Standardization Activities in ITU-T

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Standardization activities for Future Networks in ITU-T have produced 19 Recommendations since it was initiated in 2009. The brief history of the activities is described here, especially starting with the first Recommendation Y.3001 that shows the vision of Future Networks including its four objectives and twelve design goals. In particular, the current standardization activities regarding the two of the objectives, namely service awareness and data awareness, are elaborated.

1 Introduction

In today's borderless society, networks play a most important role in the information communication infrastructure, and enable cross-border transmission of any information. Consequently, network technology is absolutely essential for international interconnection. ITU is an international standardizing body which, at the time of writing this paper in 2015, has completed 150 years since its establishment, and has so far worked toward the standardization of numerous communication architectures, interfaces, protocols, and so on, supporting international communication. Moreover, ITU has been focusing on Next Generation Networks (NGN), and is actively working toward the rapid standardization of Future Networks (FN). This paper gives an overview of the background of the standardization activities of ITU-T with regard to FN, and as part of that explains the important standardization recommendation ITU-T Y.3001. We describe the key concepts, and give a summary after explaining the service aware networking and the data aware networking.

2 Background of ITU-T's standardization activities for FN

ITU-T focused on FN, for which research and development had just started as a network to succeed the NGN. The theme of the Kaleidoscope Event held in 2008 was "Innovations in NGN-Future Network and Services."[1] This event is held annually, with the objective of exchanging ideas between the research and development (R&D) community and the standardization community. At the event held in 2008, both communities recognized the importance of the standardization of future networks. ITU has a study period system for revising the organization framework each four years, and in the 2009 to 2012 study period, it established Study Group (SG) 13 for standardizing Next Generation Networks (NGN) and Future Networks (FN), which has set up the new Q21 (Question21). However, the R&D on future networks has started only recently, and there was an issue in that the R&D process had not yet fit the standardization phase wherein the discussion among stakeholders could result in narrowing down multiple elemental technologies into a single method, or in other words, an issue that the future networks technology was not mature enough to enable stakeholders to prune a number of verified technologies and choose one after discussing their performance and economic viabilities, etc. Accordingly, to continue the discussion with the R&D community, particularly to enable participation of a large number of people who were in academia but not members of ITU, SG13 set up the Focus Group on Future Networks (FG-FN) to run for a limited time, and this was approved in the first ITU-T SG13 meeting (January 2009) held during the study period that started in 2009. FG-FN first studied the R&D trends across the world and the standardization target fields, then summarized the study results in multiple documents, and submitted this to ITU-T SG13, which then went on to study these results, and decided its strategy which would lead to standardization. FG-FN held its first meeting in June 2009, and went on to hold 8 meetings after that till December 2010. In the first year, FG-FN meetings were held in the same places and on the same occasions as workshops and conferences on future networks of Japan, Europe and USA were conducted, and many researchers also participated in FG-FN and deepened the discussions on this topic. The first FG-FN was held in Lulea, Sweden, in parallel with the FIRE week 2009 event

held by the FIRE (Future Internet Research Experimentation) testbed project of the European Commission. The second meeting was conducted at the same place as the 6th periodic GEC (GENI Engineering Conference) of the U.S. GENI testbed project. The active period of the FG-FN had initially been set as one year, but was later extended by six months, until it ended with the 8th meeting held in Ljubljana, Slovenia, in December 2010. The results of FG-FN were submitted to SG 13 in January 2011 in a total of five documents: Draft Deliverable on "Future Networks: Objectives and Design Goals," Framework of network virtualization for Future Networks, Draft Deliverable on "Overview of Energy-saving of Networks," Draft text of "Terminology of Future Networks," and Project descriptions. Of these five documents, the vision document which especially describes the overall perspective of future networks was very complete, and work began immediately to turn it into a recommendation, with it being recommended as ITU-T Y.3001 Future Networks: Objectives and Design Goals in the May 2011 meeting. NGN has a numbering system using Y.2000. This was changed so Future Networks standardization recommendations start anew from 3000. Y.3001 mentioned above is part of that series.

