Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band	)	GN Docket No. 12-354
	)	

To: The Commission

COMMENTS OF INTERDIGITAL, INC.

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InterDigital, Inc. ("InterDigital") hereby submits its comments in the above-captioned docket in response to the Commission's Further Notice of Proposed Rulemaking FNPRM 14-49, regarding commercial operations in the 3550 – 3650 MHz band.

InterDigital is an industry leader in exploring and developing technologies for shared and dynamic spectrum use. Since its founding in 1972, the company has been a wireless pioneer that has designed and developed a wide range of technologies used in digital cellular and wireless products and networks, including 2G, 3G, 4G and IEEE 802-related products and networks. The company actively participates in and contributes to the standards bodies that drive the design and function of each generation of wireless technologies. These bodies include IETF, ETSI, 3GPP, SAE, and IEEE 802 among others.

Some of InterDigital's recent contributions to the worldwide standards have been in areas involving multi-carrier technology, heterogeneous deployments, interference management, dynamic spectrum management and use, small cell support, relays, machine-type communications, security and video over wireless.

InterDigital is motivated by its commitment to wireless innovation and believes in the strong potential of spectrum sharing technology to meet the unprecedented spectrum demand. InterDigital's Dynamic Spectrum Management (DSM) solutions exploit and aggregate the capacity of underutilized bands to dynamically add more capacity to commercial LTE and Wi-Fi® systems, dramatically supplementing bandwidth. Our Wi-Fi (DSM-Wi-Fi) and LTE (DSM-LTE) solutions are being developed for standards-based interoperability to enable scalable and cost-effective solutions. InterDigital is working actively to lead initiatives within key standards organizations such as ETSI, 3GPP, IETF and 802.11 to foster adoption of spectrum sharing capabilities, and is motivated to work across the ecosystem to drive market adoption of shared spectrum in 3.5 GHz. We are also actively contributing to regulatory discussions on shared and dynamic use of spectrum within FCC, CEPT and ITU-R.

Introduction

In these comments, InterDigital provides its views on the proposed rules for the Citizens Broadband Radio Service and complements its earlier comments submitted in response to the Commission's Notice of Proposed Rulemaking and Order regarding commercial operations in the 3550 – 3650 MHz band [FCC_1], [IDCC_1], and its views presented in the White Paper submitted in response to the Commission's Public Notice on the Proposed Spectrum Access System (SAS) for the 3.5 GHz Band [FCC_2], [IDCC_2]. We are addressing in this document especially the following aspects: the feasibility and benefits of using small cell technology to facilitate sharing and to reduce the exclusion zones from those proposed in NTIA's Fast Track Report [NTIA_1] and the capabilities and utilization of the SAS to manage the use of the

Citizen's Broadband Radio Service in a dynamic manner, as well as employment of technologies by the SAS to enable the safe and legally authorized use of the Service.

InterDigital welcomes the FCC approach on the 3.5 GHz Band where new methods of spectrum sharing are explored and a diverse array of network technologies is promoted, focusing on relatively low-powered applications. We do believe that the proposed sharing model can be applied also in other bands in the future, which can significantly increase the efficiency of the overall utilization of the frequency spectrum.

I. General rules

Scope (§96.1)

FNPRM (22) "The specific Part 96 rules we propose today would apply the three-tier authorization model across the entire 3.5 GHz Band, based, at least in part, on concerns about the impact that Balkanization of this spectrum may have in terms of limiting the development of a robust and varied shared spectrum ecosystem in the band. We seek comment on the proposed section 96.1…"

InterDigital supports the Commission's proposal to apply the three-tier authorization model across the entire 3.5 GHz band and shares the concern about the potential impact of spectrum Balkanization on the shared spectrum ecosystem. Additionally, we believe that applying the three-tier model across the entire 3.5 GHz band would significantly increase the efficiency of spectrum usage as compared to a transitional approach where the 3.5 GHz band is divided between two and three-tiered authorization schemes.

Frequencies(§96.11)

FNPRM (27) "We propose to include the 3550-3650 MHz band in Part 96. These proposed rules could be expanded to include the 3650-3700 MHz band or other encumbered spectrum bands in the future. We discuss our supplementary proposal to include the 3650-3700 MHz band in greater detail below. We seek comment on the proposed section 96.11."

InterDigital supports the inclusion of both the 3550-3650 MHz and the 3650-3700 MHz bands in Part 96. We share the view that the creation of such a continuous block of 150 MHz spectrum would be beneficial in terms of spectrum efficiency and availability, and would provide economies of scale for the equipment.

The proposed rules would seem to protect the investments of the incumbents in the 3650 – 3700 MHz band sufficiently. The proposed five year transition period would seem long enough from the point of equipment upgrade cycles. However, the Grandfathered Wireless Broadband Providers should be allowed to transfer from operating under Part 90 into operating under Part 96 before the transition period has passed, and thus have access to the full band earlier, if they so wish.

