Cisco Systems, Inc. Comments
March 2023

Response to IMDA Public Consultation on Proposed Allocation of 6 GHz Band in Singapore

Executive Summary

Cisco Systems, Inc. hereby files comments in response to the Infocomm Media Development Authority (IMDA) Consultation on the Proposed Allocation of 6 GHz Band in Singapore issued on 14 February 2023.

Opening 6 GHz

To fully enable next-generation technologies and support Singapore's rapidly growing digital economy, there is a need for a spectrum plan that ensures both 5G mobile and Wi-Fi technologies can thrive in Singapore, so that users can leverage both technologies in a complementary way to meet their connectivity needs.

Cisco supports IMDA's proposal of opening up much needed spectrum in the lower 6 GHz range (5,925-6,425 GHz) for RLAN / Wi-Fi use on a license-exempt basis. In this submission, Cisco urges that IMDA also, at the same time, make available the upper part of the 6 GHz band (i.e., 6,425-7,125 GHz) available for license-exempt use.

We set out in our detailed submissions why the full 6 GHz band (i.e., 5,925-7,125 MHz) should be made available for licence-exempt use to enable people and businesses in Singapore to take advantage of the latest networking innovations to provide improvements in speed, performance and capacity, support an increasing range of use cases under different operating scenarios, and sustain the growth of economic activities that Wi-Fi has historically supported.

In doing so, IMDA will join a growing group of forward-looking regulators like those in the United States, Canada, South Korea, Saudi Arabia, Brazil, Colombia, Costa Rica, the Dominican Republic, Guatemala, Honduras and Peru[1], and, more importantly, take advantage of the benefits of global technological harmonization to continue the government's efforts in making Singapore a world-class digital economy.

Power Levels

Cisco also encourages IMDA to consider allowing the use of Standard Power (e.g., 36 dBm E.I.R.P.) in the 6 GHz band. Standard power devices are needed for a range of enterprise use cases, both indoors and outdoors.

Cisco appreciates the opportunity to provide the above input to IMDA's Consultation. This topic is important for the future of Singapore, for connecting residents and accelerating industry digitalisation. We would be happy to discuss further on any further questions or follow up that you may have.

[1] https://www.wi-fi.org/countries-enabling-wi-fi-in-6-ghz-wi-fi-6e

Contact Information

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Introduction

Cisco Systems, Inc. hereby files comments in response to the Infocomm Media Development Authority (IMDA) Consultation on the Proposed Allocation of 6 GHz Band in Singapore issued on 14 February 2023.

Cisco is a global provider of Internet Protocol (IP)-based networking solutions with a strong presence in Singapore. Cisco supports IMDA's proposal of opening up much needed spectrum in the lower 6 GHz range (5,925-6,425 GHz) for RLAN / Wi-Fi use on a license-exempt basis. In this submission, Cisco urges that IMDA also, at the same time, make available the upper part of the 6 GHz band (i.e., 6,425-7,125 GHz) available for license-exempt use.

Need for Full 6 GHz Band for Licence-Exempt Use

To fully enable next-generation technologies and support Singapore's ambition to be a world-class digital economy, Singapore must adopt a spectrum plan ensuring the success of both 5G mobile and Wi-Fi technologies, so that users can leverage both technologies in a complementary way to meet their connectivity needs. This means making available the right amount of spectrum to support each type of technology. In this regard, Cisco welcomes the IMDA's proposal to make available the 5,925-6,425 GHz band for RLAN / Wi-Fi use on a license-exempt basis in Singapore. Opening the band for such use will enable people and businesses throughout Singapore to take advantage of the latest networking innovations, such-as Wi-Fi 6E and emerging Wi-Fi 7, to provide improvements in speed, performance and capacity, and support an increasing range of use cases under different operating scenarios.

