DECISION PAPER ISSUED BY THE INFO-COMMUNICATIONS MEDIA DEVELOPMENT AUTHORITY OF SINGAPORE

USE OF LONG TERM EVOLUTION TECHNOLOGIES IN LICENCE-EXEMPT SPECTRUM BANDS

7 February 2020

PART I: INTRODUCTION

PART II: SUMMARY OF INDUSTRY RESPONSES AND IMDA'S DECISIONS

PART I: INTRODUCTION

1. In Southeast Asia, Singapore has one of the highest mobile broadband subscription and mobile penetration rate. By May 2019, Singapore's mobile penetration rate is approximately 154 percent[1], far above the regional average of 67 percent[2]. Singapore's yearly mobile data usage has also reached 226.08 petabytes in 2018[3]. This is approximately double the yearly mobile data consumption of 123.75 petabytes in 2015.

2. Singapore started our 5G journey with the release of the first public consultation document by the Infocomm Media Development Authority ("**IMDA**") in May 2017 on key 5G mobile technology developments and the associated spectrum requirements ("**2017 Public Consultation**"). Having taken in global developments and views from the public consultation, IMDA issued a second public consultation in May 2019, setting out Singapore's vision and strategies to become a global 5G front-runner for innovation in secure 5G applications and services.

3. As part of the 2017 Public Consultation, IMDA noted that the standards released by the 3rd Generation Partnership Project ("**3GPP**") has included features that enable carrier aggregation of licensed and licence-exempt spectrum bands (i.e. the 2.4GHz and 5GHz bands), which are predominantly used for the provision of Wi-Fi services today. IMDA thus sought views from the industry on facilitating the development of mobile technologies by allowing the use of Long Term Evolution ("**LTE**") technologies in licence-exempt spectrum bands. IMDA also sought views on the necessary regulatory measures to be adopted to ensure coexistence and fair sharing of licence-exempt spectrum in Singapore if the use of LTE technologies is permitted in these bands. On this issue, IMDA received comments from the following fifteen respondents[4] at the close of the 2017 Public Consultation (individually referred to as a "**Respondent**" and collectively, the "**Respondents**"):

- Arete M Pte Ltd
- Ericsson Telecommunications Pte Ltd
- GSM Association
- Huawei International Pte Ltd
- Intel Corporation
- Mr Khoo Teng Lock
- M1 Limited
- Microsoft Operations Pte Ltd
- Nokia Networks
- Qualcomm Incorporated
- Ruckus Wireless Inc
- Singtel Mobile Singapore Pte Ltd
- StarHub Mobile Pte Ltd

[1] https://data.gov.sg/dataset/mobile-penetration-rate
[2] The Mobile Economy Asia Pacific 2019, GSMA, https://www.gsmaintelligence.com/research/?file=fe8735424e3058f98c3a83bc57bc2af5&download
[3] https://www.imda.gov.sg/infocomm-media-landscape/research-and-statistics/telecommunications
[4] Full responses to the Public Consultation can be found at: https://www.imda.gov.sg/regulations-and-licensing/Regulations/consultations/Consultation-Papers/2017/public-consultation-on-5g-mobile-services-and-networks

- Wi-Fi Alliance
- Wireless Broadband Alliance

4. IMDA would like to thank all Respondents for their comments. This explanatory memorandum sets out the key issues raised in the 2017 Public Consultation on the use of the licence-exempt spectrum and IMDA's decisions on these issues.

PART II: SUMMARY OF INDUSTRY RESPONSES AND IMDA'S DECISIONS ON KEY RESPONSES

Background

5. Over the years, due to the surge in demand for mobile data services and traffic, the Mobile Network Operators ("**MNOs**") have taken to using licence-exempt spectrum in the 2.4GHz and 5GHz bands to complement the use of licensed spectrum to more effectively handle rising mobile data traffic on their networks.

6. Today, there are several advanced methods that enable LTE technologies to operate in the licence-exempt spectrum to provide additional data capacity. These methods are:

i) Licensed Assisted Access ("**LAA**") and LTE-Unlicensed ("**LTE-U**"): LTE is primarily deployed in the licensed spectrum, while leveraging on the licence-exempt bands to provide a boost in data rates;

ii) MuLTEfire: LTE is deployed primarily in the licence-exempt spectrum; and

iii) LTE-Wi-Fi aggregation ("**LWA**"): Integrating Wi-Fi in licence-exempt bands more closely to the cellular network.

