

**Before the
NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION
Washington, DC 20230**

In the Matter of

The Benefits, Challenges, and Potential Roles
for the Government in Fostering the
Advancement of the Internet of Things

COMMENTS OF QUALCOMM INCORPORATED

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SUMMARY

Qualcomm is pleased to provide comments on NTIA's inquiry into the potential roles the U.S. Government can play to best enable the advancement of the Internet of Things ("IoT"). As the leading developer of advanced wireless chipsets that are used in today's wireless devices and equipment, Qualcomm is working with many industry partners to weave an IoT fabric that is improving our homes, businesses, cities, and farms, and enabling advancements in major sectors of our economy, such as manufacturing, transportation, agriculture, healthcare, and education.

IoT communications needs vary widely depending on the application or service, ranging all the way from a body-worn sensor that sends a short burst of non-time- and non-life-critical data each day to a drone that needs a highly reliable and very low latency command and control link while in flight. Qualcomm is working to support these and many other device types, and new IoT applications and services, as detailed in these Comments. To enable such diverse IoT implementations and encourage continued innovation in the IoT space as NTIA hopes to do, Qualcomm provides the following core components that we respectfully submit should be part of the U.S. Government's IoT policy framework.

First and foremost, NTIA, the FCC, and the federal agencies with spectrum needs should redouble their efforts to free up additional spectrum resources that can be used for the IoT and other types of wireless applications and services. Spectrum has been and will continue to be the fuel driving today's mobile broadband revolution. There is no question that more spectrum is needed to support what could well be trillions of IoT devices that will be in use this century. Fully-cleared, exclusively licensed spectrum should be the primary goal, but Qualcomm recognizes that spectrum sharing among federal and commercial operators will become more common given that the spectrum needs of these operators and U.S. consumers will continue to increase.

Qualcomm has been directly involved in the opening of spectrum bands that will soon be online, such as the 600 MHz band being repurposed for mobile use via the FCC's incentive auction, the 3.5 GHz band that will be shared with naval radars and other federal systems, and the millimeter wave bands that are part of the FCC's *Spectrum Frontiers* proceeding. Qualcomm will continue this close collaboration with the FCC and NTIA so future spectrum bands that can support IoT and other wireless applications are made available in a timely manner.

Second, to best support successful IoT growth, the U.S. Government should maintain its policy of technology neutrality to facilitate the virtuous cycle of innovation fueling the mobile revolution. The U.S. Government should not pick technology winners (and losers) or define IoT-specific spectrum allocations. It should instead implement flexible use policies and rules in future spectrum bands to allow new, improved technologies to be freely developed and deployed. This policy will be essential to serving the increasingly diverse needs of the IoT.

Third, the U.S. Government should continue to support industry-led standardization processes to continue U.S. technology leadership on IoT. These standardization processes have enabled the U.S. to lead the world in 4G LTE deployment and are now enabling the U.S. to lead the way on 5G. The global standardization efforts conducted through the 3GPP organization for 4G LTE, for example, have been very successful in enabling the commercialization of new technologies without governmental intervention.

Qualcomm also actively participates in the IEEE's Wi-Fi standards efforts and the oneM2M organization that is defining an operating system for IoT devices. Furthermore Qualcomm engineers are actively engaged and serve on the boards of the Wi-Fi Alliance, the Bluetooth Special Interest Group, the Thread Group, and the Homeplug Alliance, among others. All of these industry associations are developing and promoting specifications and

interoperability programs for IoT connectivity technologies. Qualcomm's goal is to actively work across the various standardization bodies that touch the IoT to consolidate efforts to maximize effectiveness and enable broad interoperability by reducing fragmentation.

Fourth, Qualcomm encourages NTIA and other U.S. government agencies to continue their dialogue and engagement with their counterpart agencies in other countries, with particular emphasis on the aforementioned priorities of spectrum allocation, industry led standards and pro-competitive investment policies.

Finally, the U.S. Government should continue to enact policies that support investment in IoT technology development and streamline the deployment of wireless infrastructure for IoT by reducing unnecessary regulatory burdens. These policies will be essential to IoT success because the networks of tomorrow will be increasingly complex and have greatly densified infrastructure.

Qualcomm respectfully requests that NTIA incorporate these five core components into the U.S. Government's policy framework to support continued IoT growth. With the proper policy framework in place, the IoT will transform our homes, our workplaces, and our lives as well as critically important sectors of our economy — from manufacturing and transportation to urban planning, healthcare, and agriculture. Qualcomm is very excited about developing and deploying the communications technologies, services, and applications for the IoT.