5G and Wi-Fi have complementary roles in enabling digital innovation across telecommunications service providers, enterprises, public sector and various verticals in Singapore. Cisco is heavily invested in both technologies, and believes that 5G and Wi-Fi each have their unique characteristics in enabling innovation. The choice will depend on the specific use cases and associated economics. 5G standalone networks can support network slicing features to enable certain use cases with custom connectivity requirements. Wi-Fi is a cost-effective, complementary wireless technology to connect local area devices to other transmission channels like mobile 5G wide area networks. Our customers who deploy private 5G networks to support mission critical applications also find it necessary to concurrently operate Wi-Fi networks in their environments to support other connectivity requirements for other applications. Wi-Fi is the most established technology for indoor connectivity. Wi-Fi is also the preferred enterprise wireless technology for many networking needs, and continues to evolve in capability with the introduction of Wi-Fi 6 and Wi-Fi 6E, and the emerging Wi-Fi 7 standard. The benefit of license-exempt technologies cannot be overstated, as they remove the barriers to entry for wireless networks, allowing anyone to deploy a network whenever and wherever it is required, in a cost effective manner. This links directly to the economic benefits Wi-Fi creates, with the global value

projected to reach nearly USD 5 trillion by 2025[2]. The value created is tied directly to spectrum availability. Ensuring that those networks continue to scale and support next generation applications should be a key consideration for governments and regulators.

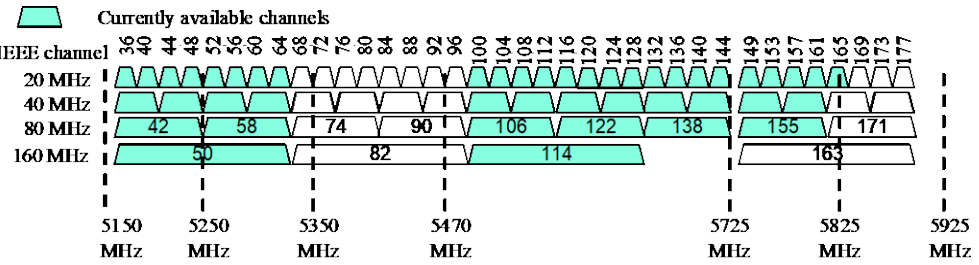
Moreover, we believe that with only 500 MHz in the lower 6 GHz band available, Wi-Fi will not fully succeed in its efforts to address the networking needs of Singapore for the next 5 years. As IMDA noted in the Consultation, the capabilities of Wi-Fi in Singapore need to keep pace with the significantly higher speeds availed from 10 Gbps fiber connections and 5G cellular connections to avoid becoming the bottleneck. Having a single large contiguous block of spectrum in the 5,925-7,125 GHz range to support not just the current, but also the future generations of Wi-Fi is essential to the continued growth in connectivity and density required to enable the expanding services within enterprises and make Wi-Fi speeds above 1 Gbps available with low latency. Releasing only the bottom 500 MHz for license-exempt use results in similar constraints currently in 5 GHz, as users would not get effective use of wider channels compared to today, particularly in dense deployments, and would not be able to fully support next-generation technologies like augmented and virtual reality (AR/VR) and 8K video streaming at scale. As a result, applications based on these technologies in sectors like healthcare, education, and manufacturing may not be as available to Singapore citizens as in other countries that have made the full 6 GHz band available for Wi-Fi use.

