BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C. 20554

In the Matter of Promoting More Efficient Use of Spectrum Through Dynamic Spectrum Use Technologies	ET Docket No. 10-237

COMMENTS OF MICROSOFT CORP.

I. Introduction and Summary

Microsoft wholeheartedly supports the Federal Communications Commission's (Commission's or FCC's) Notice of Inquiry (NOI) requesting comment on dynamic spectrum access technologies and techniques. As the Commission has recognized, mobile data usage is exploding in the United States and the need for additional wireless broadband capacity will only continue to grow (likely exponentially). To meet this growing demand, the Commission must consider not only reallocation of spectrum but also innovative technologies – such as dynamic spectrum access – that can make higher and better use of limited spectrum.

As Microsoft and other parties demonstrated in the TV white spaces proceeding, greater use of dynamic spectrum access technologies will enable consumers to make more productive use of limited spectrum resources. The TV band white spaces provides a golden opportunity for the industry to demonstrate the benefits of devices that can adaptively operate on different spectrum bands and protect primary users from harmful interference by: (1) determining their location and (2) accessing online databases providing lists of available spectrum bands and operating parameters. This proceeding provides an opportunity to expand on both the technical and policy lessons learnt during the FCC's allocation of the TV band white spaces for wireless broadband. In a relatively short period of time, spectrum databases are evolving from simple

lookup tables to services providing primary and secondary users the ability to negotiate spectrum access and usage rights in real time (*e.g.*, accounting for the cost of interference, power limits, geolocation and mobility, prioritization, and duration). In order for the U.S. to remain a global leader in spectrum innovation, it is imperative that the FCC, in cooperation with NTIA and other federal agencies, promote home-grown dynamic spectrum access technologies such as those being developed for use in the TV band white spaces.

As we look forward, the FCC should ensure that: (1) Sufficient amounts of spectrum are available in the TV bands for white space device access; and (2) Underutilized spectrum, especially below 3 GHz, is made available for additional dynamic spectrum access. Initially, the ideal spectrum blocks for expanding dynamic spectrum access technologies are those underutilized blocks located near existing unlicensed spectrum allocations. But, other underutilized blocks should also be considered. Notably, because Commercial Mobile Radio Service ("CMRS") providers intensively use their spectrum, mandated access by smart radios would not be appropriate in spectrum bands licensed for their exclusive use. However, CMRS carriers should remain free to use dynamic spectrum access technologies and techniques to enhance their own services or in the context of voluntary secondary markets arrangements.

II. Industry Trends Demonstrate the Urgent Need for Commission Action Promoting More Productive Use of Spectrum

A variety of industry trends illustrate that demand for spectrum resources – especially those below 3 GHz – is intensifying. For example, AT&T's mobile data traffic has experienced a fifty-fold increase over a three year period.[1] The FCC has estimated that there will be 35 times

[1] Federal Communications Commission, Staff Technical Paper, Mobile Broadband: The Benefits of Additional Spectrum, OBI Technical Paper No. 6 (Oct. 2010), at 5 ("FCC OBI Technical Paper No. 6"), available at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-302324A1.pdf.

as much mobile data traffic in 2014 than in 2009.[2] The Commission has observed that mobile voice traffic also continues to grow.[3]

Meanwhile, the sheer number of wireless devices used both for person-to-person and machine-to-machine communications is also increasing. According to Ericsson, there will be 50 billion connected devices by 2020 – making up the so-called "Internet of Things".[4] Machine-to-machine communications – for example, providing home and industrial automation, energy monitoring, lighting and environmental controls, and health monitoring – are rapidly increasing. As Professor Dirk Grunwald of the University of Colorado points out in his paper filed concurrently in this docket, some of these machine-to-machine networks (*e.g.*, linking video devices) use much more bandwidth than "human centric" networks.[5]

Exponential growth in demand for wireless data services is not restricted to devices using licensed spectrum. In 2009, Microsoft filed a paper with the Commission by Richard Thanki, entitled *The Economic Value Generated by Current and Future Allocations of Unlicensed Spectrum*.[6] As illustrated in Figure 1, Thanki's paper describes both the growth in wirelessly-connected devices *and* the shift from devices relying on the wireless carriers' licensed spectrum to devices relying more on unlicensed spectrum (such as the 2.4 and 5 GHz spectrum often used by Wi-Fi) for connectivity.