In our view the approach that a minimum of 50 percent of available bandwidth would be made available for GAA use at any given time over the full 150 MHz band could be applied as a baseline. However, considering the capabilities of the SAS to manage the spectrum use by the PA users and the GAA users dynamically, the exact partitioning of the band between the PA and GAA use could be also determined dynamically, based on the need, as the needs can evolve over the time.

We are also confident that the proposed spectrum management approach could be applied in the future also to other encumbered bands, and thus the efficiency of the overall spectrum use can be further increased.

Frequency Assignments (§ 96.13)

FNPRM (28) "To foster a robust GAA ecosystem, a meaningful amount of the 3.5 GHz Band must be reserved for GAA use in any given geographic area. To that end, we propose to reserve for GAA use a minimum of 50 percent of the 3.5 GHz Band in any given census tract – after accounting for

any frequencies reserved for Incumbent Access tier use in the area - with the remainder to be assigned as PALs. We do not propose to assign GAA users and Priority Access Licensees to fixed spectral locations (e.g., GAA from 3550-3600 MHz and Priority Access from 3600-3650 MHz). Rather, under our proposal, the SAS would dynamically assign PAL channels and GAA bandwidth in real time to promote efficient spectrum use."

We fully support the Commission's proposal that the SAS dynamically assigns PAL channels and GAA bandwidth in real time. As previously commented in [IDCC_1], we believe this approach goes a long way to enhance efficient use of the 3.5 GHz band.

We support reserving a percentage of the bandwidth for GAA use at any given time, however a fixed value of 50 percent may not leave enough room for the operation of competing network providers as Priority Access Licensees. For example in locations where the maximum amount of spectrum would be available (assuming no incumbent, 10 MHz PALs and full 150 MHz made available for CBRS), 80 MHz could be reserved for GAA use, and 70 MHz would be available for PA use. Two PA users could reserve up to 30 MHz each, leaving 10 MHz for a third PA user. Such a configuration may allow sufficient competition among the PA users, but if a significant portion of the band is reserved for incumbents, or only 100 MHz is made available for CBRS, the remaining portion may limit the proper deployment of the PA usage.

The SAS capabilities to perform dynamic assignments could be further leveraged to enable a flexible amount of spectrum to be reserved for GAA. The amount reserved for GAA use can be location specific, as well as time specific. As the SAS determines the spectrum usage, it could also maintain high level, historical information of the PA and GAA spectrum use. This information may be used to adjust the amount of spectrum reserved for GAA (and thus the spectrum available for PA) for the 1-year term that corresponds to the next window for PAL applications. The initial setting can be set to 50% reserved for GAA, as proposed by the Commission, but using the adaptation scheme mentioned above, the setting could be adjusted in

time and location, as a function of the actual spectrum use. This mechanism may have the potential to further improve the spectrum use and increase the competition.

FNPRM (36) The rule we propose here would allow GAA use on unused PAL channels to promote efficient and consistent use of spectrum.

FNPRM (37) … How should "use" be practically and consistently determined in this context? How should the determination be made in the context of our dynamic frequency assignment proposal? If an assigned but previously unused PAL channel is later determined to be "in use," how long should a GAA user be given to vacate the Priority Access channel? What should be the triggering event that reserves assignment of a channel for PAL use? Should the event be based on action by a Priority Access Licensee (e.g., initiating service in a portion of the PAL) or by the SAS (e.g., assigning a channel to the PAL in response to a request from a Priority Access licensee)?

InterDigital supports the proposed rule, as any practically implementable measures to increase the efficiency of the overall spectrum use should be taken. Therefore, any unused PAL's should be taken into use, as much as possible. The current scheme proposes that auctions are to be used initially and in case there are mutually exclusive applications, and otherwise the applicants that fulfill the pre-determined criteria will be authorized, in which case there seems to be no mechanism for facilitation of economic incentives towards efficient use of PALs. Therefore other measures need to be considered. One possibility is that the PA licensees could be allowed to request assignment of PAL's only in case they will be taken into actual use, for the time they are expected to be in use. That being the case, the SAS can assign the unused PAL's to GAAs. When the PAL channels need to be taken into Priority Access use, the PA licensee can send, as a triggering event, a request to the SAS to assign the PALs. Unless there are unused PAL channels available, the SAS may need to evacuate some GAA users or dynamically modify the current assignments, i.e., reassign or repack the assignments, to make some spectrum available, and assign the requested PAL's to PA use. We believe that this approach (PA licensee sending an "initiate service" request to the SAS) is consistent with the SAS responsibilities listed

in Paragraph #95 of the FNPRM and the “Spectrum Access System Purposes and Functionality” proposed in Section 96.43. Specifically, as the SAS is responsible for assigning channels to CBSD (PA and GAA use), the SAS has up-to-date information on the channel assignments and channel use in any specific areas under its control. Thus, when a PA Licensee signals the need to use a PA channel, the SAS is in the position to either evacuate or reassign some GAA users.

