched in 1998 by the Telecommunication Technology Committee (TTC) and Association of Radio Industries and Businesses (ARIB) in Japan, the European Telecommunications Standards Institute (ETSI) in Europe, the T1 Committee (now the Alliance for Telecommunications Industry Solutions [ATIS]) in North America, and the Telecommunications Technology Association (TTA) in South Korea to study and develop standard specifications for a third-generation system having a core network based on Universal Mobile Telecommunication System

Terrestrial Radio Access (UTRA) and Global System for Mobile Communications (GSM). The China Wireless Telecommunication Standards Group (CWTS) (now the China Communications Standards Association [CCSA]) was later added as an organizational partner, giving 3GPP its current form (**Figure 1**). Although 3GPP initially targeted a third-generation mobile communications system centered on a core network based on W-CDMA and GSM for study and development work, it later added Enhanced Data GSM Environment (EDGE) as a high-speed data communications technology based on GSM as a target specification standard. It also took on the work of developing standard specifications for LTE and evolved packet system (EPS) technologies, which were released in 2008 as a set of specification documents called Release 8.

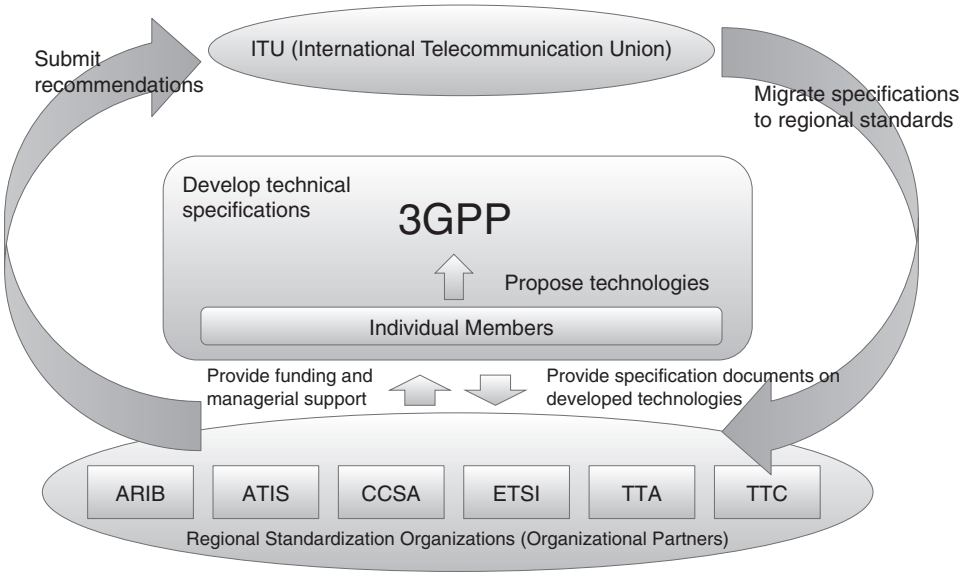
The work of 3GPP is focused on the study of standard specifications and the drafting of specification documents for use with third-generation mobile communications systems. Specifications prepared by 3GPP are released as standards in various countries and regions by the six regional standardization organizations known as "organizational partners." Furthermore, to make these specifications into an international standard, the organizational partners collaborate to propose 3GPP specifications to the International Telecommunication Union (ITU) so that they can be issued as ITU recommendations.

3. 3GPP organization

The 3GPP is broadly divided into four technical specification groups (TSGs): TSG-GSM/EDGE Radio Access Network (GERAN), TSG-Radio Access Network (RAN), TSG-Services and Systems Aspects (SA), and TSG-Core Network and Terminals (CT). Each TSG oversees a number of working groups (WGs), where most of the work of studying and developing specifications is performed. The 3GPP organization chart is shown in **Figure 2**.

4. Standardization trends

The goal has always been to increase



ARIB: Association of Radio Industries and Businesses
ATIS: Alliance for Telecommunications Industry Solutions
CCSA: China Communications Standards Association
ETSI: European Telecommunications Standards Institute
TTA: Telecommunications Technology Association of Korea
TTC: Telecommunication Technology Committee

Figure 1
Relationships between standardization organizations.

