Activity Report of ITU-T Focus Group on IMT-2020

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Abstract

In 2015, the ITU-T (International Telecommunication Union - Telecommunication Standardization Sector) established the Focus Group on IMT (International Mobile Telecommunication)-2020 (FG IMT-2020) to study the non-radio part of IMT-2020. The FG worked until December 2016 and produced key concepts such as the network slice and network softwarization components constituting the IMT-2020 system. This article presents the activities of FG IMT-2020.

Keywords: network slice, network softwarization, fronthaul

1. Introduction

The International Telecommunication Union - Telecommunication Standardization Sector (ITU-T) established the Focus Group on IMT (International Mobile Telecommunication)-2020 (FG IMT-2020) in April 2015 in a decision taken by Study Group 13 (SG13), which is the parent group of FG IMT-2020 as well as the lead study group on the non-radio part of IMT. The FG carried out its activities until December 2016. The FG was mandated to examine new network technologies, which were originally studied under the topic of future networks, for possible application in future mobile networks. In the latter half of the FG's study period, new approaches were investigated such as prototyping new technologies and collaborating with open source communities as a way to promote standardization activities. This attempt was a unique feature of this FG, and it prompted the ITU-T to consider further actions to be taken at higher levels such as the World Telecommunication Standardization Assembly (WTSA).

2. History of FG IMT-2020's activities

Technologies examined in FG IMT-2020 were rooted in the study of future networks, which had been a topic of study in SG13 since 2009. When study on future networks began, these networks were a high-level concept without tangible and implementable technologies. Nevertheless, SG13's activities resulted in ITU-T Recommendation Y.3001, which described the objectives and design goals in 2011.

As the concept of IMT-2020 attracted interest from industry, the experts working on future networks began to consider how their achievements might contribute to the realization of IMT-2020. SG13 had a technical background in future networks and was also responsible for studying the non-radio part of IMT. This background and also the increased interest in IMT-2020 led SG13 to establish FG IMT-2020 at its meeting in April 2015.

Standards development groups in the private sector play major roles in the standardization of mobile networks. The 3rd Generation Partnership Project (3GPP) is the most prominent group in this area. Institutions such as ITU-T that set de jure standards play a more limited role. This means that this FG may not be successful by simply taking the conventional approach to standardization without considering a standardization strategy.

The conventional standardization approach usually starts with gathering requirements, and then drawing a high-level architecture and making detailed technical specifications. In contrast, this FG took a new approach that began with a gap analysis of existing standardization work to find technical areas where

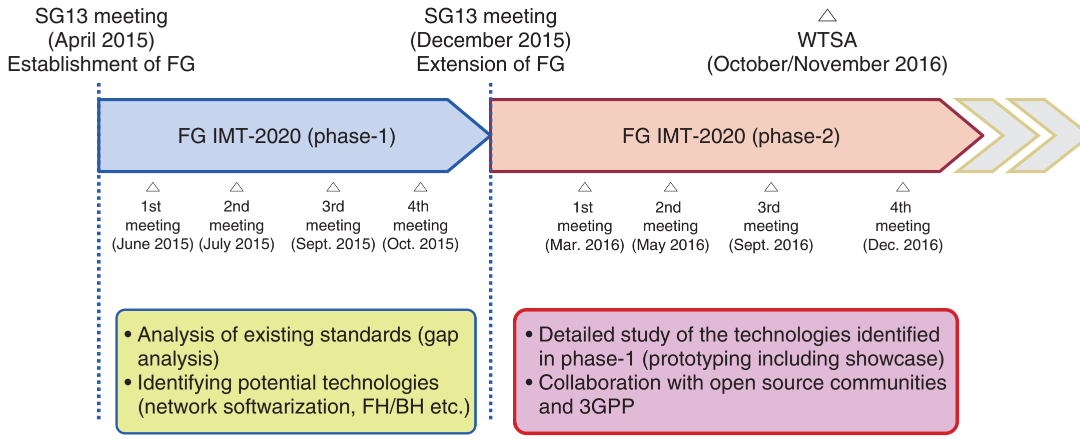

Fig. 1. History of FG IMT-2020.

ITU-T had a competitive advantage. In the more than two years of work done by the FG, this period (from June 2015 to October 2015) is referred to as phase-1. This author served as vice-chair of SG13 and along with other members played a leading role in building a consensus to create a ToR (Terms of Reference) document describing the direction of phase-1 of the FG.