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Qualcomm Incorporated is pleased to provide these comments in response to NTIA's request for public comment on the roles U.S. Government should play in partnership with the private sector to foster the advancement of IoT technologies.¹ Qualcomm respectfully submits these comments to inform NTIA's efforts to prepare a "green paper" identifying the key issues impacting IoT deployments, the potential IoT benefits and challenges, and suggested roles for the federal government to foster IoT technology growth. If properly supported by the policies delineated herein, the IoT will enable smarter homes, smarter cities, improved transportation systems, enhanced healthcare, and greater efficiency and productivity in countless other fields.² Qualcomm is very excited by the IoT and is engaged on multiple fronts to enable IoT technology in tags, sensors, devices, and machines that interact with each other and form the basis of services that improve all aspects of our lives.³

¹ See NTIA, The Benefits, Challenges, and Potential Roles for the Government in Fostering the Advancement of the Internet of Things, *Notice, Request for public comment*, 81 Fed. Reg. 19956 (Apr. 6, 2016) (the "Request").

² See Qualcomm Internet of Everything website, *available at* <https://www.qualcomm.com/products/internet-of-everything> (last accessed June 2, 2016).

³ In these Comments we refer to "Qualcomm" for ease of reference. In connection with our fiscal 2013 reorganization, Qualcomm Incorporated operates our patent licensing business,

INTRODUCTION

Since its founding over thirty years ago, Qualcomm has been working to interconnect all devices, places, and people so they can use such connectivity to create new applications, services, and industries that enable economic efficiencies and continued growth. Qualcomm is helping a growing swath of industries evolve through the IoT. As IoT technology in homes, cars, cities, farms, schools, healthcare facilities, and individuals share data and more interactions occur across a wide collection of communications networks, the realm of possibilities will continue to be redefined.

The NTIA Request is timely because we are still in the early stages of IoT deployments. By defining core principles and goals for the government's role in the IoT, the U.S. will be better positioned to lead in this 21st Century technological space. Qualcomm therefore applauds NTIA for seeking input on a U.S. Government framework to best foster IoT innovation and growth.

DISCUSSION

I. Qualcomm Is Enabling The IoT On A Multitude Of Fronts

Qualcomm is working on many fronts to enable entire industries to evolve via IoT communications technologies. Our wireless solutions are being used today to help businesses, homes, cars, cities, and farms, as well as students, educators, patients and doctors share richer interactions and data across a variety of networks and systems. Qualcomm is transforming the way people use all kinds of devices and access nodes, not just by connecting things, but also by adding intelligence to devices and things, such as machine learning and interoperability.

QTL, and owns the vast majority of our patent portfolio, while Qualcomm Technologies, Inc., its wholly-owned subsidiary, now operates, along with its subsidiaries, substantially all of our products and services businesses, including our semiconductor business, QCT, and substantially all of our research and development functions.

A. Qualcomm Is The World's Largest Provider Of Wireless Chipsets

With a three-decade-long heritage of creating wireless connections and ecosystems, Qualcomm technologies are already at the heart of the IoT. Qualcomm created the integration of wireless connectivity and computing that ignited the wireless revolution, and we have been enabling platforms that connect and deliver necessary intelligence since well before the phrase “Internet of Things” was part of the popular lexicon.

Qualcomm’s Snapdragon microprocessors and radio-frequency (“RF”) modems provide solutions for a variety of industries and products — from sensors and wristwatches to automobiles and drones. Snapdragon processors are driving innovation beyond the smartphone to IoT devices, making them more aware, connected, intelligent, and interactive. They support cutting-edge performance, ultra-fast connectivity, and extended battery life. As explained below, Qualcomm is helping people and “things” share more interactions and data across a variety of networks.

