Cyberinfrastructure Advisory Framework

A Net@EDU Campus Cyberinfrastructure Working Group White Paper

October 2008
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Net@EDU helps higher education shape and take full advantage of emerging networking opportunities. Our activities span the spectrum of academic and cutting-edge research networking, from the administration of campus and state networks to identifying the most appropriate network projects for implementation to acting as a national center for research and advocacy in network policy issues. For more information, visit www.educause.edu/netatedu.
Purpose
The purpose of the CCI Framing Cyberinfrastructure Focus Group is to create a set of guidelines to help campus officials:

- Assess their involvement in the cyberinfrastructure based on local considerations (or academic agendas)
- Identify integration points with the national cyberinfrastructure
- Plan the development of their campus cyberinfrastructure

Overview
To develop these guidelines we have started to put together a checklist or list of questions CIOs and other campus officials might use to assess their current CI environment. We have also included, when information is available, data points that provide some quantitative measures. As we started making lists, we found that our discussions fell into four broad categories: Campus Readiness, Cyberinfrastructure Touch Points, Cyberinfrastructure Data Points, and Leadership and have organized this document around these categories. Additionally, we have created a worksheet in the appendix.

We have also built on work previously done by the Campus Cyberinfrastructure (CCI) Working Group and have not provided content that is available in other documents, including a definition of the term cyberinfrastructure.

Your Campus Readiness
Your institution’s characteristics, mission, and current resources influence cyberinfrastructure (CI) planning. In preparation for planning, these questions guide an analysis of your institution’s CI readiness. Worksheets in the appendix can guide more detailed investigation.

Your Institution’s Demographics
Your organization’s population and the number of faculty, graduate and undergraduate students engaged in research and creative activities, influence the need and the budget available for CI resources.

Campus Research Mission
A 2006 ECAR study, IT Engagement in Research, reported that institutional mission was a strong indicator of an institution’s current and planned IT environment for research. Some key questions to consider when determining cyberinfrastructure needs according to institutional mission include:

- What is your institution’s Carnegie classification? (Consider how the relationship between research and teaching missions influences CI needs.)
- What is the balance of research and teaching in your institutional mission? (An institution’s disciplines define its culture and determine the unique cyberinfrastructure characteristics required.)
Which disciplines at your institution utilize significant large-scale IT resources for teaching and/or research?

How many faculty in each discipline use these resources? To what extent do graduate, undergraduate, and distance students use these resources?

**Policy and Funding**

Campus CI policies and standard practices clarify expectations, rights, and responsibilities. Some key questions to consider include:

- Who has access to resources, with what priority and for what purposes?
- What security and privacy practices are required?
- What resources are supported and by whom?
- Who has rights to collaborative or joint development?
- Are some of the questions to be answered in a policy review?
- What CI policies and standard practices have been established?

Funding for research and creative activity cyberinfrastructure is too often finely targeted and short term and therefore is not scalable or sustainable. Expectations from scholars and funding agencies are that institutions will provide base and ongoing cyberinfrastructure. How well does your campus CI funding model fit campus research expectations?

**What Major IT Assets Supporting Research Does Your Institution Now Have?**

An inventory of the IT resources used by members of your institution reflects past priorities and provides a basis for strategically addressing Cyberinfrastructure issues as an institution. The asset inventory can be organized under five sets of technologies.

**Advanced Network Infrastructure Resources**

The campus network service levels (accessibility, capacity, security, and reliability) determine readiness to respond to demanding research and learning requirements.

- Does your campus network have the functionality and scalability to meet these higher-level demands?

Research increasingly involves multi-institutional teams and utilizes resources and services beyond campus including support for massive data transfers to and from high-performance computing (HPC), real-time visualization, and remote instrumentation.

- Is your off-campus network connected to major regional and national research networks with the ability to scale up capacity to meet significant research demands?

Research and teaching involves collaboration within virtual communities beyond the campus.
Does the campus network meet the quality of service requirements for real-time communication?

**High-Performance Computing**

Solving the important problems in science, engineering, mathematics, and medicine require high-performance capacity to handle complex computations, large dataset analysis, and visualization processing. The research community anticipates a tiered approach in which some of those resources are available within the institution, shared among institutions (TeraGrid, Open Science Grid), at supercomputing centers and at national and international labs.

- What are the current HPC resources on your campus? Are they located/managed centrally or by local campus research units?

- What off-campus resources are institutional researchers using?

- Are researchers self-supporting, or are these HPC services supported by a campus computational center?

