Future Network, IMT-2020 and Beyond Network Standardization in ITU-T Study Group 13

National Institute of Information and Communications Technology
Ved Prasad KAFLE

1. INTRODUCTION

I have been involved in the standardization of advanced network technologies (non-radio aspects) at the International Telecommunication Union (ITU) since 2007. I am mainly involved in Study Group 13 (SG13) of ITU's Telecommunication Standardization Sector (ITU-T) for the standardization of advanced network architecture and related technologies.

Long before starting to actively involve in ITU standardization activities, I had used many ITU standards during my education. While studying at the undergraduate level of electronics and communications engineering, I studied several ITU standards (formerly called the standards of the CCIR-International Radio Consultative Committee and CCITT-International Telephone and Telegraph Consultative Committee), mainly related with satellite communications, telephone signaling system (SS7), public telecommunication numbering plan, and telephone audio coding systems. Since that time, I had been very curious to experience in person with the process of development of global standards that had enabled telecommunication systems of the world to interoperate and connect people of one corner to the other.

After joining the National Institute of Information and Communications Technology, Tokyo as a researcher in 2006, I got opportunity to start involving in the ITU standardization process by submitting contributions to initiate and progress new Recommendation drafts. Note that ITU standards are called Recommendations. In the remainder of this article, I explain about my involvement in the ITU standardization of advanced networks, namely, Next Generation Network (NGN), Future Network, IMT-2020 and beyond networks.

2. INITIAL INVOLVEMENT

In 2007, I submitted my first Contribution to ITU-T SG13 to initiate a new Recommendation draft on the requirements of ID/locator separation in NGN. Working on this document as a contributor and editor inspired me to continue my involvement in ITU standardization activities.

Besides participating as a contributor and editor, I also started participating in the ITU initiated academic conference, called ITU Kaleidoscope, from its first episode held in ITU headquarters in Geneva, Switzerland in 2008. I submitted a paper on ID/locator split network architecture (my research topic of that time) to it, which was accepted to present at the conference.

In the ITU Kaleidoscope conference, many famous professors from several Japanese universities such as the University of Tokyo,

Keio University, Waseda University, Osaka University, Otani University, and Iwate Prefectural University, and leading researchers from various organizations such as NTT, KDDI, and NICT attended the conference and presented their papers. Prof. Tomonori Aoyama (then affiliated with Keio University, Professor Emeritus of The University of Tokyo) had given a keynote talk on New Generation Network (NwGN) based on the research activities of the AKARI Architecture Design Project, which was leaded by NICT with the support from industry and academia.

While participating in the ITU Kaleidoscope conference, I got plenty of opportunities to interact freely with the professors and senior researchers who had experience of involving in ITU standardization work for many years. I could meet them every day during coffee-breaks, lunches, and dinners. They taught me about various topics of telecommunication systems covered by ITU standards and the position or relation of these standards with other standards developed by different standards development organizations such as the Internet Engineering Task Force (IETF), Third Generation Partnership Project (3GPP), and IEEE Standards Association. They also provided me with the information about domestic standards development organizations of Japan and other countries.

I started applying the knowledge learned from the seniors to write contributions and gradually progress the Recommendation draft on the topic of ID/locator separation in NGN that I edited for the first time. It took about two years to finalize the draft and get it approved as the ITU-T Recommendation Y.2015 (Requirements of ID/locator separation in NGN). I was extremely happy to know that the number Y.2015 was assigned to the Recommendation because the NwGN, whose architecture was planned to be based on the concept of ID/location separation, was expected to get deployed in the year of 2015. My then senior at NICT, Dr. Toshio Morioka (currently a professor at Technical University of Denmark) mentioned this coincidence several times to encourage me to continuously involve in ITU standardization work as a delegate from Japan.

Since the approval of the first Recommendation ITU-T Y.2015 that I contributed and edited, I have so far finished editing 12 Recommendations and several Supplements. Next, I discuss my involvement in ITU standardization as an editor of these Recommendations that specify the technologies of future networks, IMT-2020 and beyond networks, as well as a Rapporteur of ITU-T SG13.

