White Paper

Wireless Connectivity
Wi-Fi

Spectrum Sharing Using Automated Frequency Coordination

Authors

Hassan Yaghoobi
Carlos Cordeiro
Reza Arefi

Next Generation and Standards
Intel

David Horne

Global Government Affairs
Intel

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Abstract

As regions around the world go through proceedings for the adoption of 6 GHz band for license-exempt operation, interest is building on enabling Standard Power mode under the supervision of Automated Frequency Coordination (AFC) for enhanced performance and spectrum utilization. This paper provides an overview of AFC System use cases, an implementation model, regulatory requirements, operation and compliance considerations.

Introduction

AFC is a spectrum sharing mechanism developed for license-exempt (LE) devices to safely share spectrum with incumbent terrestrial services such as Fixed point-to-point microwave Services (FS) and radio astronomy observatories. Compared to Low Power Indoor (LPI) mode, AFC mode permits higher power indoor and outdoor RLAN operations by requiring the RLAN access point to obtain location-specific, frequency-specific authorization to transmit. While the indoor restrictions and transmitter power levels for LPI were designed so that harmful interference to incumbent operations is avoided without any specific knowledge of incumbent systems, the AFC mode of operation takes a different approach in order to safely expand the use cases beyond those that can be enabled without any specific knowledge of incumbent operations.

The AFC System uses information about nearby incumbent operations (retrieved from a database of location-specific incumbent operating parameters), then makes calculations of the interference potential versus frequency, and authorizes only the RLAN frequency channels where there is no risk of harmful interference to nearby incumbent operations. The incumbent database may be updated to reflect changes in incumbent operations and even the expansion of their services. The AFC System should use up-to-date information for protection of all incumbent links as they are updated. Restrictions that AFC Systems bring on available channels, especially wider channels, further highlight the importance of authorizing the entire 6 GHz band for license-exempt operation.

In its first commercial instantiation, AFC is being employed to allow sharing of the band with Wi-Fi at standard power level as the target license-exempt service. As such, for the remainder of this paper, we consider Wi-Fi in describing the AFC architecture and functionality, although the AFC System can be used to protect incumbents in any frequency band where a database of incumbent operating parameters exists (or can be enabled), and it can be used by any RLAN technology (e.g., Wi-Fi and IEEE 802.11-based technologies) as well as by 3GPP-based technologies such as License Assisted Access (LAA) and 5G New Radio Unlicensed (NR-U).

Other related frequency coordination schemes in license-exempt bands are Spectrum Access System (SAS) in the US Citizens Broadband Radio Service (CBRS) band and geolocation database spectrum sharing for TV White Space (TVWS) band. A simpler registration-based mechanism is also used in different bands.

The AFC is designed to support Standard Power (SP) mode for indoor and outdoor operation as one of the three main regulatory modes of license-exempt operation for Wi-Fi to enable enterprise and high-performance outdoor and indoor use cases. The other two modes are Low Power Indoor (LPI) and Very Low Power (VLP). Client to Client (C2C) communication under LPI and SP is also being authorized or considered in various regions. This multi-mode regulatory approach was devised to address a comprehensive set of use cases required by the Wi-Fi industry. The operational distinctions relate to differences in the coexistence mechanisms across the modes.

The US FCC adopted Standard Power AFC mode in April 2020[1] for license-exempt operations in the 5925-7125 MHz band. In September of 2021, the FCC issued a Public Notice[2] to begin the process of authorizing 6 GHz Band Automated Frequency Coordination Systems. Following the US, Canada ISED published its consultation[3] in May 2022 on Automated Frequency Coordination (AFC) System Specifications for the 6 GHz (5925- 6875 MHz) Frequency Band. In November 2022, Brazil Anatel published a consultation[4] on AFC System. At the time of the development of the paper, countries from all three main global regions (Americas, Europe, Middle East, and Africa (EMEA) and Asia-Pacific (APAC)) have been working on the AFC mode.

Given that the AFC development process is more advanced in North America than in other regions of the world, this paper is primarily based on and uses the US FCC[5] technical regulatory requirements for 6 GHz band.

Fixed point-to-point microwave services are the primary incumbent services protected by the AFC System. In addition, other special incumbent services such as Radio Astronomy and incumbent services at international borders with neighboring countries (Canada and Mexico borders in the case of the US) may be protected by the AFC System.

Use Cases

Standard Power mode under the supervision of an AFC System is a key element in enabling an important and broad set of Wi-Fi use cases for outdoor operation and complementing LPI for indoor operation. Outdoor use cases include multigigabit per second outdoor coverage (e.g., parks, stadiums, other venues, city public Wi-Fi, school and college campuses, etc.), low-latency Wi-Fi calls, and next-gen experiences with AR/VR and multigigabit point-to-multipoint rural connectivity.