7. LAA/LTE-U is one of the carrier aggregation approaches that combines the use of licensed and licence-exempt spectrum. LAA was introduced in 3GPP Release 13 to standardise LTE operations in the 5GHz Wi-Fi spectrum and it utilises the listen-before-talk ("**LBT**") protocol which is a well-established approach in ensuring fair access in the licence-exempt spectrum. In contrast, LTE-U was developed outside of established standards bodies and it uses a proprietary Carrier Sensing Adaptive Transmission ("**CSAT**") technique to ensure coexistence with Wi-Fi users in the unlicensed spectrum. As CSAT allows for wide implementation and configuration choices, there are concerns from some industry players and the Wi-Fi industry on the ability of LTE-U to share the licence-exempt spectrum fairly with Wi-Fi users and other unlicensed operations.

8. MuLTEfire is another technology which allows LTE to be deployed in the licence-exempt spectrum, particularly the 5GHz band. However, it does not require an anchor LTE carrier in the licensed spectrum. By allowing LTE operations in the licence-exempt spectrum, proponents of MuLTEfire are of the view that it offers the benefits of LTE (e.g. speed and security) with the deployment simplicity of licence-exempt spectrum. Although MuLTEfire also operates on LBT protocol and opens up new opportunities for the industry, congestion in the licence-exempt spectrum is likely to be exacerbated because it operates primarily in the licence-exempt spectrum.

9. LWA is also a feature of 3GPP Release 13 and enables the aggregation of LTE and Wi-Fi spectrum to improve the capacity of cellular networks. However, aggregation occurs at the Radio Access Network level and user devices are configured to intelligently, dynamically and simultaneously utilise the LTE and Wi-Fi links. Similar to LAA, the primary connection remains with an LTE channel in the licensed spectrum and the additional Wi-Fi data path is only used to increase bandwidth when required. It optimises traffic over the two data streams which will lead to more capacity being made

available over the licence-exempt spectrum which will benefit other licence-exempt users as well.

10. Given Singapore's densely urbanised environment and extensive Wi-Fi deployments that are already operating in the licence-exempt spectrum bands, IMDA sought the industry's feedback on the necessary regulatory measures to be adopted to ensure coexistence and fair sharing of licence-exempt spectrum in Singapore should LTE technologies be permitted to operate in these spectrum bands. IMDA also sought the industry's views on the possibility of deploying LAA and/or MuLTEfire in other frequency bands besides the licence-exempt 5GHz band.

11. At the same time, IMDA has encouraged any interested MNO or mobile virtual network operator ("**MVNO**") to conduct technical trials and share its findings with IMDA. Insights from these trials would assist IMDA in better understanding if there are any coexistence issues with other technologies and develop an appropriate regulatory framework to facilitate the deployment of these technologies if shared use is feasible.

12. To minimise any impact of LAA/LTE-U/MuLTEfire/LWA trials on existing licence-exempt users, IMDA had proposed for all technical and market trials to be in compliance with the key technical requirements prescribed in the Short Range Device Framework for licence-exempt use in the 5 GHz band. Particularly for LTE-U trial, prior to any deployment, companies will also have to submit site survey results and proposed parameters to IMDA for approval.

Summary of Responses

<u>Coexistence Issues and Recommended Regulatory Approaches</u>

13. A majority of the Respondents supported the adoption of LBT protocol and agreed that any LTE-U networks should be upgraded to LAA once software or hardware products are commercially available. Conversely, a few Respondents pointed out that the decision to upgrade from LTE-U to LAA should be left for the operators to determine based on their business needs, and that LBT adoption would not be necessary as the CSAT mechanism would sufficiently address LTE-U/Wi-Fi coexistence. There were also recommendations from the industry for IMDA to conduct additional tests in Singapore to take into account the local conditions (e.g. high density of Wi-Fi deployment) to provide a better assessment of the impacts of LAA/LTE-U on Wi-Fi end-users. One Respondent proposed for IMDA to impose the requirement for all LTE-U devices to undergo the Wi-Fi Alliance Coexistence Plan which promotes fair coexistence and compatibility between technologies.