3 ITU-T Y.3001[3]

The outline of Y.3001 is given below. Y.3001 is the world's first standardization document for future networks, comprised of 4 Objectives and 12 Design Goals. The 4 Objectives compare the future networks with the Internet used so far and NGN etc., describe the differences, see which parts of the future networks need to be focused on, and describe the structure of the network; this serves as the "flag" for Future Networks. The 4 Objectives are explained below.

(1) Service awareness

The basic Internet architecture (such as the E2E principle) which forms the core of the current Internet was created 30 years ago, and the same architecture is used for all services. Future networks aim to appropriately provide services required by applications and users, and have the flexibility to adopt the optimum architecture from the viewpoint of fulfilling that aim.

(2) Data awareness

In the current Internet network, data is acquired and delivered by accessing the place where it is stored or the address in the memory linked to the IP address and so on. The Internet itself does not have a function for linking data to a place. The aim of the future network is to have the optimum configuration for processing huge volumes of data stored in a distributed environment, and regardless of where the data is located, users can access it safely, simply, quickly and accurately.

(3) Environmental awareness

For networks until now, the designers did not strongly consider the power used by the network, nor the amount of carbon dioxide emitted by them. The future networks will be environment friendly, and their basic structural design and their resulting implementation and operation will reduce the amount of materials and energy used and greenhouse gases, with the aim of minimizing impacts on the environment. Moreover, the future networks are designed so that by utilizing them, the environmental burdens of other fields (manufacturing field and retail field, etc.) can be reduced.

(4) Social and economic awareness

The networks until now were mostly built as national projects, particularly the legacy telephone networks. Consequently, they were publicly owned, and their closed nature proved to be an obstacle to the growth of new business and for providing cheaper services in many cases. The future networks address various socioeconomic issues, to enable easy entry by diverse players in the economic cycle centering on the networks. And for future networks to easily deployed and sustainable, they are configured to reduce their life cycle cost. Thus, they enable universal services which give healthy competition and adequate profits to all the stakeholders.

Y.3001 only gives a vision of the future networks, and based on this vision, standardization of the researched and developed technologies is currently being implemented. All the recommendation titles of the Y.3000 series that were turned into Recommendations by August 2015, including the recommendation of Y.3001, are listed in Table 1.

4 Service aware networking

Networks serve as the infrastructure for supporting

Table 1 ITU-T Y.3000 series recommendations list

Y.3001	Future networks: Objectives and design goals
Y.3011	Framework of network virtualization for future networks
Y.3012	Requirements of network virtualization for future networks
Y.3013	Socio-economic assessment of future networks by tussle analysis
Y.3021	Framework of energy saving for future networks
Y.3022	Measuring energy in networks
Y.3031	Identification framework in future networks
Y.3032	Configurations of node identifiers and their mapping with locators in future networks
Y.3033	Framework of data aware networking for future networks
Y.3034	Architecture for interworking of heterogeneous component networks in ID/locator split-based future networks
Y.3035	Service universalization in future networks
Y.3041	Smart ubiquitous networks — Overview
Y.3042	Smart ubiquitous networks — Smart traffic control and resource management functions
Y.3043	Smart ubiquitous networks — Context awareness framework
Y.3044	Smart ubiquitous networks — Content awareness framework
Y.3045	Smart ubiquitous networks — Functional architecture of content delivery
Y.3300	Framework of software-defined networking
Y.3320	Requirements for applying formal methods to software-defined networking
Y.3321	Requirements and capability framework for NICE implementation making use of software-defined networking

