Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of Promoting the Deployment of 5G Open Radio Access Networks	GN Docket No. 21-63

COMMENTS OF QUALCOMM INCORPORATED

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April 28, 2021

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Qualcomm is pleased to respond to the FCC's Notice of Inquiry on the status of Open Radio Access Networks ("Open RAN") that seeks input on how the Commission can further the deployment of Open RAN technologies in the United States.[1] Previously, Qualcomm participated in the 2020 FCC Technological Advisory Council ("TAC") initiatives concerning Open RAN that are discussed in the NOI, and we support the TAC's recommendations that the FCC monitor and encourage the development of the Open RAN ecosystem and associated innovation via industry standardization, research and development, and testing to ensure the security and reliability of successful Open RAN deployments.[2] These multi-faceted private sector efforts, which are occurring in parallel and in which Qualcomm is actively participating with our many industry partners, are paving the way for the wireless industry to begin the transition to Open RAN — a transition that will occur over the next several years.

As explained herein, Qualcomm is providing Open RAN-capable infrastructure communications platforms and actively working with its industry partners to enable the

[1] *See Promoting the Deployment of 5G Open Radio Access Networks*, Notice of Inquiry, GN Docket No. 21-63, FCC 21-31 (rel. Mar. 18, 2021) ("NOI").

[2] *See* NOI at ¶ 16.

ecosystem. Accordingly, we welcome the FCC's interest in acquiring information on the status of Open RAN through the agency's all-encompassing NOI and in monitoring the wireless industry's development of, and ultimate transition to, Open RAN.

INTRODUCTION and SUMMARY

The private sector-led development of Open RAN is aimed at opening the wireless infrastructure space to provide increased infrastructure vendor options, which will ultimately lower costs for consumers while ensuring the utmost network security. Major operators in the U.S. and around the world are welcoming this move towards disaggregation of portions of the radio access network ("RAN") and disaggregation of hardware and software. These efforts to open radio interfaces to make RAN interoperability possible for the networks of tomorrow are intended to increase competition among infrastructure suppliers and reduce RAN-related costs. The development of Open RAN goes hand-in-hand with the increasing densification of wireless networks, a trend that began in 4G and is accelerating in 5G.

Qualcomm is very excited by the development of an Open RAN ecosystem and is actively participating in wireless industry efforts to advance Open RAN solutions along multiple parallel tracks aimed at research and development, standardization, testing, and ensuring reliability and security. These tracks are gaining momentum in the broader context of the deployment of 5G networks.

Qualcomm is aggressively advancing the Open RAN ecosystem. We offer both emerging and established network infrastructure vendors with comprehensive horizontal semiconductor infrastructure platforms to support the deployment of high-performance, virtualized, interoperable, and modular 5G networks at scale — making cellular infrastructure more innovative and competitive and lowering costs. Qualcomm's infrastructure solutions support

Open RAN interfaces, and all global frequency bands for both sub-6 GHz and millimeter wave; they are flexible and scalable from macro cells to small cells, supporting both distributed units ("DU") and radio units ("RU"), and the solutions are power efficient, leveraging Qualcomm's industry-leading low-power technologies.

We welcome the FCC's interest in monitoring and supporting the Open RAN ecosystem and are pleased to offer detailed responses in these comments to many of the questions in the Commission's NOI.

DISCUSSION

I. The Wireless Industry Is Working To Advance Open RAN Solutions Along Multiple Parallel Tracks Focused On R & D, Standardization, Testing, Reliability, And Security

The mobile industry has been working to advance Open RAN infrastructure solutions for the past several years. As described below, several different organizations are working along parallel tracks directed at Open RAN research and development, standardization, testing, system reliability, and security. Qualcomm is actively engaged in each of these organization's efforts to enable Open RAN solutions around the globe.[3]

A. Qualcomm Is Working With Industry Partners To Enable Open RAN

The O-RAN ALLIANCE, Small Cell Forum ("SCF"), and the Third Generation Partnership Project ("3GPP") each provide key standards and specifications for Open RAN. The O-RAN ALLIANCE has attracted more than 200 companies focused on developing open architecture and interfaces, use cases, multi-vendor testing, demos, white box reference designs, and open-source projects. O-RAN ALLIANCE efforts currently involve mobile operators and

[3] *See, e.g.*, NTT DoCoMo Press Release, "Creation of "5G Open RAN Ecosystem" to Accelerate Open RAN to Operators Globally," (Feb. 3, 2021) *last accessed* Apr. 28, 2021.

suppliers of all sizes and from all regions of the world. In the U.S., all major mobile operators are involved.