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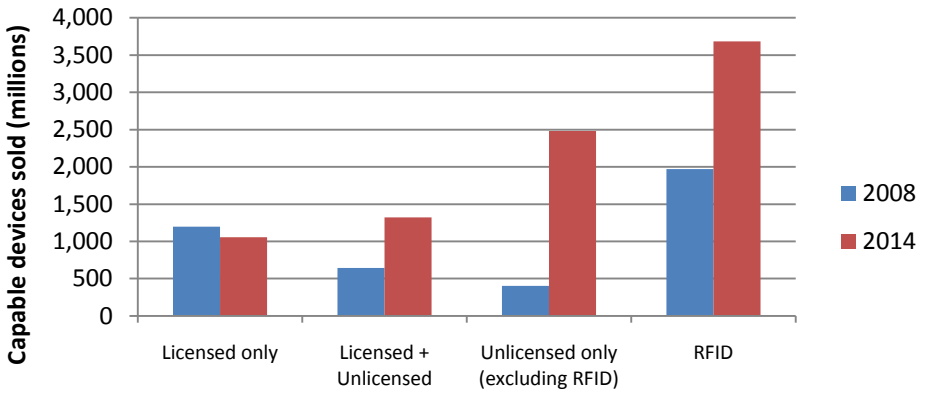
[2] *See id.* at 9.
[3] *Id.*
[4] Hans Vestberg, President and CEO, Ericsson, Address to Shareholders, April 13, 2010, available at http://www.ericsson.com/thecompany/press/releases/2010/04/1403231.
[5] *See* Prof. Dirk Grunwald, How New Technologies Can Turn a Spectrum Crisis into a Spectrum Opportunity, at 12, available at http://systems.cs.colorado.edu/mediawiki/index.php/User:Grunwald (Microsoft Research sponsored Professor Grunwald's paper).
[6] *See* Richard Thanki, *The Economic Value Generated by Current and Future Allocations of Unlicensed Spectrum* at 19 (Sep. 2009) ("Thanki Report"), http://fjallfoss.fcc.gov/ecfs/document/view?id=7020039036.

Figure 1 – Global Sale of Devices by Type of Spectrum Used in 2008 and 2014



Source: Perspective analysis

Recent high-profile events vividly demonstrate that spectrum constraints are not just limited to licensed spectrum bands.[7] U.S. consumers are increasingly connecting to broadband networks over unlicensed Wi-Fi connections. For example, AT&T has reported significant growth in Wi-Fi connections on its nationwide network, with more connections – 106.9 million connections – made in the third quarter of 2010, exceeding the total 85.5 million connections during the entire year in 2009.[8] According to Bango Inc, at the start of 2011, Wi-Fi accounts for over 50% of mobile user connections to the Internet.[9] In February 2010, 23% of website visits connected through Wi-Fi.

These trends are not just limited to the United States. Many of the world's major broadband network operators are now focused on increasing Wi-Fi hotspot coverage. O2 has

[7] *See* Erica Ogg, *Even Steve Jobs Has Demo Hiccups*, CNET News, June 7, 2010, available at http://news.cnet.com/8301-31021_3-20007009-260.html (recounting how Steve Jobs's iPhone 4 demo came to "an abrupt halt" when Wi-Fi access points became overloaded in the Moscone Convention Center in San Francisco, CA).

[8] *See* Press Release, Third-Quarter Wi-Fi Connections on AT&T Network Exceed Connection for 2009, October 22 2010, available at http://www.prnewswire.com/news-releases/third-quarter-wi-fi-connections-on-att-network-exceed-total-connections-for-2009-105520733.html.

