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Request for Information on the National Spectrum Research and Development Plan

Spectrum Effect

SPECTRUM EFFECT

Spectrum Effect Response: NSF RFI on the National Spectrum R&D Plan

Networking and Information Technology Research and Development (NITRD) National Coordination Office (NCO), National Science Foundation

March 21, 2024

Spectrum Effect welcomes the opportunity to respond to the National Science Foundation's (NSF) Request for Information (RFI) on the National Spectrum R&D Plan.

COMPANY PROFILE

Spectrum Effect develops software for the global mobile operator community with state-of-the-art solutions for radiofrequency (RF) interference analysis and mitigation. Spectrum Effect's leading product, Spectrum-NET, utilizes patent-protected machine learning (ML) algorithms in private and public cloud environments to analyze cellular network performance data and provide operators with improved situational awareness and the ability to mitigate harmful interference in near-real time. More than 7,000,000 hours of labeled RF interference data from 50+ mobile operator networks are used to train Spectrum-NET's Convolutional Neural Network (CNN) models, resulting in the industry's highest accuracy solution for automatically classifying RF interference signatures.

We are a U.S. company headquartered in Kirkland, WA. The Spectrum Effect team is passionate about creating disruptive technologies, engineering excellence, and enhancing the experience of mobile operators. Our perspectives reflect our role as a developer of software used by Tier-1 U.S. mobile carriers and as a party interested in assisting federal stakeholders better craft solutions for efficient spectrum management.

SPECTRUM EFFECT'S OVERALL COMMENTS ON THE RFI

Spectrum Effect appreciates that NSF, through the NITRD NCO, is collecting industry feedback as it implements the National Spectrum Strategy (NSS) and works towards promoting an R&D ecosystem that can aid the future spectrum economy.

From our perspective, it is essential that federal R&D efforts select the correct targets for promoting key areas of innovation. The creation of an R&D plan that supports the strategic goals of the NSS will undoubtedly lead to closer public-private collaboration on technical standards and policy related to spectrum management technologies. This is particularly true for Spectrum Effect, which has historically operated in the commercial market, but would be further enabled by the opportunity to partner with federal agencies and research organizations on their efforts to promote the adoption of advanced spectrum management capabilities.

Our data scientists and engineers have developed innovative solutions in-house which are covered by over 30 patents. However, we have not yet had the opportunity to collaborate more broadly with academic institutions or civil society organizations. We understand how costly the R&D value chain can be for private sector entities. We support NSF's efforts to coordinate R&D investment amongst government agencies, academia, and civil society groups. This would help ensure spectrum management technologies are designed and built to better meet the public interest and the needs of federal stakeholders alike.

Due to our company's limited engagement with federal R&D stakeholders, we feel most credentialed to assist with several specific items on this RFI. We believe we can share our experience utilizing Artificial Intelligence (AI)/ML technologies for automatic and rapid mitigation of interference problems, spectrum situational awareness at scale, and spectrum resilience and assured access for critical mission applications **[Question #2].** We also appreciate the opportunity to share our perspective on defining "dynamic spectrum sharing" in the context of federal R&D lines of effort **[Question #7].**

PROMOTE STANDARDS FOR COLLECTING AND REPORTING INTERFERENCE DATA

Our flagship product, Spectrum-NET, has been deployed in real-world, nationwide mobile networking scenarios. This has given our company insight on the feasibility of collecting and analyzing reported network performance data in near real-time using AI/ML applications in the software layer of mobile networks.

We believe that the largest barrier to broader spectrum efficiency – either maximizing the utility of a given spectrum asset for a licensee or proving out the feasibility of a sharing environment for federal bandwidths – lies in opening up access and standardizing select key network data for researchers and engineers.

To understand better where certain frequencies could feasibly be shared, we believe the federal government should:

1. Facilitate the establishment of standards for software developers to enable the reporting, ingestion and analysis of mobile network performance data and build upon the foundations being set by the O-RAN community.
2. Promote the creation of regulatory framework(s) which encourage collaboration without onerous technology mandates or reporting requirements.

