

Automated Frequency Co-Ordinator (AFC) for U-NII-5 and U-NII-7 Band

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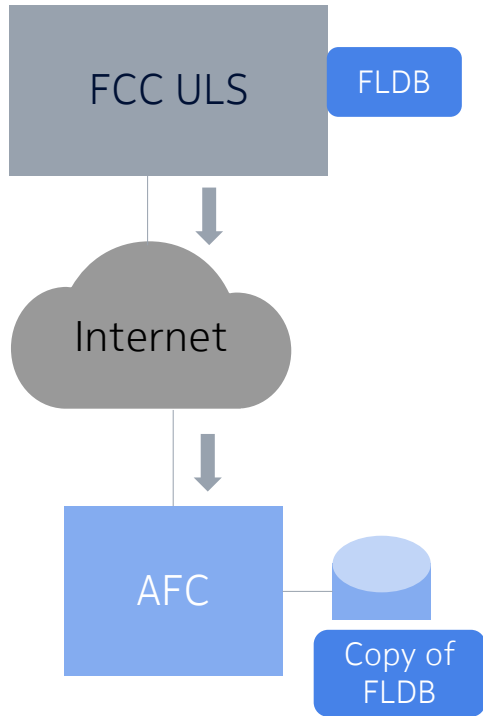
Overview

- ❑ Concept of AFC and its Objectives
- ❑ How does AFC protect incumbents?
- ❑ Concept of Operations (CONOPS) from perspective of U-NII-5/7 APs
- ❑ Implementation Options for AFC
- ❑ Summary

AFC Concept and Objectives

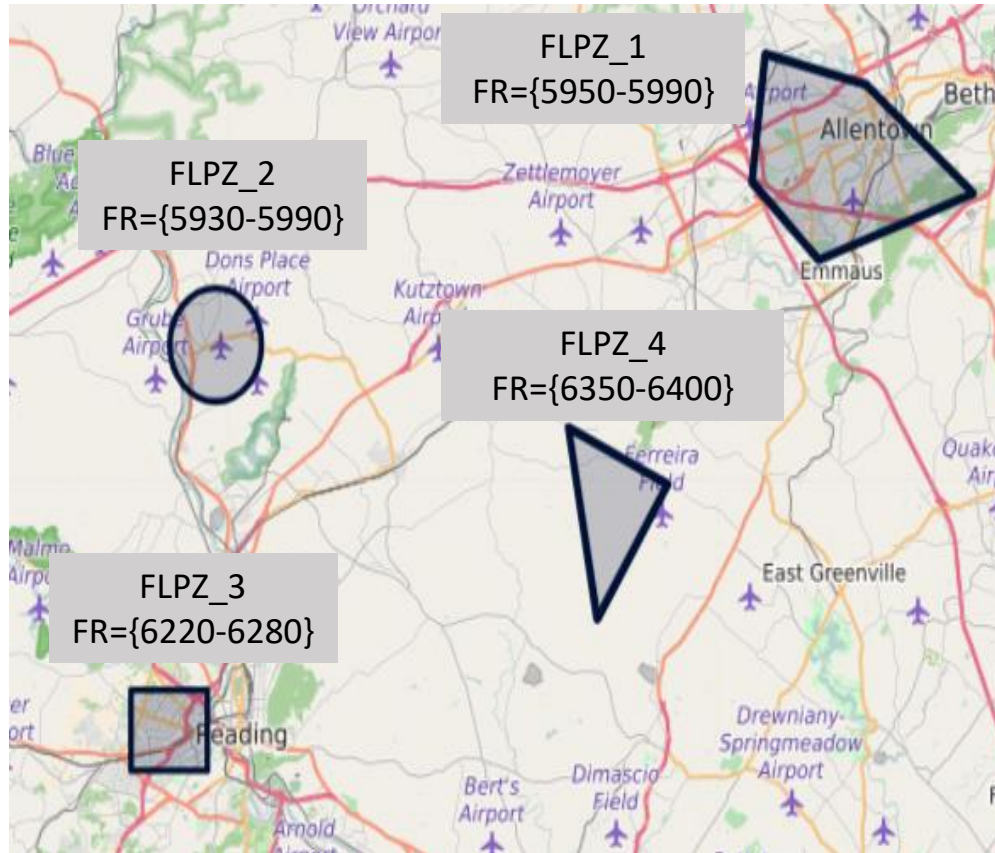
- ❑ AFC is a network resident server that coordinates use of U-NII-5 and U-NII-7 spectrum
- ❑ **Objective I:** Guaranteeing much needed protection to incumbents
 - **Existing Fixed Link (FL) wireless systems** that provide critical backhaul service to commercial cellular networks – specifically in the 5.925-6.425 GHz (U-NII-5) and 6.525-6.875 GHz (U-NII-7) bands
- ❑ **Objective II:** Providing rapid access to U-NII-5, UN-II-7 spectrum
 - For new shared indoor and outdoor use
 - Without requiring tedious manual coordination with existing incumbent systems.