[9] *See* Vanessa Daily, *Wi-Fi grows to over 50% of mobile web connections*, February 2, 2011, available at http://news.bango.com/2011/02/02/wi-fi-grows-to-over-50-percent/.

announced plans to deploy a public Wi-Fi platform in the United Kingdom.[10] BSkyB has likewise recently announced plans to buy The Cloud, which operates 22,000 Wi-Fi hotspots across Europe.[11] China Mobile, the world's largest wireless carrier with about 600 million subscribers, has announced plans to use Wi-Fi to provide Beijing with a city-wide wireless network by the end of this year.[12]

These trends also point to a growing recognition of the economic benefits of wireless applications utilizing unlicensed spectrum access. Thanki examined the U.S. economic value generated by the following unlicensed applications: (1) Wi-Fi broadband access within homes; (2) Voice over wireless local area networks and wireless electronic health records in hospitals; and (3) RFID tags for in-store item-level tagging in the clothing retail sector.[13] Thanki's analysis showed that over the next 15 years these three applications together could generate between $16 to $37 billion per year in economic value for the U.S. economy. Thanki's economic analysis did not account for the many other applications utilizing unlicensed spectrum, including those utilizing spectrum below 1 GHz.

III. The Commission Should Prioritize Further Development of Efficiency-Enhancing Technologies

In order to keep pace with all of this increased demand and because radio spectrum is a finite resource, FCC policies should at a minimum promote: (1) the reallocation of large blocks of currently underutilized radio spectrum for wireless licensed broadband; (2) the construction of more infrastructure (*i.e.*, reducing the distance between wireless end-user devices and fiber-based

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[10] *See 02 UK to roll out free-for-all 02 WiFi*, January 26, 2011, available at http://www.telecompaper.com/news/o2-uk-to-roll-out-free-for-all-o2-wifi (reporting that "[t]hese investments will allow O2 to offer customers access to a suite of layered technologies, including 2G, EDGE, 3G, 4G, HSPA+ and Wi-Fi, seamlessly, simply and at speed.").

[11] *See* Daniel Robinson, *BSkyB confirms The Cloud acquisition*, Yahoo! News, January 27, 2011, available at http://uk.news.yahoo.com/16/20110127/ttc-bskyb-confirms-the-cloud-acquisition-6315470.html.

[12] *See* Quan Li, Beijing to go fully WiFi this year, China Daily, January 18, 2011, available at http://www.chinadaily.com.cn/china/2011-01/18/content_11875157.htm.

[13] *See* Thanki at 20-32.

networks); and (3) the identification of underutilized spectrum and the greater use of smart radio technologies to make more intensive/efficient use of these available spectrum resources. None of these steps are a complete solution. The FCC has projected that the U.S. wireless industry will need an additional 300 MHz of spectrum by 2014, even while accounting for continued significant investment in cell sites (and backhaul) and increased spectral efficiency from the transition to fourth generation (4G) Long Term Evolution (LTE) technology.[14]

With U.S. wireless carriers already spending about $20 billion annually on capital expenditures,[15] it is unlikely that more network build out can alone cost-effectively (or even realistically) address growing demand.[16] Moreover, in spite of significant technological advancements, physics – expressed in Shannon's Law – continues to place limits on spectral efficiency in terms of delivered bits/second/hertz. As the FCC has itself noted, looking to new more efficient wireless technologies, such as LTE and Wi-Max, is only a partial solution to addressing the spectrum crunch.[17] New air interfaces are delivering ever smaller improvements to spectral efficiency. We, therefore, concur with the Commission that *"*there is a critical need for increased efficiency in use of spectrum, *as well as* the need for additional spectrum."[18]

IV. The FCC Should Ensure that Additional Spectrum Bands Are Available for Dynamic Access Use

A. The Commission Should Continue Supporting Secondary Markets

We agree with the Commission that as demand for scarce spectrum resources becomes more acute and as technologies evolve, "licensees and spectrum users will find ways to employ