Qualcomm currently offers a broad range of RF wireless modem chipsets that are cost-optimized, flexible, and scalable. These chipsets support global cellular operations in multiple spectrum bands so devices may operate throughout the world and short-range connectivity in unlicensed bands to enable IoT applications like health monitoring, smart metering, security, product tracking, wearables,⁴ point-of-sale interactions, and industrial automation. For example, Qualcomm’s MDM9207-1 3G/4G LTE multimode/multiband chipset has integrated positioning,

⁴ See, e.g., Qualcomm Press Release, “Qualcomm Extends Industry-Leading Snapdragon Wear Lineup with New Processor, Platforms and Support for Targeted-Purpose Wearables – Snapdragon Wear 1100 SoC Ideal for Connected Kid and Elderly Watches; New Reference Platforms Support Fast Development Time,” (May 31, 2016) *available at* <https://www.qualcomm.com/news/releases/2016/05/31/qualcomm-extends-industry-leading-snapdragon-wear-lineup-new-processor> (last accessed June 2, 2016).

an advanced power save mode that provides up to 10 years of battery life, and the ability to add voice, 802.11ac Wi-Fi and Bluetooth Low-Energy (“BLE”) interfaces.⁵ Snapdragon 4G LTE multimode chipsets also are backwards compatible to legacy 2G/3G networks so devices can perform at rural customer sites that may only have 2G/3G connectivity and in metropolitan areas that offer 4G LTE coverage.

Cellular technologies that traditionally have operated in licensed spectrum will become increasingly integrated with unlicensed technologies, like Wi-Fi, LTE Unlicensed, and Bluetooth, to provide the essential connectivity for all “things” and thus leverage the ubiquitous coverage, reliability, and scale of cellular with short-range wireless technologies to support a rich and varied collection of IoT applications and services.

B. Qualcomm Offers A Broad Collection Of IoT Connectivity Solutions And Is A Leader In Many Standardization Organizations That Support IoT Applications

Qualcomm has a rich connectivity portfolio that operates in both licensed and unlicensed spectrum to provide both spectrally-efficient and power-efficient technologies that address specific IoT needs. LTE technologies enable a wide range of high-performance IoT services scaling from broadband IoT operations at Gigabit speeds to new narrowband LTE IoT

⁵ See “New cost optimized Cat 1 LTE modem for IoT supports devices for global business,” Qualcomm OnQ Blog, (Oct. 25, 2015) *available at* <https://www.qualcomm.com/news/onq/2015/10/26/new-cost-optimized-cat-1-lte-modem-iot-supports-devices-global-business> (last accessed June 2, 2016). Qualcomm also offers Snapdragon-based reference designs that include a 4K connected camera with 64-bit heterogeneous computing and comprehensive connectivity, *i.e.*, Ethernet, Bluetooth, Wi-Fi, 3G and 4G LTE interfaces, advanced video analytics, such as motion and facial detection, facial recognition, object tracking, and other machine learning capabilities. See “Snapdragon 650 IP camera brings consciousness to camera security,” Qualcomm Snapdragon Blog by Jim Merrick, (Feb. 5, 2016) *available at* <https://www.qualcomm.com/news/snapdragon/2016/02/05/snapdragon-650-ip-camera-brings-consciousness-camera-security> (last accessed June 2, 2016).

technologies. LTE Advanced Pro (in Release 13 of the 3GPP standard) introduces two new technologies that have been optimized for IoT, *i.e.*, so-called eMTC, for enhanced Machine-Type Communications (Cat-M1), and NB-IoT for Narrowband IoT applications (Cat-NB1). Another technology called LTE Direct (which is part of 3GPP Release 12) is a device-to-device discovery technology that provides mobile devices with a continuous, always-on awareness of their proximal surroundings. It leverages the LTE network for timing, resource allocation, and user authentication to allow for the efficient discovery of nearby services, offers, and friends by relying upon a limited set of sub-frames for efficient discovery.⁶

eMTC and NB-IoT technologies support longer range, lower power, and lower complexity for wide area IoT applications such as smart metering, security, asset tracking, wearables, point-of-sale and industrial automation — many of which require extremely reliable and power-efficient connectivity to cloud services. Qualcomm’s MDM9207-1 chipset, which is anticipated to be available in commercial products this year, includes support for: LTE Category 1 with up to 10 Mbps downlink and 5 Mbps uplink speeds, LTE FDD, LTE TDD, DC-HSPA, GSM and TD-SCDMA interfaces, a 10+ year battery life, advanced security features, integrated global positioning support, and Qualcomm VIVE™ Wi-Fi 1x1, 802.11ac featuring Qualcomm MU | EFX MU-MIMO technology and BT 4.1 BLE.⁷ Also, the MDM9206 modem will allow device manufacturers to enable cost-optimized solutions for low data rate IoT applications more

⁶ See Qualcomm LTE Direct Proximity Services *available at* <https://www.qualcomm.com/invention/technologies/lte/direct> (last accessed June 2, 2016).