Implementation Restrictions with less than Full 6 GHz Band

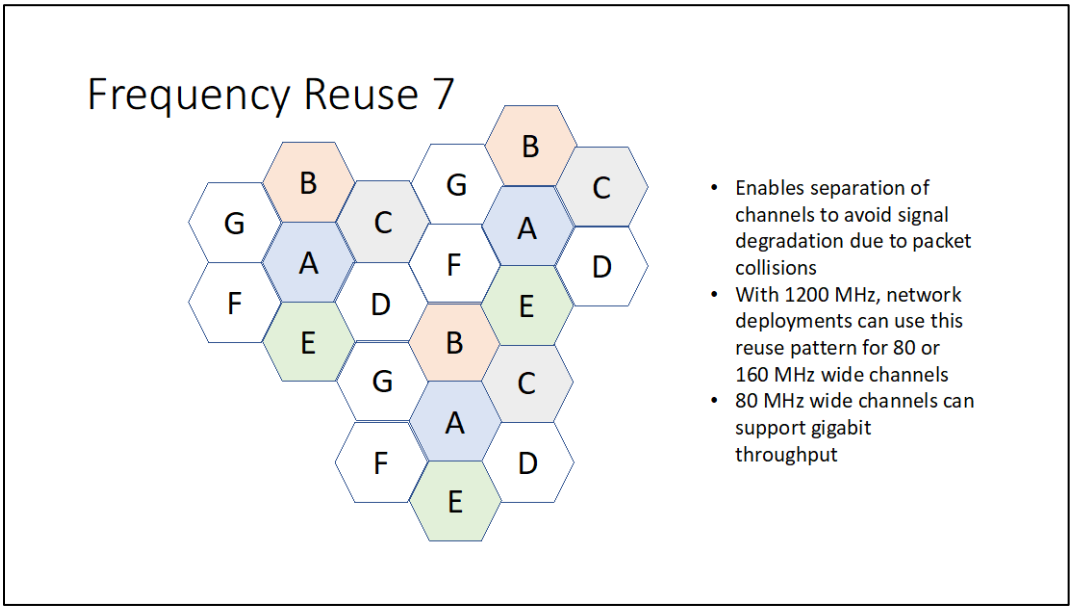
For a decade and a half, the Wi-Fi industry has been innovating new generations of technology using spectrum that was identified for license-exempt use in the 5 GHz range by the World Radio Conference (WRC) of 2003. Over the years, numerous technological improvements – both standardized and vendor-specific – were made to ensure that Wi-Fi networks could be relied upon to serve a variety of purposes in government and enterprise settings, even as the number of use cases and volume of data continued to increase exponentially. During this period, the industry learned to deploy dense networks of the type found in convention centres, stadiums, university campuses, and transportation hubs. We learned, for example, that the minimum practical distance between access points (APs) in a network is 12 metres, given the total number of available 40 MHz channels and the need to avoid co-channel interference. One way to boost throughput is to use wider channels, which the industry set out to do in Wi-Fi 5. As customers migrated from Wi-Fi 4 to Wi-Fi 5, however, 40 MHz wide channels remained the norm for government and enterprise networks, despite Wi-Fi 5's support for 80 and 160 MHz wide

[2] "The Economic Value of Wi-Fi: a global view (2021 – 2025)", Wi-Fi Alliance, https://www.wi-fi.org/download.php?file=/sites/default/files/private/The_Economic_Value_of_Wi-Fi-A_Global_View_2021-2025_202109.pdf

channels. There are simply not enough of these wider channels to enable a networked deployment at typical AP densities.

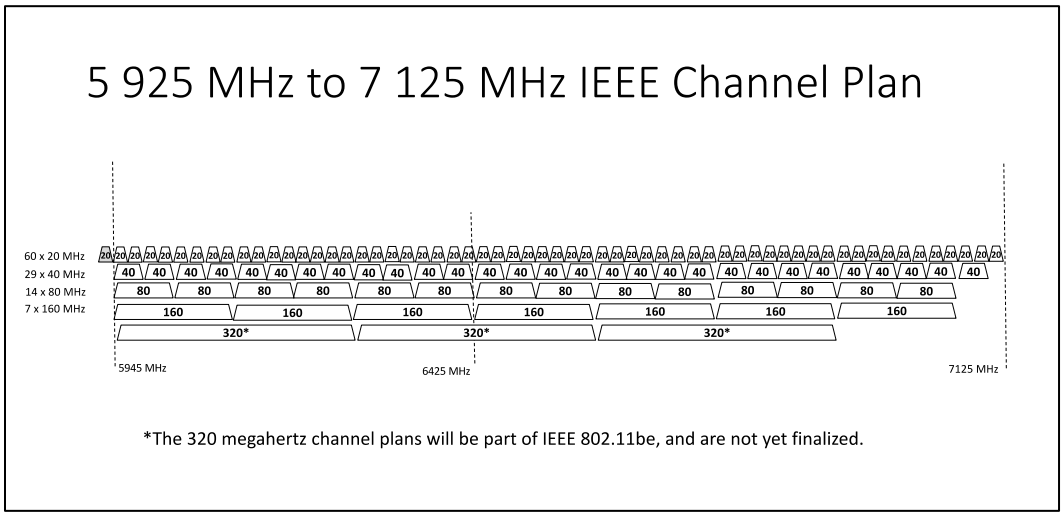


As the industry began to evaluate what it would need for its sixth generation of product (i.e., Wi-Fi 6), it was clear that technological innovation by itself would no longer be sufficient to address the demands of the future – such as more intensive wireless networking with denser deployments, more end points due to the Internet of Things, increasingly data-heavy and latency sensitive applications such as AR/VR, and more. Not only do we need a new set of technologies to address these issues, but we also needed the spectrum to enable them to run on wide channels in networked configurations. The concept of Wi-Fi 6 was not just to make a step change function in Wi-Fi capability, but also to create a technology that could take full advantage of a contiguous swath of spectrum supporting the use of wide channels. That contiguous swath of spectrum became 6 GHz – selected because it afforded manufacturing and operational synergies with 5 GHz but also because license-exempt equipment is highly complementary to the incumbent licensed services in the band. In Cisco's experience, the use of Wi-Fi in the 6 GHz band enables networks to be designed with "frequency reuse 7" channel plans featuring 80 or 160 MHz wide channels, as follows:



The frequency reuse 7 methodology minimizes packet collisions that degrade throughput by keeping "like" channels separated. With the full 1200 MHz available, government and enterprise deployments have access to up to fourteen 80 MHz wide channels and up to seven 160 MHz wide

channels. This is important because 80 MHz wide channels can deliver gigabit throughput with low latency, which is desirable now but will soon be a necessity.



Even today, these advanced networking capabilities are needed in government and enterprise networks. This is particularly true when the use case is broadband access. While in some cases, users and their devices might be uniformly distributed inside a facility – or at least predictably distributed – we find that most network users will move around and cluster in meeting rooms, lecture halls, training rooms, at specific booths or event spaces inside convention halls, etc. We not only need better technology to deliver a good user experience, but we also must rely on more than one access point to reach these dense spaces. These problems only get more challenging as we look ahead to deployments of AR/VR or robotics where the pressures on the network become more extreme. With Wi-Fi 6 in the full 6 GHz band (i.e., Wi-Fi 6E), Singapore businesses will have future-proofed spectrum to meet these coming technological challenges.

The addition of 500 MHz is certainly appreciated and useful for the requirements of today's wireless networks. Further, the lower 6 GHz spectrum is greenfield in that there are no prior generations of Wi-Fi operating in it,[3] which drives additional efficiencies. However, given emerging technologies, such as AR/VR, it is clear that 80 and 160 MHz channels will be increasingly important for wireless networks. Enterprise grade wireless networks are currently designed to support real-time voice and video, which require latencies on the order of 100 milliseconds (ms). AR/VR have much tighter requirements, approaching latency requirements of 10 ms. As such, availability of the full 6 GHz band is not just about improving Wi-Fi experience today, but also about enabling and supporting the next generation of emerging applications.

[3] The existing technology supporting Wi-Fi spectrum at 2.4 GHz and 5 GHz currently allows every Wi-Fi protocol since its inception to operate. The additional requirement of interoperability and burden of backward compatibility results in further reductions in efficiency and determinism which further negatively impacts voice and video quality when using the existing 2.4 and 5 GHz bands for Wi-Fi. The 6 GHz band would, for the first time, eliminate outdated and inefficient radio access technology, permitting the far more spectrally efficient Wi-Fi 6 (and above) to operate without the burden of legacy radios. This will dramatically improve the user experience and efficient use of the spectrum. This much-improved experience can only further the adoption of Wi-Fi technologies.

Constraints on Innovation

One of the key use cases enabled by the full 6 GHz band through Wi-Fi 6E is low latency AR/VR streaming, particularly in dense deployments. This technology has transformative applications in many sectors, such as collaborative design in VR[4,5], telehealth patient care and virtual clinics[6,7,8], high-quality social gaming experience[9], and specialized immersive training, such as for military training and heavy equipment handling[10].

Innovative AR/VR companies currently face challenges in innovation and expansion due to spectrum limitations for Wi-Fi. An example is Zero Latency, a Cisco customer, which is at the bleeding edge of AR/VR social gaming and provides arena-scale free-roam VR offerings. Testing by Zero Latency using Wi-Fi 6E shows that 80 MHz channels are necessary to provide a quality user experience with less than 10 ms latency. With only 500 MHz, it is challenging to support multiple cells with 80 MHz channels, while minimizing co-channel interference. In an environment such as Zero Latency's VR arena that is highly sensitive to co-channel interference, the company has found that no more than four 80 MHz channels can realistically be utilized when only the lower 500 MHz of the 6 GHz band is available, which translates to a maximum of 8 concurrent users in a given confined space. Increasing the number of users within this environment will materially impact the VR experience, as even a single interfering client with a data stream of 10 Mbps will have a noticeable negative impact on user experience[11]. Zero Latency has also found that when they deploy their VR area in environments using the existing 5 GHz band compared to the 6 GHz band, over 92% of VR sessions were impacted due to the significant presence of external interference and congestion in the 5 GHz band. These constraints on the maximum number of users will also be faced in other scenarios such as a classroom or training environment requiring similar network performance for a good experience, limiting the number of participants in a group learning or training setting.

