Executive Summary

High-speed broadband access is the key to transforming India into a knowledge-based economy and for the success of the Digital India\(^1\) initiative. Today India ranks 116\(^{th}\)\(^2\) in the world in terms of individuals using the internet, and a major effort is needed to boost broadband access for all its citizens, both rural and urban.

Future urban broadband access will be driven by the deployment of WiFi and 4G networks that require "fiber speed" backbone networks. These high-speed backbone networks will need to support a dense deployment of WiFi access points and base stations. The cost structure of a fiber backbone for such deployments is prohibitive. The next generation backbone networks will be wireless operating in the millimeter wave bands. And, although backbone networks operating in the E-band are less than fiber in a point-to-point deployment, dense deployments make them uneconomical for a widespread broadband buildout. Emerging technology in the 60 GHz band (57-64 GHz) can reach cost points that are an order of magnitude less than deployed fiber with fiber like reliability and multi-gigabit speeds.\(^3\)

60 GHz band technology can now offer one or two orders of magnitude cost reduction over fiber and existing milli-metric band backbone networks. In this paper, we discuss the advantages of the 60 GHz band and why we believe that with suitable policy

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\(^1\) Digital India, Power to Empower, Vision of Digital India, at http://www.digitalindia.gov.in/content/vision-and-vision-areas


\(^3\) Sanjai Kholi, interview by Professor Abhay Karandikar, October 2015
support, it can make broadband access affordable in India. The 60 GHz opportunity will allow India to leapfrog in broadband backbone networks just as the country leapfrogged wireline phone with mobile voice networks.

A confluence of several factors makes 60 GHz very cost attractive. First, the 60 GHz band with 7 GHz of spectrum provides offers massive capacity compared to the existing milli-metric band allocations. Second, the high oxygen attenuation and narrow beams in the 60 GHz band reduces interference between links making it particularly suited for uncoordinated operation. Delicensing will boost innovations at many levels driving rapid technology advancement. Third, silicon technology innovations combined with global momentum behind the IEEE 802.11ad, or WiGig, standard that also uses the 60 GHz band, is making available very low cost semiconductors and system solutions. Fourth, the large bandwidth available in 60 GHz band allows for wide channelization (e.g. 2.16 GHz in 802.11ad) and hence supports high-speed links with 10 Gbps and higher data rates.

It is noteworthy that many national administrations have delicensed the 60 GHz band and also have not imposed specific channelization plans. This has begun to trigger technology innovation and eco-system growth. This process repeats the WiFi story where the use of unlicensed 2.4 and 5 GHz bands enabled a massive eco-system around WiFi and drove down costs dramatically. There would have been no WiFi revolution if the 2.4 and 5 GHz bands had been licensed.

For these reasons, we believe that to unleash the full potential of the 60 GHz band India should delicense the 60 GHz band for both access and backhaul applications as well as avoid any mandates on specific channelization. These two policies will allow a spate of technology developers and connectivity providers to deliver high-speed backbone services at very low cost, which in turn will enable the proliferation of affordable broadband access across India.
1. 60 GHz Band Technology Today

With 7 GHz of capacity, the 60 GHz band offers an unmatched capacity compared with lower frequency spectrum. Moreover, the 60 GHz band has unique characteristics that set it apart from other high frequency bands. For example, the 60 GHz band propagation characteristics are significantly different from other fixed service bands, including the E-band (70/80 GHz). In the 60 GHz band, multiple oxygen absorption lines merge together to form a single, broad absorption band, as shown in the following figure. Atmospheric absorption peaks around 16 dB per kilometer at band center, and exceeds 10 dB per kilometer across 86% of the band. This renders the 60 GHz band unsuitable for traditional multi-kilometer fixed links. It also significantly mitigates interference between 60 GHz band systems.
In the E-band, atmospheric absorption is only 0.6 dB per kilometer. While this supports multi-kilometer fixed links, it necessitates some form of licensing to prevent disruptive interference. Many countries have imposed “light licensing” for E-band fixed links. Light licensing is a user self-coordination process typically based on a national database of previously coordinated links. But due to the high atmospheric attenuation in the 60 GHz band, there is significant isolation between links, which mitigates interference and makes link registration unnecessary.