**Data Storage and Management**

Researchers create and import large amounts of data relative to their research. Creative activities have an equal stake with science and engineering in information storage and access. Different storage and management is needed depending on the nature of the data requirements (some imposed by funding agencies): private, temporary, long term archive by agreement, open to community, and others. Librarians can aid institutions in planning for acquisition and access.

- How do scholars store, manage, and secure their research information? What institutional resources are available for scholar use?

- Does the institution play an active role in retaining data or information beyond the life of the research project? What is the role of the campus library with respect to data sets and storage?

**CI Applications and Tools**

A foundation of general applications and tools such as those for parallelization, visualization, simulation, data and statistical analysis are needed for science, technology, engineering, and mathematics (STEM) and medical research. There is a growing need in social science and liberal arts to gain new knowledge from the vast information stores.

- What applications and tools are offered to campus scholars?

Skilled information technology personnel are needed to allow scholars (including students) to use these applications and tools without having to be IT experts. These personnel should have sufficient discipline knowledge to understand scholar needs.

- What staff are available to help scholars get started? How does your campus plan to meet ongoing CI human support needs?
**Resources for Collaboration Within Virtual Communities**

Teleconferencing, presence technology, and remote instrumentation can give a near face-to-face and face-to-observable-event feel to collaborative scholarship unimpeded by distance or environmental characteristics.

- What cyberinfrastructure does your campus have in place to support scholars’ collaboration? In what off-campus collaborations are campus scholars engaged?

Institutional identity and access management systems are commonly used to identify users, their roles and their access to IT resources and information in a secure manner. Federated identity systems extend this ability to the greater research community allowing scholars to allow and be allowed authenticated access to virtual environments.

- What capabilities does the campus identity management system offer to campus scholars? Is federated identity in use or planned for the institution?

**Cyberinfrastructure Touch Points**

**Organizations Promoting Cyberinfrastructure**

A number of organizations are promoting and contributing to the development of the national cyberinfrastructure. These organizations provide guidance and relationship building opportunities as you develop your institutions Cyberinfrastructure activities. If you are a Research Essential or a Balanced institution and you are not on the member list of the following organizations, you should especially consider asking your institution to join one or more.

- CASC—Coalition for Academic Scientific Computing (www.casc.org)
- EDUCAUSE (www.educause.edu)
- Internet2 (www.internet2.edu)
- Net@EDU (www.educause.edu/netatedu)
- NLR—National LambdaRail (www.nlr.net)
- The Quilt (www.thequilt.net)

**Research Collaborations Supporting Cyberinfrastructure**

A number of multi-institutional research efforts could serve as integration points for your institutional CI efforts. If researchers at your institution are involved in these projects, they are using (or planning to use) the national cyberinfrastructure. Some examples of these efforts include:

- BIRN—Biomedical Informatics Research Network (www.nbirm.net)
- caBIG—Cancer Biomedical Informatics Grid (http://cabig.cancer.gov)
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- CLEANER—Collaborative Large-scale Engineering Analysis Network for Environmental Research (http://cleaner.ce.berkeley.edu/)
- CTSA—Clinical and Translational Science Awards (www.ctsaweb.org)
- Open Science Grid (www.opensciencegrid.org)
- Particle Physics Data Grid (http://www.ppdg.net/)
- TeraGrid (www.teragrid.org)

**Cyberinfrastructure Data Points**

This section contains lists of questions and, in some cases, data points that will serve as a guide for campuses contemplating their involvement and investment in cyberinfrastructure. We’ve organized this section based on the following list of technologies that lie at the core of campus cyberinfrastructure (see the ECAR study, *Higher Education IT and Cyberinfrastructure: Integrating Technologies for Scholarship*):

- High-performance computing resources
- Cyberinfrastructure applications and tools
- Data Storage and management resources
- Advanced network infrastructure resources
- Resources for collaboration within virtual communities

**The CI Trajectory**

As one drills down into the technological complexities of CI, it is important to keep in mind your institution’s overall expectations. In a July/August 2008 *EDUCAUSE Review* article, Fran Berman describes cyberinfrastructure as presenting two faces: as a focus for invention, and as an enabler of innovation. She outlines a trajectory or maturity model for cyberinfrastructure linking these two faces that has three stages:

1. Cyberinfrastructure as a target for research
2. Engineering cyberinfrastructure for use
3. Cyberinfrastructure as an accelerator for research and education

The impact of each stage increases as you progress from one to the next. The potential funding sources for each stage also evolve.