To enable the SAS functionality of ensuring incumbent protection, as well as optimum spectrum assignments/re-assignments, the CBSDs may be required to provide periodic reporting of traffic and measurements. The periodic traffic measurement reports by the CBSDs may be used by the SAS to determine the spectrum use, as described in an example below.

Examples of such measurement (see our white paper [IDCC_2]) may consist of the average over-the-air data rate (or the average throughput), peak data rates, usage events. To account for short and bursty transmissions (which may correspond to a low utilization of the channel), the effective throughput (normalized to real time and channel bandwidth) may be used instead. To detect the use of spectrum, some criteria can be established to determine reasonable use of the channel. Lastly, if there are no traffic measurement reports received by the SAS for an assigned PAL channel, the SAS may flag that channel as ‘unused.’

It is assumed that as the CBSDs need to be certified by the Commission to operate in the band, they will meet the requirements for measurements and reporting. Compliance with these requirements, as well as with policy constraints, can ensure that false reporting (or over reporting) of the traffic cannot be used as a means to artificially keep the channel occupied.

The required time to vacate a channel should be chosen based on the nature and needs of the services deployed by the PA and GAA users. It should be short enough for the PA licensee to get access in due time, but long enough for the GAA users to avoid harmful interruption for their

transmissions. Timing of the PAL assignments can be based on communication between the PA licensees and the SAS and on some pre-determined timing characteristics, such as the maximum PAL reclaim time (time from reclaim request until assignment/availability), or requested PAL usage duration by the PA licensee. The timing of the GAA assignments can be based on the concept of Time-to-Live (TTL) or on evacuation commands from the SAS. The required channel evacuation time may be signaled by the SAS to the GAA during the setup phase, for example when the SAS signals the channel assignment to the GAA. This mechanism can thus support flexible channel evacuation times, as indicated above.

II. Incumbent protection

Protection of federal Incumbents (§96.15)

> *FNPRM 140. … As a starting point for continued analysis and discussion, we propose to implement the geographic Exclusion Zones proposed in the Fast Track Report. Nevertheless, preliminary studies have been performed on the potential effects of small cells on radar operations, with additional studies planned, that could lead to a reduction in Exclusion Zones in the near future. We also note that the rules proposed in this FNPRM contemplate additional uses other than small cells, with varying maximum transmit power levels and antenna gains, which must factor into the consideration of Exclusion Zones.*

We acknowledge that the rules proposed in the FNPRM contemplate additional uses other than small cells, with varying maximum transmit powers and transmitter characteristics. To make efficient use of the spectrum while accommodating a wider range of use cases, the exclusion zone could be based on the actual technical characteristics of the particular technology and network deployment of the PA licensee or the GAA user. This would mean the SAS could determine the exclusion zones individually for each network.

We agree that small cell use can significantly reduce exclusion zones from those proposed by NTIA's Fast Track report to expand the area where the 3.5 GHz Band could be used

by PA licensees and GAA users. We provided in our previous comments [IDCC_1] an example calculation of required exclusion zones around several types of shipborne radars assuming small cell deployment e.g. with 23 dBm EIRP small cell transmitter and compared the results with NTIA Fast track report. The comparison is reproduced below, in Table 1. Further details of the calculation can be found in [IDCC_1].

Table 1 Calculated exclusion zone for small cells and Friis path loss model

Radar Identifier	Interference Threshold (dBm)	Small Cell Exclusion zone distance (km)	NTIA Fast Track report exclusion zone distance (aggregate values, Table 5-4 NTIA)
Shipborne Radar 1	-114	49	310
Shipborne Radar 2	-101	11	45
Shipborne Radar 3	-100	9.7	53

This calculation based on a conservative model showed already significant reduction in the required size of the exclusion zone; the use of more accurate models such as the terrain dependent model used by the NTIA in the Fast Track Report, could further reduce requirements for these exclusion zones for small cell use. In addition to lowering the base station transmit power, the use of below rooftop antennas (BRT) or a transmitter Height Above Average Terrain (HAAT) restricted to the order of 20-30m (as compared to the height of 60 m used in the NTIA Report), can also help to reduce the exclusion zone. This observation is also supported by the analysis performed by Qualcomm, Inc. in its comments submitted to the NPRM [Q_1], as well as in the comments submitted by Google, AT&T, Motorola and others ([G_1], [AT&T_1], [MSI_1]).

For other use cases which require higher transmit power (such as for backhaul applications, or for WiMax deployments), the exclusion zone size may need to be comparable to those presented in the NTIA study [NTIA_1].

Moreover, we believe that the geographic exclusion zones could also be time dependent and dynamically managed by the SAS for a more efficient use of the spectrum. The scale of time dependency could be relatively long-term (e.g. hours, days or weeks) and could take into account the presence or absence of Federal incumbent sources such as Naval vessels within defined U.S coastal regions. When the incumbent is not active or not present, there is no need for an exclusion zone in the area, and consequently there is no need to have restrictions for the Priority Access and/or GAA use in the area. There may be cases when the Incumbent use varies over time in a manner that allows different sizes or shapes for the Incumbent Use Zone. The size of the exclusion zone will also depend on the frequency and bandwidth used by the Incumbent: for co-channel operation the Zone is largest, whereas with sufficient frequency separation there may not be a need for any Protection Zone, and for adjacent channels operation the Zone size may be smaller than the maximum.

