Enabling and Sustaining Campus-to-Campus Cyberinfrastructure
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1. Introduction
Cyberinfrastructure resources are deployed at many levels in the nation’s academic research community, but the use of those resources is critically hindered by a lack of accessibility in the software and the social models employed to administer those resources. This lack of organization and accessibility has created inefficiencies and gaps in our ability to successfully utilize available CI resources in support of the academic enterprise. Identity management and trust are particularly thorny issues, but many other technical issues loom as well. There have been concerted and well-funded Federal efforts to bridge some of these gaps between campus and national CI services. What we have not seen is a similar effort to lower the barriers to the deployment of campus-to-campus CI services, services deployed for use within and between campuses. This is a fundamental gap that campus IT organizations are seeking to bridge.

SURAgrid (http://www.sura.org/suragrid), a community of campuses engaged in the adoption of a coordinated campus-to-campus CI, is working to bridge the CI gaps between its member institutions. SURAgrid participants recognize the advantage of working with a community of peers to address the many existing barriers to the effective deployment of CI services. The SURAgrid model allows expertise to be shared and not duplicated across member campuses. The campus-to-campus barrier exhibits most if not all the problems encountered in linking up disparate CI. One could view inter-campus CI deployment efforts as addressing the “horizontal” problems of CI (intra- and inter-campus CI services) whereas efforts like the TeraGrid address the “vertical” problem (researcher to national CI services).

2. The Growing Need for and Challenges of CI Tools and Services
A desire to grow our collective body of knowledge has connected people throughout history. Each generation has leveraged the tools of their era to share insights and build common understanding. The Internet has most recently and strikingly accelerated our ability to collaborate across significant geographic and organizational boundaries. This ease and density of interconnection has led us to a point where a new infrastructure – Cyberinfrastructure – is evolving to advance peer interaction and shared discovery.

The promise of a Cyberinfrastructure (CI) that provides seamless collaboration across all boundaries is widely discussed today, within and beyond the research and education (R&E) community. Within R&E in particular we have shared this vision for nearly a decade but still find ourselves facing numerous hurdles in implementation. Impressive CI resources have been established through nationally focused funding initiatives. Significant obstacles must be eliminated, however, before these resources can function as a pervasive CI from which the vast majority of researchers can benefit. Many of the obstructions are well known; others we are just beginning to see and understand.

3. A Horizontal CI Perspective
The barriers to successful adoption of CI are easier to understand by considering the three major dimensions of the CI landscape: Resources, Users and Organizations. The figure below is an illustration of the national CI environment that considers both horizontal and vertical communities of practice and includes campus, multi-campus and national CI resources and helps to identify unmet needs that confront the development of a coherent national CI. This diagram emphasizes the “horizontal” perspective of a campus-to-campus coordinated CI that has not yet been effectively addressed in both funding and effort. While most recent dialog and major funding initiatives have focused on the vertical issue of creating and accessing national CI resource centers (the NSF Tier 1 and Tier 2 centers), the potential to maximize and leverage the large aggregate number of users, resources and organizations at the nation’s academic campuses has largely been overlooked. It is campuses, however, that are the fundamental

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1 Cyberinfrastructure consists of computational systems, data and information management, advanced instruments, visualization environments, and people, all linked together by software and advanced networks to improve scholarly productivity and enable knowledge breakthroughs and discoveries not otherwise possible. From: "Developing a Coherent Cyberinfrastructure from Local Campus to National Facilities: Challenges and Strategies", pg 4. http://www.educause.edu/Resources/DevelopingaCoherentCyberinfra/169441

organization of academics. It is at this horizontal level that many barriers are encountered, many of which can be most effectively and sustainably addressed by leveraging resources, perspectives, and collaborations across campus boundaries.

4. Barriers to CI Adoption and Use

As discussed above, the landscape of CI adoption includes both vertical and horizontal perspectives. Barriers to the effective use and adoption are also varied and may be technological, sociocultural, or policy-related with interdependencies that add to the complexity. Over the past 10 years, technologies like the grid have made it significantly easier to meet some of these challenges. For example, in the areas of high performance and high throughput computing, large numbers of similarly configured resources can now be harnessed as a coordinated pool with significantly reduced effort. Still, incompatibilities between systems are real, and differences in the size of memory, disk space, inter-process communication tools and schedulers seriously impact the transparency of the infrastructure. The responsibility for resolving these incompatibilities can be shifted to dedicated personnel, however, the effort required to build traditional organizations with sufficient talent to address these challenges is considerable and effectively prohibits all but the most determined and well funded campuses or research teams from engaging in the effort to harness large resource pools.

