

**GitHub**

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Rebecca Dorch

National Telecommunications and Information Administration (NTIA)
U.S. Department of Commerce
325 Broadway
Boulder, CO 80305

Re: 5G Challenge Notice of Inquiry (86 FR 1949)

Dear Ms. Dorch,

GitHub offers these comments in response to your 5G Challenge Notice of Inquiry. Below we respond to your questions 1(A), 1(C), 2(A), 2(C), and 3(A) in order to explain how collaborative software development best practices can accelerate construction of the open 5G stack and encourage you to consider using our platform to host NTIA Challenge submissions. GitHub does not produce 5G-related technology and would not directly participate in a challenge if the NTIA and DoD were to organize one.

GitHub is the largest software development platform in the world. Headquartered in San Francisco, GitHub enables more than 56 million developers, students, startups, small businesses, large companies, nonprofits, and governments around the world to host and collaborate on open source and proprietary software projects. We count more than 40 federal agencies, sub-agencies, and laboratories among our current customers, and the General Services Administration uses GitHub to develop the Challenge.gov website and application.

Responses

Question 1(A)

How could a Challenge be structured such that it would take advantage of DOD's role as an early U.S. Government adopter of 5G technology to mature the open 5G stack ecosystem faster, encourage more participation in open 5G stack development including encouraging new participants, and identify any roadblocks to broader participation?

The technical motivation for the Challenge notes that “[m]any innovations are being explored in the greater 5G economy” which is “diverse, with a wide variety of organizations in academia, government, and private industry [...] focused on different portions of the stack, with no clear division among the multiple



implementations currently available” and “interoperability among the community’s implementations is not guaranteed.”

Open source¹ collaboration is a well-established approach to these same challenges and opportunities: prolific exploration of innovations by diverse entities, with a strong need for coordination in order to coalesce into a widely adopted and well-maintained stack. For example, open source development of cloud computing infrastructure has produced rapid innovation and wide industry adoption in recent years, including Kubernetes and other projects hosted by the Cloud Native Computing Foundation.

Open source and, more broadly, software collaboration best practices are directly applicable to the challenges of software-intensive 5G. The Challenge should be structured to explicitly address these opportunities and challenges: to encourage diverse innovators to work together toward a complete, mature, interoperable stack that is widely adopted, so as to secure ongoing maintenance and innovation.

Question 1(C)

What should be the goals of a Challenge focusing on maturation of the open 5G stack ecosystem? How could such a Challenge be structured to allow for the greatest levels of innovation? What metrics should be used in the assessment of proposals to ensure the best proposals are selected?

Proposals should be assessed on open source and software collaboration best practices, including:

- Plan to develop solutions in public, for example in a public repository on GitHub.
- Plan to utilize modern software development practices, including continuous integration and security scanning.
- Plan to foster engagement with external contributors during development, for example by establishing clear documentation for contributors, adopting a standard code of conduct for all contributors, and publishing a security policy for how researchers should report any discovered vulnerabilities. Solutions could also be assessed on their actual engagement with external contributors by looking at project maintainer activity and change in contributors and individual commits over the duration of the Challenge.

¹ Open source is defined by the [Open Source Initiative \(OSI\)](#) based on ten criteria. The OSI also maintains a [list of open source-compliant licenses](#).



- Plan to work with “upstream” -- if the solution needs to change any dependencies, those changes should be done in coordination with and contributed back to the developers of those dependencies to the greatest extent possible. This is to the benefit of the ecosystem, and also to the sustainability of the Challenge solution in question by reducing the amount of code the solution developers are solely responsible for maintaining -- which includes keeping up to date with all security issues found in the dependency.
- Plan to exhaustively document any dependencies taken on; see Question 2(C) below.
- Plan for long-term governance of the solution, such as potential transfer to a multi-stakeholder consortium or foundation.
- A clear strategy for understanding the intellectual property used by the solution and vetting the license terms of the software dependencies. Insofar as the Challenge seeks to promote open-source implementations, existing open source licenses that are well-known and understood should be used to facilitate compatibility with other open source projects.
- A clear articulation of what role the proposed solution plays vis-a-vis the open 5G ecosystem, and specifically how it avoids contributing to fragmentation and redundancy, and instead will contribute to the maturity and adoption of the open 5G stack.