The phase-1 FG concluded its activities in October 2015 and produced a deliverable, which is the major output of an FG as defined in ITU-T Recommendation A.7. The deliverable of this FG describes the candidate technologies such as network softwarization, FH/BH (fronthaul/backhaul), information centric networking and content centric networking (ICN/CCN), as well as proposed directions for further study in ITU-T. With this conclusion of the phase-1 FG, SG13 decided to extend the FG into phase-2, which was mandated to study details of identified technologies and to conduct prototyping activities (**Fig. 1**).

3. Technical study

Studies were carried out on the various technical elements of IMT-2020. These are described in more detail in this section.

3.1 Architecture

The network slice is a technology that was newly introduced in FG IMT-2020 discussions. The first challenge of the FG is to determine how to define the architecture of this virtual concept of a network slice. At the beginning of the phase-2 study, the FG tried to draw a typical architectural diagram containing functional blocks and reference points. The efforts continued until the second phase-2 meeting (May 2016), but the FG did not produce an architectural diagram that was satisfactory to the FG experts.

Faced with the slow progress and the difficulty of drawing an architectural diagram, the chair and vice-chairs considered that once a simplified diagram that was agreeable to the experts was produced, the discussion on further details could be accelerated. Therefore, at the meeting in September 2016, the meeting attendees worked on producing a minimal agreeable diagram.

In this discussion, an idea centered on the concept of a network slice was proposed. The network slice architecture consists of two different aspects. One is the network provider which owns all the network resources and provides the necessary elements of the resources at the request of the slice users. The other is the slice instance that is actually produced by the slice users and offered for actual services to the end users. Consequently, the different natures of a slice meant that a specific architecture would be necessary for each case.

In the FG, the former aspect was called a network slice blueprint, and the latter was called a network slice instance (**Fig. 2**). The network slice blueprint consists of all resources and functions of data, control, services, and other elements that are used as foundations of network slice instances. The orchestrator combines the necessary resources and functions to produce a network slice instance. There are two cases of network slice instances based on whether the application is included in the slice—for example,

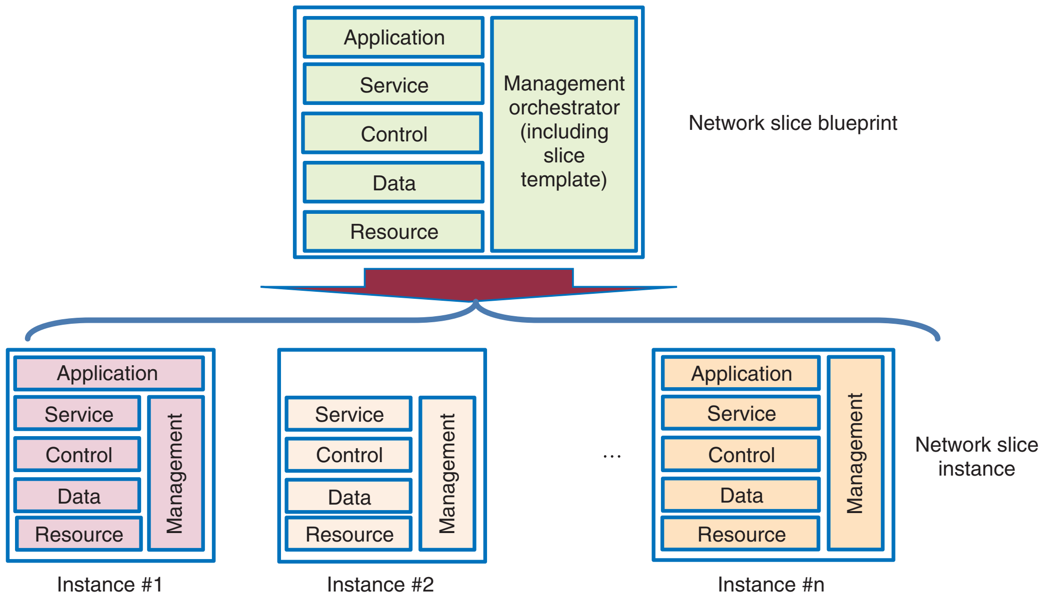

Fig. 2. Concept of network slice.

an application provided by the slice user—or not included—for example, when only connectivity is provided by the slice user.

