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.

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InterDigital, Inc. ("InterDigital") hereby submits its comments in the above-captioned docket in response to the Commission’s Notice of Inquiry NOI 14-154 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 has significant Research and Development efforts that create next generation wireless technologies. InterDigital develops platforms and prototypes to validate its technologies and bring them to the market through industry partners and standardization. Examples of current efforts include, but are not limited to: mmW mesh backhaul platforms, Dynamic Spectrum Management (DSM), and user adaptive video.

InterDigital actively participates in and contributes to the standards bodies that drive the design and function of each generation of wireless technologies. These bodies include 3GPP,
IEEE 802, ETSI, SAE, and IETF, among 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 small-cells and cell densification 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. Mesh technologies are a promising solution that can provide added reliability and extended connectivity to small-cell 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. Phased array antennas are of course also crucial to mobile applications such as the access link in mmW based ‘5G’ cellular systems.

InterDigital’s Millimeter Wave small-cell backhaul solution is an intelligent directional mesh operating in mmW frequencies (e.g., 60 GHz or E-band) and provides high performance, reliability and redundancy required for carrier-grade backhaul [IDCC-1].

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

InterDigital welcomes the Commission’s Notice of Inquiry on the use of spectrum bands above 24 GHz for mobile radio services. The efficient use of large blocks of spectrum available in mmW bands, alongside small-cell deployments and spectrum sharing, is one of the key 5G technologies that will address the anticipated increase in demand for wireless 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 that can sustain the expected continued growth in capacity. In the frequency bands discussed in this NOI (24 GHz and above), 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.

We also believe that allowing unlicensed Part 15 operations in the 64-71 GHz band segment with amendments to enable backhaul use will foster innovative solutions leading to efficient use of spectrum.

Highly directional and electronically steerable antennas have the potential to be part of the solutions for many of the problems facing access and backhaul. The mmW bands are particularly well suited for these phased array antennas, and it is important to ensure a regulatory framework that does not present an un-warranted barrier to their adoption.
In these comments, InterDigital addresses the following aspects: (i) Antenna Technology, (ii) Operation, (iii) Bandwidth, (iv) Performance and Coverage, (v) Network Architecture, (vi) Alternative Uses, including Backhaul, and (vii) 60 GHz Band Rules.

II. Technology

Antenna Technology

NOI (18) “We seek comment on the current development of antenna technology in the mmW bands. What advanced antenna technologies are anticipated to be feasible in the mmW bands? What is the potential timeframe for commercial implementation of these technologies in mobile broadband services in the mmW bands?”

NOI (19) “What do commenters anticipate the size and configuration of the antenna arrays will be, including the orientation of the vertical and horizontal elements and the predicted number of beams? With respect to antennas located at base stations, what factors are likely to affect the physical size of and space needed for the antenna arrays?”

NOI (20) “We seek comment on the types of base station configurations that may be used to support advanced mobile services in the mmW bands.”

The development of electrically steerable phased array antennas is a critical component for the evolution of wireless systems in these millimeter wave bands. Historically mmW systems have been served by high-gain fixed antennas constructed with parabolic or horn configurations. This has generally limited the use of these frequencies to fixed point-to-point and satellite communications. Recently, cable replacement radio solutions using the 60 GHz band are emerging which can support high data rates over a short range (10 m) and take advantage of significant advancements in digital and analog circuit integration, enabling the first consumer use of mmW equipment [WiGig]. To enable mmW usage in broader markets such as mobile, antenna gain needs to be sufficient to cover a range of 100 m - 300 m, with electrically steerable beams. We believe that the small cell backhaul market will benefit in the near term from lower cost integrated radio solutions using phased array antennas. These devices can be implemented in
small form factors suitable for “millimeter wave hotspot” base stations (BTS) and access points. For instance, a 32 element phased array at 60 GHz could be implemented in an area of approximately 2 cm² and integrated into a small enclosure. Several companies have recently announced phased array research and products specific to the small-cell backhaul market [IDCC-IMEC] [SIMG] [IBM-ERIC].

5G mobile terminals will require small form factor mmW antennas capable of beam tracking, fast beam discovery and switching, and adaption to interference and propagation conditions which are subject to rapid change. Research and development is on-going at several companies to develop state-of-the-art phased array antennas and radios for the mobile market [IMEC] [RAP].