3. FUTURE NETWORK STANDARDIZATION

The standardization of future networks in ITU-T SG13 began in the study period of 2009-2012 when most standardization activities on NGNs had completed, and SG13 had started looking for new visions of networks beyond NGN. To collect ideas on future network visions and design goals from the broader participation of both ITU members and non-member experts affiliated with industry and academia, SG13 established the Focus Group on Future Networks (FG-FN) under the chairmanship of Mr. Takashi Egawa (NEC). In its lifetime of almost two years, FG-FN produced four deliverables on the terminology, objectives and design goals, network virtualization framework, energy saving, and identifiers and identification processes. These deliverables were submitted to SG13 for further consideration on approving their updated versions as Recommendations.

Table 1. ITU-T Recommendations based on FG-FN deliverables

Serial No.	Rec. No.	Title
1	Y.3001 (2011)	Future networks: Objectives and design goals
2	Y.3011 (2012)	Framework of network virtualization for future networks
3	Y.3021 (2012)	Framework of energy saving for future networks
4	Y.3031 (2012)	Identification framework in future networks
5	Y.3035 (2015)	Service universalization in future networks

ITU-T SG13, after having several rounds of further improvements, approved them as four Recommendations shown in Table 1. Recommendation ITU-T Y.3001 identified four important aspects of future networks, namely, service awareness, data awareness, environmental awareness, and socioeconomic awareness. It was focused on the vision and goals rather than implementable specifications to achieve interoperability among different components, devices, or systems. Together with the four objectives, Y.3001 listed twelve design goals of future networks as shown in Figure 1. This Recommendation provided a reference model for all activities related with future network standardization.

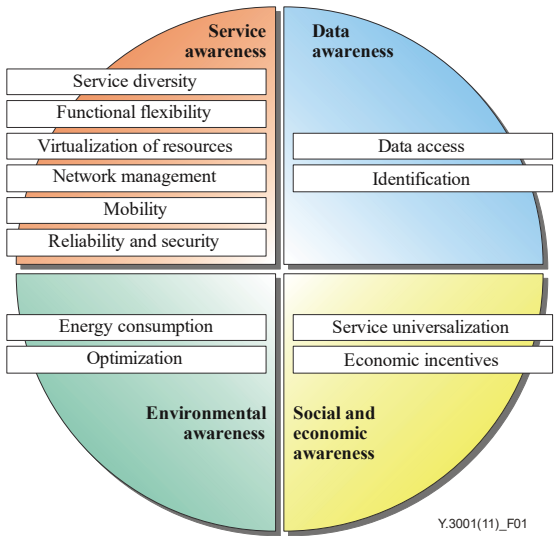

Figure 1. Four objectives and twelve design goals of future networks (ITU-T Y.3001)

The technological aspects of four objectives of service awareness, environmental awareness, data awareness, and social and economic awareness were separately described in the ITU-T Recommendations Y.3011, Y.3021, Y.3031, and Y.3035, respectively.

I took the responsibility of editing a Recommendation draft on the data awareness based on the FG-FN deliverable. The draft was updated several times in SG13 meetings by additional contributions submitted by delegates. It took about one year of editing work before it could get approved as the ITU-T Recommendation Y.3031. Figure 2 shows the identification framework that connects various communication objects and physical networks. It consists of three components, namely, ID spaces, ID discovery service, and ID mapping service. ID spaces define and manage various types of IDs. The ID discovery service discovers all types of IDs related to communication objects. The ID mapping service performs mappings of IDs of one type with the IDs of other types using the ID mapping registries, which maintain mapping relationships between various types of IDs.

The editors, including me, of the future network related Recommendations also wrote a manuscript describing the ITU standardization activities on future networks. The manuscript was published in the IEEE Communications Magazine [1].