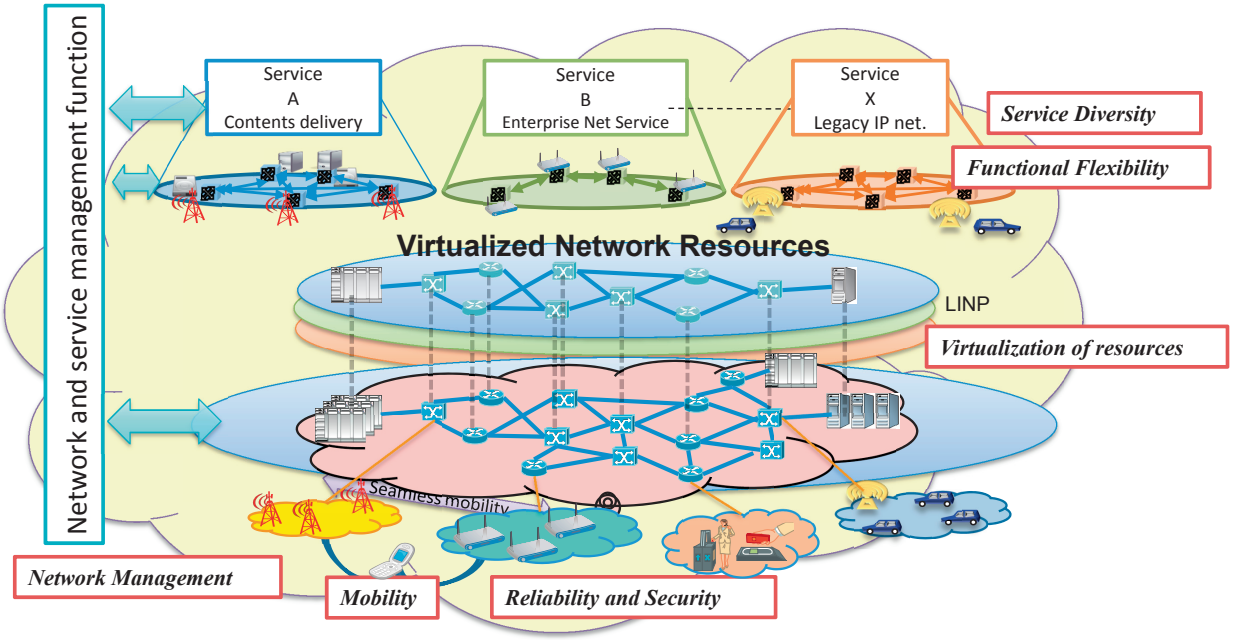

Fig. 1 Outline of a service aware networking

society, and the applications used on them are no doubt important. If we look at the history of ICT services, we can see that earlier they were used for transmitting text data and image data, and from the age of transmission itself being the purpose, the aims steadily changed to social networking services and information search, then to electronic business transactions. With the expansion of the market size of the ICT industry itself, its mass market is undeniably shifting from networks to services. One of the features of NGN is the separation of networks from services, but is this a proper form of a network that can achieve future services?

In future networks, the services control the networks, and in order to implement various services, the transmission resources, computer resources, memory resources, etc. which exist in the networks are provided flexibly to the services, thereby aiming to reduce the time it takes to launch them in the market and improve user experience. Figure 1 shows the concept of a service aware networking.

The virtualization of networks is one of the technological points for achieving a service aware networking. This technology regards a single network or a group of multiple networks as one network, and separates it into multiple networks for each service. Networks here include the computer resources and memory resources existing in networks as well, and so it will not be an exaggeration to call it virtualization of the ICT system. The importance of this network virtualization is that it was considered as a promising technology right from the initial stage of standardization of future networks by ITU, and this standardization is a step ahead of other technologies. As described in Section **2**, the results of FG-FN submitted to ITU-T SG13 in January 2011 include a document on the framework of network virtualization. ITU-T closely inspected the contents of the network virtualization framework document, and added further study, before approving the recommendation of ITU-T Y.3011 Framework of Network Virtualization for Future Networks[4] in January 2012, and has also created the requirements document after that. Japan's network virtualization research community has actively made contributions regarding the requirements document. As a result, in April 2014, the recommendation was enacted as ITU-T Y.3012 Requirements of network virtualization for future networks[5]. Many of the results of the R&D on network virtualization in Japan which have been described in this special issue have been adopted. As of August 2015, the document for prescribing the architecture meeting the requirements is also being made.

5 Data aware networking

ITU-T Recommendation Y.3001[3] defined the data access design goal of Future Networks that Future Networks should be able to deal with enormous amount of data efficiently in a distributed environment and enable users to access desired data safely, easily, quickly, and accurately, regardless of data locations. This design goal has been realized in the form of a network architecture named Data Aware Networking (DAN) in ITU-T, which corresponds to Information Centric Networking (ICN) in the network research community.