Given that the technical and legal implications for network data collection vary greatly depending on the networking environment (i.e., public vs private networks), there are myriad software and hardware standards which would have to be further developed to make network data collection a useful venture for performing bulk data analytics.

In Spectrum Effect's April 2023 submission to NTIA's Inquiry on the Development of a National Spectrum Strategy (Docket Number 230308-0068), we presented a view on how best to promote and implement a non-regulatory regime to collect and manage reported network performance data from incumbent users and advocated for the adoption of a common spectrum management framework.[1]

In that document, we asserted several positions that we believe should be a key consideration in the establishment of an R&D plan – particularly on how federally-sponsored testbeds may

[1] https://www.ntia.gov/sites/default/files/publications/spectrum_effect.pdf

provide opportunities for closer public-private collaboration.

For NSF, these items could be enabled by broader investment and engagement with federal and non-federal R&D stakeholders. In our filing, we recommended that the federal government take a few specific actions. Those recommendations included the following:

1. NTIA and FCC should jointly establish and operate a Spectrum Analysis, Strategy, and Planning Organization tasked with managing the collection of spectrum usage data.
2. Leverage the vast deployment of RAN equipment by mobile operators to measure and report on interference in adjacent government bands.
3. Drive real-time monitoring and control within mobile networks and private networks for optimal spectrum sharing.
4. Serve as a world leader in setting global standards for spectrum management and equip allies with a common standardized framework.

These recommendations are policy suggestions, not technical ambitions, and should not directly drive R&D efforts. However, to achieve more efficient spectrum use and enable closer collaboration on dynamic spectrum sharing between federal and non-federal users, the federal government needs to encourage federal and commercial incumbents to adopt technologies within the network software layer. Those technologies should be guided by standards that are informed by federal R&D efforts and exercised through the testbeds proposed in the NSS.

As a template for technical standards that federal research organizations could help develop, we want to highlight some of the capabilities that we provide to our customers. We believe these should be minimum standards in the future mobile networking environment.

Spectrum-NET's capabilities include:

1. Automated (AI/ML) analysis and mitigation of RF interference on a continuous basis.
2. Seamless operation on all RF bands (shared spectrum and non-shared spectrum) across multi-vendor radio equipment and multiple technologies (NR, LTE).
3. Ingestion of performance data reported regularly by the operator's Radio Access Network (RAN) equipment for analysis.
4. Ingestion of network topology data and tailored analysis for each type of site (outdoor, indoor, power level, etc.).
5. Machine learning to accurately classify RF signals and trigger mitigation actions.
6. Enhanced visibility into spectrum resources including spectral efficiency, RF interference, and Quality of Service data collection.
7. Closed-loop actions to maneuver spectrum resources and avoid RF interference.

When compared to traditional network management methods that rely on manual network monitoring and lengthy, complex troubleshooting of RF interference issues, developments in

AI/ML provide capabilities that can make dynamic spectrum sharing possible. However, this relies on the creation of underlying standards and requirements that enable the reporting and sharing of structured data for use in AI/ML-powered network analysis and management tools.

DEFINITION OF "DYNAMIC SPECTRUM SHARING (DSS)"

As a provider of software that helps mobile operators use spectrum assets more efficiently, Spectrum Effect is fully invested in the future of the mobile networking software layer and policy efforts to standardize related terminology.

As the federal government uses its R&D investments to pursue developments in technologies which could enable federal and non-federal users to share spectrum assets, we believe that NTIA and FCC should accompany any R&D advancements with a well-defined regulatory framework which can set forth responsibilities for both agencies to jointly collect network data. We believe these entities should also set minimum standards for the software layer of mobile networks which could be applied across LTE, 5G, and O-RAN deployments. However, for the purpose of R&D, we would encourage NSF to adopt a technology-agnostic definition of DSS.

Spectrum Effect supports major carriers globally, including several major mobile carriers in the U.S. Spectrum Effect would benefit by suggesting policies which using our existing capabilities to push a narrow definition for DSS. However, we believe that at this stage, an overly narrow definition of DSS would discourage civil society engagement, limit the ability for innovative proposals, and prematurely restrict the ability for researchers and engineers to work through U.S. universities and Federally Funded Research and Development Centers to propose new standards or mobile networking capabilities.