The Small Cell Forum ("SCF") is responsible for 5G Functional Application Platform Interface ("FAPI") specifications, which are at the core of small cell solutions. These also are applicable to other 5G base station classes, such as pico and macro base stations. In addition, 3GPP provides the overall system definition including multiple interfaces for the O-RAN ALLIANCE architecture. The FCC NOI mentions the Telecom Infra Project ("TIP") and Open Networking Foundation ("ONF") as potential sources of Open RAN solutions. These two groups are forums for implementers to work together on solutions. In this regard, there is some overlap between the TIP and the O-RAN ALLIANCE.

Qualcomm is a leading contributor to each of the foregoing organizations that are actively working to ensure the success of Open RAN.

The NOI asks if the Common Public Radio Interface ("CPRI") is a viable alternative to Open RAN.[4] CPRI has been deployed and provides existence proofs of RAN disaggregation, where baseband processing is separated from radio units. Unfortunately, each of these implementations are proprietary. The O-RAN ALLIANCE open fronthaul is designed to provide a standard mechanism where CPRI vendor-proprietary systems are currently used and has the potential to interwork with this legacy equipment. Open RAN approaches also incorporate the advanced technologies emerging from the data-center space, such as virtualization, containerization, and orchestration, and from the networking space, such as Software Defined Networking and IEEE 802.3 multi-gigabit links. U.S. leadership is significant in each of these technology areas.

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4 *See* NOI at ¶ 24.

There is no question that system integration is critical for Open RAN.[5] The role of system integrator can be played by an infrastructure vendor, service providers, or some other entity. One notable technology trend on this front is the interest in Open RAN from cloud computing leaders, such as Microsoft Azure, Amazon Web Services ("AWS"), Google, and Facebook, each of whom is offering platforms to streamline the system integration effort.

B. Qualcomm's 5G RAN Platforms Support Open RAN Interfaces

Qualcomm offers comprehensive horizontal semiconductor ASIC solutions to small cell and larger base station infrastructure vendors. Our small cell FSM ("Femtocell Station Modem") solution offers infrastructure vendors a means of developing high performance and power efficient small cell products. Qualcomm's small cell FSM solution is used by many small cell vendors, including Airspan, Altiostar, Baicells, Corning, Radisys, Samsung, and Sercomm.[6] And, service providers are deploying Qualcomm's FSM small cell platform in their networks.[7] Combined with its advanced capabilities, including the flexibility to support virtual RAN and open RAN interfaces, Qualcomm's 5G RAN platform gives infrastructure providers the ability to provide connectivity solutions so end users have increased access to the reliable, robust, and powerful mobile experiences enabled by 5G.

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5 *See* NOI at ¶ 50.

6 *See, .e.g.*, Corning News Release, "Corning Announces 5G mmWave In-Building Network Systems Utilizing Qualcomm Technologies 5G Expertise," (Feb. 20, 2020); Qualcomm Press Release, "Samsung and Qualcomm Work to Deliver Industry Leading 5G NR Small Cell Infrastructure," (Oct. 22, 2018); *see also* Qualcomm Press Note, "Global Cellular Infrastructure Firms Select Qualcomm 5G RAN Technologies," (Feb. 25, 2020) *each last accessed* Apr. 28, 2021.

7 *See id; see also* Qualcomm Press Release, "Rakuten and Qualcomm Technologies Lay Foundation for a 5G-ready Mobile Network across Japan by Utilizing the Latest in Small Cells," (Feb. 25, 2019); Samsung Newsroom U.S., "Samsung Brings 5G Indoors With New Commercial 5G mmWave Small Cell For In-Building Use," (Sept. 24, 2020) *each last accessed* Apr. 28, 2021.