The predominant technology for the 60 GHz band is IEEE 802.11ad also known as WiGig. Formed in January 2009, the IEEE 802.11ad task group developed an amendment to modify both the PHY and medium access control (MAC) layers of the IEEE 802.11 protocol to achieve very high throughput in the 60 GHz band. The 802.11ad standard was released in December 2012 and established four 2.16 GHz wide channels in the 60 GHz band with center frequencies of 58.32 GHz, 60.48 GHz, 62.64 GHz, and 64.80 GHz. The 802.11ad market is expected to grow to $10.53 billion in 2019.4

Global momentum behind IEEE 802.11ad chipsets is key to driving opportunities in the 60 GHz band. Currently, the 802.11ad based 60 GHz band hosts a broad range of services including outdoor wireless links that extend the reach of fiber networks and personal networking technologies that deliver multi-gigabit speeds between devices.5

Standardization often leads to widespread adoption, and this has been true for 802.11ad. The huge global demand for spectrum capacity is driving investment in 60 GHz band unlicensed technologies for wireless backhaul and other uses, particularly as the technology is evolving to allow for non-line-of-sight applications.6 Since the release

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of the 802.11ad, there has been participation by not only large, established communications semiconductor manufacturers such as Qualcomm, Intel and Broadcom, but also wireless semiconductor startups.

The highly innovative approaches that are being proposed utilize the significant 802.11ad bandwidth to form novel network topologies. These hybrid access and backhaul (or mesh) topologies improve link availability by operating in both line-of-sight and non-line-of-sight modes. Non-line-of-sight operation exploits alternate paths generated by deterministic reflectors which exist at 60 GHz.

Recent innovations and announcements include the following.

Facebook announced Terragraph, its 60 GHz wireless system for dense urban environments. Facebook’s motivation to develop Terragraph is to achieve its mission of connecting the unconnected and improving the experience of the underserved. Terragraph uses a standard WiGig chipset and implements a number of software features to enhance network performance and achieve gigabit speeds at fraction of the cost of laying traditional fiber optic. Facebook will deploy in the City of San Jose, California, USA summer 2016 with further trials and deployments globally in 2017. Facebook has

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also stated its intention to make available Terragraph technology via its Telecom Infrastructure Project on an ‘open’ basis.\textsuperscript{11}

Broadcom, a San Jose, CA and Singapore based semiconductor company, recently announced its 60G WiMesh chipset solution designed for lower-cost wireless infrastructure applications including mobile backhaul and wireless access points.\textsuperscript{12} Broadcom’s 60G WiMesh solution implements novel beamforming antenna technology and custom time division duplex protocol to enable a robust wireless mesh network operating at node distances up to hundreds of meters. Broadcom intends to make its chipset solution available to wireless system designers seeking to implement low cost, high bandwidth connectivity.

Google entered the 60 GHz in 2014 with the acquisition of Alpental, a startup focused on 60 GHz wireless networking technology.\textsuperscript{13} Eric Schmidt, Chairman of Google’s parent company Alphabet, at a shareholder meeting mentioned how wireless technology to beam 1 Gbps internet connections is, “cheaper than digging up your own garden.”\textsuperscript{14} Craig Barratt, CEO of Google Access, stated Google is “experimenting with a number of different wireless technologies” and believes that wireless “allows you to reach houses and users that are in lower density settings -- where fiber becomes too expensive.”\textsuperscript{15}

2. A Survey of 60 GHz Band Licensing Around the World

This section surveys the radio regulations applicable to the 60 GHz band around the globe. In this section, the 60 GHz band is defined as 57 – 66 GHz and includes the 64

\textsuperscript{11} Facebook, “Introducing Facebook’s new...” (see footnote 9)


\textsuperscript{14} “Alphabet Looks to Wirelessly Connect Home to Internet” available at http://www.wsj.com/articles/alphabet-looks-to-wirelessly-connect-homes-to-internet-1465417866

\textsuperscript{15} “Google Fiber wants to beam wireless Internet to your home” available at http://www.recode.net/2016/4/14/11586114/access-google-fiber-ceo-interview
– 66 GHz segment allocated by several countries. The international regulations are followed by national regulations grouped by regional regulatory organization membership. Regulations in 59 of the 179 member countries were surveyed. Table 1 summarizes the results by regional regulatory organization, showing the number of member countries, the number surveyed, the number that have not yet allocated the 60 GHz band, and the number that have allocated it for unlicensed use.