Since 2014, in addition to the role of a contributor and Recommendation draft editor, I have assumed the role of a Rapporteur of ITU-T SG13. In the beginning (2014-2016), I was responsible for the coordination of discussion and editing work for progressing data-aware networking (DAN) related Recommendation drafts in Question 15. During the period of two years, I edited two Recommendations of

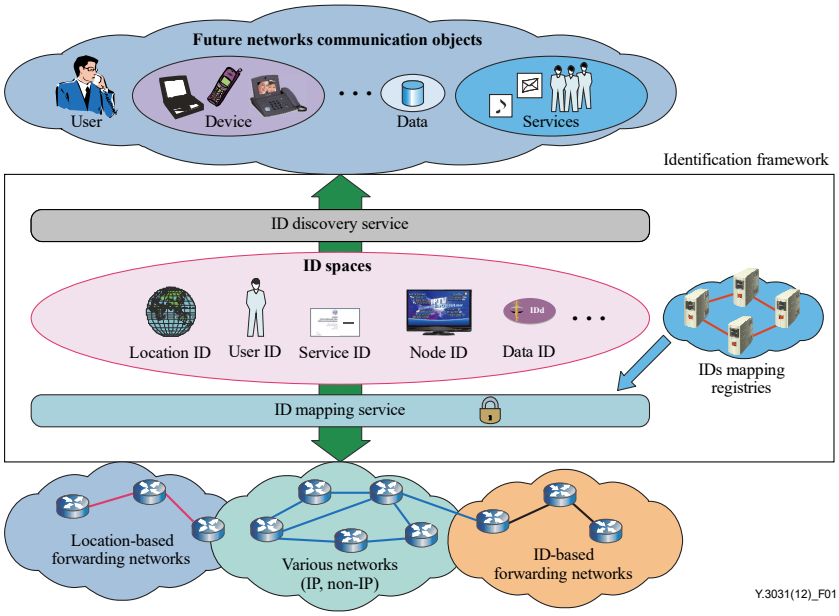

Figure 2. Identification framework in future networks (ITU-T Y.3031)

Y.3032 (Configurations of node identifiers and their mapping with locators) and Y.3034 (Interworking of heterogeneous component networks in ID/locator split-based future network). I coordinated the Question 15 meeting sessions as Rapporteur for the development several other Recommendations edited by ITU-T delegates.

4. IMT-2020 AND BEYOND NETWORKS

In the study period of 2017-2020, ITU-T SG13 was reorganized with the title of "IMT-2020 and new network vision" to study the non-radio aspects of International Mobile Telecommunication (IMT)-2020. (IMT-2020 is the ITU-coined term to denote the 5G mobile networks system.) I became Rapporteur of the new Question 22 titled "Upcoming network technologies for IMT-2020 and future networks" with the terms of reference to continue work on data-aware networking (with the new name of information-centric networking, ICN) as well as on the applications of emerging technologies such as distributed ledger technology (DLT) and service function chaining in ICN. In this study period (which was extended through 2021 due to COVID-19 pandemic), Question 22 developed many Recommendations that got numbers in the range of Y.3071-Y.3078. Among them, Y.3071 (Data aware networking (information centric networking)-Requirements and capabilities) and Supplement 47 (Information-centric networking–Overview, standardization gaps and proof-of-concept) provided the foundation on which the other Recommendations were based.

As the study on IMT-2020 gradually matured in the later phase of this study period, the study focus shifted to adding advanced features such as artificial intelligence (AI) and machine learning (ML) capabilities to the network architecture of IMT-2020. To explore more in this area by having involved experts from both inside and outside ITU membership, ITU-T SG13 established the Focus Group on Machine Learning for Future Networks including 5G (FG ML5G) in 2017. In its active lifetime of slightly more than two years, FG ML5G produced several deliverables covering the topics of architecture framework, use cases, evaluation of intelligence level, data handling, and ML model marketplace

integration. These deliverables were submitted to the parent SG13, where most of them were upgraded as Recommendation drafts after having several rounds of updates. As listed in Table 2, the four drafts were approved as Recommendations and one as a Supplement by 2020.