FLDB: Incumbent Information Database



- ❑ Information on existing and any future FL systems will be maintained in a continuously updated FL database (FLDB) that AFC servers periodically download.
- ❑ FLDB entries record parameters of FL systems – specifically characteristics of TRXs in the FL links
 - Geo-location
 - Antenna height (H)
 - Antenna characteristics (e.g., gain, sectorization)
 - Frequencies/channels (i.e. portions of U-NII band) used.
 - Maximum power
- ❑ Commission's ULS database can be such an FLDB as long as the information is accurate, up-to-date and covers above FL parameters

Fixed Link Protection Zone (FLPZ) Concept



- ❑ AFC relies on a concept of FLPZ to protect the incumbent
 - Defined as spatial area characterizing the area of operation of the fixed links over which receivers in the fixed link endpoints need to be protected
- ❑ Each FLPZ also has associated with it a set **FR** of frequencies/channels that FL system uses.

Establishing FLPZ

❑ Three methods

1. Via in-field measurements reported by incumbents
2. Specified by the incumbent owner, in the form of a closed polygon (as a list of geo-coordinates of its vertices) over which the FL needs protection
3. Using a **coverage estimator** – a computational procedure that leverages propagation models and FL TRX characteristics (such as location, antenna height, characteristics and transmit power)

- ❑ Estimated coverage can be further increased with an additional spatial area called *protection buffer* to obtain final FLPZ estimate.
- ❑ In option (1) and (2), the FLPZ can be stored in the FLDB entry where as in option (3), the AFC will compute it.

Enforcing FLPZ for FL Protection

- ❑ **Protecting FL links:** Ensure that no unlicensed systems whose location falls inside FLPZ are granted the same channels that FL systems use.
- ❑ **Concept of Operation (CONOPS)**
 1. When an unlicensed system boots and needs to configure a radio channel in U-NII-5/7 band, it contacts the AFC system and presents its geo-location $L = (\text{Latitude}, \text{Longitude})$
 2. AFC consults its FLPZ database to find the set FZ of all FLPZ polygons in which the candidate location L falls. Set **FR_ALL** containing all frequencies associated with these FLPZs represents all frequencies in use by incumbent FLs and, therefore, blocked for use
 3. AFC forwards the set FR_ALL to the unlicensed system which can then select a channel in the U-NII-5/7 band that does not belong to the set FR_ALL
- ❑ This way, AFC eliminates co-channel use of frequencies used in FL systems and segregates the FLs and new unlicensed systems into independent (orthogonal) frequencies and eliminates the interference.

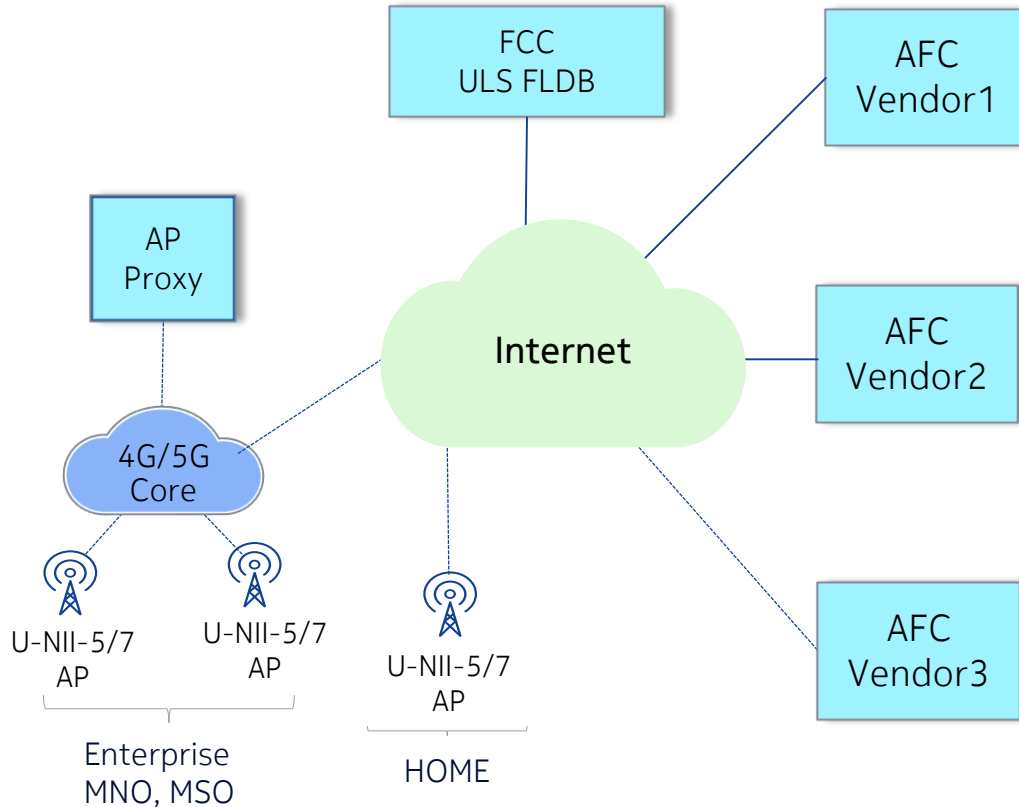
More Aggressive Sharing Possible but not Necessary