As you consider your investments in cyberinfrastructure, you will need to be aware of what stage in the CI trajectory the technologies you want to invest are and the risks and opportunities indicated by the maturity of the technologies. For example, technologies in “CI as a target for research” stage will not be ready for use by most on your campus, but they may be eligible for research funding through programs in all of the NSF directorates, NIH, and DOE. In contrast, technologies in the “CI as an accelerator for research and education” could have a broad impact on your campus but will require careful planning to ensure the services supporting these technologies are economically sustainable for as long as the technology will be in use.
High-Performance Computing Resources

Supercomputers and clusters of computers or other computational devices integrated in such a way as to provide supercomputer-like performance to individual applications.

A very broad benchmark is the Branscomb pyramid that shows the distribution of computing capacity from leading-edge systems, national centers, and campuses (see Figure 1).

Figure 1. High-Performance Computing Capacity

Clearly different institutions have to assess their willingness and ability to support faculty engaged in research activities that require large amounts of computational resources. While many researchers can support their research with computing power that can be obtained from their research grants, the cost to support independent computational centers on a campus has led many institutions to examine the need for coordination and sharing of resources among researchers, where feasible. Large-scale projects rarely can be handled exclusively with local resources, and many multidisciplinary and multicampus collaborations are now common to address global challenges and breakthroughs. However, not all computing power is the same—depending on the problem to be solved, certain computing configurations are more suitable than others. The key is to understand the varied computational needs of researchers on or coming to your institution.

As Figure 1 shows, not all computing resources need to be obtained on campus: a growing number of regional and national resources are available to researchers on campuses, provided they have sufficient network capabilities from their research labs to the external resources. Many institutions also have provided some computational resources to campus researchers by pooling the excess computational power in personal computers on campus computer labs and offices. Again, the caution is that not all computer cycles can be applied to all problem sets; it remains very application-specific.
Even institutions with faculty not directly engaged in computational research activities can benefit from computational resources provided elsewhere—some researchers make their facilities available to experiment in the classroom and help further the knowledge transfer of their techniques. The shortage of people who know how to use and apply applications that require high-end computational resources has already arrived. Many interdisciplinary research projects require expertise in areas traditionally not associated with high-end computation—one example is the many discipline-specific science portals that are becoming available. Ease of use and integration of computational power, storage, and presentation techniques in a secure fashion require skill sets different from straight computational skills.

In conclusion, determine what high-end computational resources are required to meet the strategic goals of your campus, assess your readiness by addressing the questions outlined in the readiness section, determine the gap, and map out a strategy to obtain the resources and skill sets to close the gap.

**Cyberinfrastructure Applications and Tools**

“General cyberinfrastructure applications and tools are those that support research but are not specific to a particular discipline. These include software for simulation, parallelization, visualization, job scheduling, data mining, and statistical analysis.”

This is an area where the CI trajectory of the technology should be carefully considered. A general CI application that is in one of the first two stages could require significant work just to integrate it into your campus environment. Also, finding developers with the skill sets in these areas can be challenging, depending on your local workforce demographics.

**Data Storage and Management Resources**

Consider large-scale research data storage systems for real-time use and for archival purposes, as well as facilities, software, and procedures for periodic backup of research data sets.

Figure 2 illustrates a Branscomb pyramid for data.
Applying Branscomb to Data: The Data Pyramid

Facilities
- National-scale data repositories, archives, and libraries. Maintained by professionals. High capacity, high reliability.
- Regional libraries and targeted data centers. Maintained by professionals. Medium capacity, medium-high reliability.
- Private repositories. Supported by users or their proxies. Low-medium reliability, low capacity.

Target Collections
- Reference, nationally important, and irreplaceable data collections. (PDB, PSID, Shoah, Presidential Libraries, etc.)
- Research and project data collections.
- Personal data collections.

Advanced Network Infrastructure Resources

This terminology refers to the institution’s high-performance networks on campus and their connections to off-campus high-performance networks that support such capabilities as massive data transfers to and from clusters, real-time visualization, and use of remote instrumentation. Off-campus networks used for advanced network infrastructures include regional or university consortial networks and such networks as Internet2 and National LambdaRail in the United States and CANARIE, AARNET, DEFN, JANET, SURFnet, and others outside the United States.

We recommend reading the ECAR study on IT engagement, which includes some related, valuable data based on a survey of 300 colleges and universities according to their institutional mission, including:

- The percentage of institutions with given network bandwidth.
- The percentage of institutions participating in network consortia.
- The percentage of institutions participating in national research networks.