**Network Operation**

NOI (27-29) “… it seems possible that mmW band technologies within a cellular network will be a supplementary component within an architecture that will continue to use lower frequencies... In this multi-layer architecture, does a mmW band network rely on the overlay network for any type of assistance in order to provide a seamless service?...”

Future "5G" network architectures are likely to include a hybrid fiber-mmW backhaul system and a heterogeneous access network with a preponderance of small-cells supplying the bulk of transport capacity at the data plane. Long-range lower frequency bands will be used as a control plane and a means to provide wide area coverage and fill small local coverage gaps.

Small-cells are essentially an extension of the original cellular concept of spatial frequency reuse that the Commission adopted in the early 1980s. In the mobile wireless networks of 2020 and beyond, the inter-site distance (ISD) will be largely determined more by the local clutter of buildings than the classic land-mobile propagation from high above ground
level (AGL) towers/rooftops to ground level UEs. Moreover, for outdoor deployments, the location of such BTSs (eNodeBs) will likely be at lower elevations such as on lamp posts, street lights and other so-called "street furniture," or side-mounted on buildings [SRG-1].

Truly ubiquitous mobile wireless coverage includes both nomadic and vehicular coverage: this will require both low and high frequency bands. The lower bands will fulfill a vital network function: control plane signaling as a wide-area overlay. The higher frequency bands will serve as ultra-high capacity underlay transport (see Figure 1 for an illustration of a possible network architecture). Moreover, both high levels of small-cell “densification” as well as the lower frequency network channels (< 3 GHz) will dominate the Internet-of-Things (IoT) requirements that demand very large link budgets to effectively communicate in tunnels, through heavy foliage and very low-height locations such as ground level meters or sensors.

We also believe that there will be a market, just as there is today, for "hot spot" systems that will operate in a stand-alone fashion, much as enterprise broadband and home broadband 802.11 Wi-Fi networks operate currently (also illustrated in Figure 1 below). These will also benefit from WiGig LAN nodes where there is nomadic or fixed use without the demands of high vehicular speed handoffs.
Advanced future networks then will be of two main varieties: hybrid “het nets” operated primarily by today’s commercial mobile radio service (CMRS) operators and stand-alone networks operated by entities that don’t own licensed lower frequency bands. In the case of the former, vehicular speed voice traffic is likely to be managed and maintained using the rooftop macro cells, with handoffs to the mmW groundlevel small-cells when possible and to accommodate higher capacity needs. Operators of hot-spot networks, such as MSOs and other entities will make use of their Hybrid Fiber Coax (HFC) to extend wireless coverage using Wi-Fi (or unlicensed LTE or other standards) and can make extensive use of newer mmW transport/backhaul networks (as will be described later under Backhaul (NOI 45)) that uses a combination of millimeter wave transport in the 60/70/80 GHz bands.
With respect to 60 GHz operation in particular, the use of phased arrays to steer beams both to achieve range and avoid interference is critical. We believe that the current state-of-the-art and future advances in beam forming as applied in backhaul networks will be able to accommodate dramatic growth in terrestrial network capacity without suffering performance losses.

**Bandwidth**

NOI (30) “We seek comment on how much contiguous spectrum will be needed to support advanced mobile services and other contemplated services in bands above 24 GHz... We also seek comment on whether technology will allow licensees to effectively aggregate smaller, non-contiguous blocks of spectrum for use in providing mobile services, possibly reducing the need for large blocks of contiguous spectrum.”

Contiguous blocks of spectrum are of course most efficient and should be sought where possible. The spectrum should be allocated in a manner that best enables the use of low-cost electrically steerable antennas to support very high data rates in both access and backhaul links.

Large channels will be required to support large data rates. We note that, in the 60 GHz unlicensed band, IEEE 802.11 has adopted the 802.11ad addendum [11ad-1] which uses ~2 GHz channel bandwidths.

Similarly, in the 70/80 GHz bands, system level simulations performed by NSN for outdoor small-cell deployments use 2 GHz channel bandwidths to achieve average user throughputs in the range of 2 to 5 Gbps [NSN-1], [NSN-2], which are consistent with the user experienced data rates being considered in ITU [ITU-1]. It should be noted however, that the current rules for the 70/80 GHz band need to be revisited to enable the use of the innovative phased array antenna technology assumed in the simulations.