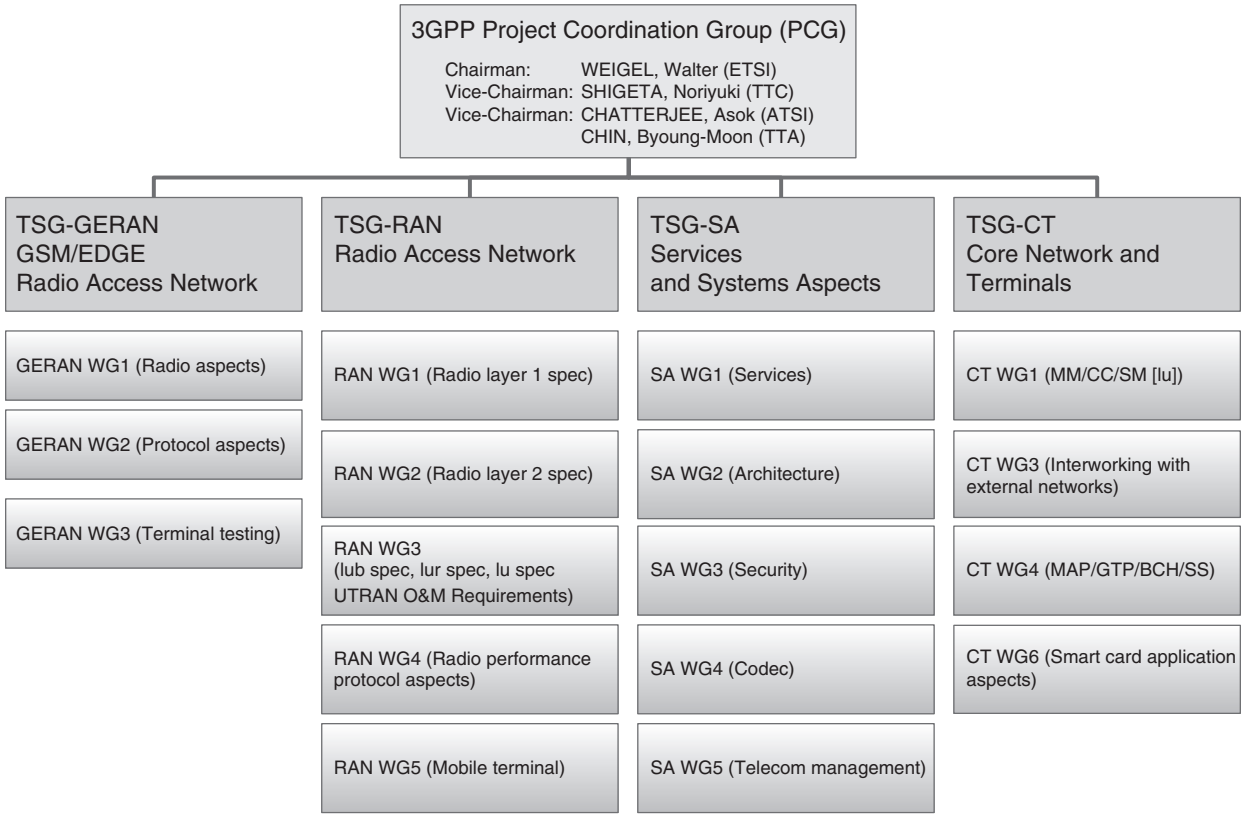


Figure 2
3GPP organization chart.

throughput and broaden the bandwidth of mobile communications systems. Throughput jumped dramatically over a ten-year period, from about 20 kb/s for the second-generation systems to about 300 Mb/s with the introduction of the LTE third-generation system in 2008. It rose again to a maximum of 1 Gb/s with the introduction of the LTE-Advanced fourth-generation system in 2011. The evolution of radio access technologies and increase in throughput from the second-generation system (GSM) to the LTE-Advanced fourth-generation system is shown in **Figure 3**. Third- and fourth-generation radio access systems are compared in **Table 1**.

