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

In the Matter of	)	
Use of Spectrum Bands Above 24 GHz For Mobile Radio Services	)	GN Docket No. 14-177
	)	

To: The Commission

COMMENTS OF INTERDIGITAL, INC.

Robert Stien
Vice President, Government Relations and Regulatory Affairs

InterDigital
200 Bellevue Parkway, Suite 300
Wilmington, DE 19809

Telephone: (202) 349-1711
Email: rob.stien@interdigital.com

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

In the Matter of	)	
Use of Spectrum Bands Above 24 GHz For Mobile Radio Services	)	GN Docket No. 14-177
	)	

COMMENTS OF INTERDIGITAL, INC.

InterDigital, Inc. ("InterDigital") hereby submits its comments in the above-captioned docket in response to the Commission's Further Notice of Proposed Rulemaking 16-89 regarding the use of spectrum bands above 24 GHz for mobile radio services.

InterDigital is an industry leader in exploring and developing millimeter wave (mmW) technologies. Since its founding in 1972, the company has been a pioneer in the design and development of a wide range of technologies used in digital cellular and wireless products and networks, including 2G, 3G, 4G and Wi-Fi. The company is at the forefront of the 5G standardization, with significant Research and Development efforts in standardization bodies such as 3GPP and IEEE 802, as well as ETSI, SAE, and others.

Some of InterDigital's recent contributions to the development of worldwide standards have been in areas involving multi-carrier technology, heterogeneous deployments, interference management, dynamic spectrum management, 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 mmW technology in conjunction with small-cell deployments to meet the unprecedented spectrum demand. A problem of particular interest in the context of dense deployments is finding cost effective ways of provisioning high capacity backhaul. For areas where wired backhaul is scarce or cost prohibitive, the abundant millimeter wave spectrum can provide "fiber-like" data rates without the high costs and installation times of fiber trenching. A broad market exists for these solutions including cellular small cells, residential broadband, extension to cable systems, and enterprise connectivity. Mesh technologies are a promising solution that can provide added reliability and extended connectivity to dense deployments. Such mesh networks need to be flexible in order to simplify deployment. Phased array antennas are a key technology for enabling an easily deployed and self-configuring mesh for backhaul, and are also critical to mobile applications such as the access link in mmW based '5G' cellular systems.

InterDigital's Millimeter Wave mesh solution [IDCC-1] is an intelligent directional network operating in mmW frequencies (e.g., 60 GHz or E-band) and provides high performance, reliability and redundancy required for carrier-grade backhaul. The system provides Gbps throughput with a link range up to 300 meters. A mesh software system has been built to enable multi-hop topologies. This software interfaces to an IEEE 802.11ad (WiGiG) baseband solution. An SDN-based architecture, with a centralized controller that is easily virtualized in the cloud, provides network management, controls data routing, and maintains data path redundancy to ensure topology resiliency.

Figure 1: InterDigital EdgeHaul™

InterDigital is motivated to work across the ecosystem to drive market adoption of mmW and 5G technologies.

Introduction

InterDigital welcomes the Commission's Report and Order and Further Notice of Proposed Rulemaking on the use of spectrum bands above 24 GHz for mobile radio services.

The unprecedented amount of spectrum made available by the Spectrum Frontiers Report and Order represents a significant step in enabling the key 5G technologies that will address the ever-increasing mobile communication bandwidth needs.

In addition to spectrum, the use of small cells is emerging as one of the main approaches to providing significant increase in capacity, provided that cost effective solutions are available. One of the biggest challenges for the widespread deployment of small-cells is the backhaul. While fiber is widely used for macro-cell backhaul, its availability and cost make it a non-ideal solution for small-cells in many cases. Indeed, it is estimated that up to 80% of the small cells will be connected with wireless backhaul [FW-1][FW-2]. Suitable rules and spectrum are required in order to sustain the expected continued growth in capacity. In the additional frequency bands discussed in the FNPRM, large swaths of bandwidth are available; to make efficient use of this spectrum, the regulatory framework needs to be enhanced to enable the use of both access and backhaul technologies.

