Abstract

Keyword：Spectrum sharing mechnism、The fifth mobile generation network (5G)、Internet of things (IoT)、Spectrum policy、Spectrum refarming, Wireless microphone, Interference, Digital Television, Vechile-to-everything (V2X), Proof of Business , unmanned aerial vehicles (UAVs), 3.3-4.2GHz, 28GHz.

The fifth-generation (or "5G") of mobile broadband technologies will bring faster speeds and improved network capacity and efficiency. New spectrum is critical for the success of 5G services. Globally, there are significant on-going activities to identify suitable spectrum, including bands that can be used in as many countries as possible to enable global roaming and economies of scale. Various efforts around the world are underway to find harmonization around spectrum to be used for 5G.

Notably, the range 3.3 - 4.2 GHz consists a large amount of continuous spectrum, enabling wide channel bandwidth. Spectrum in this frequency range allows for wide area coverage and high data speed, rendering it most suitable for the provision of 5G services. A challenge is that the 3.4 - 4.2 GHz band, commonly known as the C-Band, has been allocated to downlinks of fixed satellite service (FSS).

In view of the possible interference problems between future 5G and FSS systems, this research conducts theoretical analysis and calculation for the protection distance between different scenarios, and analyzes the appropriate conditions for interference suppression when the two systems coexist. The measurement results show that it is impossible to coexist between 5G and FSS if no improvements are made.

Furthermore, it affirmed that with the implementation of appropriate mitigating measures, such as band-pass filter (BPF), FSS systems operating in the 3.61 - 3.71 GHz band can co-exist with systems of future 5G services operating in the 3.3 – 3.57 GHz band, based on the laboratory and field experiment performed.

The findings along with the proposed mitigating measures are summarized as follows:

a) In order to reduce the interference between 5G and FSS systems operating in adjacent frequency bands an additional filtering is

included to improve the transmitter Adjacent Channel Interference (ACLR).

b) In general, the 5G base stations may be require antenna adjustment, additional filtering and site engineering to facilitate coexistence and sharing between 5G and FSS systems.

c) Further coordination required for 5G base stations deployed within the interference coordination zone up to a radius of 150 meters.

The explosive emergence of wireless technologies and standards, covering licensed and unlicensed spectrum bands has triggered the appearance of a huge amount of wireless technologies, with many of them coexisting in the same band. As such, there is a need to introduce more advanced techniques to access and share the wireless medium, either to improve the coordination within a given band, or to explore the possibilities of intelligently using unused spectrum in underutilized (e.g., licensed) bands.

There are many questions yet to be answered by future research, experiment and demonstration regarding dynamic spectrum sharing technologies, architectures, operation models, and associated regulatory policies. This year's work completed and was detailed in Final Report with suggestions provided to existing technical specifications and regulations for spectrum sharing.

a) Design of PoC for Dynamic Spectrum Sharing in Licensed Bands
This study continues to follow the development of international dynamic spectrum sharing mechanisms, especially focusing on the laws and regulations, and the development of industrial ecosystems of the Citizen Band Radio Service (CBRS) in the United States. First, the Citizen Band Radio Service Device (CBSD) needs to be assigned by the Spectrum Access System (SAS) to obtain the right for spectrum usage. Restrictions and specifications of interference management for CBSD include: (1) within the radius of 80 km centered by Incumbent (IA), no other users are allowed to use the band of same frequency; (2) the Environmental Sensing Capability System (ESC) can be used to determine the signal range to effectively reduce the interference

radius; (3) Within the radius of 150 km centered by an existing FSS, all CBSDs using the band of same frequency cannot induce interferences more than -129 dBm/MHz. This study also implements the specifications of data exchange between CBSD and SAS, including the operations of registration requests, channel requests and transmission requests, and channel selection and dynamic assignment among a certain number of CBSDs.

b) Design of PoC for Dynamic Spectrum Sharing in License-free Bands

In view of the evolutionary development of the license-assisted access (LAA) technology in the 3rd Generation Partnership Project (3GPP), this study used LAA Small Cell to build a test environment for coexisted LAA and Wi-Fi in a Shared Spectrum Access experiment platform to measure interferences and analyze the corresponding Quality-of-Service (QoS). The Team conducted simulation experiments to study the inferences on Wi-Fi due to LAA. Based on the Listen-Before-Talk (LBT) channel access mechanism, the Team experimented and designed the settings of LAA competition window parameters, and developed a scheduling algorithm and an effective spectrum management system to improve the fairness and spectrum utilization in both licensed and license-free spectrums.

c) ViSSA2.0 Demo

We have integrated and demonstrated the PoC operations of the ViSSA 2.0 platform. Continuing the development of the Virtually Shared Spectrum Access (ViSSA) platform for dynamic spectrum sharing management, this study implemented both deliverables in b) (Design of PoC for Dynamic Spectrum Sharing in Licensed Bands) and c) (Design of PoC for Dynamic Spectrum Sharing in License-free Bands) by simulating several scenarios of various use cases. The platform is also presented in the Annual Spectrum Management Forum on October 26, 2018 to demonstrate its feasibility and effectiveness. Opinions and suggestions from different viewpoints are thus gathered through information exchange and people's interactions to continuously optimize the platform. In the next phase, we plan to validate the ViSSA2.0 platform with field trials to demonstrate its ability to effective spectrum sharing management.