Table 1 – Survey Summary

<table>
<thead>
<tr>
<th>Organization</th>
<th>Members</th>
<th>Surveyed</th>
<th>Not Allocated</th>
<th>Unlicensed</th>
</tr>
</thead>
<tbody>
<tr>
<td>APT</td>
<td>38</td>
<td>14</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>ASMG</td>
<td>22</td>
<td>4</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>ATU</td>
<td>44</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>CEPT</td>
<td>48</td>
<td>34</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>CITEL</td>
<td>35</td>
<td>5</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>179</strong></td>
<td><strong>59</strong></td>
<td><strong>15</strong></td>
<td><strong>24</strong></td>
</tr>
</tbody>
</table>

In 15 of the surveyed countries, the local regulator had not yet made any allocations in the 60 GHz band. Of the remaining 44 countries, the regulations in 22 of them (50%) allow unlicensed (license exempt) outdoor fixed operation. Two additional countries allow unlicensed operation, but prohibit outdoor fixed usage.

The regulatory trend is towards allowing unlicensed operation in the 60 GHz band. Countries which have recently updated their 60 GHz regulations have made the band available on a license exempt basis. These include the Philippines (2016 update), Malaysia (2015 update), South Africa (2015), Belgium (2014 update), New Zealand (2014 update), Sweden (2014 update), the United States (2013 update), and Germany (2012 update). Each of these countries has made at least 4 GHz of the band available for unlicensed usage.

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16 Eight of the ASMG member countries are also members of the ATU.
17 Egypt is a member of both the ASMG and the ATU.
18 Egypt is a member of both the ASMG and the ATU.
Article 5 of the International Telecommunication Union (ITU) Radio Regulations\textsuperscript{19} includes co-primary fixed service (FS) and mobile service (MS) allocations in the 60 GHz band for all three ITU Regions.

Recommendation ITU-R F.1763, Radio interface standards for broadband wireless access systems in the fixed service operating below 66 GHz\textsuperscript{20}, identifies specific radio interface standards which may be utilized for broadband wireless access (BWA) systems in the fixed service operating below 66 GHz. In developing this recommendation, the ITU Radiocommunication Assembly (RA) considered that:

• It is useful to identify standards for broadband wireless access (BWA) systems in the fixed service for international use
• The standards for BWA systems for fixed services are developed by standardization development bodies with broad international participation
• Standards for systems operating in the mobile service can be utilized to provide fixed BWA
• Standards for BWA support a wide range of fixed and nomadic broadband applications, such as voice and videoconferencing, in urban, suburban, and rural areas

F.1761-1 recommends that Recommendations ITU-R M.1450, M.1457, M.1801, M.2003, and M.2012, which can also be utilized to provide fixed BWA operations below 66 GHz, should be used.

Recommendation ITU-R M.2003, Multiple Gigabit Wireless Systems in frequencies around 60 GHz\textsuperscript{21}, provides general characteristics and radio interface

\textsuperscript{19} International Telecommunication Union Radiocommunication Sector; Radio Regulations, Edition of 2012.

\textsuperscript{20} Recommendation ITU-R F.1763-1 (02/2014) Radio interface standards for broadband wireless access systems in the fixed service operating below 66 GHz.

standards for Multiple Gigabit Wireless Systems (MGWS) in frequencies around 60-GHz. In developing this recommendation, the RA considered that:

- MGWS are widely used for fixed, semi-fixed (transportable) and portable computer equipment for a variety of broadband applications
- MGWS are expected to encompass applications for wireless digital video, audio, and control applications, as well as multiple gigabit wireless local area networks (WLAN)
- MGWS standards have been developed for operation in the 60 GHz frequency range
- MGWS should be implemented with careful consideration to compatibility with other radio applications
- Many administrations permit MGWS, including radio local area networks (RLANs) devices to operate in the 60 GHz frequency range on a license-exempt basis
- Harmonized frequencies in the 60 GHz frequency range for the mobile service would facilitate the introduction of MGWS including RLANs

The RA further recognized that both consumers and manufacturers will benefit from global harmonization of the 60 GHz spectrum for MGWS and that although MGWS systems have been predominantly used for indoor applications there are administrations which allow outdoor use of these systems.