In these comments, InterDigital addresses aspects related to the 70/80 GHz Bands.

70/80 GHz Bands (71-76 GHz and 81-86 GHz)

We agree with the Commission's proposal to establish three tiers of users for the 71-76 and 81-86 GHz bands, using a SAS-based regulatory framework, updated to reflect the propagation characteristics and the specific constraints of those bands. This approach will enable rapid dense deployment of millimeter wave systems which are needed as a fabric to wireless economic growth.

Incumbent Access

We believe that the existing non-Federal licensees and registered links should be grandfathered in the band(s) for a specific amount of time sufficient to permit a smooth transition. After this grace period they should be required to transition to the new service rules. This will result in more efficient use of the band, as the equipment will be able to communicate with a SAS, which can effectively handle the coexistence between different users (tiers).

Moreover, we believe that using a sensor-based system similar to the Environmental Sensing Capability (ESC) to provide sensing information to the SAS, will provide appropriate protection to the Federal Incumbent users, and will enable dynamic use of the spectrum.

Priority Access

Regarding the Priority Access Tier, we agree with the proposal to authorize PALs for a limited term, with each PAL terminating automatically at the end of the term. The licensee(s) should be allowed to reapply for a license (in the same licensing area) during the next open PAL

application window. The term duration should seek to balance the time to build the network and obtain a return on investment, with the need to promote competition and incentivize innovative use of the spectrum. As such, the three year term limit for PAL as used in the CBRS band [FCC 16-55] may be a good compromise.

General Authorized Access

With respect to the General Authorized Access, we believe that the GAA tier should be licensed by rule, because this will help in implementing a more dynamic use of spectrum than the existing lightly licensed approach. The license by rule for GAA will also enable a larger number of users to have access to the band, as this access can be made without the additional overhead of the existing two-pronged approach. Under the license by rule, GAA users must first register with the SAS before operating in the band. This can enable the SAS to coordinate with NTIA's "green light/yellow light" mechanism, thus ensuring that the Federal Incumbents are protected from harmful interference from the GAA tier.

Technical Rules

With respect to "dynamic beamforming antennas to serve mobile user equipment," careful consideration must be given to the beamwidths to enable feasible antenna implementations, and to antenna tilting angles, height and transmit power restrictions (to reduce interference). Dynamic beamforming antennas most often take the form of Phased Array Antennas (PAA) with electrically controllable antenna weight phase shifters. Such antennas are a natural choice to support dynamic beam forming with sub-microsecond beam switching times. In order to maximize the coverage angle, i.e., the angles over which the PAA can be steered

without large grating lobes, the inter-element spacing is typically on the order of half the wavelength. The resulting beamwidth in azimuth depends on the number of elements along the azimuth. A typical rule-of-thumb to approximate the beamwidth at broadside is theta = 1.8/N [rads], where N is the number of elements along the azimuth. The same holds true for the elevation dimension. A Uniform Rectangular Array (URA) with MxN elements (M along elevation and N along azimuth) would have a broadside beam width of 1.8/M and 1.8/N in elevation and azimuth, respectively. Furthermore, the beamwidth increases as the beam is steered away from broadside. To maintain 2.2 degrees beamwidth (paragraph 436 of [FCC-1]) with full steerability in azimuth and elevation, would require greater than 48x48 = 2304 elements. At least a 64x64 = 4096 element array would be needed after considering the broadening due to steering. An array with this many elements is not yet commercially practical. Therefore, the considerations below should lead to reducing the number of required elements.