Protections for Citizens Broadband Radio Service Devices from Federal Radar Systems

FNPRM 142. Additionally, in the NPRM, the Commission stated that GAA use could be allowed in areas where small cell operations would not cause harmful interference to Incumbent Access tier users but where signals from incumbent users could possibly interfere with GAA uses. However, the NPRM noted that Priority Access users, which have quality-of-service expectations, would only be permitted where CBSD operations would not interfere with incumbent operations, and where harmful interference would not be reasonably expected from Incumbent Access tier operations. It may eventually be practicable to authorize coordinated operations for GAA – and possibly Priority Access - tier users inside the proposed Exclusion Zones. We anticipate such use would involve a level of dynamic access to the spectrum and would be authorized through the SAS. However, adding this kind of dynamic element to the SAS raises many technical and operational questions that are not ripe for resolution at this time. Accordingly, we will explore the topic of dynamic coordinated access within the Exclusion Zones (i.e., converting Exclusion Zones to protection zones) in future phases of this proceeding . We seek comment on allowing Citizens Broadband Radio Service operations within currently designated Exclusion Zones and encourage commenters to submit technical analyses to support their positions.

We believe that LTE or Wi-Fi systems are likely technologies to be deployed within the CBRS, to be operated by Priority Access licensees or GAA users within the shared spectrum. In our earlier response [IDCC_1] we described how the properties of radar systems give rise to significant spectrum opportunities that can be exploited by GAA users and Priority Access tier users to achieve co-channel coexistence with Radar outside of the Exclusion Zone. We also described Dynamic Spectrum Management technologies that exploit these spectrum opportunities.

In our view the Priority Access systems and devices should also be allowed to operate, on an informed basis, in regions where interference from incumbents may occur, as such systems can also use flexible and resilient technologies to make use of these spectrum opportunities. We believe that LTE or Wi-Fi systems can both be adapted to mitigate possible interference from Federal Incumbents, including high-powered radar signals. Technology specific measures can be taken, including reactive interference management and proactive interference avoidance in connection with sensing and access to the SAS. It should be noted that Wi-Fi systems operating in certain portions of the 5 GHz band are already today required to implement Dynamic Frequency Selection (DFS) to avoid interference to or from radars.

Protection of Existing Fixed Satellite Services Earth Stations in the 3550 – 3650 MHz band (§96.17)

FNPRM 150. We propose to require CBSDs to avoid causing harmful interference to currently operational grandfathered FSS earth stations. It may be possible to minimize or eliminate geographic protection areas around FSS earth stations by incorporating detailed information on the "look angles" of FSS earth stations, the emissions characteristics of CBSDs and End User Devices, detailed regional topographical information, and other relevant variables into the SAS . …… We seek comment on the

necessity of geographic protection areas and, if necessary, the size of such areas. We also seek comment on additional or alternative mitigation strategies that could be employed to prevent harmful interference to FSS earth stations from CBSDs. What criteria should the SAS incorporate to ensure that FSS earth stations are protected while maximizing the areas available for Citizens Broadband Radio Service operations? How would the SAS manage this data?

FNPRM 151. We also seek comment on protection approaches other than protection areas . For example, we are interested in whether field strength, power-flux density, or some other technical metric, measured in relation to the earth station's technical configuration (antenna characteristics, etc.) might provide FSS earth stations with adequate protections while maximizing the available geographic area and bandwidth for Citizens Broadband Radio Service Users. To the extent such an approach is dependent upon operation of the SAS, we seek comment on what functionalities would need to be required by rule and what functionalities could be specified through other means (e.g., industry standards, multi-stakeholder groups, etc.).

In our view the baseline approach to protect the FSS earth stations should be to have a sufficient exclusion zone around each station, in which the portions of the band that are used by the FSS earth station are not used by CBSDs. This can be ensured by utilization of geo-location technologies, and CBSDs operating under the control of the SAS. In addition, we believe that it is possible to minimize the geographic protection areas around FSS earth stations by incorporating detailed technical and operational information of FSS stations and the CBSDs into the SAS.

All FSS stations operating in-band should register with the SAS database, and provide their geo-location information (latitude, longitude and altitude coordinates), nominal antenna pointing orientation (beam width, azimuth and elevation angles) and the information on frequencies in use (e.g. center frequency, bandwidth) to the SAS database. Furthermore, due to FSS stations solely servicing Geo-Stationary Orbiting (GSO) satellites and the very small shifts with normal FSS station keeping operations, real-time re-pointing updates are not anticipated. Existing FSS stations receiving signals from satellites in new GSO orbital positions could be handled as a required update to an existing FSS station registration.