Table 2. ITU-T Recommendations and Supplement based on FG-ML5G deliverables

Serial No.	Rec./ Supp. No.	Title
1	Y.3172 (2019)	Architectural framework for machine learning in future networks including IMT-2020
2	Y.3173 (2020)	Framework for evaluating intelligence levels of future networks including IMT-2020
3	Y.3174 (2020)	Framework for data handling to enable machine learning in future networks including IMT-2020
4	Y.3176 (2020)	Machine learning marketplace integration in future networks including IMT-2020
5	Supplement 55 to Y.3170 Series (2019)	Machine learning in future networks including IMT-2020: use cases

ITU-T Y.3172 provides the generic architectural framework for using machine learning in advanced network architecture, not restricted to IMT-2020 network only. It specifies two different environments, namely, ML sandbox in which ML algorithms are trained by using simulators and ML pipeline in which the trained ML algorithms are applied to real networks for control and management. Based on this architecture framework, several other Recommendations were subsequently developed to address various issues related to the architecture. For example, based on the outcome of a Japan Government funded project jointly handled by KDDI, NEC, Hitachi, and NICT, we proposed to SG13 two Recommendation drafts to specify the architectures and interfaces of AI-based network service provisioning and network resource and fault management. After having progressed the drafts with several rounds of updates through contributions submitted from us, they could finally be approved as ITU-T Recommendations Y.3177 and Y.3178, which are listed in Table 3.

Table 3. ITU-T Recommendations on AI-based resource and fault management and network service provisioning

Serial No.	Rec. No.	Title
1	Y.3177 (2021)	Architectural framework for artificial intelligence-based network automation for resource and fault management in future networks including IMT-2020
2	Y.3178 (2021)	Functional framework of AI-based network service provisioning in future networks including IMT-2020

The ITU-T study period of 2017-2020 of was extended by one year through 2021 as the World Telecommunication Standardization Assembly (WTSA-20) could not be held in 2020 due to COVID-19 pandemic. WTSA-20 was held in March 2022, which mandated SG13 for the new study period of 2022-2024 with the Question structure similar to the previous study period. I have remained in the role of Rapporteur of Question 22, whose terms of reference mandate to standardize ICN and in-network computing related technologies.

Besides the role of Rapporteur, I am recently also taking the role of a contributor and editor to progress the control architecture of fixed, mobile and satellite convergence in Question 23 of SG13. The various kinds of terrestrial networks such as data network, fixed wireless networks (e.g., WiFi) and mobile cellular networks) are already interconnected by well-established standard technologies. However, non-terrestrial networks such as satellites are

still mostly working in an isolation. Therefore, the issues of terrestrial and non-terrestrial network integration have been considered crucial for the architecture of mobile networks of beyond IMT-2020. I have proposed a Recommendation draft on an integrated network control architecture framework for providing high quality network services spanning over the fixed, mobile and satellite integrated network infrastructure. I have been editing this draft, which is in plan to finalize in March 2024.

5. CONCLUSION

I have been involved in ITU-T standardization activities, mainly of SG13, for more than 15 years, and I plan to continue my contributions to the standardization of advanced network technologies for more years. ITU-T SG13 has been playing a central role in the standardization of non-radio aspects of NGN, Future Network, IMT-2020 and beyond network architectures. It has also recently explored emerging technologies of network slicing, AI/ML, quantum key distribution, and trusted network infrastructures.

Based on my experience, I can clearly say that involvement in global standardization activities enhances not only our technical knowledge but also our negotiation skill. We get opportunity to work with experts coming from different countries of the world. We gain hand-in experience to amicably address the issues of socioeconomic diversity and differences in the expression of opinions by people belonging to different countries speaking different languages. Moreover, ITU provides a platform where we can work together with participants affiliated with industry, academia, and government. The moment a new technology that we proponent becomes a global standard, we get immense happiness and satisfaction from the achievement. I would like to take this opportunity to encourage young engineers and professionals to contribute to global standardization work.

REFERENCES

[1] D. Matsubara, T. Egawa, N. Nishinaga, V.P. Kafle, M.-K. Shin, and A. Galis, “Towards future networks: A viewpoint from ITU-T,” IEEE Communications Magazine, Vol. 51, Issue 3, pp. 112-118, March 2013.