There was a general agreement that the network slice instance does not include its own orchestrator since the orchestrator does not play any operation role inside the slice. However, it was pointed out that multi-layered slicing is possible, for example, in an FMC (fixed mobile convergence) slice combining a mobile slice and a fixed slice, and that the orchestrator in the slice could play certain roles in such cases.

In contrast to the architectural diagram discussed in 3GPP, which was drawing a physical entity diagram, the diagram drawn in the FG was created from the viewpoint of the hierarchical structure of a network slice blueprint and instance. There was no contradiction between the two kinds of diagrams; however, further study is needed to clarify the relationship between these two.

3.2 Network softwarization

Network softwarization (**Fig. 3**) is one of the major results of FG IMT-2020 for which Japanese experts actively contributed. This subject is strongly connected to the architecture discussion, and it includes the major characteristics of the network slice.

The IMT-2020 system consists of a radio access network, mobile packet core, and other components. In cases where the network slice provides applications by itself, IMT-2020 includes the datacenter. All the elements mentioned above are referred to as resources in the concept of network softwarization. The network slice is considered as a collection of resources. It was discussed whether the user equipment would be considered as a resource consisting of a slice. This point was not clarified due to a lack of sufficient use case studies. A future study will reveal this point as potential use cases are studied in depth.

3.3 Fronthaul

The fronthaul is a link between the baseband unit (BBU), which generates baseband signals, and the remote radio head (RRH), which emits radio signals. Fronthaul technology improves the quality of a radio access network by utilizing multiple base stations in a collaborative manner, although it requires a high level of time and frequency synchronization among the base stations.

The consensus of the experts of the FG at the beginning of phase-1 was to use RoF (radio over fiber) technology for the fronthaul, which is expensive but considered to be a promising and technically reliable approach. However, the Japanese experts proposed a packet based approach as an alternative. Because of the expected cost effectiveness of a packet based approach, the majority of the members shifted their support in favor of the Japanese proposal. Among packet based approaches, Ethernet based methods

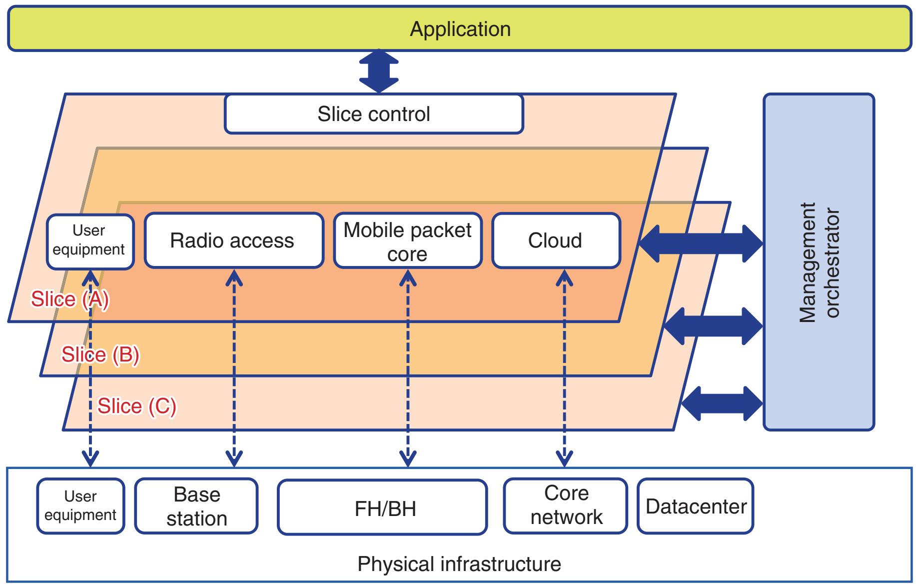

Fig. 3. Concept of network softwarization.

have been the most intensively developed and discussed. At the FG meeting in May 2016, China Mobile demonstrated a prototype product based on its proposed technology to the IEEE* 1914 Working Group. Additionally, a Chinese manufacturer presented FlexEthernet as a solution to achieve time and frequency synchronization.