Noting that several standards provide options for MGWS implementation, the RA recommends that the MGWS standards and their system characteristics contained in Annex 1 of M.2003-1 should be used. Annex 1 states that “a 2160 MHz channel bandwidth is required. It is important that MGWS standards employ the same channelization in order to promote better coexistence. Four center frequencies are recommended to be at 58.32, 60.48, 62.64, and 64.80 GHz.” These are the same channel bandwidths and center frequencies standardized in the internationally developed IEEE Standards 802.11ad-2012 and 802.15.3c-2009.
**CITEL (The Americas)**

Radio regulators in 5 of the 35 Inter-American Telecommunication Commission (CITEL) countries have been surveyed. In 2 of these countries (Argentina and Mexico), the local regulator has not allocated the 60 GHz spectrum. The remaining 3 countries have made the band available license exempt. Allocations are shown in Table 2 with maximum EIRP and power limits, and minimum antenna gain, were applicable. In the United States, the FCC has recently proposed to make the 64 – 71 GHz band available for unlicensed use with the same rules as the 59 – 64 GHz band.22

**Table 2 – Survey of 60 GHz Fixed Service Regulations in CITEL Member Countries**

<table>
<thead>
<tr>
<th></th>
<th>Frequency (GHz)</th>
<th>Max EIRP (dBm)</th>
<th>Max Pwr (dBm)</th>
<th>Min Gain (dBi)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>57 – 64</td>
<td>43</td>
<td>27</td>
<td></td>
<td>Unlicensed</td>
</tr>
<tr>
<td>Canada</td>
<td>57 – 64</td>
<td>43</td>
<td>27</td>
<td></td>
<td>Unlicensed</td>
</tr>
<tr>
<td>United States</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>57 – 64 (indoor)</td>
<td>43</td>
<td>27</td>
<td></td>
<td>Unlicensed</td>
</tr>
<tr>
<td></td>
<td>57 – 64 (outdoor)</td>
<td>85</td>
<td>27</td>
<td></td>
<td>Unlicensed, EIRP reduced 2 dB for every dB gain &lt; 51 dBi</td>
</tr>
</tbody>
</table>

**CEPT (Europe)**

Radio regulators in 34 of the 48 European Conference of Postal and Telecommunications Administrations (CEPT) countries were surveyed. In 4 of these countries (Albania, France, Italy, and Romania), the local regulator has not allocated the 60 GHz spectrum. In an additional 12 countries (Bulgaria, Croatia, Cyprus, Finland, Hungary, Luxemburg, Malta, Netherlands, Norway, Portugal, Russia, and Ukraine), portions of the band have been allocated, but no service rules have been issued. Allocations in the remaining 18 countries are shown in Table 3.