While 5G is also being considered for AR/VR applications, there are some challenges that make it unsuitable for use in cost-conscious applications. Amongst other reasons, the cost for leasing private 5G spectrum from Governments are prohibitive. Even in the case of remote rendering

[4] https://www.nvidia.com/en-au/design-visualization/technologies/holodeck/
[5] https://hardware.webex.com/capabilities/hologram
[6] https://xrhealth.com.au/
[7] https://www.hopkinsmedicine.org/news/articles/augmented-reality-guides-surgeries-for-johns-hopkins-patients
[8] https://www.cisco.com/c/en/us/solutions/collaboration/healthcare.html
[9] https://zerolatencyvr.com/
[10] https://seriouslabs.com/
[11] A cap of 8 players is placed on Zero Latency's gaming platform with only the lower 6 GHz band available. However, based on Zero Latency's projection, 16 players would be a requirement to achieve a viable business case. Without the full 6 GHz band, to support more users with only 500 MHz, the user experience would be significantly compromised with the need to user narrower channels. The streaming bandwidth for each user will drop from 50 Mbps to 30 Mbps with the use of 40 MHz instead of 80 MHz channels. This places serious limitations on Zero Latency's innovative potential.

over public 5G networks, the costs are also very high, especially if special provisions have to be made to ensure that compute resources are physically close to end-users to ensure latency requirements (<10ms) are met. As such, 5G for AR/VR is usually not an option for start-ups and small and medium enterprises seeking to create new innovations.

Separate to the spectrum costs, AR/VR headsets supporting 5G are still very much in the early stages. The costs of 5G chipsets, as well as the power requirements—which link to battery weight and heat dissipation issues—are non-trivial, and as such, we expect Wi-Fi to remain the technology of choice for such technologies for the foreseeable future.

As noted, similar constraints on innovation are faced by other sectors beyond gaming where similar high bandwidth and high capacity are demanded. For instance, Zero Latency has applied its technology to provide a 400m^2 squad-based VR training facility for the Australian Defence Force, and for architects and real estate developers to visualize building designs within a warehouse-scale VR environment.

These examples demonstrate the innovative and limitless potential of Wi-Fi 6E and future Wi-Fi generations over the full 6 GHz band, but cannot be realised unless the full 6 GHz band is open for license-exempt use. This is not simply about enabling AR/VR, but ensuring support for other future applications and technologies. A policy of making the whole 6 GHz band available will allow innovative companies such as Zero Latency the freedom to continue innovating in Singapore, finding new use cases, and deploying products and solutions at a reasonable price point. It ensures that the innovation potential of Singapore's economy is maximized, and is not limited only to large organizations.

Time Criticality

The demand for bandwidth will only continue to grow. Future generations of Wi-Fi technologies will require wider and wider channels to support next-generation technologies. In the United States, the Federal Communications Commission (FCC) believes that wider channels, including 160 MHz for Wi-Fi 6E, and even up to 320 MHz for Wi-Fi 7, will be critical for the United States' economic benefits in terms of the capabilities and services that would be enabled. That was what led the FCC to ultimately decide to open the full 1200 MHz for license-exempt use in the 6 GHz band in 2020.

Further, IMDA should consider the opportunity costs of inaction on making the entire 6 GHz band available for license-exempt use. For Cisco's enterprise customers, opening the 6 GHz band for license-exempt use ensures that in their use of Wi-Fi, they can finally move beyond the 40 MHz wide channels used in enterprise networks since the mid-2000s, and toward 80 MHz or 160 MHz wide channels that they will need to power their networks in the future. For our telecom operator

customers, the 6 GHz band as license-exempt spectrum allows for more mobile offload[12] to Wi-Fi in congested areas and deep indoors, and supports enhanced in-home applications together with fibre broadband expansion, such as the 10 Gbps fiber connections that are now available for trial in Singapore. Telecom operators can also consider the use of 5G NR-U (including within the 6 GHz band) to supplement macro 5G for specific locations. For consumers, IMDA needs to evaluate the steps already taken by the global consumer electronics industry to enable their equipment for the full 6 GHz band, with more than 1,200 devices already in the market as noted in the Consultation, ranging from smartphones to smart TVs to laptops and more. Waiting and holding back the upper 6 GHz band also means that innovation using next-generation Wi-Fi technologies cannot be tested and developed in Singapore, presenting an impediment to Singapore's digital economy ambitions.