⁷ See Qualcomm Press Release, “Qualcomm Announces New Modem Solutions Designed to Support Reliable, Global Connectivity to the Internet of Things — New MDM9207-1 Enables Scalable, Power-Efficient and Cost-optimized Cat 1 LTE Connectivity — New MDM9206 Provides a Path to LTE Cat-M (eMTC) and NB-IOT Standards,” (Oct. 26, 2015) *available at* <https://www.qualcomm.com/news/releases/2015/10/26/qualcomm-announces-new-modem-solutions-designed-support-reliable-global> (last accessed June 2, 2016).

efficiently addressed by a narrowband modem while providing enhancements for ultra-low power and extended range. Feature support for and the availability of the MDM9206 chipset is expected to align with the 3GPP Release 13 standards timing for new eMTC and NB-IoT technologies.

At Mobile World Congress 2016 earlier this year, Qualcomm demonstrated a number of wireless industry milestones, such as: (i) breaking the 1 Gbps mobile data rate barrier with our Snapdragon X16 LTE modem, (ii) 4x4 LTE MIMO operations in a smartphone, and (iii) several demos showcasing the IoT future using LTE-based and 5G connectivity.⁸ One demo showcased how LTE-enabled IoT devices can achieve 10 years of battery life on two AA batteries, via the advanced power save mode of the MDM9207-1 modem. A second demo, conducted in collaboration with Ericsson, previewed the Extended Idle DRX feature for LTE Cat-M1/NB1 that allows the mobile network and IoT device to synchronize timing where the device awakes to receive data from the network in between very long intervals of downtime, thereby extending precious battery life.

Qualcomm's chipsets also are enabling devices, systems, and people to interact in new and intelligent ways by using cognitive technologies that incorporate computer vision, always-on awareness, and machine learning. Computer vision allows smartphones and tablets to interact with things such as books, catalogs, toys, and clothing to enable real-time interactions. Qualcomm also is driving interoperability across brands and ecosystems. Qualcomm companies

⁸ See Qualcomm Press Release, "Qualcomm Announces Showcase of Connectivity Leadership with Debut of Several Live Demonstrations— Highlights Include Gigabit Class LTE Speeds with Qualcomm Snapdragon X16 LTE Modem, Additional 4G, 5G and Wi-Fi Milestones at Mobile World Congress," (Feb. 17, 2016) *available at* <https://www.qualcomm.com/news/releases/2016/02/17/qualcomm-announces-showcase-connectivity-leadership-debut-several-live> (last accessed June 2, 2016).

originally developed the AllJoyn open source framework that enables apps and devices from various manufacturers to discover and securely communicate with each other using standard interfaces. AllJoyn is now hosted and developed by the AllSeen Alliance, a cross-industry consortium dedicated to enabling the interconnectivity of the billions of devices, services and apps that will comprise the IoT.⁹ Qualcomm also is a member of the Open Connectivity Foundation (“OCF”) that is creating an IoT specification to connect devices, phones, computers, and sensors from diverse manufacturers with one another regardless of manufacturer, operating system, or chipset.¹⁰

Qualcomm is very active in many standards bodies that are working to support IoT applications. In addition to the 3GPP standardization efforts (on e-MTC, NB-IoT, LTE Direct, and other cellular technologies) noted above, Qualcomm also actively participates in the IEEE 802 efforts to define enhancements to existing Wi-Fi standards, such as 802.11ah (for low power operation in the 902-928 MHz band), 802.11ac (for 5 GHz unlicensed uses), and 802.11ad and 802.11ay (for 60 GHz unlicensed uses), and we are working with our wireless industry partners on 802.11ax, the next Wi-Fi standard that will bring improved performance in dense networking scenarios. Qualcomm also serves on the boards of the Wi-Fi Alliance, the Bluetooth Special Interest Group (“Bluetooth SIG”), the Thread Group, and the Homeplug Alliance. All four industry groups are actively pursuing industry interoperability programs for IoT connectivity technologies: Wi-Fi, Bluetooth, 802.15.4, and Powerline technologies, respectively.

In addition, Qualcomm is an active participant in the oneM2M organization that is developing standards for machine-to-machine (“M2M”) and the IoT. Specifically, oneM2M is

⁹ See AllSeen Alliance website available at <https://allseenalliance.org/>.