To enable future growth of networks and interference management, multiple channels need to be supported. Ideally, these multiple channels should be adjacent such that a single
radio, and phased array antenna, can support a maximum number of channels. In this way, extended use of the band is not inhibited by the burden of added radio costs, and the use of real-estate in mobile devices may be optimized.

However, if no large contiguous blocks of spectrum are available in specific bands, then channel bandwidths smaller than 2 GHz may be used. For example, prototypes developed by Samsung in the LMDS band (28 GHz) use channel bandwidths of 520 MHz for testing of outdoor small-cell deployments [SAM-1], [SAM-2]. In this case, we encourage allocations that at least permit uniform channelization within a relatively small fractional bandwidth to permit aggregation within the band(s) with common radio and antennas.

While current technology supports carrier aggregation (or channel bonding) for frequencies below 6 GHz [3GPP-1], [11ac-1], some challenges may need to be addressed for mmW channel aggregation. Radios need to support wide bandwidths and be able to tune to the required channel(s). Such capabilities should be factored into allocations. While low cost antennas tend to support smaller bandwidths efficiently, some work has shown progress on support of wider bandwidths. Planar antenna arrays with a superstrate or lens structure placed above the radiating elements, can achieve significant increase in bandwidth ranging from 5% to above 15% of center frequency value [Ant-1]. For example, at 60 GHz, a 15% bandwidth will more than cover the available 7 GHz of allocated WiGig (US) spectrum. Bandwidth can also be improved by increasing the antenna substrate thickness and by using organic board material with low dielectric constant [Ant-2].

Another motivation to allocate large blocks of spectrum is to better enable wideband beam forming with low cost phased arrays. When using such arrays, there is a limit on the frequency spacing of the channels to be aggregated (depending on the gain of the phased array).
Specifically, as the distance between elements (as measured by wavelength) changes with frequency, the beam points in different directions for different frequencies. While this can be mitigated by using delays rather than phase shifters, a cost effective solution has not yet been demonstrated in the mmW bands. Other challenges include wide band A/D and D/A converters, robust antenna designs for manufacturing, and the design of wide band radios. Once these challenges are resolved in a cost effective manner, aggregation of smaller non-contiguous blocks of mmW spectrum could be used to provide high data rates.

Therefore, while it is highly desirable to use large contiguous blocks of spectrum where possible, the regulatory environment should not preclude intra-band aggregation of smaller non-contiguous blocks of spectrum.

**Performance and Coverage**

NOI (34) “We also seek comment on the specifications for data throughput, latency and other performance metrics that would be associated with advanced mobile services in the mmW bands. At least one source suggests that 5G would provide data rates up to 10 Gbps maximum and at least 100 Mbps at cell edges, with latencies of less than 1 millisecond. We ask whether these are reasonable expectations for the performance of advanced mobile services in these bands....”

The key performance indicators (KPI) for 5G systems are still under discussions and not finalized yet. However, based on member countries contributions to ITU WP 5D, consensus seems to be building towards peak data rates of 10 Gbps (min), user experienced data rates of 100 Mbps (min) and 1 ms latency (radio interface), as reflected in Appendix A of [ITU-1].

While it is clear that many factors will impact the data rates, including the location of the mmW base stations, inter-site distance, topology (and thus propagation characteristics), and others, our simulation results [IDCC-2] indicate that it is reasonable to expect these target data rates could be reached with 5G technologies. Similar results have been reported in the literature, for example [NSN-2] for the 72 GHz band.
Additionally, the use of large mmW bandwidths enables significantly smaller TTI durations (as compared to current LTE), which will allow latency optimizations.

NOI (35) “…we encourage commenters to describe how to characterize coverage in comparison with today’s networks that typically provide coverage over wide areas. What are the likely or possible coverage areas of individual mmW base stations that enable mobile service as part of a 5G network?…”

The path loss for mmW bands (e.g. the 28 and 73 GHz) is near 20dB higher than that of current cellular frequencies near 2 GHz. Additionally measurements and ray tracing studies show that mmW signals arrive in spatial clusters, presumably from significant reflections and scattering. As pointed out in [NYU-1], this path loss can be compensated by using beamforming, and beamforming be helpful to enable spatial multiplexing. Our simulations performed at 28 GHz for a Manhattan deployment, indicate that 100-200 m site separation can yield good coverage in urban scenarios, as shown in Figure 2 below (for 28 GHz, 40 dBm EIRP and 500 MHz channel bandwidth).