Standard Power mode can also be deployed indoors when frequency coordination through AFC allows Wi-Fi to operate at a higher power than LPI (but in a more limited frequency range). This higher transmit power not only enables high throughput and low latency applications but also offers the equivalent range as Wi-Fi at 5 GHz.

In the US, Standard Power mode is also considered[6] for enabling C2C communications to allow direct communication between client devices at channels authorized by the AFC System without going through Standard Power Devices. Short-range C2C use case permits lower transmit power than more distant AP as a middleman, lower (e.g., half) airtime transmission duration, hence more efficient spectrum utilization, and lower latency. In the context of Standard Power mode, in this paper, we use the term AFC Device to refer to Standard Power Standalone AP, a Proxy representing one or more Non-Standalone APs, or a Fixed Client Device. The terms "AFC Device" and "Standard Power AP" are used interchangeably in this paper.

Automated Frequency Coordination in the 6 GHz Band

Overview

The AFC System model is shown in Figure 1. AFC is a system that calculates available frequency, along with maximum permissible transmit power, for Standard Power operation within a target spectrum range. The availability calculation is per Standard Power AP, based on its reported 3D position (latitude, longitude, and height), to meet an Interference over Noise (I/N) based criteria called Incumbent Protection Criteria (IPC, see Requirements) at incumbent receiver points subject to potential interference from the AP.

In the calculation of I/N (see the section on Frequency Availability and Max Tx Power Calculation) at the incumbent receiver point, an appropriate propagation model (see Requirements) is applied, depending on the morphology at the locations of the Standard Power AP and the Incumbent FS link. The calculation of I/N considers the information of incumbent links, including location and other radio receivers' characteristics. Incumbent information is provided by National Regulatory Agencies (NRA) through access to relevant databases of incumbent information. In the case of the US, the FCC's Universal Licensing System (ULS) is used. US FCC regulation authorizes the operation of Standard Power mode in U-NII-5 (5925-6425MHz) and U-NII-7 (6525-6875MHz) at a maximum transmit power of 36dBm. Refer to Requirements for detailed requirements.

AFC System Implementation Model and Architecture

Regulations allow the operation of multiple simultaneous AFC Systems serving different AFC Devices or groups of devices, even in the same general geographical area.

AFC Systems require access to an incumbent database, but all the frequency availability and exclusion zone calculations are done per AFC Device and hence, do not require any coordination among AFC Systems. Centralized and decentralized models are considered for AFC Systems. In a centralized model, each AFC Device remotely accesses an AFC to obtain a list of available frequency ranges and the maximum permissible power in each frequency range. In a decentralized system, a copy of the incumbent database is maintained locally at Standard Power APs, and frequency availability and maximum permissible power are calculated locally per AP. To enable the widespread adoption of new services and facilitate regulatory bodies to oversee operation, accuracy, identification, and resolution of potential cases of interferences, regulations currently only allow a centralized mode for AFC Systems.