Qualcomm's expanded infrastructure RAN platform furthers the Open RAN ecosystem, because we provide both emerging and established network infrastructure vendors with a comprehensive horizontal semiconductor infrastructure platform to support the deployment of high-performance, virtualized, interoperable, power-efficient, and modular 5G networks at scale — making the cellular infrastructure ecosystem more innovative and competitive. Qualcomm's infrastructure solutions support both sub- 6 GHz and millimeter wave frequency bands and are flexible and scalable from high-power, high-capacity macro cells to low-power, cost-effective small cells, supporting both distributed units and radio units.[8]

As noted above, Qualcomm's solutions have received strong support from many industry players for the extension of our infrastructure portfolio, including mobile service providers such as AT&T, T-Mobile, and Verizon as well as Vodafone, Dish, DoCoMo, KDDI, KT, Deutsche Telecomm, Reliance Jio, Softbank, Rakuten, KT, SKT, LGU+, and infrastructure vendors such as Samsung, VMware, Fujitsu, and NEC.[9] The traditional strengths of U.S. semiconductor suppliers together with cloud computing providers creates significant opportunities in this space for American companies. To realize this potential, an Open RAN vendor would integrate component technologies into a final product.

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[8] *See* Durga Malladi, Qualcomm OnQ Blog, "5G network virtualization and interoperability: Why the time is now," (Oct 20, 2020) *last accessed* Apr. 28, 2021.

[9] *See, e.g.,* Qualcomm Press Note, "Qualcomm Introduces New 5G Infrastructure Platforms to Drive Cellular Ecosystem Transition to vRAN and Interoperable Networks – New Portfolio of Qualcomm 5G RAN Platforms is Designed to Enable a New Generation of Flexible, Virtualized and Interoperable Cellular Networks Worldwide," (Oct 20, 2020); Qualcomm Press Note, "DISH and Qualcomm to Collaborate on the Development of the Nation's First O-RAN Compliant 5G Network," (Nov 11, 2020) *each last accessed* Apr. 28, 2021.

II. While Qualcomm Does Not See A Need For Direct Regulatory Action Relating To Open RAN, The FCC Can Support Open RAN By Continuing To Release Spectrum For Commercial Uses And Streamline Infrastructure Deployment

Qualcomm does not see any regulatory burdens to developing and deploying Open RAN technologies and does not believe the FCC needs to revise or implement any new regulations to promote Open RAN. Mobile carriers can deploy the technology today, and Qualcomm expects that Open RAN deployments will ramp up as the private sector completes the key pieces necessary to support widespread deployments — including standardization, R & D, and testing. The private sector is aggressively working in each of these areas.

At the same time, the Commission should continue monitoring the many ongoing federal efforts in the Open RAN space that are detailed in the NOI and maintain its present experimental spectrum licensing policy for testbeds. In addition, the FCC should request that the Technological Advisory Council ("TAC") maintain an Open RAN working group focused on this space and continue to track the various national and international Open RAN initiatives.

In addition, the Commission should continue its active efforts to unleash more spectrum for commercial purposes in low-, mid-, and high-bands, and also take action to further streamline infrastructure deployment. These ongoing and much-needed regulatory actions will help create an environment in which Open RAN would not be thwarted by any regulatory obstacle as the need to continually densify wireless infrastructure continues to accelerate.

Open RAN v. Virtual RAN. Open RAN should be clearly distinguished from vRAN or virtual RAN. Both use the same high-level design to move RAN processing to new platforms with functions performed on different virtualized nodes according to various fronthaul and midhaul "splits." While network operators are moving in this direction, Open RAN can help to accelerate the transition by using standardized, open interfaces supported by multiple vendors. The O-RAN ALLIANCE provides key technical specifications and testing procedures to enable

multi-vendor interoperability. In Qualcomm's view, the fundamental problems impeding large scale Open RAN deployments are the lack of maturity of the Open RAN vendor ecosystem.

There is no question that Open RAN is a disruptive technology that provides an entry point for more suppliers to a market that has consolidated around a small set of infrastructure vendors. As the NOI's questions indicate,[10] while there are potential roadblocks to interconnection and interoperation with legacy equipment, Qualcomm expects that broad industry adoption of the open interfaces from 3GPP, the O-RAN ALLIANCE, and the Small Cell Forum would be a major step towards the goals of vendor diversity and healthy competition.