- ❑ AFC can facilitate more aggressive sharing of FL channels used by carefully allocating transmit power to unlicensed systems such that their aggregate interference to FL links is below a threshold.
 - Such fine-grain sharing may be useful especially for indoor systems
- ❑ However, it does lead to additional complexity
 - AFC must actively track all unlicensed APs and actively control them to adjust their transmit power to maintain aggregate interference below a certain threshold

Implementing AFC

- ❑ **Basic implementation:** AFC's role is limited to protecting FL systems
- ❑ **No coordination of secondary sharing:** It does not concern itself with how unlicensed systems – owned by different entities in a given region overlapping FL systems – share the spectrum.
- ❑ This makes AFC implementation rather simple and consistent with unlicensed access mode envisioned for U-NII-5 and U-NII-7 bands
 - No need to track a large number of unlicensed systems that may use the U-NII bands

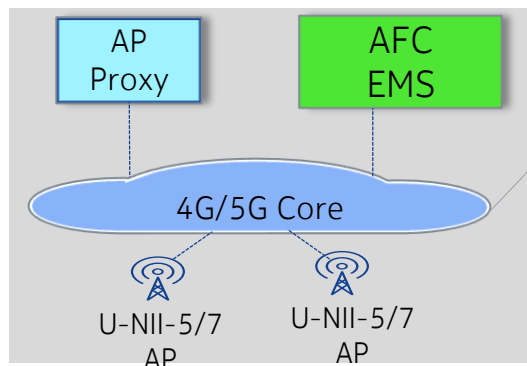
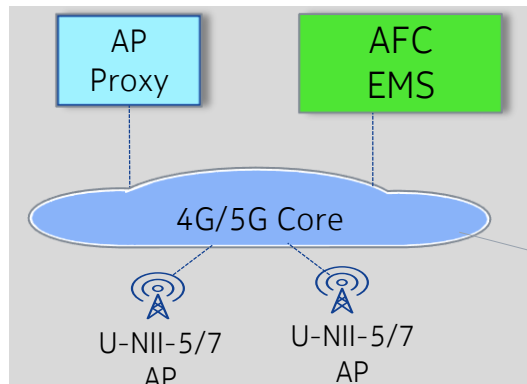
Option I: Implementing AFC as a Cloud Resident Server



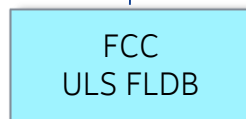
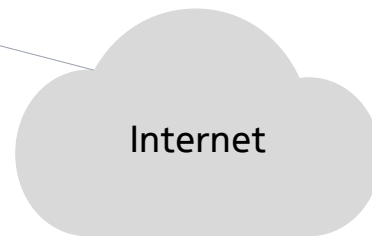
- ❑ Network resident service accessed by unlicensed access points (APs)
 - Direct connect (e.g., in homes)
 - Via a proxy of a network of APs (e.g., deployed in large venues, enterprise networks, or networks of MNOs, MSOs)
- ❑ Multiple AFC servers can be present in the ecosystem and all can offer same basic service of providing a list of safe channels.
- ❑ AFC servers can collaborate to optimize sharing and offer value-added services:
 - Services to unlicensed systems to help them optimize their performance
 - Services to incumbents that enable interference reporting and revisions of FLPZs.

Option II: Implementing AFC as a Element Management System (EMS) Function

MNO1



MSO2



- ❑ In this scenario, unlicensed systems are deployed in a managed scenario such as (a) APs provided by cable or fiber operators for home, office (b) MNO and (c) enterprise deployments
 - Organic deployment wherein APs are standalone (e.g., APs bought at a retail store and deployed in-home) is not supported
- ❑ AFC server is implemented as an EMS function that obtains the FLDB and provides available channels to all APs under its control.
 - Here, AFC can also deconflict the APs into independent channels to optimize their capacity.

Summary

- ❑ Automated Frequency Coordinator (AFC) can help open up 850 MHz of spectrum in U-NII-5 and U-NII-7 bands rapidly
 - Can be flexibly split into two options -- managed and organic deployments
- ❑ AFC represents WIN-WIN for all interests
 - Effectively protect existing incumbents without disruptive migration
 - Provides rapid access for 5G use cases alleviating sub-6 GHz 5G spectrum crunch in USA
- ❑ Given incumbents are static, AFC is not a complex service
- ❑ AFC can provide avenue to incumbents to report interference events and resolve them much more rapidly
 - Reduces enforcement burden on FCC

NOKIA