Figure 2 Simulated urban coverage (28 GHz, 40 dBm EIRP, 500 MHz BW)
Other system level simulations were run by InterDigital for the 60 GHz band, to compare the coverage and attainable data rates of mmW to a sample LTE deployment. Specifically, a 100 MHz bandwidth LTE system operating at 2 GHz was compared to a 2 GHz bandwidth mmW system operating at 60 GHz. The simulation results for an urban and a campus deployment (assuming a single basestation each in the same location for comparison) are shown in Figures 3 and 4, respectively.

![Figure 3 Coverage comparison (simulated), urban, 2 GHz vs. 60 GHz](image1)

![Figure 4 Coverage comparison (simulated), campus, 2 GHz vs. 60 GHz](image2)

Although for the 60 GHz results on the right of Figure 4, the area of very high data rate coverage (> 1 Gbps) is much smaller than for cellular frequencies, the results are encouraging as they indicate that several hundred square meters of coverage are possible with 60 GHz base
stations in outdoor deployments. Coverage gaps in mmW systems due to the greater impact of blockage can be minimized by proper deployment of low-cost base stations with phase-array antennas; however, those gaps that remain would be serviced by the lower-frequency cellular network overlay as discussed above in the context of using a “het-net” system architecture. Interference between basestations was not considered in this analysis which is expected to impact the 2 GHz scenario more than the 60 GHz.

Lastly, in [IDCC-1] we provided range estimates based on 802.11ad simulations (for the 60 GHz band, with ~2 GHz channel bandwidth), which showed, for example, that for 81 elements per Tx and Rx antenna (e.g., a 9x9 array) and a total Tx power of 10 dBm, an ISD of 150 m can be supported at the highest rate.

The above results, together with other results published in the literature (see for example [NSN-1], [NSN-2] and [SAM-1]), indicate that mmW networks with appropriate inter-site distances are practical for outdoor deployments.

**Network Architecture**

NOI (39) “...What type of deployment model – operator-driven, user-driven, or a new model or models – do commenters envision for mmW mobile services, and what network architectures could support the anticipated scale of deployment? How would mmW mobile network architecture compare with the current 3G/4G architecture or Wi-Fi-like hotspot architecture? Would there be a hybrid model that can support various types of deployment, and what are the enabling technologies to achieve such goals ...”

As the Commission has identified, there are several current deployment models that are in operation today. These include: CMRS Mobile Networks, Home/Enterprise Wireless Networks, and DAS systems. Each of these models include both a transport (backhaul) network and a Radio Access Network (RAN) component. In this section we propose a “Third Network” component required to provide wireless data distribution to densely deployed small cells.
CMRS Mobile Networks are operator-driven, and use licensed lower frequency (< 3 GHz) bands privately held, with privately owned BTSs (eNodeBs) available exclusively to the customers of each separate network. This type of RAN uses shared structures such as towers and rooftops for deployments. The RAN is connected to a private core network for switching, control and transport to the voice network (PSTN) and the internet using either dedicated, or more commonly, shared leased facilities from either the Incumbent Local Exchange Carrier (ILEC) or MSO as transport. Microwave transmission is also an alternative used for such transport.

Home/Enterprise Wireless Networks are also private RANs owned by consumers and businesses in the form of access points or licensed “femto cell” products. In these networks the end user(s) own/operate the RAN and deal with issues of coverage and capacity vis-à-vis a CMRS network where the mobile carrier addresses performance issues on behalf of the customers. This configuration permits the end users the flexibility of rapidly scaling capacity and coverage needed for the RAN as their unique needs grow. Like the CMRS network, they also rely on an external transport network from the ILEC or MSO or other provider to transport their RAN traffic to core voice and data services. In this model both licensed and unlicensed spectrum can be used depending on the requirements of the enterprise or home.

Lastly, DAS systems (“distributed antenna systems”) are a combination of the CMRS and Home/Enterprise networks above, that use private carrier RAN equipment to connect to a distribution of antenna systems in large venues such as shopping centers and stadiums. These networks are a hybrid deployment model as increases in capacity require additional equipment to be added by the carrier as well as the venue. Like the other models, the DAS systems generally also use leased facilities for the transport between the RAN and the core networks.
All three of these network architectures have a common attribute: transport to/from the RAN is generally provided by a leased facility from either the ILEC, an MSO or providers of dark (or lit) fiber services in either long range or metropolitan markets. That is, for each wireless network, there are essentially two networks that form a hybrid: the core fiber/copper transport network whose facilities are leased by the mobile network operator (MNO), and the RAN network that is operated by the MNO – or - the business/enterprise – or – the consumer. InterDigital believes that a third network will be necessary to meet the demands of 2015 and beyond – an ultra-high capacity wireless terrestrial network based on millimeter wave transmission.