These are some illustrative examples of the types of metrics that should be considered in a Challenge that aims to foster solutions that are durable. Further resources can be found at:

- Core Infrastructure Initiative’s [Free/Libre and Open Source Software Best Practices Criteria](#)
- Linux Foundation’s [Setting an Open Source Strategy guide](#)
- GitHub’s [Best Practices for Maintainers](#) and other [Open Source Guides](#)

Question 2(A)

What are the incentives in open 5G stack ecosystem development that would maximize cooperation and collaboration, promote interoperability amongst varied open 5G stack components developed by different participants, and mature desired feature sets faster with greater stability?

Principles of effective software development and open source, in particular, are critical to the open 5G stack ecosystem. Even beyond the context of a particular Challenge, the assessment criteria described in 1(C) can incentivize constructive collaboration and interoperability among components of the open 5G stack.



Question 2(C)

Could a Challenge be designed that would require participants to leverage software bill of materials design principles in the development of components for an open 5G stack?

Software bill of materials (SBOM) design principles are essential for the adoption, maintainability, security, and transparency of an open 5G stack, and to take full advantage of increasing “use of open-source implementations for various components of a 5G system” noted in the technical motivation for the Challenge.

Global contribution to and adoption of an open 5G stack is highly dependent upon trust. Applying SBOM principles throughout the open 5G stack builds trust through transparency, both for adopters, and for developers, who value transparency and accurate credit, per open source and academic norms.

Requiring Challenge solutions to provide an exhaustive accounting of components included, particularly in a standard SBOM format, brings a number of security and other risk-mitigation benefits, including:

- Visibility into what components are used across the ecosystem, so that investment can target the most critical components;
- Rapid discovery and possibility of remediation of security vulnerabilities in components;
- Reduction in intellectual property or other legal risk from undocumented components and their licenses.

Such a requirement would bring further benefits. It would incentivize solutions to utilize standard software packaging and consumption mechanisms, in order to make SBOM provisioning as efficient as possible. Adoption of such standard methods facilitates continued maintenance and open source collaboration after the completion of the Challenge. It also enables Challenge solutions to leverage advanced tools for managing the security of dependencies, such as GitHub’s dependency graph and Dependabot; and issuing and tracking vulnerabilities, such as by using GitHub’s Advisory Database.

Question 3(A)

What software and hardware infrastructure will be needed to successfully execute this Challenge?



As the largest software collaboration platform in the world, GitHub is well suited to host the Challenge. Past innovation challenge participants, including participants in those hosted on Challenge.gov, have often used GitHub to host their software code. Preexisting open 5G stack development efforts are also hosted on GitHub, including the Open Network Automation Platform and OpenAirInterface, which are working with the DARPA Open, Programmable, Secure 5G Program and the NSF Platforms for Advanced Wireless Research testbed POWDER in Salt Lake City, respectively.

GitHub presents several advantages to host participants' Challenge entries. First, insofar as the Challenge aims to promote interoperability with preexisting open 5G stack technologies, participants can collaborate directly with these developer communities where they already congregate on GitHub. Second, GitHub offers a Repository Statistics API that could permit Challenge administrators to judge the health of collaboration on solutions within the Challenge and to assess the outcomes of the Challenge after the fact, for example by monitoring subsequent collaboration against solutions' state plans and documentation efforts. Third, GitHub offers security features to improve the quality of Challenge entries: code is automatically scanned for (1) vulnerabilities and errors, (2) secrets like keys or tokens, and (3) vulnerable dependencies or newly discovered vulnerabilities that may affect dependencies. These security features free on publicly available repositories.

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GitHub thanks you for the opportunity to respond to your questions and discuss how open source best practices and the GitHub platform can support NTIA's goals for a Challenge to accelerate the development of the open 5G stack ecosystem.

Respectfully submitted,

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