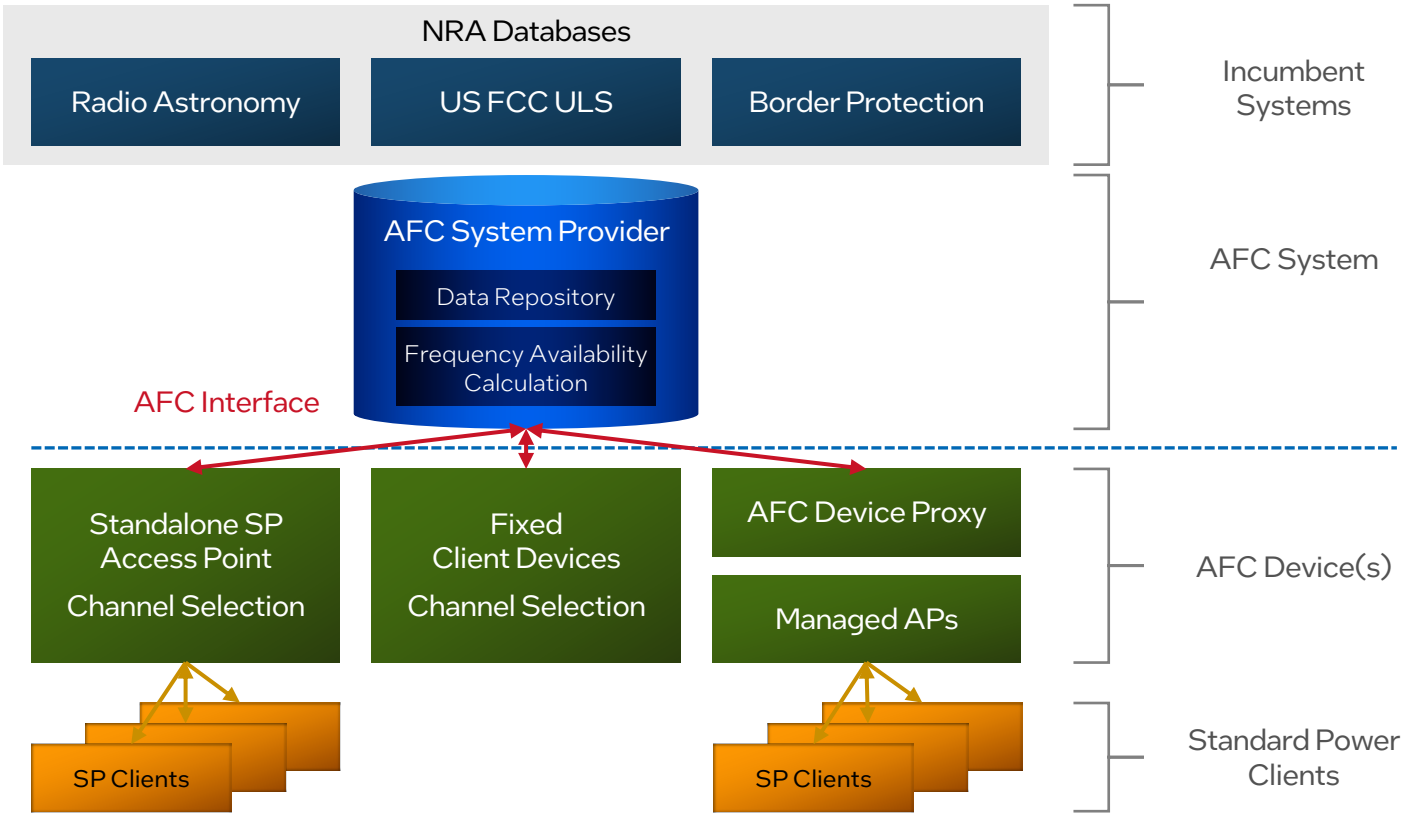

Figure 1. AFC System Model

Figure 1 illustrates a reference AFC System model with its interconnection with US FCC ULS database on one side and AFC Devices under its supervision on the other side. The AFC System maintains an up-to-date copy of the ULS database in its Data Repository. From the perspective of calculation of frequency availability for AFC Devices, the Wi-Fi Alliance AFC System Reference Model[7] assumes a stateless realization of the AFC System when AFC Devices initiate sessions. AFC Devices transmit Registration messages, report their locations, and request available frequencies through the AFC System to Device Interface (AFC SDI; See AFC System to AFC Device Interface). The AFC System calculates available frequency ranges along with corresponding maximum permissible transmit powers and responds to AFC Devices through AFC SDI.

Centralized AFC Systems can be implemented in two models. In a third-party AFC System, the database and AFC operation are typically cloud-based and not co-located with the Wi-Fi access network and the network premises. It may serve different enterprise or residential retail customers through a standard interface. In this model, the Wi-Fi access network and AFC System are operated and managed by different entities. In a third-party AFC operator model, the AFC System provides frequency availability to the managed and/or standalone APs for conducting channel selection and other operational optimization. In a private Cloud AFC operation mode, the AFC System and Wi-Fi access network may be managed or operated by the same entity, and as such, frequency availability reporting, channel selection, and Standard Power AP location reporting may be integrated and optimized for an enterprise deployment model.

Requirements

Table 1 provides a summary list of the main regulatory requirements for the AFC System, AFC Devices, and related interfaces.

Item	Description	Values
AFC System	Frequency Range/Band	US: 5925-6425MHz (U-NII-5) US: 6525-6875MHz (U-NII-7) Canada: 5925-6875MHz
	Incumbent Protection Criteria (IPC) Threshold	I/N = -6 dB for co-channel and adjacent channel
	Incumbent Information Database	US FCC: ULS Database[8] Canada ISED: SMS Database[9] Incumbent Information Used by AFC System • Fixed Service link identifier (e.g., Call Sign in US) • Receiver location (latitude and longitude) • Receiver antenna information for main and diversity antennas (if applicable) for each link • Antenna height and gain • Center frequency • Channel bandwidth • Receiver losses (e.g., feeder loss) • Passive repeater /reflector information (if applicable) • Latitude and longitude location and height, antenna gain and dimensions

	Propagation Model	• Up to 30 meters: free space path-loss model
		• 30 to 1000 meters: WINNER II model[10]; LoS/NLoS determination through site specific if available or a probabilistic combining model; parameters according to relevant Urban, Suburban, or Rural morphology
		  • Land Category Data required (National Land Cover Data (NLCD)[11] in US)
		• More than 1000 meters: ITM model[12] combined with the appropriate clutter models (ITU-R P.2108-0 (06/2017)[13] for urban and suburban and the ITU-R P.452-16 (07/2015)[14] for rural)
		  • Terrain and Elevation Data required (Digital Elevation Model (DEM)[15] in US)
		  • Climate Data and Surface Refractivity (available by ITU)

