

1. Introduction

Japan led the world in mobile feature phone services, such as e-mail services via the internet, wide variety of information services by websites specifically designed for mobile phone screens, TV broadcasting service by One-Seg, and electronic payment services. With the advent of the 4th generation mobile communication system (4G), the people of Japan have gained access to a nationwide mobile broadband network. As users of smartphones are growing rapidly in Japan, services with rich content, such as HD video, e-books, music, and video games are widely provided. With these cutting-edge services, Japan has one of the most mature mobile communication markets which are able to enjoy the world leading mobile services.

As these new content-rich services have become more popular year after year, internet traffic has sharply increased along with the need for more network capacity and higher speeds. The services being offered are also diversifying, and both human-to-human and human-to-device communication is increasing. As network and sensor technology advances, device-to-device communication, what is called, the Internet of Things (IoT) is also expanding worldwide, leading to a further increase in traffic. This facilitates changes in ICT services for entertainment, transportation, industry/verticals, and emergency and disaster relief. Examples include artificial intelligence and adorable robots that assist people in their home and work lives, autonomous vehicles like unmanned taxis as well as vehicles that can provide mobility for senior citizens, and wearable devices that collect and analyze vital data to assist in health and medical services. These are just some of the services that are expected to be implemented in the near future as these trends continue to accelerate. However, the current 4G technologies, as well as its extension, may limit the growth of mobile services, especially when considering the needs of the 2020s. In order to accommodate the rapid growth with sufficient capacity and speed, there is strong global interest for research and development of the 5th generation mobile communication system, known as 5G.

The Fifth Generation Mobile Communications Promotion Forum (5GMF) was established in Japan on September 30, 2014 to actively promote 5G study in line with trends both in Japan and abroad based on a roadmap on 5G implementation policy published by the government of Japan. This white paper discusses the expected many

new uses of ICT in the 5G era by various industries, as well as the new businesses and markets that will be created and the expectations of the fuller lifestyle that it will bring to people everywhere. 5GMF has collected in this white paper the opinions and ideas of experts in industry, academia and government concerning their views of the future of applications, networks, and wireless technology related to 5G in order to provide a clear goal for the development of 5G.

The description contents in each chapter are indicated easily in the following.

- **Market and User Trends of ICT (Chapter 3)**

This chapter, in addition to gathering information by industries promoting ICT services on their customers, broken down by age group, type of content, and type of device, attempts to predict future trends in order to understand what the communication environment will be, and thus what mobile communication services will be in demand, in 5G era.

- **Traffic Trend (Chapter 4)**

This chapter provides an analysis of the latest communication traffic trends. For the past years, considerable increase of communication traffic has been observed and several estimation studies consistently forecast that the increase would be continued to the next decade. In addition, new traffic nature different from ever happened one could come in considering new traffic types generated in variety of use cases with variety of ‘connected things’ or ‘connected services’.

- **Cost Implications (Chapter 5)**

This chapter discusses the cost of mobile communication systems and analyzes from the perspective of several ‘5G’ related use cases. The fundamental cost implications of ‘5G’ were analyzed in [1] where every element of a mobile communication system was analyzed in terms of CAPEX or OPEX. The analyses were made with a focus on the domestic market of Japan, in light of demographic and survey data as well as local market indexes. Since the market in Japan is one of the leading markets in the world, these case studies may be of use when considering markets in other locations around the world.

- **Key Concepts in 5G (Chapter 6)**

This chapter proposes two key concepts for 5G: “Satisfaction of End-to-End (E2E) quality” and “Extreme Flexibility.” “Satisfaction of E2E quality” means providing every user access to any application, anytime, anywhere, and under any circumstance. “Extreme Flexibility” is the communications system which will allow 5G networks to always achieve E2E quality.

This chapter identifies two key technologies necessary to support the wide range of use cases expected in the 5G era through “Extreme Flexibility”. The first is an “Advanced Heterogeneous Network”, which will include multiple technologies far in advance of previous heterogeneous networks. The second is “Network Softwarization and Slicing”, which will make networks easier to upgrade and maintain.

In addition, using the ITU-R vision report M.2083-0 as a base, typical use cases (high reliability, ultra-low latent communications, large scale communications, advanced mobile broadband) with examples of what technology and requirements will be needed to make these use cases a reality is discussed.

- **Typical Usage Scenarios of 5G (Chapter 7)**

This chapter considers future market trends and user trends discussed in section 3, this section first surveys some examples of new usage scenarios, which are expected to realize by 5G, and categorizes them into four facets: 1) Entertainment, 2) Transportation, 3) Industries/Verticals, and 4) Emergency and disaster relief.

It further analyses the usage scenarios and develops the list of required capabilities of individual usage scenarios. It finally provides key items of 5G capabilities for deriving overall 5G requirements in Chapter 8.

The section also gives an insight of “dynamic approach” into nature of 5G capabilities which must dynamically change corresponding to the wide variety of 5G usage scenarios.

- **Requirements for 5G (Chapter 8)**

This chapter describes the requirements related to radio access network, front-haul/backhaul and communication networks. 5G systems should include “Extreme Flexibility”, in order to satisfy the end-to-end quality required in each use scene even in extreme conditions. End-to-end context in the ICT environment includes not only

UE-to-UE, but also UE-to-Cloud, which implies that the technology focus on flexibility extends beyond 5G radio technology to the backbone networks.

- **Spectrum Implications (Chapter 9)**

To realize the “Extreme Flexibility” of 5G, it is necessary to utilize all frequency bands, including both the lower ranges (below 6GHz) and the higher ones (above 6GHz), while considering the different characteristics of each frequency band.

The first section of this chapter will describe the roles of both lower bands and higher bands, and the following section will focus on the evaluation of preferable frequency bands in the range between 6 and 100GHz. The results came from a study that includes three stages of evaluation, i.e. 5G intra-system, inter-system, harmonization point of view, respectively. The resulting preferred bands from the results of Stage 2 are then discussed.

- **Overview of 5G Technologies (Chapter10)**

This chapter overviews the following two chapters, in which several key technical enablers are discussed.

- **5G Radio Technologies (Chapter11)**

This chapter discusses promising radio access technologies in order to realize 5G system. The subsections contain information on the latest radio access technologies embraced in [1] or newly introduced technologies. The 5G communications system should be constructed by selecting, combining or modifying these technologies in order to make 5G systems work in each use case.

- **Network Technologies for 5G (Chapter12)**

This chapter describes network technologies for 5G. Based on the guiding concept "Network Softwarization", which elaborates the overall transformation trend including Network Functions Virtualisation (NFV) and Software Defined Networking (SDN), technology focus area is identified as the result of study in the network architecture group of 5GMF. The brief description of the area and the associated technical issues are described in the following sections.

- **Future business and services (Annex)**

This annex introduces the perspectives of future business and services for reference, using market trends and future capabilities.

Reference

- [1] “Mobile Communications Systems for 2020 and beyond,” ARIB 2020 and Beyond Ad Hoc Group White Paper, Oct.2014 (URL: <http://www.arib.or.jp/ADWICS/20bah-wp-100.pdf>).