14. With regard to MuLTEfire, some Respondents were of the view that since it utilised the LBT protocol and adopted the same channel access mechanism as LAA, the regulatory and coexistence measures adopted for MuLTEfire should be similar to those measures applied to LAA. There were also recommendations for IMDA to apply the same regulations for LAA and MuLTEfire as a short term measure, and to revisit the MuLTEfire regulations in future. However, some Respondents had also highlighted that the MuLTEfire technical specifications had not been rigorously vetted and further work was required to establish that such operations were able to share spectrum fairly with

Wi-Fi. As MuLTEfire would not require an anchor in the licensed band, one Respondent was also concerned with the introduction of new entrants who might rely on the licence-exempt band to provision an LTE network without an LTE licensed anchor.

15. Most Respondents were of the view that LWA would have the least impact on existing Wi-Fi services since it utilised Wi-Fi standards in a licence-exempt band. However, it was noted that the equipment ecosystem was lacking and availability of commercial devices were limited.

Operations in Other Frequency Bands

16. On the possibility of deploying MuLTEfire or LAA in other frequency bands besides the 5GHz licence-exempt band, most Respondents were positive that these technologies could be deployed in other spectrum ranges (e.g. 3.5GHz band) as the designs of LAA and MuLTEfire are frequency band agnostic. However, the new bands would have to be identified and standardised. Currently, the 3GPP is looking at standardising LAA/enhanced LAA ("**eLAA"**) operations in the 3550 – 3700MHz for the US market[5]. Multefire is already deployable in the 3.5GHz band in the U.S. market.[6]

Trial Parameters

17. With regard to IMDA's proposed LTE-U trial parameters, some Respondents had recommended imposing stricter restrictions on LTE-U trials in Singapore and also the provision of additional information on their deployments. However, a majority of Respondents agreed that IMDA should not limit these trials to parts of the 5GHz licence-exempt spectrum, instead there were suggestions to operate in the heavily utilised 5GHz bands to provide a most realistic assessment on the potential impacts on existing Wi-Fi usage. Several Respondents had also suggested for IMDA to require trial devices to comply with the test requirements stipulated in Wi-Fi Alliance Coexistence Plan[7].

Deployment Scenarios

18. It was also highlighted in the feedback to the public consultation that while the LTE-U/LAA and LWA would require an anchor LTE carrier, the deployment scenarios were different. For example, the LTE-U/LAA would likely be deployed in a co-located base station, with both the licensed band radio and unlicensed 5GHz radio integrated into a single small cell. LWA deployment, on the other hand, would not be co-located, MNOs would have the option of utilising its own Wi-Fi network or partner with another Wi-Fi operator. In view that LTE-U/LAA, MulteFire and LWA could serve different use cases or deployment scenarios, some Respondents had recommended for IMDA to adopt a technology neutral approach to allow industry deployment flexibility.

19. It is also important to note that LTE-A Pro evolution will continue to put a focus on unlicensed spectrum, particularly the 5GHz band. Support for LAA uplink is already incorporated into 3GPP Release 14 specifications, and support for uplink via Wi-Fi with LWA is also a candidate feature for future 3GPP releases. LAA is also likely to evolve

[5] Refer to 3GPP TR 36.790 on "LAA/eLAA for the "CBRS" 3.5GHz band in the United States" for more information

[6] https://www.multefire.org/wp-content/uploads/MulteFire-Release-1.0-whitepaper_FINAL.pdf

[7] https://www.wi-fi.org/news-events/newsroom/wi-fi-alliance-delivers-lte-u-coexistence-test-plan

towards supporting dual connectivity, which will allow use of LAA in non-co-located deployments with licensed spectrum, and with relaxed requirements from the backhaul connections.

Other Issues

20. On a separate note, some Respondents had encouraged IMDA to release more licence-exempt spectrum in the 6GHz (i.e. 5925 – 7250MHz) to ease the congestion in unlicensed bands. The wide contiguous bandwidth (i.e. 80MHz or 160MHz channel) available in this band will likely enable gigabit wireless speeds which is a performance requirement in 5G networks. Both U.S. and Europe are studying this band for unlicensed operations and the possibility of coexistence with existing incumbent services.