In Feb, 2012, a draft Recommendation was initiated in ITU-T/SG13/Q15 as a first step toward achieving the data access design goal specified in ITU-T Recommendation Y.3001. The draft Recommendation aimed to describe the overview, problem spaces, and design goals of data aware networking. It defined DAN as a new network architecture whose essence lies in the name based communication that routes a data object in the network by its name or identifier (ID). The name based routing enables not only end hosts but also intermediate nodes to be aware of user requests, and so individual DAN network elements are able to cache

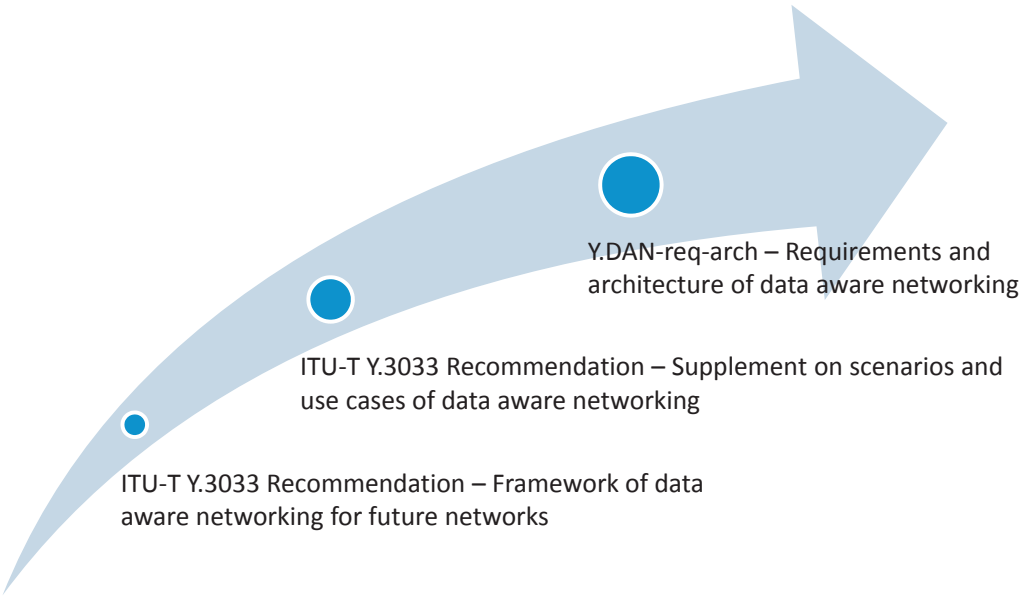

Fig. 2 Standardization activity on data aware networking in ITU-T

or store data objects. Thus, data objects can be distributed in the DAN network, and so users can retrieve them in the most efficient manner considering various performance metrics, e.g., hop counts or delay, etc. In Nov, 2013, the draft Recommendation was consented, and became ITU-T Y.3033: "Framework of data aware networking for future networks"[6].

Once the first stage of the standardization process had been cleared—the completion of the framework document, the draft Supplement named Y.supFNDAN to ITU-T Y.3033 was initiated in Feb, 2014, which introduces DAN use-case scenarios. The aim of the draft Supplement is to provide the understanding of the requirements in the design of DAN architectures using the use-case scenarios. The Supplement document currently has six use case scenarios (May, 2015) including 1) content dissemination, 2) sensor networking, 3) vehicular networking, 4) networking in a disaster area, 5) advanced metering infrastructure in smart grid, 6) proactive video caching. As the draft is being mature, it enables us to derive the requirements of DAN architectures, which triggered the initiation of the draft Recommendation named Y.DAN-req-arch: "Requirements and Architecture of data aware networking" in May, 2015. It specifies the requirements of DAN derived from the use-case scenarios in Y.supFNDAN, and defines its functional architecture to fulfill the requirements.

6 Conclusion

This paper describes the standardization of Future Networks in ITU-T. The standardization activity started in 2009 has approved 19 recommendations by this year (2015). The next plan is to practically implement these technologies, and along with it, apply them to the new communication systems like the 5th generation mobile communications system.

References

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3 http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=Y.3001
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5 http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=Y.3012
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