While the data points are guidelines, each institution must assess its network infrastructure and capacity to determine if it is suitable for its campus needs, especially for researchers and instructors. The network infrastructure includes both wired and wireless connections, sensor networks, and the ability to support voice, data, and video. A common problem seen on many campuses is that the efforts to secure campus networks have made it difficult to use any applications that are latency dependent, including video conferencing and many video based services.
collaboration tools. Spam filters, firewalls, traffic shapers, and bandwidth limiting are all necessary tools to protect campus network infrastructures but they can often cripple many of the research efforts that require high-speed point-to-point network connections. Any faculty engaged in efforts to improve the Internet protocols, distributed computing, security, sensor networks, new wireless protocols, and improved collaborations tools using video or voice all have encountered difficulty using standard campus network configurations.

Even Teaching Favored or Teaching Essential institutions have conflicts with running a common campus network. One traditional tactic was to throw unlimited or sufficient bandwidth to overcome the latency issues, but even that method did not work. The amount of spam mail has required many campuses to use tactics that are not dependent on excess bandwidth capacity. Many campuses are struggling with how to support unique research and teaching needs that require specialized networks or protocols without creating duplicate networks. One example of an effort to solve these issues is GENI (www.geni.net), an NSF-funded project to help create new ways to leverage the Internet.

Wireless technologies have expanded, but the various competing protocols create both challenges and opportunities for institutions. Integrating various personal devices—laptops, PDAs, and cell phones—remains out of reach for many institutions.

The intersection of all these factors creates an interesting situation for campuses. While simply connecting to various regional and national networks will solve traditional bandwidth issues, lower costs, and improve accessibility for point-to-point collaborations, the role that ubiquitous Internet access from personal devices must be considered when planning and architecting the campus network of the future. While traditionally CI has concentrated on high-performance networks, the ability to make computational resources available, and access to large data sets, CI applications and collaboration with virtual communities must be taken into account. The network capability to access both on- and off-campus resources by personal devices may shape the CI applications and collaborations in the future.

Steps institutions should take include:

- Assess the current campus network infrastructure by answering the campus readiness questions, including the ability of the core campus network to support the emerging trend of data- and video-intensive CI applications. Decide if point-to-point network connections are required for all or some on-campus locations to selected off-campus locations and can exist on the current production network or if an alternative path or protocol is required. Ensure that access to the appropriate regional and national networks is established; that these selected off-campus locations can be accessed; and that some control over future Internet connections costs is possible.

- Determine the future campus needs of faculty, staff, and students to access the growing CI applications and resources available both on and off campus.
Establish the gap between the current infrastructure and future needs, including the role that personal devices may or may not play.

Chart a course to obtain the resources and skills to close the gap.

**Resources for Collaboration Within Virtual Communities**

Facilities and support for teleconferencing, for hosting collaborations with off-campus researchers, and for the operation of remotely located research instrumentation and related devices; support for identity management and associated middleware in collaborative research activities.

Identity management is a key infrastructure for enabling multi-institutional collaborations. Giving off-campus investigators access to on-campus shared data resources is a growing need that benefits from centrally operated interinstitutional identity management tools.

Identity management can also better enable your campus researchers to access regional and national computational resources, as noted in a recent CASC white paper:

> A straightforward migration path between campus, state, and TeraGrid facilities would ensure that the many tens of thousands of researchers working in areas of science related to the NSF mission make the best possible strategic use of local, state, and national resources.

**Recommendation:** Authentication and authorization processes should correspond to national standards, perhaps by adoption of InCommon credentials.

Many different collaboration environments exist (see the list in the “Cyberinfrastructure Touch Points” section above); often these are built with a specific discipline or set of applications in mind. When you do your campus readiness assessment, you will need to make note of key areas of research and find out what collaboration environments are already in use. You should determine how your campus identity management system might fit into the identity management system of any of the collaborative environments in use on campus.

**Leadership**

A critically important factor in the success of cyberinfrastructure is the understanding that senior leaders on campus have of this topic as well as their support to strengthen cyberinfrastructure in areas that need an investment in resources. The CIO, or equivalent, as well as other senior administrators, such as the research vice president or dean and academic vice president or provost, need to take the initiative to reach out to faculty, department chairs, and fellow academic leaders to discuss this topic.