	Re-check Interval for Incumbent Data	Once a day
	Storage of Registered Information of AFC Devices	3 months secured storage
AFC Device	Maximum Permissible Transmit Power (EiRP)	AFC Device Power: 36 dBm AFC Device PSD: 23 dBm/MHz Minimum Permissible Transmit Power Range for AFC Device: 21-36 dBm (steps of 3 dB) Note: Clients operate under guidance of APs with the following requirement: • Client Power: 30 dBm • Client PSD: 17 dBm/MHz • Client power: 6dB lower than AFC Device
	Maximum Out of Channel Emission	• 20 dBm at 1 MHz away from channel edge • 28 dBm at 1 x channel bandwidth from channel center • 40 dBm at >= 1.5 x channel bandwidth from channel center
	Location Reporting and Uncertainty	• Lat/Lon/Height geographic coordinates • Location uncertainty (in meters), with a confidence level of 95%
	Update Frequency	Once a day
	Registration with the AFC System	• Geographic coordinates (latitude and longitude referenced to North American Datum 1983 (NAD 83)), • Antenna height above ground level, • FCC identification number and • Unique manufacturer's serial number

Security	AFC Device	• Security measures to prevent it from accessing AFC systems not approved by the FCC • To ensure that unauthorized parties cannot modify the device to operate in a manner inconsistent with the rules and protection criteria set forth in this section
	AFC System – AFC Device Communications	• To ensure that communications between standard power APs, fixed client devices and AFC systems are secure to prevent corruption or unauthorized interception of data.
	AFC System	• Must incorporate security measures to protect against unauthorized data input or alteration of stored data • Including establishing communications authentication procedures between client devices and standard power APs.

Table 1. Summary Regulatory Requirements

AFC System to AFC Device Interface

An industry-specified standard interface specification may greatly facilitate the development and enablement of AFC Systems, the adoption of various deployment models, and the testing and certification of AFC Systems and AFC Devices. To facilitate regulatory compliance of AFC Systems and AFC Devices utilizing such a standard, the interface needs to specify a secured messaging protocol and transport for the interface between an AFC System and an AFC Device that supports regulatory messaging, including registration parameters (Refer to Table 1) and available spectrum inquiry request and response messages.

The Wi-Fi Alliance AFC System to AFC Device Interface Specification[16] (AFC SDI) developed by Wi-Fi is an industry-adopted specification to offer such a standard interface. The AFC SDI utilizes industry-standard proven transport and security protocols to carry required AFC messages between AFC System and AFC Devices. The AFC messages are JSON objects and are transported by using HTTPS (HTTP[17] plus TLS[18]), which is widely adopted and well understood by developers and is undergoing improvements and upgrades. The TLS is used by AFC Devices to authenticate an AFC System prior to any communication. After successful authentication, the AFC Device and AFC System shall encrypt all communications between the two entities.