In order to understand the development of the regulation of 5G, we analyze the roadmap of 5G technology, the innovation application for vertical industries, and the 5G spectrum policy and license scheme in 9 comparative countries, including the European Union, United Kingdom, United states of America, Australia ,Japan ,Korea, Germany, Ireland and Canada.

We also analyze the spectrum policy for IoT, ITS and unmanned aerial vehicles (UAVs) in 5 comparative countries, including the European Union, United Kingdom, United states of America, Australia and Japan.

We study the IMT-2020 project proposed by the ITU, the 5G technology specifications will be completed in 2020. 3GPP formula the 5G technology specifications, they completed the Release 15 Non-Standalone (NSA) draft specifications in 2017. Then completed the Release 15 Standalone network specifications in June 2018. The main feature technology in 5G NR is the use of massive MIMO technology, operating in the frequency band below the 6 GHz, over the 6 GHz band and even the millimeter wave band. It is expected the launch time for 5G will be in 2019.

We research the mobile market status and 5G development in Taiwan. The results of comparative countries help us to provide the advices for the spectrum policy and license scheme of 5G ,IoT, ITS and UAVs in Taiwan.

In order to provide sufficient spectrum resource for innovative application, NCC announced the draft of the "Administrative Regulations on The Establishment And Operation of Telecommunications Network for the Academic and Educational purpose or Dedicated Experiment, Research and Development purpose" in Oct 2018. The innovator can through the proof of business (PoB) to evaluate the opportunity for business trial. We believe this measure can help innovator get the right to spectrum access, meet current requirements from innovator and operator of vertical sector. In the long term, we advise continuing to observe the international trends on the spectrum need for vertical industry.

This research recommends the candidate band for 5G spectrum in Taiwan, we recommend the first step release band for 5G should include 1775-1785/1870-1880 MHz , 2355-2390MHz, 3300-3570MHz and 27-29.5 GHz. Then the next step for the second release band should review the opportunity for release 600MHz, 800MHz, 1.5GHz and 4.5-5GHz. We advise the regulator can research spectrum sharing mechanism on 3.8-4.2 GHz. In the high band, the candidate band should be 24.25-26GHz and 37-40GHz. We also recommend 64-71GHz can be unlicensed band.

This research also analysis the spectrum policy for IoT, ITS and UAVs. At this moment, the most license schemes on those applications still adopt unlicensed spectrum. We advise the regulator should continue observe the development trends for IoT, ITS and UAVs.

There are some countries like UK and Australia already set up the light license regime for IoT. It can promote the development of the innovation and lower the risk of interference. The light license regime might be the option for the regulator in the future.

Wireless microphone devices are primarily used to transmit sound to recording or amplifier equipment and are widely used in communications companies, broadcast sports events, news gathering, theaters, schools, public events and video programming, etc. Under the license and management of the Commission, FCC, depending on the user's identity and the wireless microphone application context, Licensed and Unlicensed can be obtained separately, mainly operating in the available spectrum of the TV band. It must comply with the relevant technical specifications of 47 CFR Part 74, Subpart H - Low Power Auxiliary Stations and 47 CFR 15.236. It is known from the technical specifications that wireless microphone devices are defined as Low Power Auxiliary Stations (LPAS). The relevant technical specifications and operational principles should be established without affecting television equipment (and other licenses in this band). The premise of the device, to protect the TV broadcast and other secondary operations, is the focus of the wireless microphone interference.

According to the previous report, allow the operating frequency band of less than 50 MHz for use by wireless microphone devices in Taiwan, and other communication service devices (such as 4G) are in use in the operating frequency band, and because wireless microphone devices are exempt from license in Taiwan. Equipment, in terms of operational priority, is equal to other licensed RF equipment. Under the double restriction, the current wireless microphone equipment in Taiwan is seriously affected. According to the press release issued by the competent authority on 2014, NCC will search for the appropriate frequency band to provide domestic. The wireless microphone is used and continues to be negotiated with relevant frequency users and operators. Therefore, the plan proposes the

following three-point planning objectives to evaluate whether the wireless microphone operating frequency band has open space, in order to effectively manage the wireless microphone device and other RF. Interference issues between devices. First, research and development measures on the frequency and power of low-power RF motors such as wireless microphones in the advanced countries of the United States and the European Union. Second, discretion of international experience, domestic status and analysis of relevant technical specifications (draft) for low-power RF motors using wireless microphones. Third, the wireless microphone device operates in the actual field of interference test.