IMDA's Views and Responses

21. In 2018, local trials were conducted and findings indicated that in the presence of LAA deployments, there were minimal impact to the Wi-Fi services that were occupying the same licence-exempt channels in the 5GHz band. In addition, two published test reports have indicated that there is no negative impact on the usage experience of Wi-Fi users with coexistence of LAA[8]. With both services employing LBT protocols, the impact of LAA to a Wi-Fi device can be deemed to be similar and comparable with the performance impact caused by other Wi-Fi devices operating on the same licence-exempt spectrum bands.

22. The industry had indicated that following these trials, there were plans to deploy LAA as a commercial service in localised areas. As such, IMDA will take steps to facilitate the introduction of LAA devices into Singapore. IMDA will work with industry to review and update the existing Technical Specifications for Cellular Base Station and Repeater System ("**TS CBS**").

23. In comparison, IMDA notes that there is limited industry interest in deploying LTE-U, MuLTEfire and LWA systems. As of today, IMDA has not received any application for the trial or deployment of these technologies in Singapore. Given that MuLTEfire allows LTE operations in the licence-exempt spectrum without an anchor LTE carrier in the licensed spectrum, IMDA understands that there could be an opportunity for some operators to deploy private MuLTEfire networks to serve industry users for applications such as the Internet of Things. Some MNOs might also consider deploying MuLTEfire networks to extend its coverage.

24. IMDA is of the view that it is necessary that MuLTEfire services are properly regulated and licensed as the services can be offered to consumers using licence-exempt spectrum and without an anchor in the licensed band. Hence, operators interested in deploying MuLTEfire services will need to be licensed depending on the networks they intend to deploy and services they intend to provide.

[8] Licence Assisted Access test report was released by SmarTone in Jan 2018, followed by a live trial report in Aug 2018

25. As for the operations of LTE-U in Singapore, given the limited commercial interest amongst MNOs and coupled with the fact that this technology does not support the LBT protocol, the trend is that MNOs are likely to deploy LAA instead.

26. With regard to LWA, IMDA notes that this technology involves the aggregation of LTE and Wi-Fi traffic at the transceivers and base stations (e.g. Radio Access Network segment) to improve the cellular network capacity. As the LWA process is transparent to users and is not expected to have any significant impact on existing Wi-Fi services, IMDA does not foresee the need to prescribe further regulations. In addition, IMDA also understands that LWA will leverage on existing base stations of MNOs and Wi-Fi access points with a software upgrade to accommodate LWA. Hence, IMDA does not foresee the need to change the existing technical specifications. Given the limited commercial interest amongst MNOs to deploy LWA in Singapore, IMDA will continue to monitor market developments.

27. IMDA's views and policy responses for the various LTE technologies operating in the licence-exempt spectrum are summarised as below:

i) LAA: IMDA will facilitate the deployment of LAA operations in Singapore, and will review and update its existing TS CBS to allow MNOs to deploy this technology in both licensed and licence-exempt spectrum bands (namely the 5GHz band).

ii) MuLTEfire: As there is limited commercial interest in MuLTEfire today, IMDA will continue to allow trials that comply with the technical requirements prescribed in the Short Range Device Framework for licence-exempt use in the 2.4GHz and 5 GHz bands. Operators who are interested to deploy MuLTEfire networks will need to obtain an appropriate licence from IMDA depending on the networks they intend to deploy and services they intend to provide.

iii) LTE-U: As there is limited commercial interest amongst MNOs in this technology today, IMDA will not make changes to its framework to facilitate the introduction of this technology as yet. IMDA will continue to monitor market developments.

iv) LWA: As LWA utilises Wi-Fi standards in the licence-exempt band and implements backend aggregation of the LTE and licence-exempt spectrum, it is expected that the introduction of LWA systems in Singapore will not cause significant impact to the existing Wi-Fi ecosystem. Therefore, IMDA does not foresee the need to prescribe further regulations or change the technical specifications. Given the limited commercial interest amongst MNOs to deploy LWA in Singapore, IMDA will continue to monitor market developments.

28. With regard to the request to release more licence-exempt spectrum in the 6GHz band (refer to Para 20), IMDA recognises that developments are nascent in this band and will continue to monitor the international trends and technology developments in the band before opening up for future applications. IMDA also notes that there may be demands for opening up the 6GHz as licensed band for mobile services.