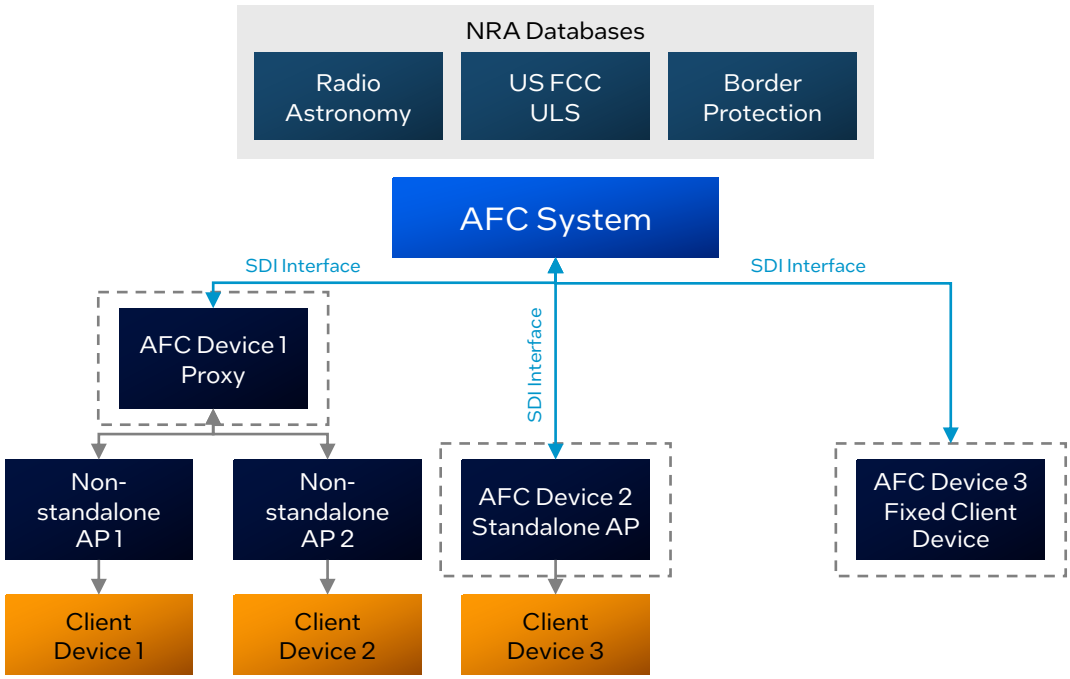

Figure 2. Wi-Fi Alliance AFC System to AFC Device Interface

Figure 2 illustrates an AFC System to AFC Device interconnect through AFC SDI. As discussed in the section on AFC System Implementation Model and Architecture, the modeled AFC System here is a stateless system. The AFC SDI is stateful extension to the baseline stateless AFC System when AFC Devices always initiate sessions by transmitting the following regulatory required quadruple:

1. Geographic coordinates (latitude and longitude referenced to North American Datum 1983 (NAD 83)) and associated location uncertainty
2. Antenna height above ground level (AGL) and associated uncertainty
3. FCC identification number
4. Unique manufacturer's serial number

The interface supports single or multiple rule set IDs to support multiple regulatory rules for AFC System and AFC Device. AFC SDI specifies Available Spectrum Inquiry Request (Request Message) and Available Spectrum Inquiry Response (Response Message) objects to support AFC Device requests and AFC System responses. There are three options to specify location uncertainty region: Ellipse, Linear Polygons and Radial Polygons. These options for the determination of uncertainty regions enable supporting location reporting generated from different methods of location determination other than common methods such as GNSS based.

AFC SDI supports two methods of height measurement for AFC Devices, Above Ground Level (AGL) and Above Mean Sea Level (ASML). Object fields are defined in the Request Messages so that the AFC Device can specify the frequency ranges and a minimum for maximum permissible transmitted power for which the device is asking the AFC System to calculate availability.

The interface supports two modes of frequency availability:

1. Frequency ranged based maxPSD (maximum permissible transmit power reported in PSD EiRP per MHz) and,
2. Channel based maxEiRP (maximum permissible transmit power reported in total EiRP per channel). Regulatory requirements only mandate support for the maximum permissible transmit power range for AFC Device to be 21-36 dBm in steps of 3 dB. AFC SDI supports a wider range of maximum permissible transmit power and a finer resolution of 1 dB.

AFC SDI supports Standalone SP APs, Fixed Client Devices as well as managed APs through Proxy networks. The interface supports AFC Devices' reporting of their Indoor/Outdoor status to enable the AFC System to incorporate proper propagation losses (Building Entry Loss) for indoor devices.

AFC SDI supports an optional and flexible vendor extension message construct that can be used to exchange information between the AFC Device and AFC System to deliver enhanced services, such as the antenna pattern of the AFC Device as well as support for non-Wi-Fi technologies such as those based on 3GPP.

Location Determination

Regulations require reporting of geographic coordinates (latitude, longitude, height) of AFC Devices along with associated uncertainty numbers in meters. The uncertainty numbers are to satisfy the required 95 percent confidence level. The AFC SDI enables the reporting of geographic coordinates as well as the height information along with the three-dimensional uncertainties to meet the 95 percent confidence level. The messaging for reporting the 3D coordinate is flexibly provisioned in the AFC SDI so that the uncertainty can be assigned to various coordinate elements independently and support various location determination mechanisms with different levels of uncertainties if they meet the required 95 percent confidence level. Although widely characterized methods such as GNSS-based location determination are expected to be the most commonly used methods, it is important to develop compliance mechanisms that support other innovative location determination mechanisms to effectively trade off cost and performance.

According to the regulations, an AFC Device must include either an internal geolocation capability or an integrated capability to securely connect to an external geolocation device or service to determine the geographic coordinates and location uncertainty. In the case of an external source, a single external geolocation source may be connected to and support multiple AFC Devices through a wired connection (cable) or wirelessly. The external geolocation device must be connected to AFC Devices securely to ensure only approved geolocation sources are used by AFC Devices. Examples of solutions with wireless connectivity are GNSS-enabled smartphones or discrete GNSS receivers. As a simple example of an implementation of the external source, a remote receiver antenna may be connected to a geolocation receiver within the AFC Device through an extender cable.

In some methods for location determination, such as GNSS, the AFC Device may not have the height information available in AGL, but in ASML. The AFC System may apply some conversion to the height information received from the AFC Devices to properly use it for the frequency availability calculations. As mentioned in the section on AFC System to AFC Device Interface, AFC SDI supports reporting of elevation information both in AGL and ASML.

