BEFORE
THE NATIONAL SCIENCE FOUNDATION

In support of the
NETWORKING AND INFORMATION TECHNOLOGY RESEARCH AND DEVELOPMENT (NITRD)
NATIONAL COORDINATION OFFICE (NCO)

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COMMENTS OF INTERNET2

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INTRODUCTION

The National Science Foundation ("NSF"), in support of the Networking and Information Technology Research and Development ("NITRD") National Coordination Office ("NCO"), released a Request for Information ("RFI") on June 13, 2019, seeking "input from all interested parties on the goals and necessary approaches for sustaining and enhancing U.S. scientific, technologic, and economic leadership in strategic computing."[1] The University Corporation for Advanced Internet Development (d/b/a "Internet2") submits these comments in response to the above referenced docket. Specifically, Internet2 recommends that:

- The U.S. must prepare to accommodate new computing modalities, which includes developing the necessary workforce.
- The country should pursue an integrated approach as it works toward developing capable exascale computing.
- Public-private partnerships should be strongly encouraged as part of the country's strategic computing plan, and Internet2 can play a key role in such partnerships.
- The U.S. must be a global leader in strategic computing and provide funding to help achieve this goal.[2]

BACKGROUND ON INTERNET2

Internet2 is a non-profit, member-driven advanced technology community founded in 1996 by the nation's leading higher education institutions. Internet2 helps U.S. research and education ("R&E") organizations work to solve common technology challenges and develop innovative solutions in support of their educational, research, and community service missions. Internet2 also operates the nation's largest and fastest coast-to-coast national research and

[1] *National Science Foundation Request for Information on Update to Strategic Computing Objectives*, FR Doc. 2019-12866, 84 FR 28338 (June 18, 2019).

[2] On August 5, 2019, Howard Pfeffer, the President and Chief Executive Officer of Internet2, spoke on a panel at the NITRD Future Computing Community of Interest Meeting as part of the RFI process.

education network ("NREN"), which now serves 320 U.S. universities, 60 government agencies, and 43 regional and state education networks. With these partners, Internet2 supports more than 100,000 community anchor institutions and almost 1,000 InCommon participants. In addition, Internet2 collaborates with numerous leading corporations that work with the R&E community, as well as a multitude of NREN partners across the globe that represent more than 100 countries. Much of the cutting-edge research that is taking place at and between research universities and private laboratories across the country is powered by the Internet2 Network.

Internet2 has a proven track record of innovating in networking, deploying and continually upgrading advanced networks, and extending those networks where connectivity is needed. This is the DNA of Internet2. The Internet2 Network was built and architected to enable sustained networking innovation across competing networking demands and great distances. The Internet2 Network has advanced services built on software defined networking ("SDN"), which allows users to optimize the network for their specific application needs. With 17.6 terabit capacity nationwide, the Internet2 Network is one of the most advanced networks in the world.

Internet2's InCommon platform provides the policy and technology backbone for secure interactions and allows single sign-on convenience for the R&E community, protecting the identities of approximately 10 million users across roughly 600 universities. Internet2 has developed the InCommon Certificate Service, providing unlimited server and other types of security certificates for higher education and research. Through InCommon, identity providers can give their users single sign-on convenience and privacy protection, while online service providers control access to their protected resources across a national and internationally connected infrastructure. Internet2 also assumed responsibility for eduroam in the U.S., which provides seamless roaming wi-fi at participating institutions.

In addition, Internet2 supports the R&E community through the NET+ Cloud Services Program, which connects R&E institutions with cloud service providers through a streamlined process that minimizes the business, legal, financial, and other challenges associated with migrating from on-campus to cloud-based solutions.

DISCUSSION

A. The U.S. must prepare to accommodate new computing modalities, which includes developing the necessary workforce.

Unsurprisingly, clock rate increases attributed to Moore's Law and Dennard scaling are expected to end in the near future. The U.S. is reaching the limits of current metal-oxide semiconductor technology. As a result, there is much uncertainty in the strategic computing ("SC") community. Accordingly, American leadership must embrace and realize the benefits of technologies emerging in both the near and long term that provide a path forward for SC in the absence of Moore's Law and Dennard scaling. This is consistent with Strategic Objective 3, Computing Beyond Moore's Law, of the 2016 National Strategic Computing Initiative ("NSCI") Strategic Plan.

