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Research Domain, discipline, and sub-discipline

Regional Research and Education Networks

Title of Submission

On the Future Needs for Advanced CI to Support Science and Engineering Research: A Perspective from the U.S. Regional Research and Education Networks

Abstract (maximum ~200 words).

Regional research and education (R&E) networks play a critical role in providing the underpinning fabric that makes possible local, regional, national, and global collaborations using advanced cyberinfrastructure. It is our collective R&E networking mission to support all science and engineering fields and their research challenges. Decades of success since the initial funding of regional networks by the NSF have taught us that the geography of resources is a significant factor in supporting research pursuits and scientific discoveries. In several of its current cyberinfrastructure programs, the NSF has recognized that coordination of specific cyberinfrastructure activities are most effectively coordinated at the regional level. Regional organizations are frequently best positioned to foster and enable collaboration across a number of institutional, disciplinary, state, regional, and national boundaries and serve to maximize NSF investments for the greatest good.

Question 1 Research Challenge(s) (maximum ~1200 words): Describe current or emerging science or engineering research challenge(s), providing context in terms of recent research activities and standing questions in the field.

The Quilt is a non-profit corporation with a mission to support and promote collaboration among 36 our country's U.S. regional research and education (R&E) networks. Regional networks play a critical role in providing the underpinning fabric that makes possible local, regional, national, and global collaborations using advanced cyberinfrastructure. It is our collective R&E networking mission to support all science and engineering fields and their research challenges. These networks provide scientific researchers with the network paths and bandwidth they need to move data as well as access remote and virtualized advanced cyberinfrastructure. The networks are engineered to support high-quality services that are consistent to researchers independent of the field of study, the number of users on the network, or the number of collaborators and collaboration sites. These organizations provide a sophisticated level of network services which may also include data centers, remote storage, identity management, high performance computing, and consulting. To be successful in their missions, regional

networks readily adapt to new scientific interests, experiments, or projects from all scientific fields at over that place new demands on the cyberinfrastructure resources. Because of initial National Science Foundation funding, regional research and education networks have close ties to the research community and play a prominent role in the cyberinfrastructure fabric that propels U.S. scientific discovery.

Regional networks are an essential component of the national cyberinfrastructure ecosystem occupying a key strategic position between campuses and national cyberinfrastructure resources. Decades of success since the initial funding of regional networks by the NSF have taught us that the geography of resources is a significant factor in supporting research pursuits and scientific discoveries. Regional networking organizations are geographically closer to the 900+ colleges and universities they connect, are trusted conveners within their regions, and are more easily accessible to the community of users that they serve. These regional networking organizations have specific geographic expertise and direct personal relationships that position them to support campuses in a unique way. Regional networks serve as trusted convener of among those that have cyberinfrastructure resources to pool and share thereby increasing collaboration and coordination among cyberinfrastructure owners.

Regional network constituencies extend to the K-12 educational communities where early access to STEM tools is critical to furthering the fields of science and engineering. These organizations provide infrastructure to the continuum of education institutions such as K-12, community colleges and universities and contribute to building the pipeline of human capital on the student learning continuum.

Not only are regional networks key enablers for research grants to sponsor scientific discovery, but they are also frequently principal investigators, co-principal investigators and key collaborators on cyberinfrastructure projects from a number of current NSF programs that include; IRNC, EPSCoR, NSFCloud, DIBBs, Campus Cyberinfrastructure, Regional Big Data Innovation Hubs, Cybersecurity Innovation for Cyberinfrastructure, and U.S. Ignite. Several of these programs have recognized that coordination of specific cyberinfrastructure activities are most effectively funded, managed, and coordinated at the regional levels with organizations that are best positioned to foster and enable collaborations at a number of different levels. Levels that cut across institutional, disciplinary, state, regional, and national boundaries and serve to maximize NSF investments for the greatest good.

Question 2 Cyberinfrastructure Needed to Address the Research Challenge(s) (maximum ~1200 words): Describe any limitations or absence of existing cyberinfrastructure, and/or specific technical advancements in cyberinfrastructure (e.g. advanced computing, data infrastructure, software infrastructure, applications, networking, cybersecurity), that must be addressed to accomplish the identified research challenge(s).

As large-scale scientific collaborations across disciplines, institutions and national boundaries continue to grow, the R&E networking ecosystem must be ready to address the cyberinfrastructure needs for science and engineering in the next decade and beyond. Our regional network community encourages the continuation of a National Science Foundation focus that develops a robust set of shared cyberinfrastructure capabilities, services and resources. We believe the following advancements in the development, deployment, and utilization of advanced cyberinfrastructure will be a key part of an on-going national strategy to address scientific and engineering research challenges.

1) Keeping Pace with Network Capacity Demands
We are currently seeing regular data flows of 400G and 1 TB capacity and this will only become more pervasive in the next 2-3 years. Future program investment in additional capacity for U.S. campus, regional, national and international connectivity is critical to keep pace with the needs of scientific discovery and research collaborations.