While the case of an internal GNSS-based location determination may involve common and straightforward options with widely known confidence level and uncertainty characteristics, other options, including more advanced innovating technologies and proprietary methods with internal or externally integrated sources of geolocation information, are both supported by the regulations and accommodated by industry-developed compliance specifications. Compliance of internal GNSS-based solutions to the required confidence level and claimed uncertainty levels may be verified through attestation. In the case of more advanced solutions implemented internally or through an externally integrated source, a confidence analysis study is expected to prove compliance to the minimum regulatory confidence level with an

associated declared uncertainty level. In the case of an externally integrated geolocation source, the external nature of the source and associated distance from the physical location of the AFC Devices must be factored in as uncertainty elements of the total uncertainty or calibration factors in the reported location.

Frequency Availability and Max Tx Power Calculation

According to the regulations, AFC Systems must calculate and establish location and frequency-based exclusion zones around Fixed Services receivers operating in the Standard Power mode frequency bands (5.925-6.425 GHz and 6.525-6.875 GHz bands for US and 5.925-6.875 GHz in the case of Canada). The exclusion zones are calculated based on IPC of I/N=-6 dB, taking into account both co-channel and adjacent channel interference from individual Standard Power APs or Fixed Client Devices.

The exclusion zone, reported through responses to AFC Devices' request for frequency availability, may be in the form of unavailable frequency ranges or reduced maximum permissible transmit power for specific devices at specific locations.

In its calculation of frequency availability and maximum permissible transmit power, AFC Systems uses the following sets of information: 1) NRA incumbent information, 2) Propagation models, 3) AFC Device location information (latitude, longitude, height), and requested frequency and transmit power range.

- **NRA incumbent information:** The main parameters used by AFC Systems for frequency availability calculation are incumbents' frequencies of operation and channel bandwidth, location and heights of receivers, antenna, and receiver characteristics (gain, diameters, radiation pattern, polarization noise floor, losses, etc.). Additional antenna configuration information such as diversity and/or repeaters/reflectors antenna may be considered for the protection of these types of antennae.
- **Propagation models:** Regulatory-required propagation models for different ranges and morphology areas are specified by regulation and listed in Table 1. Additional parameters and assumptions need to be specified as related to propagation models for a well-defined and unambiguous compliance requirement. Examples of important parameters to be taken into account are Building Entry Loss (BEL) for the calculation of frequency availability for Indoor Standard Power APs and confidence and availability percentages for WINNER II and ITM models.
- **AFC Device location information:** AFC Systems calculate frequency availability and maximum permissible transmit power based on the AFC Device reported location (latitude, longitude, height) along with uncertainty regions. In addition, the AFC Device may request for frequency availability within a specific sub-range of frequency or subset of channels and within a range for maximum permissible transmit power.

Based on the above information, the AFC System calculates frequency availability and maximum permissible transmit powers at locations within the uncertainty region using two options per request from the AFC Device: 1) channel-based or 2) frequency-based. In the channel-based option, the availability is over the list of industry/standard specified channel sets (20, 40, 80, and 160 MHz channels within the frequency range authorized for Standard Power operation, U-NII-5 and U-NII-7 for US) using maxEiRP. This mode is expected to be popular for Wi-Fi systems and devices using the IEEE 802.11 standard[19] set of global operating classes and channel sets. In this mode, AFC Systems consider the interference from in-channel and adjacent channel Wi-Fi devices. In the case of frequency-based, a set of sub-frequency ranges along with associated maxPSD per range is calculated and responded to the AFC Devices. In this case, because the exact frequency used by the AFC Device, within the range of allowable frequencies, is not known to the AFC System, AFC Devices will be responsible for confirming compliance with the adjacent channel requirements. The maxEiRP and maxPSD are such that the AFC Device would not result in more than an IPC of −6 dB I/N at any fixed service receiver antenna. The AFC System then returns the resulting spectrum availability and power levels to the AFC Device through AFC SDI.

Frequency availabilities are precalculated or calculated in real time based on the IPC evaluated over the entire 3D uncertainty volume reported by AFC Device. Exclusion zones or reduced maximum permissible transmit power are determined accordingly per AFC Device. Figure 3 shows a visualization of AFC System determination of spectrum availability by computing protection contours around each fixed service receiver and color coding for different levels of maxEiRP or maxPSD on the incumbent operating frequencies. At points closer to the incumbent receiver and within the receiver antenna boresight, maximum permissible transmit power is typically constrained most as it is shown in red and maximum permissible transmit power is maximized or most relaxed when moving away from the receiver and within the receiver antenna boresight as shown in blue. At points outside an incumbent protection contour, there is no transmit power constraint due to that incumbent (the device can transmit at the maximum allowed by regulation, i.e., 36 dBm for US). However, other incumbents may affect spectrum availability at that point.