To maximize national progress with respect to SC, leaders in this space must ensure that the public, private, and academic sectors are prepared for new computing modalities (such as optical computing, probabilistic computing, and machine learning) as they relate to the necessary hardware, software, and workforce. This means accommodating highly distributed, diverse, and rapidly changing computational resources; providing remote access to large data sets, data distribution capabilities, and the ability to process large data sets; and ensuring that the workforce behind this integrated system has the requisite training and support. The current goal in the NSCI Strategic Plan is to develop low-energy-per-operation, low latency, and high-speed computing platforms. With these mechanisms in place, the country can support critical next

generation research, especially as it relates to exascale computing and its potential to impact real-world problems, such as cybersecurity and cancer.

Increasingly, many fields of study, commercial endeavors, and critical infrastructure are becoming computational. While any of these segments individually can generate vast amounts of data, a trend toward multidiscipline data analytics is pushing the boundaries of scalability further. Hybrid-cloud and multi-cloud architectures are used widely, and the need for edge computing is emerging for near real-time applications. The combination of these trends requires new approaches to data movement to optimize the tradeoffs between networking and storage. Continued advancements in storage, transmission, and networking technologies also will be required.

There are, of course, many more dimensions to a fully realized SC ecosystem than just network, storage, and compute. Environmental systems, such as space, power, heating/ventilation/air conditioning, operating models for agility and availability (e.g., Development-Operations "DevOps" and Site Reliability Engineering "SRE"), and security also are important considerations. But the ultimate scaling limitation on the use of SC likely will be the workforce. Scientific discovery, economic competitiveness, and public safety will require more researchers, data scientists, and IT professionals. To this end, it is important that the government ensure that researchers and students from under-resourced institutions and citizen scientists have access to SC tools to accelerate scientific discovery and engage with larger national research efforts. There currently is no workforce pipeline for the kind of research computing and data professionals that work directly with researchers to enable their use of advanced digital resources and services.

This emerging profession helps bridge the gap between the researchers and the technology. First, research computing and data professionals work directly with researchers to understand and match their needs to resources and services. In addition, they facilitate the awareness and effective use of that technology by the researchers. Therefore, the workforce aspect of the cyberinfrastructure ecosystem must be emphasized more than it has been up to this

point. Some mechanisms that could enable professional development in this field could include: the creation of more internships at national labs and in the private sector; certified boot camps; providing education and training at Land Grant Cooperative Extension Centers; apprentice programs at computing centers; and the development of local expertise, campus expertise, and training for researchers outside of the standard curriculum.

Providing this developing workforce access to a fully realized SC ecosystem in the context of the enumerable policy regimes related to data governance will require, among other things, a federated multi-lateral identity and access management system, data management tools, and middleware. If the future of SC is a fully realized ecosystem of network, storage, compute, infrastructure, middleware, people, etc., then the goal should be nothing less than having the top leadership class SC ecosystem that is needed for next generation research.

The U.S. also must focus on the security and privacy challenges related to the ever-expanding Internet of Things (IoT). As IoT expands, so does society's interaction with systems that silently can collect, process, create, and act on information that humans generate, individually and collectively, as they conduct their lives. IoT represents a computing system in which the data is our environment, including the people who live in it. The R&E community is in a unique position regarding IoT because the community is both a testbed for innovation and standards, in partnership with funding agencies and the private sector, and a consumer of IoT technologies in the context of developing Smart Campuses.