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Table 3 – Survey of 60 GHz Fixed Service Regulations in CEPT Member Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Frequency (GHz)</th>
<th>Max EIRP (dBm)</th>
<th>Max Pwr (dBm)</th>
<th>Min Gain (dBi)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>57 – 59</td>
<td>55</td>
<td>10</td>
<td></td>
<td>General license, 50 &amp; 100 MHz</td>
</tr>
<tr>
<td></td>
<td>59 – 63</td>
<td>55</td>
<td></td>
<td>35</td>
<td>General permit, 2,000 MHz max</td>
</tr>
<tr>
<td>Belgium</td>
<td>57 – 59</td>
<td>55</td>
<td>10</td>
<td>30</td>
<td>License exempt</td>
</tr>
<tr>
<td></td>
<td>59 – 63</td>
<td>55</td>
<td>10</td>
<td>30</td>
<td>License exempt, Class 2 RPE</td>
</tr>
<tr>
<td>Bosnia and Herzegovina</td>
<td>57 – 59</td>
<td>55</td>
<td>10</td>
<td>30</td>
<td>First come, first served, 50 &amp; 100 MHz</td>
</tr>
<tr>
<td></td>
<td>64 – 66</td>
<td>85</td>
<td>35</td>
<td>30</td>
<td>First come, first served, 30 &amp; 50 MHz</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>57.1 – 58.9</td>
<td>55</td>
<td></td>
<td>30</td>
<td>Point-to-point, 50 &amp; 100 MHz</td>
</tr>
<tr>
<td>Denmark</td>
<td>57.1 – 58.9</td>
<td>55</td>
<td>10</td>
<td>30</td>
<td>Licensed</td>
</tr>
<tr>
<td>Germany</td>
<td>57.1 – 57.8</td>
<td>55</td>
<td>30</td>
<td></td>
<td>Unlicensed, 50 &amp; 100 MHz</td>
</tr>
<tr>
<td></td>
<td>58.6 – 58.9</td>
<td>55</td>
<td>30</td>
<td></td>
<td>Unlicensed, 50 &amp; 100 MHz</td>
</tr>
<tr>
<td></td>
<td>59 – 63</td>
<td>55</td>
<td>30</td>
<td></td>
<td>Unlicensed, 150 MHz to 2 GHz</td>
</tr>
<tr>
<td>Greece</td>
<td>57 – 63</td>
<td></td>
<td></td>
<td></td>
<td>Unlicensed, 50 to 2500 MHz, no outdoor fixed</td>
</tr>
<tr>
<td>Ireland</td>
<td>57 – 59</td>
<td></td>
<td></td>
<td></td>
<td>Licensed</td>
</tr>
<tr>
<td></td>
<td>59 – 64</td>
<td></td>
<td></td>
<td></td>
<td>Unlicensed, SRD</td>
</tr>
<tr>
<td>Latvia</td>
<td>57 – 62</td>
<td></td>
<td></td>
<td></td>
<td>Unlicensed</td>
</tr>
<tr>
<td>Liechtenstein</td>
<td>58 – 63</td>
<td>55</td>
<td>10</td>
<td>30</td>
<td>General license, EIRP reduced if gain &lt; 45 dBi</td>
</tr>
<tr>
<td>Lithuania</td>
<td>64 – 65.5</td>
<td>85</td>
<td>30</td>
<td></td>
<td>Light licensing, EIRP reduced 2 dB for every dB gain &lt; 50 dB</td>
</tr>
<tr>
<td>Poland</td>
<td>57.1 – 58.9</td>
<td>55</td>
<td>10</td>
<td>30</td>
<td>Unlicensed, 50 &amp; 100 MHz</td>
</tr>
<tr>
<td>Slovakia</td>
<td>57 – 66</td>
<td></td>
<td></td>
<td></td>
<td>Unlicensed, SRD, MGWS</td>
</tr>
<tr>
<td>Slovenia</td>
<td>57 – 66</td>
<td>40</td>
<td></td>
<td></td>
<td>Unlicensed, no outdoor fixed, 13 dBm/MHz</td>
</tr>
<tr>
<td>Spain</td>
<td>57 – 59</td>
<td>55</td>
<td>10</td>
<td>30</td>
<td>Channelized</td>
</tr>
<tr>
<td>Sweden</td>
<td>57 – 66</td>
<td>55</td>
<td></td>
<td></td>
<td>License exempt, min 30 dB in 63 – 64 GHz</td>
</tr>
<tr>
<td>Switzerland</td>
<td>58 – 63</td>
<td>55</td>
<td>10</td>
<td>30</td>
<td>License exempt, EIRP reduced if gain &lt; 45 dBi</td>
</tr>
<tr>
<td>UK</td>
<td>57.1 – 63.9</td>
<td>55</td>
<td>10</td>
<td>30</td>
<td>License exempt, Exclusion sites</td>
</tr>
</tbody>
</table>

**APT (Asia-Pacific)**

Radio regulators in 14 of the 38 Asia-Pacific Telecommunity (APT) countries have been surveyed. In 6 of these countries (Bangladesh, Indonesia, Iran, Myanmar,
Thailand, and Vietnam), the local regulator has not yet allocated the 60 GHz spectrum. Allocations in the remaining countries are summarized in Table 4.