¹⁰ See Open Connectivity Foundation website available at <http://openconnectivity.org/>.

developing technical specifications for a common M2M Service Layer that can easily be embedded into hardware and software and interconnect a wide range of devices associated with M2M application servers around the world. oneM2M will create a distributed software layer, much like an operating system, to enable interworking with different technologies, including AllJoyn and OCF IoT devices. A fundamental principle underlying the breadth of Qualcomm's activities is to actively work across the various standardization bodies to consolidate efforts to maximize effectiveness and enable broad interoperability by avoiding fragmentation and reducing duplicative efforts. In this way, standardization results in improved time-to-market for new IoT devices, applications, and service.

C. Qualcomm's IoT Solutions Are Enabling Smarter Homes And Healthcare, And Enhancing Automobiles, Drones, And Smart Cities To Improve All Our Lives

Qualcomm is developing IoT solutions directed at certain core market segments that are experiencing strong growth, as described below.

Smart Homes. Qualcomm offers connectivity solutions to make homes smarter using both wireless and wireline connections. The Snapdragon smart home reference platform integrates computing, voice recognition, audio, display, camera, connectivity, and control capabilities in a single package, and is aimed at equipment manufacturers and developers seeking to create smart home devices that are becoming increasingly intuitive.¹¹ Like other Qualcomm reference platforms, the smart home reference platform is designed to speed the time-to-market

¹¹ See Qualcomm Press Release, "Qualcomm Announces Smart Home Reference Platform Utilizing Powerful Computing, Voice Recognition, Audio, Display, Camera and Connectivity Capabilities — Platform Utilizes Snapdragon 212 Processor to Enhance and Drive New and Rich Smart Home User Experiences," (Jan. 5, 2016) *available at* <https://www.qualcomm.com/news/releases/2016/01/05/qualcomm-announces-smart-home-reference-platform-utilizing-powerful> (last accessed June 2, 2016).

for equipment makers and developers by providing them with a suite of capabilities that include smart speakers, home control hubs, home appliances, and multimedia devices like TVs and set-top boxes.

Qualcomm also has a Smart Gateway that combines several Qualcomm technologies: VIVE, Powerline, and Streamboost, and uses the AllJoyn open source framework to create a platform at the center of the smart home that is more intelligent, personalized, and secure.¹² Qualcomm VIVE with multi-user MIMO allows a Wi-Fi router to improve service to multiple devices by operating in multiple unlicensed bands simultaneously. Qualcomm Powerline solutions use a home's existing electrical outlets and wiring to enable a robust, high-performance network that solves connectivity issues in hard-to-reach areas. Qualcomm's AllPlay, which is based on AllJoyn, allows music from a range of music services to be streamed on both iOS and Android devices and connect to AllPlay-compatible speakers. Finally, Qualcomm's Streamboost intelligently manages a home's broadband connection to provide each device and application with the bandwidth it needs to ensure the best possible end user experiences in the connected home.

Mobile Healthcare. Qualcomm's Qualcomm Life ("QCL") subsidiary is a medical device manufacturer focused on medical device connectivity and data management. QCL is pioneering mobile and wireless health by enabling new connected care models for medical device manufacturers to deliver wireless health to those who need it quickly and easily. QCL has developed several medical device data system products including the 2net Hub, 2net Mobile and 2net Platform.¹³ The 2net Hub and 2net Mobile connect medical devices to the 2net

¹² See Qualcomm's Smart Home solutions available at <https://www.qualcomm.com/products/smart-home> (last accessed June 2, 2016).

¹³ See Qualcomm 2net Platform, available at <https://www.qualcomm.com/products/2net>

Platform's data center. The Hub is a compact "plug-and-play" mobile broadband gateway that supports many different wireless interfaces. 2net Mobile is a medical-grade software module that can be embedded in third-party mobile applications to enable computing devices, smartphones and tablets to function as medical-grade gateways.

The 2net Platform reliably captures and delivers medical device data to integrated portals or databases. The 2net ecosystem is an example of how Qualcomm Life is propelling mobile health care applications and services into the future, where seamless connectivity, care coordination, and patient engagement increase efficiencies, help lower costs, and improve patient outcomes.