- The use, such as proposed in Paragraph 440-Technical Rules-c, will typically not need to support full steerabiltiy in elevation. In this case, the elements (or sub arrays) may have narrower patterns and may be separated by more than half wavelength, potentially reducing the number of elements.
- Additionally, the beamwidth requirements may not need to be as tight in both elevation and azimuth. For example, if the elevation beamwidth requirement permitted a beamwidth 4x as wide as in azimuth, another factor of 4 reduction of the number of elements is possible.
- Most importantly, a PAA cannot only steer its beam, but is can also suppress interference through dynamic nulling. If the PAA is part of a system that is able to identify range and bearing to other receivers in the field, it can reduce interference in

the direction of receivers that it might interfere with. Furthermore, if the antenna pattern orientation of that receive antenna is known, the overall effectiveness is further increased. This can be accomplished if the PAA can learn its own location and orientation (e.g., GPS and compass), as well as the location, and preferably orientation, of receivers that it might interfere with by accessing the SAS.

Whereas it is desirable to encourage innovation and use of dynamic beamforming in the mmW spectrum without causing harmful interference to the incumbents and the higher tier users, we propose to consider separate requirements on beamwidth for azimuth and elevation at least for infrastructure nodes supporting dynamic beamforming.

PAAs that support Dynamic beamforming can also support nulling which, when combined with sufficient intelligence, enables interference mitigation techniques. By relaxing rules on beamwidth while requiring greater intelligence, the rulemaking will encourage innovation in mmW PAAs and advanced interference mitigation techniques

We propose that the rules regarding beamwidth (or equivalently gain) and/or EIRP for PAAs should be separate from and be more relaxed than the rules for fixed pattern antenna, at least for the following cases:

- the infrastructure node with PAA is mounted at or below streetlamp or rooftop level ("Class B") and with a specified maximum elevation angle that a beam may be directed. It is envisioned that such infrastructure nodes are providing access to terminals in the local area.
- the infrastructure node with a PAA can reliably determine the location of incumbent or other pre-existing receivers from the SAS; the node can use this

information to suppress radiation in the direction of such receiver; and the node can determine that caused interference to such receiver is below a threshold. Note that the computation of the caused interference can be much more accurately performed if the antenna pattern orientation of such receiver is included in the database.

We also propose that the database (e.g. SAS) includes the gain and antenna pattern orientation of fixed pattern antennas so that caused interference levels can be more accurately calculated.

Additionally, we propose that infrastructure nodes with PAAs that form semi-static links to other infrastructure nodes also register the gain and beam pattern orientation of all potentially used receive beams. This is so that other nodes requesting access to spectrum will also be able to limit interference to PAA nodes that were previously granted access.

Conclusion

InterDigital appreciates the Commission's consideration of its comments and welcomes any questions concerning its technologies. We will be pleased to continue to work together with the Commission to ensure that the regulatory environment will enable both access and backhaul link technologies for mobile radio services in millimeter wave bands, in a timeframe consistent with 5G developments across the world.

Respectfully submitted,

Robert Stien

Vice President, Government Relations and Regulatory Affairs
InterDigital,
200 Bellevue Parkway, Suite 300
Wilmington, DE 19809
Telephone: (202) 349-1711
Email: rob.stien@interdigital.com

References

[FCC_1] "Report and Order and Further Notice of Proposed Rulemaking on the Use of Spectrum Bands Above 24 GHz For Mobile Radio Services," GN Docket 14-177, FCC 16-89, July 14th, 2016.

[IDCC-1] "5G Infrastructure: EdgeHaul", InterDigital, http://www.interdigital.com/solution/edgehaul

[FW-1] "OFDM non-line of sight to dominate small cell backhaul in 2017," Parker, Tammy, FierceBroadbandWireless, September 12, 2012, http://www.fiercebroadbandwireless.com/story/abi-ofdm-non-line-sight-dominate-small-cell-backhaul-2017/2012-09-12?utm_medium=nl&utm_source=internal

[FW-2] "Paolini: Can wireless backhaul facilitate transition to fiber backhaul?," Paolini, Monica, FierceWireless Tech, June 6, 2015, http://www.fiercewireless.com/tech/story/paolini-can-wireless-backhaul-facilitate-transition-fiber-backhaul/2012-06-06