As shown in **Figure 4**, spectral efficiency improved by about ten times with the switchover from first-generation (analog) to second-generation (digital) technology. It improved by only about four times with the switchover from second-generation technology to third-generation (W-CDMA) technology and by only about two times with the switchover from third-generation technology to enhanced HSPA (HSPA+), reflecting a decrease in the spectral-efficiency improvement factor. There was only slight improvement with the switchover to LTE. In short, achieving dramatic improvements in spectral efficiency is becoming increasingly difficult despite the continuing trend toward higher data rates and bandwidths.

For this reason, 3GPP is studying a heterogeneous network called HetNet. This network consists of a hierarchical arrangement of cells of various sizes including macro, micro, pico, and femto. The aim is to increase the capacity of the entire system. A conceptual diagram of HetNet is shown in **Figure 5**.

Implementing HetNet will require enhancements in mobility control including cell-selection, interference-control, and

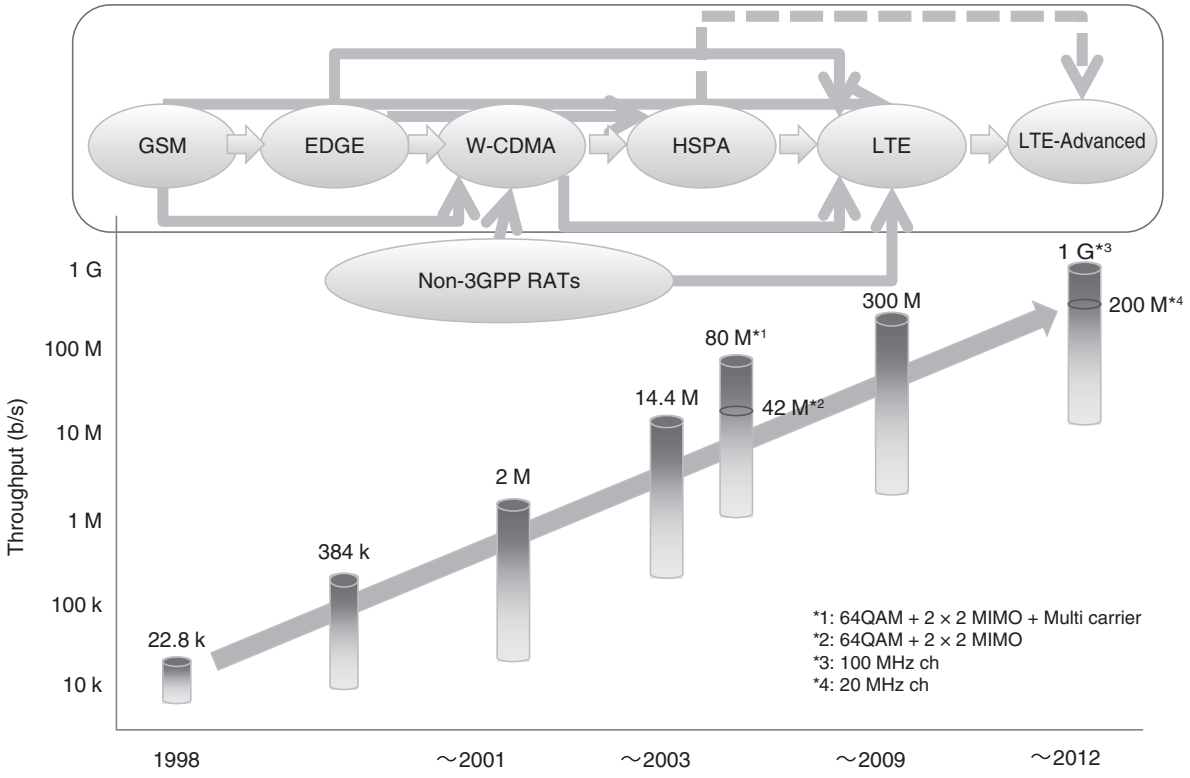


Figure 3
Evolution of radio access technologies (RATs) and throughput.

Table 1
Comparison of radio access systems.