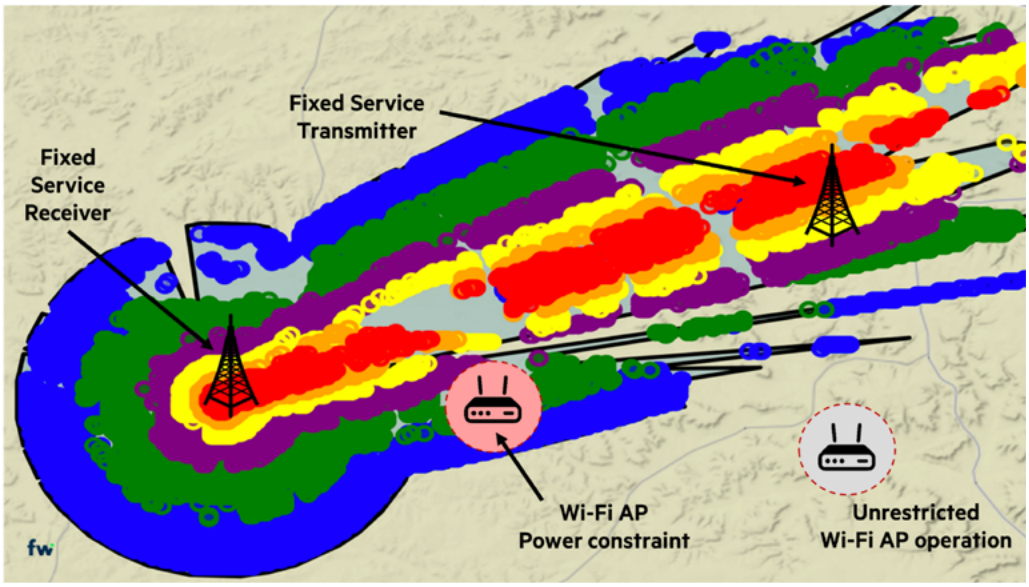

Figure 3. Fixed Service Receiver Protection Contour (courtesy of Federated Wireless)

In this process, a landcover database should be used to determine which morphology (Urban, Suburban, or Rural) to use in selecting the correct parameters for the WINNER II model or the appropriate clutter model to use in conjunction with the Irregular Terrain Model. In the case of the US, the NLCD 2019[11, 20] is being adopted by the industry to be used for this purpose.

Figure 4 shows AFC System determination of spectrum availability in a location near Dallas, TX, where there are eight fixed service incumbents that constrain transmit power at different channels. In this case, each incumbent causes a constraint at a different frequency. One of these FS links, highlighted in the upper left of the figure, operates in 6078-6109 MHz and causes a transmit power constraint of 20 dBm/MHz within this frequency range. A second FS link operates in 6710-6740 MHz with 11 dBm/MHz transmit power constraint, while a third FS link operates in 6740-6770 MHz and causes transmit power constraint of 10 dBm/MHz within this frequency range.

AFC Systems may also protect the operation of incumbent services of neighboring countries at the international borders through compliance with international agreements. In the case of the US, for example, the AFC System is to protect microwave operations in Canada and Mexico near the United States border.