[14] *See FCC OBI Technical Paper No. 6* at 18.
[15] *See Annual Report and Analysis of Competitive Market Conditions With Respect to Mobile Wireless, Including Commercial Mobile Services*, WT Docket No. 09-66, Fourteenth Report, FCC 10-81, at Para. 210 (2010).
[16] The FCC's efforts to modernize the universal service programs, focused on extending coverage to areas not currently served by wireless broadband, are unlikely to address the urban and suburban markets that tend to be the most spectrally constrained.
[17] *See FCC OBI Technical Paper No. 6* at 14-15.
[18] *See Promoting Efficient Use of Spectrum Through Dynamic Spectrum Use Technologies*, ET Docket No. 10-237, Notice of Inquiry, FCC 10-198, at ¶ 16 (rel. Nov. 30, 2010) ("DSA NOI") (emphasis added).

these secondary market mechanisms."[19] The Commission should continue promoting secondary markets by licensees and other spectrum users.[20] Wireless carriers should remain free to use dynamic spectrum access technologies and techniques to enhance their own provision of service or in the context of voluntary secondary markets arrangements. At the same time, because wireless carriers intensively use their spectrum, mandated access by smart radios would not be appropriate in spectrum bands licensed for wireless carriers' exclusive use.[21]

B. The FCC Should Focus on Underutilized Spectrum Adjacent to Existing Unlicensed Allocations

Microsoft has conducted extensive studies since 2003 demonstrating the benefits of dynamic spectrum access techniques.[22] Microsoft's on-going "WhiteFi" trial on its Redmond, WA campus was of one of the first white spaces-based networks using an experimental license issued by the Commission.[23] This network includes a new adaptive spectrum assignment algorithm to handle the spectrum variation and fragmentation unique to the white spaces environment. By using this algorithm, the network is able to adaptively configure itself to operate in the most efficient part of the available white spaces. Microsoft is eager to apply the lessons learned in developing this network prototype, which successfully demonstrates the feasibility of Wi-Fi-like networking in the UHF white spaces, to commercial applications—and, more generally, the promise of unlicensed spectrum to unleash exciting new innovations.

Based on these experiences, we believe that dynamic spectrum access can and should be applied across more spectrum blocks and that there are opportunities in the near term for use of dynamic spectrum access techniques under an unlicensed regulatory approach. We also agree

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[19] DSA NOI at ¶ 38.
[20] DSA NOI at ¶¶ 38-41.
[21] As the Commission also alludes to, protecting primary users in wireless carriers' spectrum could present particular challenges because of the mobile nature of the services they provide. DSA NOI at ¶ 48.
[22] *See* ex parte letter of Microsoft Corp., GN Docket Nos. 09-51 at 16-17 (filed Sep. 21, 2009).
[23] *See generally id.*

with the FCC that "relocation of existing services to other spectrum may not always be feasible and traditional sharing techniques may not make the most efficient use of the spectrum, particularly for services that do not operate continuously, leaving the spectrum available for others to use part of the time."[24]

We agree with Professor Grunwald that the best targets for novel spectrum management techniques for broadband networks are those underutilized spectrum bands that abut current "unlicensed" allocations and have favorable propagation characteristics.[25] As these new spectrum management techniques are demonstrated and proven, other spectrum blocks could be considered for Internet-managed dynamic access.

Focusing first on unlicensed device access makes sense given that unlicensed bands have a proven track record of supporting innovation. Technological and business innovations first developed in the unlicensed context have translated to broad consumer benefits. Indeed, the Commission has recognized the "explosive growth" of numerous unlicensed technologies in recent years, including Wi-Fi, Bluetooth, and RFID tracking.[26] In addition, innovations in the unlicensed bands have led to important advances in technologies used in the licensed bands. For example, orthogonal frequency division multiplexing ("OFDM")—which the Commission highlights as an example of an efficiency enhancing breakthrough—is a modulation technique first standardized for high-speed networking in 1999. Seven years later, OFDM first appeared in the Long Term Evolution ("LTE") standard, now primarily being used for licensed 4G mobile wireless broadband networks.

[24] DSA NOI at ¶ 44.
[25] Grunwald at i.
[26] *See Fostering Innovation and Investment in the Wireless Communications Market*, *A National Broadband Plan for Our Future*, GN Docket Nos. 09-51 and 09-157, Notice of Inquiry, FCC 09-66, at ¶ 23 (Aug. 27, 2009).