B. The country should pursue an integrated approach as it works toward developing capable exascale computing.

The U.S. has a goal of developing capable exascale computing in the next few years, consistent with Strategic Objective 1 of NSCI's 2016 Strategic Plan. Capable exascale computing should remain a primary focus of federal research and development, given the potential real-world applications, such as designing a cure for cancer or unlocking the mysteries of the human brain. Exascale computers are expected to exponentially exceed the speed of today's most powerful supercomputers. In order to meet this goal, the country will need to

address a number of issues, such as programming the machines and producing a vertically integrated software stack, ensuring an adequate memory capacity to perform new classes of scientific and engineering applications, providing adequate bandwidth, and developing affordable power sources. As it stands, major science projects are at risk because the country does not have an integrated system for preserving and sharing data resources, resulting in lost opportunities. To build an integrated system, the private, public, and academic sectors must work together, perhaps through the creation of a national cyberinfrastructure facility that would accelerate scientific discovery by ensuring that researchers have seamless access to all resources and services for their entire workflow.

C. Public-private partnerships should be encouraged as part of the country's strategic computing plan, and Internet2 can play a key role in such partnerships.

Public-private partnerships between the government, academia, and industry have proven time and again to be a successful model for pushing the boundaries of SC capabilities forward. Historically, scientific research has been the application driver for the public-private partnerships that created, among other things, the Open Storage Networks, the Open Science Grid, and even NRENs.[3]

For many reasons, Internet2 is in an ideal position to help facilitate and improve working relationships within the diverse R&E community, as demonstrated by its considerable experience in bringing together entities in the private, public, and government sectors. First, Internet2 has been involved in numerous successful public-private partnerships. For example, Internet2 currently is partnering with the National Science Foundation on Exploring Clouds for Acceleration of Science (E-CAS), a project that focuses on how scientific workflows can leverage advancements in areas such as real-time analytics, artificial intelligence, and machine learning. Internet2 also previously partnered with the National Telecommunications and Information Administration to install and manage next-generation broadband infrastructure with a Broadband Technology

[3] The Open Storage Network is a distributed system for storing and sharing scientific data that is the product of both private and public funding. The Open Science Grid is a national, distributed computing partnership that supports data-intensive research.

Opportunities Program project. In addition, since 2014, the U.S. Department of Agriculture's ("USDA") Agricultural Research Service ("ARS") has partnered with Internet2 to implement a high-speed, research-only enterprise network using the Internet2 backbone. The ARS Science Network connects six major USDA-ARS research centers at speeds of 10 or 100G, depending on the site. It also connects USDA-ARS research centers with university, domestic, and international research partners and scientific resources.

Second, as Internet2 updates services to focus on research, cloud, programmability, and ecosystem coordination, it also will reset the scale economies that allow the R&E community to deliver the massive volume of research data expected in the coming years. Once developed, these services and capabilities can be useful to countless important players, including government agencies (such as the USDA, National Oceanic and Atmospheric Administration, Department of Health and Human Services, and Food and Drug Administration), higher education institutions, and cloud service providers.

Third, Internet2 can help drive these collaborations by identifying ways to reduce barriers to access and group collaboration; building tools to automate processes and ease the use of cloud computing via a combination of open source, commercial software, authentication solutions, and network-based services; mapping research workflows and finding commonalities; identifying common building blocks for integration with existing national programs, tools, and services; and lowering barriers to entry and opening computational science to the wider community. Simply stated, Internet2 has experience in the entire supply chain and would welcome the opportunity to partner with NSF in new ways to continue pushing the boundaries of the modern digital landscape.

D. The U.S. must be a global leader in strategic computing and provide funding to help achieve this goal.

American leadership in SC is essential to the nation's ability to outpace its competitors in this area. One critical way in which the U.S. government can demonstrate leadership is by providing significant funding to support its SC goals. Once the commercial sector realizes that the government has prioritized funding for its SC goals, commercial entities will be more

inclined to increase their own investments in SC, partially as a result of the new opportunities created by the federal investments. Without a doubt, substantial government investment can kickstart the commercial sector's interest in SC significantly.

Moreover, this is an area in which the options for funding are nearly endless, but resources are not. Accordingly, by playing a key role in funding, the U.S. government can help strategically shape the future of SC. The need for continued funding is highlighted by Strategic Objective 5, Advancement through Public-Private Collaboration, of NSCI's 2016 Strategic Plan.

CONCLUSION

For the foregoing reasons, Internet2 respectfully requests that the NITRD NCO consider these recommendations as it works toward sustaining and enhancing U.S. scientific, technological, and economic leadership in SC.

Respectfully submitted,

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