Table 4 – Survey of 60 GHz Fixed Service Regulations in APT Member Countries

<table>
<thead>
<tr>
<th></th>
<th>Frequency (GHz)</th>
<th>Max EIRP (dBm)</th>
<th>Max Pwr (dBm)</th>
<th>Min Gain (dBi)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>59 – 63 (outdoor)</td>
<td>51.8</td>
<td>13</td>
<td></td>
<td>Class license</td>
</tr>
<tr>
<td></td>
<td>57 – 66 (indoor)</td>
<td>43</td>
<td>13</td>
<td></td>
<td>Class license</td>
</tr>
<tr>
<td>China</td>
<td>59 – 64</td>
<td></td>
<td></td>
<td></td>
<td>Unlicensed</td>
</tr>
<tr>
<td>Japan</td>
<td>59 – 66</td>
<td>57</td>
<td>10</td>
<td></td>
<td>License exempt, interference prevention function required</td>
</tr>
<tr>
<td>Malaysia</td>
<td>57 – 64</td>
<td>40</td>
<td></td>
<td></td>
<td>Class assignment</td>
</tr>
<tr>
<td>New Zealand</td>
<td>57 – 64</td>
<td>85</td>
<td>27</td>
<td></td>
<td>General use license, EIRP reduced 2 dB for every dB antenna &lt; 51 dBi</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>57 – 59</td>
<td></td>
<td></td>
<td></td>
<td>HDFS</td>
</tr>
<tr>
<td></td>
<td>59.3 – 64</td>
<td></td>
<td></td>
<td></td>
<td>Unlicensed, SRD</td>
</tr>
<tr>
<td></td>
<td>64 – 66</td>
<td></td>
<td></td>
<td></td>
<td>HDFS</td>
</tr>
<tr>
<td>Philippines</td>
<td>57 – 66</td>
<td></td>
<td></td>
<td></td>
<td>Unlicensed, MGWS, one-time registration and fee, Annex 1 of ITU-R Rec. M.2003-1</td>
</tr>
<tr>
<td>Singapore</td>
<td>57 – 66 (outdoor)</td>
<td>25</td>
<td></td>
<td></td>
<td>License exempt, -2 dBm/MHz</td>
</tr>
<tr>
<td></td>
<td>57 – 66 (indoor)</td>
<td>40</td>
<td></td>
<td></td>
<td>License exempt, 13 dBm/MHz</td>
</tr>
</tbody>
</table>

**ATU (Africa)**

Radio regulators in 3 of the 44 African Telecommunications Union (ATU) member countries were surveyed. In 2 of those countries (Egypt and Ghana), local regulators have not yet allocated the 60 GHz spectrum.

In South Africa, the Independent Communications Authority of South Africa (ICASA) has exempted point-to-point links in the 57 – 64 GHz band from radio frequency spectrum licenses. The use or possession of point-to-point link Radio Apparatus, in accordance with the following specifications does not require a radio frequency spectrum license: 55 dBm maximum EIRP, 10 dBm maximum transmit power, 30 dBi minimum antenna gain, and compliance with EN 305 550 (electromagnetic compatibility testing).
**ASMG (Arab Countries)**

Radio regulators in 4 of the 22 Arab Spectrum Management Group (ASMG) countries have been surveyed. In 2 of these countries (Egypt and Iraq), the local regulator has not yet allocated the 60 GHz spectrum.

In Saudi Arabia, the Communications and Information Technology Commission (CITC) has allocated the 57 – 59 GHz band for fixed services, shared by government and commercial users. It has allocated the 64 – 66 GHz band for fixed services, limited to government users.

In the United Arab Emirates (UAE), the Telecommunications Regulatory Authority (TRA) has made the 57 – 59 GHz band available for licensed use with 50 MHz channelization.

3. **Recommendations for Licensing of the 60 GHz Band in India**

Transforming India into a “digitally empowered society and knowledge economy” as envisioned by the Digital India Programme, will require connecting millions more citizens to high-speed broadband. To date, mobile has been a key onramp to Internet connectivity in India. Of the more than 400 million Internet users in India, more than 306 million access the Internet through their phones.

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23 Eight of the ASMG member countries are also members of ATU.


However, in India, as in the rest of the world, the proliferation of new mobile devices and bandwidth-hungry applications is putting more pressure than ever before on mobile networks and the spectrum they rely on. Globally, mobile data traffic grew 74 percent in 2015.\textsuperscript{26} India is no exception. In India last year, mobile data traffic grew by 50 percent and consumption of 3G data alone rose by 85 percent.\textsuperscript{27} With operators poised to launch 4G LTE networks across the country, analysts expect that faster speeds could lead to an up to fourfold increase in traffic as it has in other parts of the world.\textsuperscript{28} Still others have projected that smartphone penetration could reach 58 percent by 2020, further propelling large increases in data traffic.\textsuperscript{29}