Automobiles. Qualcomm is placing advanced wireless connectivity inside vehicles to make them more intelligent and aware, and enable them to operate cleaner and safer. Qualcomm-enabled automotive solutions are reshaping the relationship between vehicles and roadway infrastructure and drivers and passengers by supporting fully-integrated in-car connectivity that enhances safety and vehicle performance. Qualcomm's X12 LTE modem integrates advanced 4G LTE technologies to provide continuous, secure connectivity for in-car technology and personal devices while integrated in-vehicle sensors use Qualcomm's machine learning tools to provide cognitive awareness and problem diagnosis.¹⁴ Qualcomm also is enabling connected vehicles that support 802.11p DSRC for V2X (*i.e.*, Vehicle to Vehicle / Infrastructure) communications.¹⁵

(last accessed June 2, 2016).

¹⁴ See Qualcomm's Automotive Solutions available at <https://www.qualcomm.com/products/automotive> (last accessed June 2, 2016).

¹⁵ See Qualcomm Press Release, "Qualcomm Announces Breakthrough Automotive Processor with Integrated LTE Modem and Machine Intelligence to Further its Leadership in the Connected Car — Qualcomm Snapdragon 820 Automotive Family Offers LTE-Advanced

Drones. Qualcomm currently offers the Snapdragon Flight reference design platform targeted specifically for consumer drones and robotics applications. This reference design platform uses the Qualcomm Snapdragon 801 processor and integrates robust wireless connectivity with drone software and development tools.¹⁶ Snapdragon Flight integrates Qualcomm’s expertise in computer vision, cameras, connectivity, positioning location tools, and processing onto a single board half the size of a credit card, and thus allows manufacturers to build drones that are lighter, smaller, lower cost, and power efficient to provide long battery life and superior performance.

In April 2016, Qualcomm received a Certificate of Authorization (“COA”) from the FAA to conduct drone research and testing using cellular technologies, including new 5G technologies, to enable flight operations beyond visual line of sight and at night.¹⁷ This COA is unique because the Qualcomm campus is located within highly restricted Class B airspace, just several miles away from an operational airport with a very active air traffic control tower.

Smart Cities. Qualcomm is heavily involved in smart cities. We are a member of the CityBridge joint venture that the New York City government selected to replace over 7,500

Connected Platform with Heterogeneous Compute, Machine Intelligence, Scalability from Premium to Standard Tiers, and Leading Graphics and Video Capabilities,” (Jan. 5, 2016) available at <https://www.qualcomm.com/news/releases/2016/01/05/qualcomm-announces-breakthrough-automotive-processor-integrated-lte-modem> (last accessed June 2, 2016).

¹⁶ See Qualcomm Press Release, “Qualcomm Announces Reference Platform with High-end Performance Capabilities to Advance Consumer Drones — Qualcomm Snapdragon Flight Supports Small, Light Drones with Advanced Video and Image Capture, Communication and Navigation Features,” (Sept. 10, 2015) available at <https://www.qualcomm.com/news/releases/2015/09/10/qualcomm-announces-reference-platform-high-end-performance-capabilities> (last accessed June 2, 2016).

¹⁷ See “Qualcomm Technologies receives FAA authorization necessary to accelerate drone technology development,” Qualcomm OnQ Blog (Apr. 7, 2016) available at <https://www.qualcomm.com/news/onq/2016/04/07/qualcomm-technologies-receives-faa-authorization-necessary-accelerate-drone> (last accessed June 2, 2016).

payphones with “Link” structures that provide Wi-Fi access at gigabit speeds and on-street links to city services, and Qualcomm technologies are enabling each Link.¹⁸ The five-borough LinkNYC network is funded through advertising revenues and is being built at no cost to taxpayers.

Qualcomm technologies also are enabling IoT solutions that can scale to support smart buildings and smart infrastructure in America’s cities. Smart water tools can detect leakage, system pressure, metering, contaminants and hazardous chemicals via water system integrators. Smart energy tools can manage, in real time, energy delivery and consumption via smart metering. Small cell technology integrated with outdoor lighting can improve public safety. And, smart waste management tools decrease waste and recycling costs through use of smart receptacles.¹⁹ Given that 70% of the world’s population in 2050 is expected to live in urban environments, IoT investments in smart cities that intelligently synch these core operational areas will benefit an overwhelming majority of the U.S. population.²⁰

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As the discussion above makes clear, the IoT will comprise a broad suite of solutions in a multitude of places that are designed to satisfy particular needs, and Qualcomm is working with many industry partners to develop and grow these solutions. The U.S. Government should

¹⁸ See “LinkNYC officially launches free gigabit Wi-Fi—powered by Qualcomm solutions,” Qualcomm OnQ Blog (Feb. 19, 2016) *available at* <https://www.qualcomm.com/news/onq/2016/02/19/linknyc-officially-launches-free-gigabit-wi-fi-powered-qualcomm-solutions> (last accessed June 2, 2016).