Spectrum sensing cannot be used by the CBSDs to detect nearby FSS earth stations, as it is in practice not possible to sense the extremely low level satellite downlink signals with the relatively low gain antennas to be used in the foreseen CBSDs. Furthermore, the geographical coverage of the downlink FSS signals can be very large, and thus the presence of the signal would not necessarily be an indication of the presence of a FSS ES in the neighborhood. However, as the FSS information described above would be registered within the SAS database, the SAS can instruct the CBSDs to operate in-band and probably also in adjacent bands only outside of the exclusion zones.

If technical characteristics both from the particular FSS earth stations and the CBSD technologies to be deployed around the FSS ES can be made available to the SAS, it can calculate the size of the required exclusion zone on an individual basis. It is also possible to have the actual terrain data available, which further improves the estimation accuracy of the size and shape of the zone.

We would like to emphasize that the exclusion zone should not be considered as a constant contour around the FSS earth station, in which the CBSDs systems can never operate. In reality the exclusion zone could be different for co-channel operation, for adjacent channel operation and for frequencies deviating more from the frequencies used by the FSS. The better the selectivity of the FSS receiver, the less there are restrictions for CBSDs using frequencies adjacent to or different from those used by the FSS receiver. Good FSS ES input filtering and site shielding and CBSD antenna down-tilting and power adjustment to minimum required can allow operation of CBSDs even down to a close distance from an FSS earth station, especially when the CBSDs use other frequencies than the FSS station. The SAS can be aware of the

frequencies used by the FSS station, and can take note of the foreseen changes as reported by the FSS station so that the CBSDs can adapt accordingly.

All in all, assuming the SAS is cognizant of the previously specified technical characteristics of registered FSS earth stations and CBSDs that are to share the 3.5 GHz band, then we believe that the size of the exclusion zone can be determined in a manner that ensures the protection of the FSS station, while maximizing the spectrum availability for the CBSDs.

III. Priority Access

Authorization (§ 96.21)

FNPRM 42. ...We also propose that certain of the processes and requirements may be reasonably automated by SAS Administrators, in accordance with the Commission's rules. We seek comment on these proposed rules, including on any limitations posed by our Title III obligations on the scope of authority that may be delegated to such SAS Administrators.

We agree that employment of the SASs could facilitate automation of several processes and requirement by the SAS Administrators.

Obviously, the SAS can take care of the technical framework by managing automatically the use of the band. It can authorize and coordinate the access to the band, define the operational parameters and assign spectrum for the users in a dynamic radio environment while optimizing the overall spectrum use in the band and protecting the incumbent and Priority Access users from harmful interference. It could also take care of the economic framework in accordance with the policy defined by the Commission. The economic framework may cover the collection of fees from PA Licensees and GAA users for the use of the SAS and associated services, but it could even be extended towards automated auctions to solve mutually exclusive applications for PALs.

Beyond just coordinating the access and collecting the fees, the SAS could also take care of some regulatory aspects, such as issuing the licenses to the users, if so required, based on the principles of the policy defined by the Commission. In fact, the use of the SAS could offer several possibilities for issuing the licenses. Some of them would require the use of an administrative interface between the SAS and the Commission. The following approaches could be possible from the point of the SAS:

- All users that have been individually licensed by the Commission to have PAL rights are allowed to register with the SAS and are entitled to spectrum assignments. A mechanism like use of an Authorization Key or Certificate could be employed for the users to indicate to the SAS in a reliable manner that they have the required license and thus the right to use the services of the SAS.
- The policy may allow the potential users to apply for PAL rights through the SAS, which would contact the Commission on behalf of the users, and get the licenses based on delivering the required information, such as the identity, spectrum requirements and technical characteristics systems to be deployed by the users. Like for most communication between different entities and the SAS, for all these steps secure communication is needed. The Commission would issue the licenses, i.e., PAL rights.
- The SAS may be authorized by the Commission to authorize the users, i.e., assign PAL rights to users. This may be done based on pre-defined criteria in line with a policy defined and communicated to the SAS by the Commission.
- In case there is no need for an individual license e.g., for the GAA users, the SAS may allow any user to register as GAA user and get spectrum assignments, or the SAS may

choose the users that will get registered based on the policy issued by the Commission or on some other criteria.

As mentioned, the SAS could also resolve any mutually exclusive PAL applications through competitive bidding process and take care of the associated billing process.

IV. General Authorized Access

FNPRM 60. We propose to allow Contained Access Users, such as hospitals, public safety organizations, and local governments to request up to 20 megahertz of reserved frequencies from the GAA pool for indoor use within their facilities in furtherance of the public interest. These frequencies may be used only for private internal radio services and may not be made available to the general public. Other GAA users would not be permitted to utilize the reserved frequencies within designated Contained Access Facilities (CAFs).