Keeping up with this surging demand for data and meeting the government’s goals for a Digital India through expanded digital infrastructure will require adding capacity to existing networks and upgrading network architectures. To do this in an affordable way, increasing access to delicensed spectrum for both access and backhaul must become a key part of India’s digital strategy. Last year, around the world, more than half of mobile data traffic was offloaded onto fixed networks through Wi-Fi or femtocells.\textsuperscript{30} But in India, analysts have observed that consumers are not typically offloading data from their mobile networks.\textsuperscript{31} Moreover, the Telecom Regulatory

\begin{footnotesize}
\begin{itemize}
  \item \textsuperscript{29} Deloitte, Indian Tower Industry: The Future is Data, Figure 1 (June 2015) available at http://www2.deloitte.com/content/dam/Deloitte/in/Documents/technology-media-telecommunications/itmt-indian-tower-industry-noexp.pdf.
  \item \textsuperscript{30} Cisco Report.
\end{itemize}
\end{footnotesize}
Authority of India (TRAI) has noted that the existing delicensed bands available for WiFi spectrum channels are already congested.\textsuperscript{32}

For these reasons, we recommend that India’s digital strategy should include opening up unrestricted, delicensed access to the 60 GHz band (also called the V-Band). TRAI noted in its recent recommendations to the Department of Telecommunications that “there is an urgent need to identify candidate bands which can be delicensed to cater to the huge demand in the near future. The V-band is a strong candidate band for the same.”\textsuperscript{33}

As noted above, the 60 GHz band offers unmatched capacity with 7 GHz of available spectrum, particularly when compared with lower frequency bands. In addition, the natural propagation characteristics of the band mitigate interference, making it particularly suited to delicensed use. For these reasons, many countries around the world, including Canada, China, Germany, Japan, and South Korea, have already opened up delicensed access to the 60 GHz band.\textsuperscript{34} And innovative access and backhaul technologies have flourished in the countries that have opted for a delicensed framework.

\textbf{a. Recommendation (1): The 60 GHz band should be opened up under a delicensed framework for both access and backhaul.}

Like other countries have, India should open the 60 GHz band up under a delicensed framework for both access and backhaul. However, TRAI recently proposed to create a dual licensing structure based on use. That is, for indoor and outdoor “access”

\textsuperscript{32} Telecom Regulatory Authority of India, Recommendations on Allocation and Pricing of Microwave Access (MWA) and Microwave Backbone (MWB) RF Carriers, (Response to reference received from Department of Telecommunications on recommendations of 16\textsuperscript{th} October 2015) at 5-6 (Nov. 17, 2015) available at http://www.trai.gov.in/WriteReadData/Recommendation/Documents/Response%20to%20back%20reference%20on%20Microwave_17.11.2015.pdf. (“TRAI Recommendations”).

\textsuperscript{33} Id.

applications the band should be delicensed, and for “backhaul” uses the band should be lightly licensed through a link registration model.\textsuperscript{35}

We believe this is not the best approach for two reasons.

**First**, link registration (light or otherwise) for outdoor use is not required for 60 GHz operation due to the characteristics of the band. Link registration is used in other licensed spectrum to avoid interference between geographically proximate links, but due to the high oxygen attenuation within the 60 GHz band, interference is severely reduced. In addition to the self-isolation benefits of the 60 GHz band, modern wireless systems are able to implement interference rejection via new and novel antenna designs (phase array), signal processing techniques (beamforming, null steering) and modulation schemes. All of which can be used to further reduce interference risk.

**Second**, it is the unrestricted, delicensed framework promoted by the IEEE standards that has allowed innovation in the 60 GHz band to flourish and has allowed the technology to be affordable. Without the steep upfront costs of obtaining licenses, innovators can experiment with technologies that work well in a delicensed environment. As discussed in Section 1, new network topologies are being developed that would allow for non-line-of-sight links. Such a system might use an infinite combination of paths to expand the reach of high-speed wireless broadband and can be used both for both access and backhaul. Even in such deployments, interference concerns are mitigated by the characteristics of the 60 GHz band. However, if the band were subject to a “light licensing” regime that would require registration for each link, as currently envisioned by TRAI, deploying these new network architectures would be infeasible as a practical matter. Only well organized, well financed market players could participate. The only approach that ensures that India has access to the latest innovations in the band is to designate the 60 GHz band as delicensed for both access and backhaul under parameters similar to those currently used in other countries, such as Australia, Malaysia, New Zealand, South Africa, Sweden, United Kingdom, and United States.