¹⁹ See Qualcomm’s Smart Cities Solutions *available at* <https://www.qualcomm.com/products/smart-cities> (last accessed June 2, 2016).

²⁰ See Population Reference Bureau website, “Human Population: Urbanization” *available at* <http://www.prb.org/Publications/Lesson-Plans/HumanPopulation/Urbanization.aspx> (last accessed June 2, 2016).

define an IoT policy framework that implements the foundational elements delineated in the following sections of these Comments and continue working with industry to support the continuation of today's successful efforts in the IoT space.

II. Much More Wireless Spectrum Will Be Needed To Fuel Continued IoT Growth

To support well into the 21st Century the broad-range and growing number of IoT applications like those described above, more spectrum resources will be needed. Thus, NTIA should continue working with the FCC and with federal agencies that use spectrum to identify and allocate additional spectrum for the IoT and other wireless applications and services.

Fully cleared spectrum that can be exclusively licensed for mobile broadband use will remain the gold standard, but Qualcomm recognizes that the wireless industry and the U.S. Government need to consider alternative means of accessing spectrum, including sharing mechanisms that allow a spectrum band to be used for commercial wireless applications, including IoT applications, where and when the band is not being used to satisfy government needs. Any and all available spectrum that can support IoT needs should be considered closely.

A. We Are In The Midst Of Tackling The "1000X Challenge"

Several years ago, Qualcomm announced its "1000X Challenge," a company initiative to support the extraordinary growth of mobile data usage. Mobile broadband data usage has been doubling annually, and if the trend continues for ten years, the level of usage in a decade will be more than 1000 times today's level. The 1000x Challenge is aimed at supporting this growth by expanding the wireless capacity of today's mobile broadband networks by 1000 times. The opening of additional mobile spectrum is one of the key means of tackling the 1000X Challenge.

Qualcomm has a long history of working with the U.S. Government to free up additional spectrum for wireless applications. Most recently, we have been directly involved in the opening

of the 600 MHz band being repurposed for mobile use via the FCC's incentive auction. We provided technical guidance the FCC relied upon in defining the post-auction band plan that will support licensed mobile operations. We also worked closely with the FCC and with NTIA to enable sharing in the 3.5 GHz band for mobile use while protecting naval radars and other federal systems. And, we are now providing the FCC with technical submissions to support the opening for mobile use of the very-wide millimeter wave spectrum bands in the FCC's *Spectrum Frontiers* proceeding. Qualcomm will continue this close involvement with the FCC and NTIA so the pipeline for spectrum to support IoT and other wireless applications remains open.

In addition to accessing additional spectrum resources, network densification using small cells will play an important role in supporting the growth in devices, applications, services, and data usage, and Qualcomm has developed, and is continuing to refine, self-organizing networks that integrate small cell solutions. Thus, it is critically important that the U.S. Government continue to implement policies to streamline the approvals necessary to deploy wireless network equipment infrastructure.

B. U.S. Government Should Make Additional Spectrum Available For Any And All Wireless Uses And Should Avoid Defining IoT-Specific Spectrum Allocations

The U.S. Government should consider all potential spectrum bands for potential use for IoT applications but it should avoid limiting spectrum bands to IoT uses only. Low, mid and high band spectrum not only will be essential to support IoT devices, applications and services, but it also will be needed for other next generation wireless technologies (*e.g.*, 5G, 6G, 802.11ax, etc.) that will support greatly enhanced broadband connectivity for high-speed video and data services to consumers, for example. This likewise applies to mission-critical services, such as connected autonomous vehicles, critical infrastructure management, remote medical procedures, as well as command and control communications for drones and robotics, all of which will make

use of many different spectrum bands.

The U.S. Government should not define service-specific spectrum, such as IoT-only usage, because the consumers, developers, and the wireless industry at large require the flexibility to use any and all types of spectrum to support IoT services and any other wireless services. Some IoT applications will demand high-bandwidth support and thus may work best in the millimeter wave bands, while other IoT applications will need low-power, low-duty-cycle, long-range performance and thus be best supported by the sub-3 GHz bands. Without question, all spectrum bands — low-band spectrum below 6 GHz, mid-band spectrum from 6 to 20 GHz, and high-band spectrum above 20 GHz — will be needed for the continued successful deployment of the IoT and other applications and services.