2) Distributed, Federated Computing with Shared Resources
More traditional HPC computations are shifting to a combination of HPC and data-oriented processing assisted in some cases by specialized hardware coupled with a widening distribution of data sets and data sources/instruments residing sometimes across national boundaries. This model is often accompanied by resources contributed by members of a specific collaboration. The success of this model is highly dependent on the agility, performance and costs of the underlying networks, starting from campus, all the way to the core networks.

3) Hybrid Commercial/Private Cloud Services for Research
No campus-based IT organization can keep up with the speed of commercial cloud development, necessitating the shift from purely on-premises campus infrastructure to hybrid infrastructures that combine campus resources with those located in public or academic clouds.

Partnerships with commercial entities such as Amazon, Google and Microsoft that provide public cloud systems provide many turn-key solutions to common infrastructure problems for researchers. For example, AWS offers over 1,000 unique cloud-based products ranging from individual virtual machines to highly-available database systems and various computational software stacks. We expect that these hybrid models will shift some campus enterprise infrastructure, devops, or some of the domain science computational and data-intensive tasks into the public or academic clouds. In all cases, regional and national R&E network infrastructure serve as gateways into cloud infrastructure.

4) End-to-End Performance of Research Flows
As promoted by the NSF Campus Cyberinfrastructure program, software-defined networking infrastructure integrated into campus environments is making campus networks highly programmable by allowing for the creation of 'fast lanes' in campus networks to allow bulk data transfers to bypass traditional security controls. The next wave of innovation which follows these initial campus investments has already made shore in the form of the Pacific Research Platform (PRP). The PRP will establish a science-driven, high-capacity, data-centric "freeway system" on a large regional scale, providing broader range of interconnects within and between campuses, regional networks and other cyberinfrastructure providers. These capabilities are challenging the way in which end-to-end transfers are traditionally engineered, transitioning from simple point-to-point arrangements to multi-point collaborations where required data sets reside with multiple entities and when data and computation locations change based on bandwidth, replication, resilience, storage and compute resource requirements. Continued investments to evolve this new type of model will be critical to the future of cyberinfrastructure development.

5) Cyberinfrastructure Security
Continued investments in instruments, wireless infrastructure, software, HPC, storage and other critical research infrastructure must be matched with continued investments to security programs and resources to protect these assets and ensure the integrity of the research and the research institutions.

6) Development and Sustainability of a Diverse Cyberinfrastructure Workforce
Coupled with the investment in the physical infrastructure, we strongly encourage the continuation and strengthening of investment in the development and sustainability of a diverse cyberinfrastructure workforce that facilitates, coordinates and leverages resources for maximum impact. Many campus, regional and national groups have made strides in hiring and training individuals into these specialized positions of cyber-practitioners. These individuals serve as bridges between the specific discipline needs of teaching and research and cyberinfrastructure resources available to address these needs.

Preliminary investment in programs that support the development of these cyberpractitioner roles at the campus and regional levels has had meaningful impact for those researchers fortunate enough to have access to these individuals. We are just now gaining insights into the benefits of cyberpractioners on the research process with their ability to bring to bear additional research resources and tools for scientific discovery.

The next area of focus should be the scalability and sustainability of these roles within our advanced cyberinfrastructure ecosystem. We must create opportunity for longer-term career paths that encourage these specialized individuals to remain in their field of work as they mature in these positions while encouraging a new set of professionals to enter into these roles. Workshops, conferences and other peer networking opportunities are vital to professional development for these individuals. National groups that are missioned and committed to advancing cyberinfrastructure for research must be incented to continue to invest in the talent and expertise of these staff positions to coordinate and promote cooperation among resource owners.

Cyberpractioner work requires technically talented individuals that possess the ability to build relationships and collaborative teams that reflect the diversity of the community of users. Our R&E networking community is very concerned about the prevalent gender gap that exists in Information Technology (IT), particularly the fields of network engineering and high performance computing (HPC,) that are logical areas from which to develop a cyberpractitioner workforce. R&E networking organizations and our national partners have a strong interest in STEM development at the education and employee level to address gender diversity and participation in STEM professions. We believe national programs that support and encourage gender diversity are vital to our nation's ability to remain competitive in its scientific and engineering research.

While we continue to make progress in the development and availability of advanced cyberinfrastructure, the next decade and beyond will require an even greater focus on planning and investment in a broader suite of cyberinfrastructure tools that includes workforce development. There are a number of initiatives that exist today at the campus, regional, and national level to promote and facilitate the use of shared cyberinfrastructure resources. There needs a more concerted effort to tie these varying efforts together in a more cohesive manner to effectively catalog, coordinate and leverage resources. Early insights into cyberinfrastructure needs that can be captured in the

proposal process would allow for important insights on what shared resources will be needed and in what timeframe to support successful proposals as well as to discover what new cyberinfrastructure resources will be available once funded projects are complete.

Consent Statement

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