We urge Singapore to lead in making the full 6 GHz band available for license-exempt use as soon as possible. In doing so, IMDA will join a growing group of forward-looking regulators like those in the United States, Canada, South Korea, Saudi Arabia, Brazil, Colombia, Costa Rica, the Dominican Republic, Guatemala, Honduras and Peru[13], and, more importantly, allow Singapore to take advantage of technological harmonization that will bolster the government's efforts in making the country a world-class digital economy.

Power Levels

Annex A of the Consultation set out the RF power requirements for RLAN use in the lower 500 MHz of the 6 GHz band.

Cisco also encourages IMDA to consider authorizing the use of Standard Power (e.g., 36 dBm E.I.R.P.) in the 6 GHz band. Standard power devices are needed for a range of enterprise use cases, both indoors and outdoors. However, unfettered use of standard power transmitters can create interference issues for fixed link and other incumbent operations. For that reason, industry has proposed a database mechanism – the Automated Frequency Coordination (AFC) system – that would ensure outdoor license-exempt transmitters would not operate co-channel (or adjacent channel) in geographic proximity to fixed link receivers.[14]

Both the United States and Canada have authorized a Standard Power device class, subject to an AFC system that will steer devices away from frequencies in use by nearby microwave links. Brazil and Saudi Arabia are also exploring Standard Power operations under the control of an AFC system. The United States process is more advanced, with a dozen AFC applicants having received conditional approval to offer commercial services. In addition, the Wi-Fi Alliance and WInnForum

[12] In the United States, for instance, Verizon's unlimited data subscribers offload 77.7% of their data to Wi-Fi, while Comcast mobile customers offload 93.8% of their data onto Wi-Fi. https://www.lightreading.com/cable-tech/a-closer-look-at-how-cable-can-profit-in-mobile/d/d-id/782545

[13] https://www.wi-fi.org/countries-enabling-wi-fi-in-6-ghz-wi-fi-6e

[14] In addition to a database mechanism, industry also agreed that an emissions mask on standard power outdoor devices could help long term with coexistence with FSS uplink, limiting their maximum E.I.R.P. at any elevation angle above 30 degrees as measured from the horizon to 21 dBm (125 mW) to protect fixed satellite services.

are both working on test plans and requirements for testing of both Wi-Fi and New Radio-Unlicensed devices. Both groups are in the final phase of development and are positioning to turn their work over to the FCC for evaluating the proposed AFC systems and Standard Power devices. The FCC is expected to grant final approval to the AFC applications and Standard Power devices later in 2023.

Interest in Standard Power devices is high, including external antenna support, whether for outdoor use, indoor enterprise use (especially large facilities like warehouses, manufacturing, etc.) or for "whole home" coverage for residential applications where the low power indoor (LPI) signal from a single router is not sufficient and mesh type applications would otherwise be required. Countries that do not authorize Standard Power devices will not be taking full advantage of the 6 GHz band for connectivity, and we urge IMDA to consider adopting a similar AFC system to mitigate interference concerns pertaining to deploying Standard Power in the 6 GHz band.

Moreover, some applicants for AFC have initiated an "Open AFC"[15] approach using open source software. Cisco is a supporter of this initiative together with Broadcom and Meta. "Open AFC" will allow anyone interested in becoming an AFC provider anywhere in the world to utilize (and modify) AFC software to offer AFC services to device owners. This ensures a relatively friction-less expansion of market opportunity for AFC-enabled devices wherever regulators allow Standard Power, and provides confidence to regulators that standing up an AFC system is not a difficult journey. Countries may seek to run an AFC system themselves, or to turn to the private market, as the FCC has done. With Open AFC, no one needs to start "from scratch."

Conclusion

Cisco appreciates the opportunity to provide the above input to IMDA's Consultation. This topic is important for the future of Singapore, for connecting residents and accelerating the industry digitalisation of our economy. We would be happy to discuss further on any further questions or follow up that you may have.

Contact Information

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[15] The goal of the Open AFC Software Group is to develop a reference open source implementation of an Automated Frequency Coordination (AFC) system. https://telecominfraproject.com/open-afc