	W-CDMA (3G)	HSDPA/HSUPA (3.5G)	3G LTE (3.9G)	LTE-Advanced (4G)
Access system	DL: CDMA UL: CDMA	DL: CDMA UL: CDMA	DL: OFDMA UL: SC-FDMA	DL: OFDM (?) UL: (?)
Bandwidth	5 MHz	5 MHz	20 MHz	Up to 100 MHz
Modulation system	HPSK, QPSK	HPSK, QPSK, 16QAM	QPSK, 16QAM, 64QAM, etc.	QPSK, 16QAM, 64QAM, etc.
Max. data rate	DL: 384 kb/s UL: 64 kb/s	DL: 14.4 Mb/s UL: 5.7 Mb/s	DL: 300 Mb/s UL: 75 Mb/s	DL: 1 Gb/s UL: 75 Mb/s
Feature	Adaptable to circuit switching services	Higher packet data speed	Dramatically improved data rate and latency	Further improved data rate and mobility

DL: Downlink (base station to mobile phone)
UL: Uplink (mobile phone to base station)
QAM: Quadrature amplitude modulation
HSDPA: High-Speed Downlink Packet Access
HSUPA: High-Speed Uplink Packet Access
HPSK: Hybrid phase shift keying
QPSK: Quadrature phase shift keying
CDMA: Code division multiple access
OFDM: Orthogonal frequency division multiplex

handover functions as well as the development of new specifications. These enhancements and developments are considered major standardization issues to be addressed in Release 11 (functional freeze is scheduled for September 2012).

Similar to specifications developed to improve throughput, data offload is being proposed as a new direction in the development of standard specifications. To give some background, these last few years have seen the loads on mobile communications systems jump

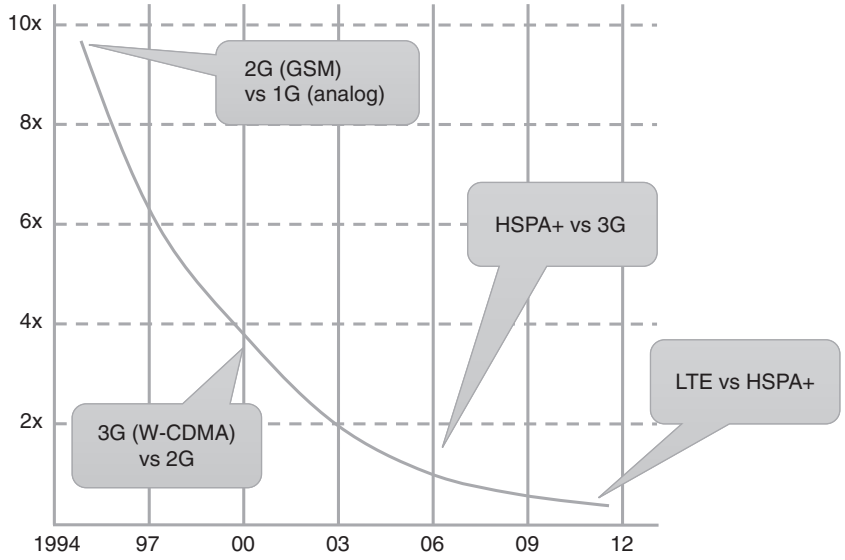


Figure 4
Improvements in spectral efficiency.