In addition to garnering support from the president and senior leaders on campus, the CIO and his or her colleagues need to engage the academic community. How you engage your academic community depends on the culture of your organization.
In general, this engagement will be an ongoing, iterative set of communication and relationship-building activities. A campus-wide research advisory council, IT steering committee, meetings of research or academic deans, and/or an open forum that invites vice presidents, deans, department chairs, and faculty are possible ways of engaging the academic community on campus.

Each institution needs to determine the best approach for reaching out to the academic community, and it will most likely depend on the governance model and culture of the institution. In a governance model where IT services are highly centralized, the CIO may be able to work with the vice president for research and provost to arrange meetings with deans, department chairs, and faculty. At a large, decentralized institution where many decisions are made at the local level by principal investigators, faculty, program managers, and research administrators, it may be more appropriate and fruitful if the CIO, vice president for research, provost (or equivalent), and department chairs engage key faculty leader(s) in each discipline. These faculty leaders could engage their colleagues and encourage them to learn more about campus activities for strengthening cyberinfrastructure, and to identify needs and give feedback regarding developing campus plans and priorities.

Regardless of culture and institutional governance structures, individuals across a wide spectrum of roles should ultimately be included and involved with the CI process. Research “rainmakers” (well-known scholars and teaching faculty) as well as junior faculty, facility managers, and individuals in financial services, the research administration office, academic affairs, and information technology must be informed and participate in CI planning and activities that will strengthen the campus cyberinfrastructure. Individuals in these roles can help educate the campus community regarding cyberinfrastructure, as well as help collect needed information, for example, the number of computer rooms, servers, systems, software programs, and instrumentation devices that are being used throughout the campus, the computer support needs identified in research proposals, the projected increase in digitization, storage, and sharing (via the campus network) of content for teaching and learning, the current and projected future energy consumption levels and proposed plans and solutions for being more “green” and efficient, and so forth.

With an educated constituency to work with, and with information gathered and key needs identified, the CIO, in concert with other campus administrative and academic leaders, can develop a plan with strategic initiatives and tactical activities for strengthening the campus cyberinfrastructure. Several goals that leaders on campus might pursue include:

- offering an even greater depth and breadth of campus computing resources and better campus services for faculty;
- bettering support the research and education community by reducing the cost and effort involved in acquiring and using CI resources;
- identifying institution space, if it is not already available, for the design, development, and support of a campus computing facility for use by scholars/researchers;
ensuring that adequate funds are made available for supporting campus cyberinfrastructure, including the development and support of a common computing facility; and

pursuing a more efficient campus CI that includes new green IT and green data center strategies.

The outcome might be the creation of a cyberinfrastructure that synthesizes a common computing infrastructure with local discipline specific applications, instruments, and digital assets. Cyberinfrastructure combines computing systems, data storage, visualization systems, advanced instrumentation, research and educational communities, all linked by a high-speed network across campus and the outside world. This common infrastructure would consolidate an array of resources, as much as possible, in order to achieve the goals identified above. These CI building blocks are essential for supporting the research, teaching and creative activities of scholarly communities, while at the same time, achieving greater energy conservation and efficiency.

Below are questions for campus leaders to consider:

**Strategic Planning**

- Does your institution have an IT Steering Committee or Advisory Committee?
- Does your institution have a strategic plan? If so, how is cyberinfrastructure included?
- Does your institution have a strategic plan for IT, if so, how is cyberinfrastructure included?
- Executive sponsorship—what executive-level engagement and support of CI initiatives do you have on your campus (senior research officer, CIO, deans, provost, president)?
- How are decisions about IT supporting research and scholarship made on your campus? What is the governance structure?
- How does your CIO communicate with the SRO?

**Funding**

- Are there institutional funds available for supporting an enhanced cyberinfrastructure on campus, and in particular, are funds available for designing, creating, and supporting a campus computing facility for use by scholars/researchers?
- How are indirect costs used to fund cyberinfrastructure?
- What direct costs can be applied to cyberinfrastructure?

**Other Topics**

- How is your campus research and scholarship community organized? Are there existing governance structures that you can align your CI development efforts with?
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- How many CI centers/institutes/facilities do you have on campus?
- Do you have an accurate inventory of CI resources?
- Is there a process of sharing computing needs as identified on research grant applications with the SRO and the CIO, so that CI needs are known, planned for, and provided to PIs when awards are received?
- Is an appropriately sized, outfitted, and supported campus computing facility available for use by scholars/researchers, and if not, can appropriate space be identified, designed, created, and supported?