**A Third Network**

As the Commission noted, small-cell architectures are the only types with sufficient “densification” to meet the demands anticipated from a RAN that can supply >1 Gbps access speeds per/user. However, and as will be described later under Backhaul (NOI 45), a backhaul/transport network that comprises a significant deployment of millimeter wave distribution using 60/70/80 GHz radio systems will be essential to the growth of mobile broadband. This system – a hybrid fiber/wireless transport network is capable today of delivering >1 Gbps speeds either directly to the RAN, or, to wireless NLOS backhaul systems operating below 6 GHz for final delivery to the RAN access network. In the future, it is reasonable to assume that technological advances will permit speeds >20 Gbps in 10 GHz of channel bandwidth (such as the 5 + 5 available in E-Band) and greater than 4 Gbps for each 2 GHz channel in V-Band.
Signals Research, with support from InterDigital, created a large scale economic and deployment model of a street-light network as a proxy for this new “Third Network” [SRG-1]. This network, as described in technical detail below, uses 60 GHz phased array-based radios to provide transport (backhaul) to a generic small-cell RAN network co-located on street-lights. As noted in section 5.11 of the report, such a system provides a “spectacular increase” in capacity of the RAN. In the model, current mobile broadband traffic use [CISCO-VNI] [SANDV] in the mobile network is increased as expected over time with a 40% cumulative annual growth rate (CAGR). By 2020 this network remains only 35% utilized thus leaving ample margin for future growth as would be needed to meet the projected post-2020 5G demand.

It is expected that such a transport network may be owned/operated by either today’s MNOs, MSOs or new entrants. Indeed such a network may be added to the existing metro fiber plant as an extension. Considering the 35% utilization mentioned above, having the network owned/operated by an entirely new entrant (or municipality) as a shared “Neutral Host” resource available to a variety of end-uses from CMRS carriers or local Hot-Spot operators or the MSO may be a very promising, and economically advantageous alternative. In any case the use of the 60 GHz bands is essential to provide the local transport.

Currently, the rules for the E-Band require larger parabolic dish antenna systems that are typically objectionable, both aesthetically and practically, for low-height lamp-post deployments. E-Band, in such a network, would be used to provide higher capacity links between the mesh-backhaul anchor points and the fiber plant. Additionally, and as noted earlier, sub-6 GHz NLOS systems can also bridge from this network to reach RAN nodes that are not in LOS range of the system.
Alternative Uses, Including Backhaul

NOI (45) “...We specifically inquire about the utility of the mmW bands for backhaul. ... We seek comment on the extent to which it is feasible to use bands above 24 GHz for backhaul, particularly non-line-of-sight (NLOS) backhaul, which may be necessary for dense cell deployments. Are there enabling technologies that will facilitate the shared use of bands for different types of uses? Could the 5G technologies discussed above also provide backhaul capabilities? Would it be possible to use “in band” service in which backhaul reuses frequencies that are also used for access? Given the short ranges of developing 5G technologies, would mesh or multi-hop architectures be viable?”

As mentioned in the Introduction, one of the challenges in small-cell deployment is finding high data rate, reliable, and cost effective wireless backhaul solutions for areas where fiber may not be available, or is time consuming and expensive to install. The spectrum availability in the mmW bands is very attractive for backhaul solutions. Electrically steerable phased array antennas and multi-hop mesh architectures are enabling technologies to solve the challenges of using millimeter wave for small-cell backhaul.

The use of steerable phased array antennas reduces implementation and deployment costs through shared radio equipment. Unlike high-gain fixed millimeter wave point-to-point equipment, a single steerable antenna is able to connect to multiple neighboring base stations to extend network connectivity. Additionally, installation can be self-configuring in the sense that finding connectivity to an existing site is automatic. Connectivity can be extended to both the access link and the mesh backhaul link to facilitate the shared use of the band for both access and backhaul links. Sufficient isolation between the access and the in-band backhaul link may be achieved by placing appropriate constraints on the transmitted beams, and by using directional narrow beams.