Many research and development groups are only beginning to require resources beyond their local reach and do not have funding to build the full spectrum of expertise dedicated to integrating distributed or advanced technologies into their workflow. Most of the support required to harness CI resources would need to come from expertise they do not possess. This is especially true for individual researchers and small research groups at campuses with limited institutional support for CI services. These researchers know that more is possible; they just don’t know how to get started short of becoming technology experts themselves. What is needed is an effective way for individuals and organizations to engage a targeted fraction of their efforts in a larger, open community dedicated to co-development of shared CI.

Expanding our definition of CI to include horizontal (multi-campus) initiatives can significantly complement other efforts for faster progress. These initiatives in general are driven by local (campus) needs and provide foundations for tool development based on the desire to collaborate. Broad and de-centralized initiatives such as SURAgird are enablers of this evolution, with the ability to draw from national initiatives and further support tools and services that become integral components of the campus IT infrastructure, creating notable efficiencies of scale in their use. Effectively organizing multiple campuses to address a given problem is a significant challenge. Multi-campus initiatives, formed from the desire to solve common problems with shared solutions, are the most naturally suited to building the trust and shared work environment needed to address these challenges.

Great economies of scale can be realized through aggregation and coordination at human, system and enterprise levels. This type of sharing freely mixes viewpoints and talents from various stakeholders – researchers, faculty, students, CIOs, and IT support staff – for successful adoption of CI at the campus and beyond – a necessary foundation for large-scale CI success in R&E. Results can be as quantifiable as group-buying power, or as subtle as
influencing industry direction; as simple as easing access for an individual researcher, or as far-reaching as promoting and expanding the value of federated identity.

National funding priorities have made significant progress toward establishing large national CI resource centers that are currently part of the TeraGrid, and generic interfacing technologies, like Globus, that enable coordination of infrastructure across administrative domains. Organizations like the Open Science Grid, caBIG and the science gateways of TeraGrid have adapted and evolved to meet the needs of specific science communities. However, the job of implementing and sustaining a truly broad-scale and integrated CI remains a major unsolved distributed systems challenge. It in itself poses a “big-science” problem – how to address social, cultural, technological, and economic challenges inherent in building a CI that can serve the competing needs of the many user communities found even within a single campus.

5. Towards Effective Investment in Horizontal CI Initiatives
Considering the elements described above, we arrive at a final but critical consideration in the realization of a coherent CI: the role of those charged with directing or influencing CI implementation through funding allocations. Major CI investments by federal agencies to-date have focused on the deployment of national services and (to a lesser extent) on individual researcher and campus CI systems. The potential to maximize and leverage the role and resources associated with multi-institutional collaborative communities like SURAgrid have largely been overlooked and rarely funded. A global view of CI that considers resources, users and organizations provides crucial guidance to effective investments in CI – Federal, State and Campus. It requires that the campus, together with its extended community, be regarded as an integral component of a national CI. Regardless of how unique each campus experience is perceived to be, the truth is that many of the same processes are duplicated between, and even within, campus environments. Supporting community efforts that build an open, operational, shared infrastructure across multiple campuses is a more effective use of funds – and ultimately more sustainable than each campus “going it alone.”

The same level of support that could in the past affect change for only a handful of users could now impact a much larger community who hold in common their investment in a coherent infrastructure. From the campus perspective, sharing the burden of infrastructure development across a larger pool of stakeholders has clear financial benefits. Each campus can’t be expected to individually meet competing demands of their members to connect with distinct national infrastructures or resources and services available through other campuses. Establishing connections through inter-campus communities enables shared expense in both delivery and support, and is more practical than expending limited funds to connect select groups to specialized resources.

In summary, we offer the following recommendations to achieve a more pervasive and inclusive national Cyberinfrastructure:

- **Encourage Community Models:** Re-enforce the proposition that communities implementing open CI infrastructures for broad availability and shared use are crucial to a coherent CI that bridges campus, regional and national resources.
- **Extend Campus CI Initiatives:** Recognize that engagement in multi-institutional communities with shared goals will accelerate campus CI deployments while contributing to the development of a broad, integrated national CI.
- **Reward Economies of Scale:** Invest in CI programs and communities that realize cost-savings, effectively coordinate talent, create sustained collaboration, and reduce barriers to new and non-traditional users.
- **Invest in Campus-to-Campus CI Collaborations:** Allocate funds to create and extend multi-institutional CI collaborations and communities. Within the National Science Foundation, the Office of CyberInfrastructure appears particularly well suited to sponsor such programs.

Extracted from full paper available at: [http://www.sura.org/programs/docs/SGWPDraftforComment0909.pdf](http://www.sura.org/programs/docs/SGWPDraftforComment0909.pdf)