Endnotes


4. In 1993, the National Science Foundation (NSF) commissioned a c to study HPC and the rapid evolution of computation and information-based technologies in academia [NAB 93-205, “From Desktop to Teraflop: Exploiting the U.S. Lead in High Performance Computing”]. The panel, chaired by Harvard physicist Lewis Branscomb, developed what has come to be known as the “Branscomb Computational Pyramid,” which describes computational infrastructure as a pyramid, with the apex representing the peak of computational performance and the base representing broad computational desktop systems.


References


Appendix: Understanding Your Campus

1. **Campus Population**

<table>
<thead>
<tr>
<th>Total Population</th>
<th>Numbers Engaged In Research/Creative Activities (estimate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty</td>
<td></td>
</tr>
<tr>
<td>Graduate students</td>
<td></td>
</tr>
<tr>
<td>Undergraduate students</td>
<td></td>
</tr>
</tbody>
</table>

2. **Carnegie Classification (check):**

   - DR
   - MA
   - BA
   - AA

3. **Institutional Mission (check):**

   - Research Essential
   - Balanced
   - Teaching Favored
   - Teaching Essential

4. **List key disciplines at your institution and scholars using large-scale IT resources**

<table>
<thead>
<tr>
<th># of scholars using for research</th>
<th># of scholars using for teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical disciplines (computer science, bioinformatics, engineering, etc.)</td>
<td></td>
</tr>
<tr>
<td>Historically computing-intensive disciplines (physics, chemistry, mechanical engineering, etc.) help provide integration points for CI efforts</td>
<td></td>
</tr>
<tr>
<td>Medical and health science disciplines (molecular medicine: pharmacology, genomics, proteomics; molecular biology: microbiology, biochemistry, immunology, etc.)</td>
<td></td>
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</tbody>
</table>
## 5. Policy and Funding

What policies and standard practices does your campus have in place to address campus CI issues?

What campus CI funding models are developed?

What is the campus annual research budget?

What is the IT portion of the research budget?
### 6. Advanced Network Infrastructure Resources

<table>
<thead>
<tr>
<th>Question</th>
<th>%</th>
<th>%</th>
</tr>
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<tbody>
<tr>
<td>What capacity does your campus network support? (Indicate percentage and transport speed.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What capacity does your campus network support for access to the commodity Internet?</td>
<td>Mbps</td>
<td>Gbps</td>
</tr>
<tr>
<td>What research network(s) does your campus connect to and at what access capacity?</td>
<td>Internet2</td>
<td>Gbps</td>
</tr>
<tr>
<td></td>
<td>NLR</td>
<td>Gbps</td>
</tr>
<tr>
<td></td>
<td>Regional</td>
<td>Gbps</td>
</tr>
<tr>
<td>Does your campus have a mobile computing strategy?</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Does your institutional IT security program include network security?</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Does your campus have a unified communication strategy (web, audio, desktop conferencing; unified, instant messaging; presence and real-time collaboration)?</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Support of advanced services (check):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>_____ end-to-end service</td>
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<tr>
<td>_____ lightpath deployment</td>
<td></td>
<td></td>
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<tr>
<td>_____ collaboration toolset</td>
<td></td>
<td></td>
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<tr>
<td>_____ quality of service</td>
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</table>

### 7. High-Performance Computing

What is the campus high-performance computing capacity? (Nodes, processors, total processing, and storage; indicate with –R those limited to a specific unit or researcher.)

What off-campus high-performance computing resources are campus researchers using (TeraGrid or other shared; supercomputing centers; national or international labs or facilities)?

Is research support available through a campus computation center? (Check.):

- _____ Systems management
- _____ Security and access management
- _____ Licensed software management
- _____ Application development
- _____ Application migration to and support for external HPC facilities

### 8. Data Storage and Management

What institutional resources are there for storing instructional and research data and information?

- _____ file storage
- _____ institutional repository
- _____ archive
- _____ data backup services

Is there an institutional role in retaining data past research project? ____ Y ___ N

How does the IT organization interact with the library organization to plan for managing and accessing stored information?
### 9. CI Applications and Tools

What applications and tools are offered to campus scholars?

What staff are available to help scholars get started?

How does your campus plan to meet ongoing cyberinfrastructure human support needs?

### 10. Resources for Collaboration Within Virtual Communities

What cyberinfrastructure does your campus have in place to support scholars’ collaboration?

In what off campus collaborations are campus scholars engaged?

Does the institution have an identity access management system with common identification, authentication, provisioning, and de-provisioning and access management?  ____Y____ N

Does the campus have a method or plan for federated identities (e.g., Shibboleth)?  ____Y____ N