Multi-hop mesh technology customized for directional links is an enabling technology for small-cell millimeter wave backhaul. In addition to the ability of a phased array antenna to capture NLOS scattering of the millimeter wave signal, a mesh configuration provides additional reduction of the traditional LOS constraint associated with P2P millimeter systems. InterDigital’s
internal design of a backhaul mesh built on top of the 802.11ad PHY/MAC protocol, shows that up to 5 hops can be supported while maintaining a latency of no more than 5 ms. The mesh solution also improves the connection reliability in difficult propagation environments. Using long-range discovery mechanisms, self-configuration techniques and electrically steerable antenna arrays, each node establishes optimal paths to its neighbors. When link congestion or deteriorating RF conditions occur, new paths are determined based on QoS requirements such as latency, throughput and packet-error rate and the mesh self-tunes itself to achieve optimal performance. Maximum throughput and minimal latency for the mesh network may be achieved using joint scheduling and routing. The self-tuning process occurs in real-time and without need for human intervention [IDCC-3].

For the reasons listed above, we believe that it is feasible to use mmW bands to accommodate different types of uses, specifically the access link and the in-band backhaul. We see the 64-71 GHz band as a good candidate for joint access and in-band backhaul deployments.

III. Frequency Bands

NOI (74) “...We seek comment on the advisability of amending our rules to allow unlicensed Part 15 operations in the 64-71 GHz band segment. As an alternative, we seek comment on the possibility of authorizing licensed operations in that band. ... We also seek comments on any interference that either licensed or unlicensed advanced mobile operations in the 65-71 GHz band segment could cause to any inter-satellite operations that might eventually develop in the 65-71 GHz band.”

60 GHz Band Rules

The Commission should maintain the current Part 15 framework for the 57-64 GHz band (the "lower 60 GHz band") and extend it with modifications to the "upper 60 GHz" band from 64-71 GHz, to enable both access and backhaul use.
For example, even considering the recent changes [FCC-2], the rules for the lower 60 GHz band may still be restrictive for outdoor use. For this large block of spectrum to see the same explosion of innovation for outdoors deployments as experienced for indoors, it may be beneficial to revisit these rules to ensure phased arrays antennas are not unintentionally discouraged with very high gain requirements.

A recent estimate of the economic value of unlicensed spectrum to the US economy indicated spectacular contributions [TAS-Katz]. According to the author(s) “the technologies currently operating in unlicensed spectrum bands in the United States generated a total economic value of $222.4 billion in 2013 and contributed $6.7 billion to the nation’s GDP.” The future value was even more staggering with estimates of $547.22 billion in economic surplus with $49.78 billion towards the GDP. However, this report also acknowledge that it will require much more unlicensed spectrum to meet the anticipated demands, which primarily come from M2M/IoT along with growth in mobile broadband (principally video) traffic.

The example of the 2.4 GHz band illustrates the usefulness of Part 15 rules in maximizing the utility of spectrum to a variety of use cases that can already be seen in the 60 GHz band. Today the interference in the 2.4 GHz ISM band when used for Wi-Fi is primarily from other Wi-Fi nodes as opposed to cordless telephones, microwave ovens, or other industrial uses of the band. It is anticipated that this will be even more true with millimeter wave use in the 60 GHz bands.

Two key services identified in this NOI - RAN access and network backhaul - can both be accomplished by adopting similar rules governing high power "point-to-point" operation for backhaul using higher power and "wide area access" similar to Wi-Fi hotspot use.
The Commission’s ruling in August 2013 [FCC-2] that increased the allowable EIRP to a maximum of 82 dBm (with reductions commensurate with antenna gain) so that longer range 60 GHz point-to-point operation would be possible, acknowledged the benefit of this unlicensed band for backhaul and metropolitan transport. The reduction in attenuation due to O2 absorption at 65-71 GHz demands that examination of beam spreading and widening over the longer distances does not result in interference in backhaul systems. While phased array systems are excellent at mitigating such interference, and keeping this band unlicensed is recommended for widespread use, the usefulness depends upon rules that allow coexistence with multiple backhaul operators alongside access nodes operating in the band.

Inasmuch as both the access and backhaul focus at 60 GHz will be dominated by, if not exclusively focused on, a low-AGL height terrestrial network architecture for both small cells and backhaul, InterDigital foresees no harmful interference to inter-satellite operations that may eventually develop in the band.

IV. 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,

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