FNPRM 61. We seek comment on the proposed rule including any costs or benefits. Specifically, what types of entities should be considered qualified Contained Access Users? Does this proposal adequately address the spectrum needs of Contained Access Users? Would this proposal effectively address a demonstrated spectrum need for certain users that would not otherwise be addressed by the proposals in this FNPRM? Should this proposed framework be limited to Contained Access Users or expanded to include other types of facilities, including outdoor facilities? Would the SAS be able to effectively manage spectrum use by a large number of facilities? How would the SAS limit the operation of other GAA users within CAF premises? Would this plan unacceptably encumber GAA spectrum?

We support the idea of allowing the Contained Access Users, such as those proposed, to request up to 20 MHz of frequencies from the GAA pool for indoor use within designated locations, the Contained Access Facilities. We understand that other GAA use would be allowed within the designated CAFs, but only in frequencies that are not reserved for CAUs. Additionally, CAU operating within a CAF should be able to operate in the presence of interference from Incumbent and PA users, which would be allowed in the same location.

As the CBSDs are permitted to operate only if authorized by the SAS, the SAS can ensure that only authorized CA users are assigned the reserved frequencies within the CAF.

To limit the operation of other GAA users on restricted spectrum within the CAF premises, the SAS could use the following mechanism. When frequency requests are received from GAA users located within the CAF area, the SAS checks the database to determine if the GAA user is an authorized CAU. If so, the SAS assigns the requested spectrum to the CAU (within the CAF premises). Otherwise, the SAS may assign to the GAA user the available (non CAF reserved) spectrum in the GAA pool. Clearly, no frequency assignment will be made if there is no GAA spectrum (non CAF reserved) available in the area at the time of the request. Lastly, frequency requests by GAA originating in a geographical location neighboring, but outside of the CAF premises, may be granted by the SAS. In this case, the RF isolation properties of the CAF, in conjunction with proper configuration of the GAA by the SAS will minimize the co-channel interference.

This would mean that even if the CAFs may be more or less isolated environments from the radio transmission point of view, the CBSDs used by the CAUs should have connectivity to the SAS for the purpose of authorizing the operation of the users. Similarly, CBSDs used by other GAA users and PA users operating within the CAF, also need to have connectivity to the SAS for the purpose of authorizing the operation of the users.

We believe that it is feasible for the SAS(s) to effectively manage spectrum use by a large number of CAFs. The concept of CAFs does not directly require additional control traffic or additional need to synchronize between the SASs, as the CAUs are treated as CBSDs. However, scenarios where the applications to be deployed within the CAFs are based on a dense network of CBSDs that need to be individually managed by the SAS, may result in increased synchronization needs between the SASs, and increased control signaling overhead. Such situation may be avoided by designing the networks that are deployed as CAUs in a manner that

concentrates the spectrum management functionality to a few network entities, which are responsible for communicating and coordinating with the SASs.

V. Technical Rules

CBRSD General Requirements (§ 96.36)

FNPRM 64. Interoperability. To facilitate our proposed dynamic approach to frequency assignment, we propose to require CBSDs to be interoperable across all frequencies from 3550-3700 MHz. … What are the implications of equipment that may only work over a portion of the band and may not be able to tune to channels as assigned by the SAS? … To what extent should we seek to align the proposed interoperability requirement with existing international harmonization efforts for the 3.5 GHz Band (e.g., 3GPP Bands 42 and 43)? Similarly, how are current coexistence efforts among products conforming to multiple industry standards (e.g., 3GPP, IEEE 802.11 series) affected by the proposed interoperability requirement?

We support the requirement that all CBSDs must be capable of operating over the whole frequency range of 3550-3700 MHz as instructed by the SAS.

The system could still work if some of the equipment would not support the entire frequency range, but with potentially increased system complexity and less efficiently, as will be explained. The SAS could take into account individual tuning ranges of CBSD's and EUDs that are to be deployed, and if they do not cover the whole band, assign only channels that are within their tuning ranges. That would require either the devices to report their tuning ranges, and possibly some other device specific characteristics to the SAS when they register, or that the SAS would have a technical database of device characteristics. For example, the unique FCC identification number given by a device in the registration could act as a pointer into that technical database, so that the SAS would be able to fetch the corresponding device specific technical characteristics and utilize those when determining the spectrum assignment. With a multitude of different devices this approach might increase the complexity of the approach to an

impractical level. Furthermore, if some devices could only cover part of the band, it might introduce operational restrictions for the efficient utilization of the band, and even prevent overall optimization of the use of the band by the SAS.

However, the scheme should allow deployment of different technologies, such as LTE and Wi-Fi, in a manner that high overall spectrum efficiency is maintained. It would also be useful to aim to solutions that allow reaching economies of scale w.r.t. deployed devices. In our view alignment as much as possible with existing international harmonization efforts for the 3.5 GHz band (e.g., 3GPP [3GPP_1], CEPT/EU [CEPT_1], [EU_1] and ITU-R [ITU_1]) would be important. This would mean, for example, that the channel plan would be harmonized. Similarly, the technical requirements for this band should be such that compliance with the specific technical requirements in the proposed new Part 96 would require only minor modifications to current industry standards (e.g., 3GPP, IEEE 802.11 series). For example, currently proposed Part 96 puts specific requirements on geo-location capability, especially related to the elevation, on interference reporting and on registration info from the CBSDs towards the SAS.