European MoU. Qualcomm agrees with the general direction of the European Memorandum of Understanding, such as its reliance on O-RAN ALLIANCE specifications to encourage interoperable implementations.[11] The U.S. can nonetheless show leadership given strong contributions by American organizations to Open RAN research, development, testing, and standardization.

IP Policy, Open-Source Software, and Open RAN. Although the FCC has no statutory authority to regulate IP and other agencies have far more experience and expertise in this area than the FCC, Qualcomm submits the following brief comments to the NOI. Qualcomm supports access through the fair, reasonable and non-discriminatory ("FRAND") based policy of the O-RAN ALLIANCE to essential patent claims that cover implementations of the O-RAN specifications because it promotes investment in and contributions by patent holders.[12] Patent holders are encouraged by the FRAND policy to contribute significant innovations to support the

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10 *See* NOI at ¶¶ 31-33.

11 *See* NOI at ¶ 30.

12 *See* NOI at ¶ 37.

Open RAN standards needed for developing competent and competitive implementations. There is a risk to the investment cycle for U.S. companies who do not desire to forgo or give up their rights to seek remedy for infringement of their patents in open-source software development, so their patented innovations will often not be contributed to such software work.

A healthy, active open-source software process with multiple participants tends to lead to a higher quality of code due to the presence of additional reviewers of that software.[13] In ideal situations with robustly funded and active projects, the quality of open-source code can approach commercial quality, but even then, it is unlikely any volunteer worker would associate a level of commercial responsibility for aspects, such as build quality testing associated with the open-source work itself. Usually, commercial grade support for what might be considered a well-vetted, secure, finished project would be part of an adjacent service-based revenue businesses, or product-based revenue businesses that are built upon the related open-source project.

Qualcomm supports the broad definition the Commission uses to define open-source software.[14] Its breadth recognizes the many ways to pursue community-based code collaboration, and that definition does not confine the Commission to a narrow definition advocated by some. As context, narrow definitions of open-source sometimes are being used to repudiate the existing FRAND-based standards development framework, and this would create a strong disincentive for companies such as ours to make research investments in key telecom-related sectors necessary for continued technical advancements at the current pace. At the same time, there are highly successful projects that produce open software for 4G and 5G networks (for both RAN

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13 *See* NOI at ¶ 42.

14 *See id.* ("Open-source software 'includes operating systems, applications, and programs in which the source code is published and made available to the public, enabling anyone to copy, modify and redistribute that code.'").

and Core Network elements), using software licenses that provide the benefits of open-source software while preserving the patent rights of technology innovators under FRAND terms consistent with the underlying standard specifications.

Security. Qualcomm believes, without a doubt, that Open RAN implementations need to be both highly reliable and secure. The transparent nature of open-source software components in Open RAN should help eliminate potential software bugs or vulnerabilities based on rigorous code-review and collaborative efforts among stakeholders. The use of open-source software also enables mobile operators to take timely actions against newly discovered vulnerabilities instead of having to rely on vendors to develop and issue patches for impacted products.

It is a misconception that disaggregation of the RAN increases the attack surface. While disaggregation does require new standardized interfaces between RAN components and protection of those interfaces, it can enable additional security protection of a RAN node comprising multiple processes whose interactions otherwise would never be protected properly in a virtualized environment. Disaggregation is realized by compartmentalization and modularization of components, and this reduces the attack surface of each component and prevents a single point of failure. Compartmentalization further enables easier and modular software upgrades and updates while minimizing impacts on system operation.

Finally, and more importantly, deployment flexibility offered by disaggregation enhances Open RAN security. Security sensitive components can be deployed in a relatively secure or even physically protected environment, such as a data center, while other performance sensitive components, but non-security critical radio functions, are deployed close to the end users of wireless services. The advances in cloud security best practices and infrastructure can be further leveraged to provide better security protection for sensitive components of the RAN. In addition,

the distributed nature of the Open RAN architecture provides natural resilience against attacks such as Denial of Service attacks that target service availability.