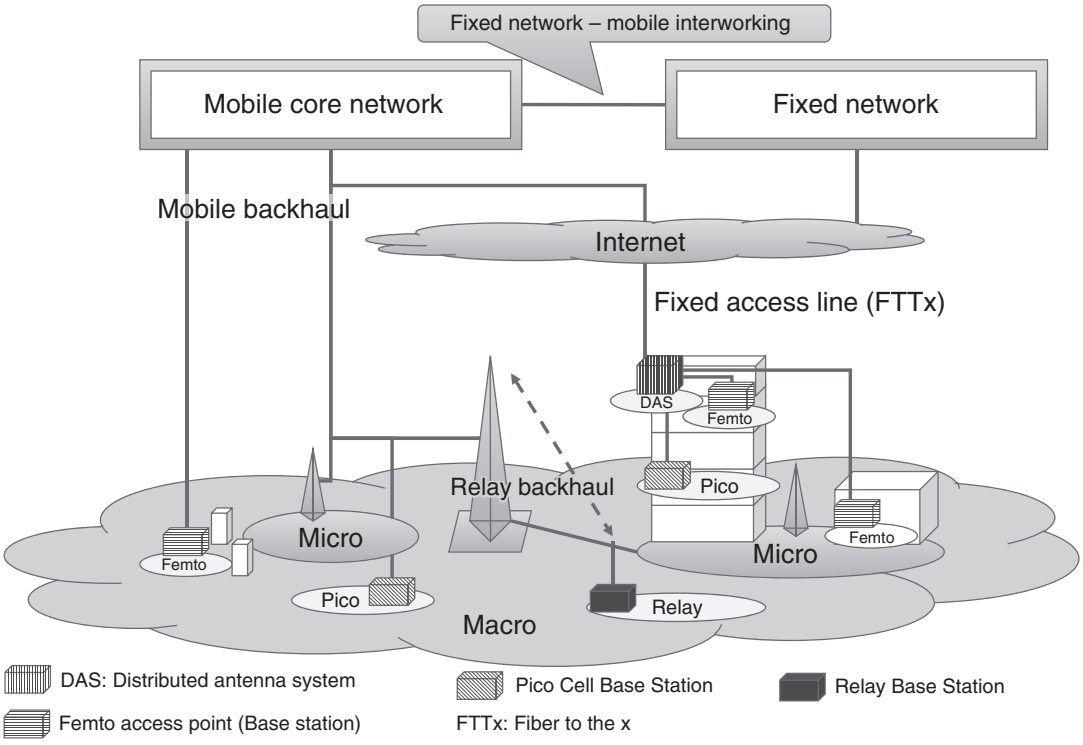


Figure 5
Heterogeneous network with hierarchical arrangement of macro, micro, pico, and femto cells and relay base stations.

as a result of increased data communications driven by the introduction of fixed-rate data-communication plans and the increase in smartphone usage. Additionally, new traffic in the form of machine-to-machine communications and new services for synchronizing the

information of multiple subscribers who wish to share calendar data, telephone numbers, etc. is expected to impose an even bigger data-communication load on mobile networks in the years to come. To deal effectively with such forms of large-capacity data communications, 3GPP is moving ahead with the development of standard specifications on traffic offloading.

The 3GPP release plan (standardization roadmap) is shown in **Figure 6**.

5. LTE as an ecosystem

Standardization activities targeting LTE are not concerned simply with the study and development of LTE technical requirements and protocol specifications. To get telecommunication operators to deploy LTE and users to accept it, a variety of business segments must be activated. That is, standardization activities tied into business activation must be promoted. This calls for the development of standard specifications that can be used with ease by all the major players in the LTE market, which means not only base-station and network vendors but also terminal-chipset vendors, service providers, and content providers to name a few. Of particular importance is the business and general consumer market, which is represented as an ecosystem in **Figure 7**. This ecosystem illustrates how it will become increasingly important in LTE standardization activities to involve not only infrastructure and device vendors but also vendors in the service and application fields.

6. Fujitsu standardization activities

Fujitsu has been contributing actively to standardization activities surrounding third-generation mobile communications systems. It contributed to the founding of 3GPP after being