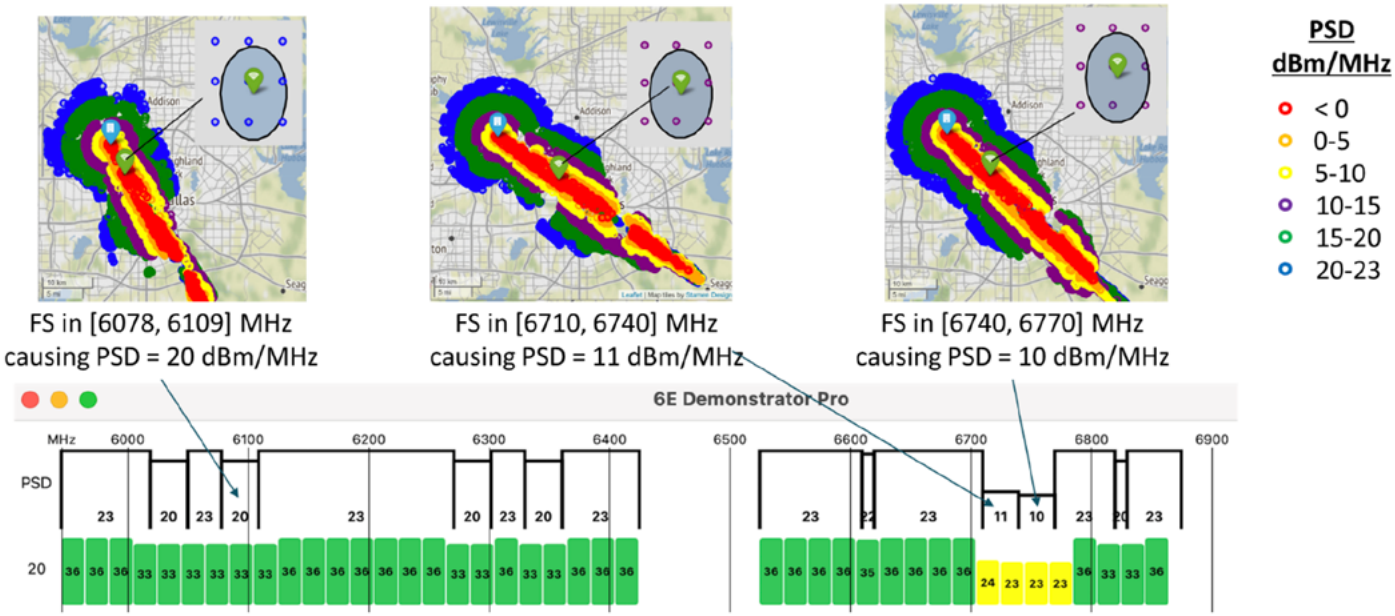

Figure 4. Spectrum Availability Near Dallas, TX, with 8 FS Incumbent Links (courtesy of Federated Wireless)

Standardization and Industry Compliance

As discussed earlier, the 6 GHz band was the first one where various regulatory modes of license-exempt operation were introduced. Wi-Fi 6, based on IEEE 802.11ax[21], was first introduced in 2019 and then extended to operate in the 6 GHz band as Wi-Fi 6E. To enable the 802.11ax technology to scale into various modes of operation including LPI, VLP and SP at 6 GHz band, IEEE 802.11 standard supports regulatory-specific operation information provisioned in the protocol to classify AP and Client devices for LPI, VLP, and SP as well as Client-to-Client modes of operation and makes it possible to set the regulatory requirements such as maximum transmit power and maximum transmit power spectral density. The IEEE 802.11[19] standard also specifies the standard set of Global Operating Classes and Channel Sets for the 6 GHz band.

The Wi-Fi Alliance, in addition to its MAC/PHY compliance specifications for Wi-Fi 6E[22] and Wi-Fi 7, has developed a set of compliance specifications to specifically address the regulatory compliance of the AFC System and AFC Devices to AFC related regulatory requirements. More specifically, the Wi-Fi Alliance has developed the following specifications:

- **AFC System to AFC Device Interface Specification[16]:** Provides the technical specification for AFC System to AFC Device Interface, which defines a messaging protocol and transport for the interface between an AFC System and an AFC Device. This specification defines the architecture, protocols, and functionality for entities that support AFC System to AFC Device Interface.
- **AFC System Under Test (SUT) Compliance Test Plan[23]:** This document describes the test methodology, equipment, and procedures based on the AFC System to AFC Device Interface that are recommended by Wi-Fi Alliance to ensure compliance of AFC Systems with requirements defined by the FCC for the operation of standard power devices in the 6 GHz band. This specification is complemented with a set of test vectors to test the compliance of AFC Systems to various test groups and test cases.
- **AFC Device Under Test (DUT) Compliance Test Plan[24]:**
  Describes a test methodology, equipment, and procedures based on the AFC System to AFC Device Interface that are recommended by the Wi-Fi Alliance, used to ensure compliance of Standard Power Access Points and Fixed Client Devices subject to Automated Frequency Coordination with requirements defined by the FCC for the operation of standard power devices in the 6 GHz band. This specification is complemented with a set of test vectors to test the compliance of AFC Devices to various test groups and test cases.

In addition to the Wi-Fi Alliance, WInnForum has developed a set of complementary specifications, including Functional Requirements WINNF-TS-1014[25] and Supplemental Databases TS-5008[26]. The WInnForum WINNF-TS-1014 technical specification defines the functional requirements for the AFC System and AFC System Operator and specifies the necessary standards to enable test and certification procedures for operation in the 6 GHz band. The WInnForum TS-5008 specifies the supplemental databases (beyond ULS) required to implement the AFC System technical specification.

Conclusions

AFC Systems are critical in the enablement of Wi-Fi use cases, both outdoor and high-performing indoor. AFC Systems effectively and optimally calculate available frequency and maximum transmit power levels based on the location of devices to protect incumbent terrestrial services. AFC System database is updated daily; therefore, incumbent operations are protected dynamically and can even grow while Wi-Fi is coexisting. Regulatory, system-level, and compliance requirements are detailed, and implementations are mature with flexible designs that can be adapted or customized to other regulatory regions.

Acknowledgment

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