\textsuperscript{35} TRAI Recommendations at 6-7.
b. **Recommendation (2): India’s policy for 60 GHz band spectrum should allow for flexible use and should not establish coordination or channelization requirements.**

We further recommend that India’s 60 GHz band spectrum policy should allow for flexible use and should not establish specific coordination or channelization requirements. As discussed in Section 1 above, the availability of a delicensed 60 GHz band in several markets, in addition to broad adoption of the WiGig standard, will ultimately result in the emergence of new applications, including for both access and backhaul non-line-of-sight links. Furthermore, it is the large production base of 802.11ad chipsets that could be leveraged to facilitate low cost 60 GHz backbone infrastructure. However, to utilize 802.11ad chipsets, backbone equipment in a point-to-point or point-to-multi-point configuration would have to operate with the same frequency channelization. This means that in order to for India to reap the benefits of low cost backbone infrastructure and avoid the costs of nonstandard equipment, its 60 GHz band policy would need to accommodate the 802.11ad channel plan.

Instead, the plan originally recommended by TRAI with 50 MHz channelization is incompatible with the 802.11ad channel plan, even with aggregation. None of the 802.11ad channels have start and stop frequencies aligned with 50 MHz boundaries. Even the 802.11ad channel bandwidth of 2.16 GHz is not a multiple of 50 MHz. Misalignment with international standards may hinder development of a vendor ecosystem, increase equipment costs for India and result in underutilization of the band.

Therefore, to facilitate rapid deployment of 60 GHz backbone infrastructure, India’s policy for the 60 GHz band should be based on flexible use of the spectrum, and should not establish coordination or channelization requirements.

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36 See Telecom Regulatory Authority of India, Recommendations on Allocation and Pricing of Microwave access (MWA) and Microwave Backbone (MWB) RF carrier, Recommendation 4.37(b) (29 August 2014), available at http://www.trai.gov.in/WriteReadData/Recommendation/Documents/MW%20Reco%20Final29082014.pdf
c. Delicensing the 60 GHz Band could also lead to broader benefits for India.

A delicensed framework would bring India broader economic and societal benefits that would further the government’s Digital India goals. Globally, the availability of delicensed spectrum has driven substantial economic benefit. This economic benefit is real and substantial. The World Bank estimates a 1.38 percentage point increase in Gross Domestic Product for every 10 percentage point increase of broadband penetration. In the United States alone, researchers have estimated that delicensed spectrum bands generated a total economic surplus of $222B in 2013, and contributed $6.7B to GDP. By 2017, the same researchers have conservatively estimated that in the United States, delicensed bands will drive at least $547.2B in economic surplus annually, and contribute at least $49.7B to GDP.

Moreover, the allocation of additional delicensed spectrum delivers a number of broad societal benefits, including:

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• Enhancing the value of wireline infrastructure and improving the performance of cellular services;\textsuperscript{41}

• Delivering substantially higher speeds than existing services through new developments like the 802.11ad WiGig standard and alleviating congestion on existing Wi-Fi bands;\textsuperscript{42}

• Enabling new technology and business model opportunities for a variety of established and emerging ecosystem players – innovations which ultimately benefit end-users\textsuperscript{43}

• Supporting the expansion of services into unserved and underserved communities because the availability of delicensed spectrum helps support the provision of affordable services to new geographies and populations.

For these reasons a delicensed regime for the 60 GHz band for both access and backhaul use cases could be economically and socially beneficial for India and could help to transform India into a “digitally empowered society and knowledge economy” as envisioned by the Digital India Programme.\textsuperscript{44} Under a delicensed framework, the unique characteristics of the 60 GHz band and existing global standards for the band will enable a multitude of new technology and business models for access and backhaul, and further enable new services for underserved communities.

4. Conclusion

Today, India faces growing demands on its existing networks and increasing pressure to expand its broadband infrastructure and meet its Digital India goals. With its unmatched capacity, the 60 GHz band has the potential to be a key piece of India’s digital

\textsuperscript{41} Id.

\textsuperscript{42} Id.

\textsuperscript{43} Id.

\textsuperscript{44} Digital India, Power to Empower, Vision of Digital India, at http://www.digitalindia.gov.in/content/vision-and-vision-areas.
strategy. By making the 60 GHz band available under delicensed framework without specified channelization, India could unleash the full potential of the 60 GHz band and leapfrog to gigabit wireless services. By adopting a delicensed approach, India could benefit from the economies of scale of existing investments and innovation in the band for both access and backhaul. And such an approach would allow India to reap the same economic and societal benefits other countries expect to enjoy.