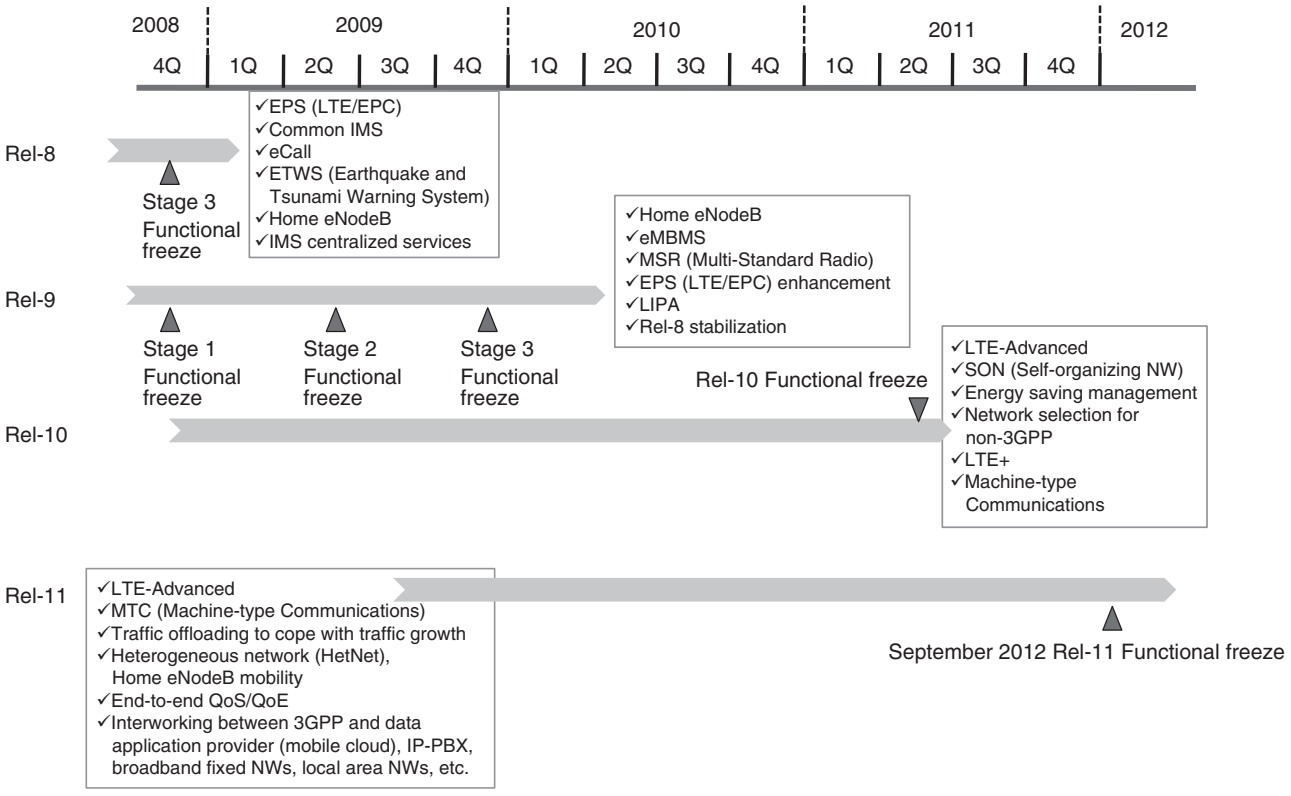


Figure 6
3GPP release plan.

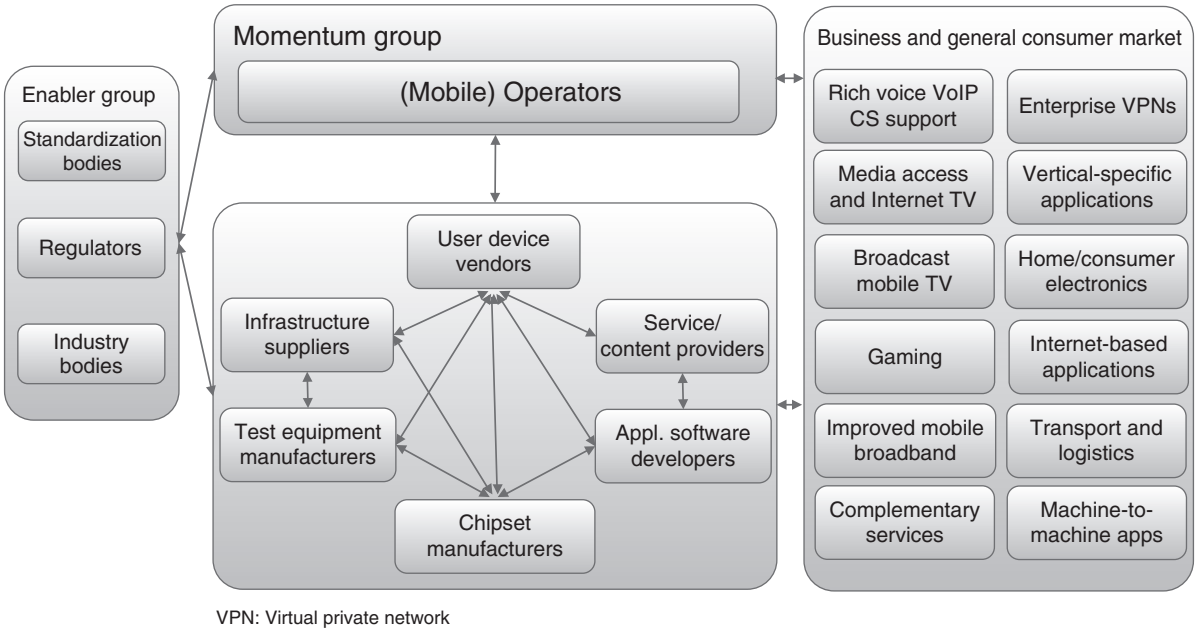


Figure 7
LTE ecosystem.