A variety of factors should be considered in determining whether a particular spectrum block should be made available for dynamic spectrum techniques, including the geographic extent to which the spectrum is used, the ability to use the spectrum without interference, and the benefits of allowing existing users to remain in a band.[27] Spectrum occupancy studies, which show that only a fraction of the available spectrum is in use at any one time, could also help inform those determinations.[28]

Professor Grunwald provides some examples of underutilized spectrum blocks that the Commission might consider for further dynamic spectrum access:

- In addition to the recent allocation of the UHF TVWS spectrum (portions of 54-72, 76-88, 174-216, 470-512, 512-608 MHz), some of the spectrum arising from consolidation of existing TV channels will provide more useable and contiguous spectrum;
- Portions of the 960-1215 MHz radio navigation and amateur bands because of their proximity to the 900 MHz Industrial, Science, and Manufacturing (ISM) band and TVWS;
- Controlled use of the 2360-2400 and the 2500-2655 MHz bands because of proximity to the existing 2400 MHz ISM band; and
- Controlled use of the 2900-3100 MHz and the 3550-3650 MHz band because of proximity to the "lightly licensed" 3650-3700 MHz band.[29]

The Commission could also consider other bands. For example, we support the FCC's proposal to allow access to un-auctioned or returned licenses, for a period of time until those licenses are re-auctioned. As the FCC notes, "once the spectrum is re-auctioned, the operator of the dynamic spectrum access system would have to vacate the spectrum, unless the conditions of the re-auction permitted the operator to stay."[30] This flexibility means that if the Commission decides to repurpose spectrum in the future, it can order databases providing dynamic spectrum access to

[27] Grunwald at 4-5.
[28] Grunwald at 30-31 (referencing various spectrum occupancy studies).
[29] Grunwald at 32-33.
[30] DSA NOI at ¶ 43.

almost instantly reflect the new band plan. The result would be that devices utilizing dynamic spectrum technologies would operate only in frequencies designated by the Commission.

Over time, new wideband radios and new radio designs will enable wireless systems, such as those controlled by databases providing near real-time access, to use a wider range of spectrum and use non-contiguous, fragmented spectrum bands.[31] This is an important development because a combination of localized and wider area networks leads to more total available bandwidth.[32] However, it is important that, in addition to the TV white spaces spectrum, other underutilized spectrum must include spectrum with better propagation characteristics, such as that located below 1 GHz, or at least below 3 GHz and no higher than 6 GHz. If the Commission intends to incentivize companies to experiment and innovate, it must make those opportunities available below 6 GHz because that is where commercial companies will invest in cognitive radio systems. Testing, for example, at 38 GHz – as suggested by the Commission – is no substitute for testing below the 6 GHz bands and simply will not attract commercial investment today.[33]

C. The Commission Should Modify Rules for Lightly Licensed Bands to Allow for Real-Time Database Access

We support the proposal to extend the concepts underlying the rules for the TV white spaces band devices to additional spectrum bands.[34] One example is the 3650-3700 MHz band, which currently involves a manual registration process. As Professor Grunwald suggests, "it is possible to automate the licensing of spectrum—such as by licensing the 3.65 GHz band using a time-of-use model (that provides access to spectrum when needed) rather than the time-of-application approach currently used (that provides access to spectrum for the duration of the

[31] Grunwald at 24-26.
[32] Grunwald at 22.
[33] DSA NOI at ¶ 46.
[34] DSA NOI at ¶ 48.

license)."[35] In addition to being more efficient, using a real-time database to provide access to the 3.65 GHz spectrum would enable the FCC to permit personal/portable, as well as fixed, applications.

V. Conclusion

Microsoft welcomes the opportunity to comment on dynamic spectrum access technologies and techniques, which will enable consumers to make more productive and efficient use of increasingly strained spectrum resources. The Commission should ensure that sufficient amounts of spectrum are available in the TV bands for white space device access and that a mix of new underutilized spectrum blocks, especially those below 3 GHz, become available for additional dynamic spectrum access.

Respectfully submitted,

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[35] Grunwald at 15.