Many researchers participating in this FG had been studying software-defined networking technology but were having difficulty in testing their ideas in an end-to-end network system without technical knowledge or the facilities of a radio access network, which is an important component of mobile networks. A solution called OpenAirInterface was introduced as a useful tool to construct a base station using off-the-shelf products. This solution uses open source software to achieve a BBU and RRH on a personal computer. Certain models of commercial user equipment products can be connected for this purpose, and many participants of the FG were interested in learning how to use this solution to set up their own test environment.

3.4 Other technologies

ICN/CCN is network technology that enables more efficient distribution of content. ICN/CCN caches the content and transcodes it adaptively in response to network conditions. In FG IMT-2020, prototyping activities and use cases, which were primarily from the US, were introduced. The FG considered ICN/CCN to be a potentially useful technology but thought that there was room for improvement to increase the possibility of identifying/caching relevant content before it was selected as an actual solution to be deployed. The FG also noted that one of the key factors in the development of IMT-2020 is determining how to address the increasing volume of traffic, particularly video traffic. In this sense, potential use of ICN/CCN technology should be considered.

The application of satellite communications technology was presented at the FG in September 2016. Satellite communications is relevant for the backhaul in mobile networks. Many developing countries still lack fiber backbone networks, so satellite communications could play a bigger role in such cases. Signal attenuation caused by weather conditions such as rain and clouds reduces the reliability of satellite communications; therefore, satellite communications plays a supplementary role where the terrestrial fiber network is available. However, some plans are being made to deploy a number of smaller satellites in the relatively low orbits (about 1000 km above earth) rather than in the conventional geostationary orbit. This type of satellite network features low latency as well as global coverage. New use cases will be developed.

* IEEE: Institute of Electrical and Electronics Engineers

Table 1. Structure of SG13 and relationship with FG IMT-2020.

SG13			FG IMT-2020 Working Group	
WP	Title	Question	Working Group	Document
1	IMT-2020 Networks & Systems	Q.6: Quality of service (QoS) aspects including IMT-2020 networks	QoS	
		Q.20: IMT-2020: Network requirements and functional architecture	Requirements & architecture	Terms and definitions for ITU-T IMT-2020
				Requirements of IMT-2020 from network perspective
				Framework of IMT-2020 network architecture
		Q.21: Software-defined networking, network slicing and orchestration	Softwarization	Report on the application of network softwarization to IMT-2020
			E2E management	IMT-2020 network management requirements
				Network management framework for IMT-2020
		Q.22: Upcoming network technologies for IMT-2020 and future networks	ICN/CCN	Report on the application of ICN to IMT-2020
		Q.23: Fixed-mobile convergence including IMT-2020	FMC	Requirements of IMT-2020 fixed and mobile convergence
				Unified Network Integrated Cloud on FMC
2	Cloud Computing & Big Data	Q.7 (DPI), Q.17 (cloud requirements), Q.18 (cloud architechture), Q.19 (cloud management)		
3	Future Network Evolution & Trust	Q.1 (innovation services), Q.2 (NGNe), Q.5 (developing countries), Q.16 (knowledge & trust)		

DPI: deep packet inspection
E2E: end to end
FMC: fixed mobile convergence
NGNe: Next Generation Network evolution
WP: Working Party

4. Future plan

WTSA-16, which is the highest level meeting in the ITU-T, was held in October and November 2016. WTSA recognized that IMT-2020 will be one of the most important subjects over the next four years and therefore adopted a new resolution to promote IMT-2020 related activities based on the outcomes of FG IMT-2020. IMT related work including IMT-2020 is coordinated by SG13 as a mission of the lead study group on this subject. SG13 also organized a dedicated working party to draft questions for particular subjects of IMT-2020 (**Table 1**). The FG IMT-2020 produced nine deliverables. These deliverables are assigned to the relevant questions and will be used as base documents for further development.

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He received a B.E. and M.E. in applied physics from Tohoku University, Miyagi, in 1992 and 1994. He joined NTT Basic Research Laboratories in 1994. He has been researching and developing cable television systems, Internet protocol television (IPTV), and machine-to-machine technology. He has been engaged in the standardization work for IPTV in ITU-T as a member of the IPTV Focus Group and Global Standards Initiative since 2006. He has also served as Rapporteur of Question 11 of ITU-T SG9, Questions 5 and 25 of ITU-T SG13, and Question 21 of ITU-T SG16. He has been a vice-chair of ITU-T SG13 since 2013. He is a member of the Institute of Electronics, Information and Communication Engineers (IEICE).