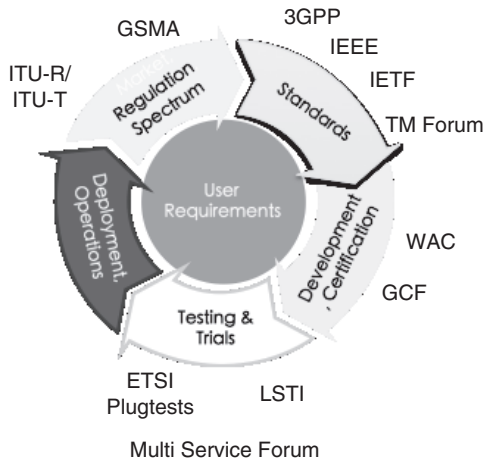
involved in a range of standardization activities conducted by the ITU, from those for the Personal Digital Cellular (PDC) system, Japan's second-generation mobile communications system, to those for the Future Public Land Mobile Telecommunications System (FPLMTS)/ IMT-2000.

Fujitsu has been a member of 3GPP from its founding and has made many proposals and contributions through its participation in the TSG-RAN, TSG-CT, and TSG-SA technical specification groups. Fujitsu personnel have served as chair and vice-chair of two working groups (TSG-RAN WG4 and TSG-SA WG2) and vice-chair of three technical specification groups (TSG-RAN, TSG-CT, and TSG-SA). Through these efforts, Fujitsu has come to be recognized as the Japanese company that has contributed the most to standardization activities as a member of 3GPP.

For standardization activities to be effective, industry organizations must cooperate with each other as they carry out their respective roles (**Figure 8**). The ITU and the Global System for Mobile Communications Association (GSMA) have the role of allocating spectrum and specifying required system performance, 3GPP and organizations like the Internet Engineering Task Force (IETF), the Institute of Electrical and Electronics Engineers (IEEE), and the TeleManagement Forum draw up standard specifications, and the Wholesale Applications Community (WAC), the Global Certification Forum (GCF), and the LTE/SAE Trial Initiative (LSTI) serve as certification bodies. At Fujitsu, the wireless network business department (Network Business Group), terminal business department (Ubiquitous Products Business Group), and Fujitsu Laboratories work together to contribute to standardization activities deemed necessary for these next-generation mobile communications systems.

7. Conclusion

Fujitsu has come to play an increasingly bigger role in standardization activities for mobile communications systems. It has made major contributions to the development of global standards in the 3GPP since the project began in 1998, and it has participated in and contributed



ETSI Plugtests: ETSI group for testing whether products conform to ETSI, 3GPP, IETF, and IEEE standards
ITU: International Telecommunication Union
ITU-R: ITU Radiocommunication Sector
ITU-T: ITU Telecommunication Standardization Sector
GSMA: Global System for Mobile Communications Association
IEEE: Institute of Electrical and Electronics Engineers
TM Forum: TeleManagement Forum
GCF: Global Certification Forum
3GPP: 3rd Generation Partnership Project
IETF: Internet Engineering Task Force
WAC: Wholesale Applications Community
LSTI: LTE/SAE Trial Initiative
ETSI: European Telecommunications Standards Institute

Figure 8
Cooperation between industry organizations.

to standardization activities surrounding the LTE and LTE-Advanced technologies through the ITU Radiocommunication Sector (ITU-R), the ITU Telecommunication Standardization Sector (ITU-T), the 3GPP, the IETF, and other standardization bodies. Fujitsu plans to step up its standardization activities with an eye to achieving convergence between cloud and mobile platforms.

Akishige Noda
Fujitsu Ltd.
Mr. Noda is engaged in standardization activities targeting mobile communications systems. He serves as vice-chair of the 3GPP TSG-SA and chair of the 3GPP WG in the TTC.