Software Vulnerabilities. The questions the Commission poses in Paragraph 55 of the NOI relating to open-source software vulnerabilities must be considered when designing a centralized open-source program office to oversee open-source projects. It is important to separate the types of activities here into two categories: (1) technical engagement on a given project inclusive of maintainer roles and contribution reviews, and (2) open-source program management across multiple projects.

For (1), volunteerism should continue to be encouraged but project organizers may need to anticipate that funding may be needed to staff certain project maintainer roles that are either particularly critical, or otherwise unfilled. There are models that enable this, including approaching key sponsors who often willingly offer the volunteer headcount with the motivation to do so fueled by the notion that the volunteer they provide would typically be an employee of that sponsor; this would, in turn, empower that sponsoring company with some level of influence over the direction of the project or at least the branch their employee maintains. So long as that self-interest is recognized as unavoidable, and so long as the particular individual in the role is receptive to community views, this model can be successful.

For (2), an overarching open-source program management function should be created. The global standards of practice in this area are published in ISO/IEC 5230:2020, and the specification is provided by the OpenChain project at https://www.openchainproject.org/ and supported by an active, global community of open-source compliance experts. The process defined by OpenChain's ISO/IEC 5230:2020 standard would result in a functional software bill of materials ("SBOM") of the underlying open-source components, and commercial components

could be reviewed under consistent criteria within the same process flow. However, on top of this, an additional process that addresses the important security concerns already identified should also be created. That security/vulnerability review, identification, and mitigation process would appropriately begin with an accurate SBOM.

Energy consumption of Open RAN is expected to be competitive with other comparable solutions.[15] Open RAN products will have an ecosystem of silicon providers, including Qualcomm, who will compete on energy consumption as a key metric. Further, the use of virtualization allows heavy workloads to be performed efficiently in a centralized data-center type environment with better access to efficient cooling and clean energy sources.

Deployment. Open RAN will need to work well for both greenfield and brownfield deployments.[16] The O-RAN ALLIANCE is working to enable both, including methods that would allow an Open RAN system to interconnect with legacy Common Public Radio Interface ("CPRI") radio units.[17] As noted above, the present lack of open interfaces in legacy systems frustrates deployment of Open RAN in existing networks.

In addition, there is nothing inherent in Open RAN designs that limits scalability. The design approach to flexibly assign workloads across virtualized hardware resources is intended to make the overall system scale at reasonable cost.

The benefit of high-speed fiber is valid not only for Open RAN, but also for any type of 5G network deployment.[18] Regulatory actions that increase and enhance access to fiber connectivity will help accelerate both Open RAN and traditional deployments of 5G networks.

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15 *See* NOI at ¶ 59.

16 *See* NOI at ¶ 58.

17 *See* O-RAN ALLIANCE at https://www.o-ran.org/.

18 *See* NOI at ¶ 59.

While it is true that deployment of Open RAN networks will benefit from easy access to fiber connectivity, in cases where the 5G base station nodes lack access to high-speed network connections, Open RAN also supports deployment of split options 2 and 6. With split option 2, the Packet Data Convergence Protocol ("PDCP") and Radio Link Control ("RLC") layers are separated from the Medium Access Control ("MAC") layer and Physical ("PHY") layer over the F1 interface specified by 3GPP, where the PDCP and RLC layers stay in the central unit, and the MAC and PHY layers are in the radio unit. Option 6 further disaggregates the MAC layer from the PHY layer, where the MAC and upper layers (PDCP and RLC) remain in the central/distributed unit, while the full PHY layer is in the radio unit. Both split options put more functionality in the radio units, thereby reducing the data rate and latency requirements for fronthaul.

CONCLUSION

Qualcomm and its many wireless industry partners are working assiduously towards Open RAN infrastructure, and we strongly support the wireless industry's ongoing evolution to Open RAN. These private sector initiatives are accelerating and expanding at a rapid pace. Qualcomm plans to continue to research, develop, standardize, and support deployment of available parts of the Open RAN architecture to achieve the goals of continuously improving performance, security, competition, and vendor diversity. As explained herein, the best thing the Commission can do to further the Open RAN ecosystem is to continue its active, successful efforts to streamline infrastructure deployment and maintain a steady stream of new spectrum for commercial purposes.

Respectfully submitted,

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