Also, while Qualcomm generally supports international harmonization of spectrum because it can simplify device design complexity, promote economies of scale and global roaming capabilities, the U.S. should not restrict itself from considering spectrum that may not immediately lend itself to harmonization — like the FCC has done with regard to the 27.5-28.35 GHz band in its *Spectrum Frontiers* proceeding.²¹

III. Flexible-Use, Technology-Neutral Regulatory Policies Will Support The Successful Design And Deployment Of Highly Useful IoT Devices, Applications And Services

In order for the IoT to continue to flourish, the U.S. Government should avoid choosing technology winners and losers and instead let the vibrant communications market flourish by relying upon technology-neutral, flexible-use policies and regulations such as those the FCC has traditionally applied to its licensed and unlicensed wireless services.

²¹ See, e.g., Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, GN Docket No. 14-177, *Notice of Proposed Rulemaking*, FCC 15-138 (Oct. 23, 2015).

Indeed, much is unknown about the future uses of IoT, including the business structures, distribution and supply chains, and the uses and flows of data that future IoT devices, applications, and services will create. For this reason, the U.S. Government should tread very carefully in the legislative and regulatory space so as to let any and all innovative, and potentially ground-breaking, technologies be freely developed. Indeed, flexible rules and policies are key to the future success of the IoT.

A. The U.S. Government Should Encourage Industry-Led Standards Efforts

Relatedly, the U.S Government should encourage industry-led standards to drive flexible, interoperable, and secure solutions that can scale across a global IoT ecosystem. The global standardization efforts conducted through the 3GPP, IEEE, and Bluetooth SIG organizations, for example, have been very successful.²² This approach to standardization also is consistent with federal policies to promote commercial-driven solutions without governmental intervention.

Global standards have accelerated adoption of wireless technologies, driven competition, enabled the cost-effective introduction of new technologies, and have provided easy-to-use plug-and-play solutions. Thus, there is no question that a certain level of standardization will be needed to drive a successful, nationwide smart cities' security ecosystem, for example, to ensure multiple applications can securely communicate with one another, with municipal infrastructure, and with public safety personnel. Federal and state governments should encourage such standardization but refrain from mandating specific technologies in order to let marketplace competition work to a successful resolution.

²² See, e.g., 3GPP - Global Standards Organization available at <http://www.3gpp.org/>.

B. U.S. Government Agencies Should Engage With Their Overseas Counterparts

Coordination among industry and governments around the world will be critical to fully realize the successful development and deployment of IoT technologies. Qualcomm encourages NTIA and other U.S. government agencies to continue their dialogue and engagement with counterpart agencies in other countries, with particular emphasis on the aforementioned priorities of industry led standards, spectrum allocation, and pro-competitive investment policies. The use of government and private sector joint dialogues will facilitate information sharing and help to advance an IoT policy and regulatory environment that is the least trade restrictive and in line with U.S. goals of advancing competition and innovation.

IV. The U.S. Government Should Implement Policies That Enable The Timely Deployment Of Wireless Infrastructure To Support The IoT

The IoT will place increased demands upon wireless infrastructure and it is essential that infrastructure be able to evolve and improve along with the evolution of the IoT. To support potentially trillions of IoT devices, wireless network infrastructure that is scalable in terms of capacity and is able to handle a broader range of communications needs — in terms of mobility, speed, latency, reliability, and battery-life, for example — could require re-architecting of key components of today's wireless networks to support a broad range of operational needs for the IoT. Thus, the U.S. Government should implement policies and regulations that serve to ease and streamline the deployment of wireless infrastructure in order to support the successful growth of IoT services and applications.

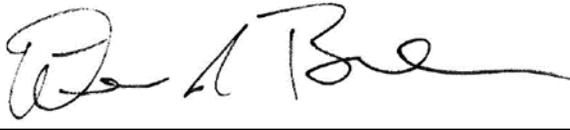
CONCLUSION

NTIA should use as a framework the foundational elements delineated in these Comments as it develops the U.S. Government's policy framework to enable the growth of the IoT. With such a framework, the IoT can transform critically important sectors of our economy from housing, transportation and urban planning to healthcare, education, and agriculture.

We are living in a very exciting time in which the IoT presents truly limitless opportunities. Qualcomm is very enthusiastic about researching, designing, and developing the technologies to support IoT equipment, applications, and services.

Respectfully submitted,

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