FNPRM 66. Interference Reporting. Some commenters suggested that, to enable the SAS to tune or update its predictive models and also address real time interference issues, CBSDs should be required to provide the SAS with signal level measurements in their band or other adjacent frequency channels as requested by SAS. Many technologies already support this capability to allow radio resource management within a network. This capability could be a valuable tool for managing interference and promoting productive coexistence between multiple operators in the 3.5 GHz Band. We propose to require CBSDs to measure and report on their local signal level environment as set forth in the proposed rules.

InterDigital supports the idea of requiring the CBSDs to report their interference measurements, which would allow the SAS to tune or update its predictive models and address the real time interference issues.

One possibility is indeed, that CBSDs are required to measure and report the quality of their active PAL channels and that the SAS uses that information in its operation. The approach can also enable the SAS to also address real time interference issues. For example, if the interference level or packet error rate increases towards to a harmful level, the corresponding CBSD can send the SAS an indication of the event, and request a new PAL channel. The CBSDs may be required to monitor also the quality of channels they do not use (alternate channels, which may be the adjacent channels) and report to the SAS also about the quality of those channels. Such measurements would help the SAS to assess the quality of the channels in the locations of the CBSDs, which information could be used by the SAS in determining suitable assignments and identifying sources of interference.

The measurements performed by CBSDs could be combined with a pixel based assignment approach by the SAS. The noise level measurements could be associated with different pixels, as the SAS could collect and combine the results into a Radio Quality Map.

The Radio Quality Map can be utilized by the SAS when it assigns PAL channels to users, taking into account the interference levels in each PAL channel within the location of the user and the signal-to-noise ratio required by the user.

The SAS could also utilize the measurement results by locating and identifying sources of interference, or misbehaving CBSDs, and by taking the required measures. Those measures may include reassignments of the users to avoid harmful impact, like performance degradation of those CBSDs that use the PAL channels that experience interference, or even shutting down the interfering CBSDs.

VI. Spectrum Access System

FNPRM (34) "We seek comment on the proposed rule, including the capabilities that the SAS would have to incorporate to manage operations in the band consistent with this proposal…"

InterDigital supports the approach proposed by the Commission that the SAS will authorize and effectively coordinate the use of shared spectrum in the 3.5 GHz band. We share the Commission's view that a SAS can be used to assign spectrum dynamically while preventing interference between incumbents and other authorized users as proposed. In our view the dynamic operation w.r.t assignments can maximize the efficiency of the overall use of the band. We also believe that the same or similar technology could be utilized in other bands as well.

The SAS can define both the operational parameters and spectrum assignments for the users in a dynamic manner while optimizing the overall spectrum use in the band and protecting the higher tier users from harmful interference. The proposed bandwidth of 10 MHz for the PA use seems reasonable, especially when there will be a possibility to have access to up to three of such units in any location. We also support the possibility to assign flexible bandwidth for the GAA use, as it is very likely that there may be GAA applications that require bandwidths less than 10 MHz.

The Commission proposes to allow the GAA use on unused PAL channels to promote efficient and consistent use of spectrum. In our view the unused PAL channels would be such channels which are not assigned to PA use. In our view each PA user needs to get first the right to use the PALs, and when they actually need the capacity, they send a PAL request to the SAS, which then assigns the requested PAL(s). In order to maintain the overall efficiency of the spectrum use, the PA licensees should only be allowed to reserve the PALs for the time they will be in actual use. As the approach proposed by the Commission requires the GAA user to vacate the Priority Access channel as soon as the PA user needs it, there has to be a mechanism for the

SAS to reclaim such channels. As mentioned in our comment to # 36 and #37 above, this mechanism can use the TTL concept, or evacuation commands from the SAS. The required channel evacuation time may be included in the channel assignment signal sent by the SAS to the GAA. This way the system can support a flexible channel evacuation time that can meet a wide range of requirements from various PA deployments, as well as GAA usage needs.

The SAS can also take care of the associated economic framework in accordance with a policy defined by the Commission. The economic framework could cover the collection of fees or conduction of various types of spectrum auctions, including periodic and on-demand auctions, etc.

The Commission is proposing use of competitive bidding procedures for auctioning the initial PALs and for resolving mutually exclusive applications of PALs. In our view the SAS could run such auctions in an automated manner. The SAS could even act as a spectrum exchange to deal with the secondary markets, suggested by the Commission.

We have studied recently the possibility of automated auctions, e.g., in [IDCC_3]. That paper focused on the framework for multi-tiered shared spectrum operation in wireless networks, where multiple SASs dynamically acquire, manage and sell shared spectrum. We derived an auction based spectrum resource assignment algorithm which maximized the overall utility value of the spectrum. We also demonstrated that the algorithm can be implemented in practice through messaging in which the SAS negotiates spectrum bidding and asking prices with the shared spectrum users dynamically. Simulations were performed under different scenarios and assumptions, which verified that the algorithm achieved the maximum utility value for shared spectrum. The paper compared the outcome behavior under each scenario.

The Commission proposes to allow CBRS users to select whether to provide service on a common carrier or non-common carrier basis, regardless of whether they operate in the PA tier, GAA tier or both. Users that choose to offer services on a common carrier basis would be required to comply with the Applicable Commission's rules. In our view the SAS could coordinate and enforce, for example, the individual service selections based on a policy provided by the Commission, provided such policy can be mapped into the algorithms and operation of the SAS. Having such functionality for the SAS is one example of possible roles the SAS could have, which would require inputs from the Commission or reporting towards the Commission.

Some Commission involvement with the SASs would be needed, as there would be a role for the Commission related to the definition of relevant policies, authorizations and supervision. The Commission would have to specify the high level operational requirements for the SAS. Before the approval for starting the operation of the system, the Commission would need to ensure that the operation of the SAS fulfills the policy and implements the required protection of the Incumbents and the PA users.

It should be noted, that employment of an automated entity such as the SAS and the communication between the SAS and the Commission can facilitate new spectrum use authorization approaches and flexible admission control, which can both significantly contribute to the proposed advanced and flexible spectrum management approach. In our SAS White Paper [IDCC_2] we described some of the possible elements for such Commission involvement.

FNPRM (91). Our proposed rules also assume that multiple SAS Administrators and, consequently, multiple SASs would be authorized to operate in the 3.5 GHz Band , much as multiple databases have been authorized in the TVWS context, to ensure that consumers are provided with a robust set of choices in the marketplace. We seek comment on what techniques could be used to effectively coordinate multiple SASs in the band . What other implementation challenges arise from the possibility of multiple SAS providers? Are they solvable? We seek comment on the proposal to authorize multiple SAS providers.

If multiple SASs are employed, then the need for inter-SAS communication or synchronization arises, to ensure efficient spectrum assignments, while managing the interference between different users.

The specific synchronization needs depend on how the SASs are configured with respect to the coverage area, the frequencies to be managed, and on the dynamisms of the spectrum use of the incumbents and other users managed by each SAS.

One possibility is to keep the SASs fully synchronized w.r.t. information on spectrum assignments and user characteristics. In the likely scenario where full overlap occurs between SASs, the "Spectrum Usage and Availability" database in each SAS need to be synchronized, in order to prevent conflicting spectrum assignments from being made by different SASs. This means that once a SAS is to make a frequency assignment/reassignment to users, when spectrum is either made available or reclaimed by a PAL user, or the Incumbent's spectrum requirements change, the relevant information needs to be shared between all SASs. This information includes:

- incumbent protection and deployment info
- PA protection info
- PA and GAA channel assignments and operational parameters (including the technical information, e.g. RAT used by the PA/GAA)

A full synchronization of the databases is needed once a new SAS is brought on-line.

It is important, that the control traffic created by the inter-SAS synchronization or communication is minimized. As an example of minimizing the control signaling, the deployment information may be abstracted by using some form of PAL identification (there

would be a 1-to-1 mapping between the PAL ID and the frequency and location, using the location units agreed upon in the proceeding). Also, the PA protection criteria may be abstracted by using standards defined classes or categories (possibly expanded to include max interference limits).

It may also be beneficial to reduce the overlap of responsibilities of the different SASs, in order to reduce the need for constant exchange of synchronization info. This could be done, for example, by reserving an own sub-band for the SASs to manage, even if the incumbents and the geographical coverage areas would fully overlap. In this case there may still be a need for the SASs to exchange information related to individual channel assignments and the related operational parameters.

Effective coordination of multiple SAS providers may be achieved by using web-based services. The interfaces and protocols that exist for the current certified TVWS database providers can be extended to support the signaling needs for the inter-SAS synchronization.

VII. Conclusion

InterDigital welcomes the Commission's proposal for a new Part 96, specific rules for a new Citizens Broadband Radio Service in the 3.5 GHz Band that would make the 3.5 GHz sharing regime originally described by PCAST into a reality. We support the use of spectrum sharing and small cells in this band. As indicated in our comments, we believe that the use of small cells helps reduce the exclusion zones in order to maximize the coverage area for the CBRS, while ensuring the protection of the incumbents. We also support the use of SAS's to authorize and assign channels for use by CBSDs in a dynamic manner, which we believe, can

significantly increase the overall efficiency of the use of the 3.5 GHz band. Furthermore, the SAS's could handle the bidding process for solving mutually exclusive PAL applications and for secondary market of PALs.

There are still many areas where further work will be needed, as pointed out in the FNPRM. InterDigital will be pleased to continue to work together with the Commission to ensure that there will be a possibility to employ advanced and efficient spectrum management technologies in the future.

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