Creating the 21st Century Platform for Scientific Research & Higher Learning

New, advanced technologies are driving university-led innovation and competitiveness

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— Jim Bottum, CIO, Clemson University

Higher education institutions are often at the forefront of the most impactful scientific and engineering research initiatives worldwide. What makes these initiatives possible is advanced technology, especially for networking and computing. Yet for many universities, technology investments haven’t kept pace with either new challenges in research or new opportunities for the academic mission.

This innovation brief discusses how institutions can harness the transformational capabilities of advanced networks and IT infrastructures available today. These solutions — including 100 Gigabit Ethernet, cloud services, trust and identity solutions, a segmented science network and software-defined networking—help universities support next-generation research and education through improved collaboration, access to big data and customized tools for innovation.

According to Clemson University CIO Jim Bottum, network capabilities are critical to the higher education mission today. “If you’re going to be serious about research, you need up-to-date, even leading-edge network capabilities because collaboration and data volumes are growing across all academic areas and in the university’s business operations,” he says.

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— Dr. Steve Corbató, Deputy CIO, University of Utah

CAN YOUR IT INFRASTRUCTURE KEEP UP?

Keeping a campus prepared for ever-increasing data needs means having a robust infrastructure refresh plan that anticipates demands through steady investment at the campus level, as well as a plan to maintain abundant connections to the global online research community. The Internet2 Network, powered by Ciena, is an example of a research-grade network that meets data-intensive science needs, in part because Internet2 member institutions drive the services and capabilities and keep it positioned not as an underfunded utility, but as a platform pre-positioned to support innovation.

The need for a robust, high-performance network and IT infrastructure may be a given, but meeting that need requires universities to address several challenges.

Limitations of current networks

Many higher education networks today are based on proprietary technologies, with the associated constraints of high costs and limited ability to grow and support new services. Research-grade networks that support growth and flexibility are essential for remaining a full participant in the rapidly changing arenas of research and education.
Global collaboration and big data

Today’s scientific research projects may involve dozens to thousands of researchers working in multiple institutions around the globe. To make this collaboration feasible and fruitful, researchers need access to shared computing resources, visualization tools and more online video conferencing.

Most of all, researchers need the ability to quickly access truly big data anywhere on the planet – with data set sizes often measured in petabytes. Collaborative work and big data are also becoming more important in other academic disciplines, even in arts and humanities.

Supporting technology innovation

In a virtuous circle, technology itself benefits from university-based research and development (R&D). For example, faculty at Clemson conduct R&D projects to improve cloud computing, software-defined networking and related technologies.

The right infrastructure supports the data capacity and performance necessary for university teams to create, refine and deliver technology innovations for open sharing or commercialization.

Competitive differentiation

“Faculty are always interested in the infrastructure that can support their research,” notes Dr. Steve Corbató, Interim CIO at the University of Utah.4 “They actively evaluate the university’s network and computing facilities as well as IT’s subject-specific expertise to help them take advantage of those technologies.” Leading faculty candidates increasingly look at these factors when choosing the institution at which they will contribute. Savvy students, especially those entering STEM fields, will also evaluate a school’s reputation for providing advanced technology capabilities when making their college choice. And, the case for grant funding and support from the private sector is stronger when a university keeps pace with leading-edge technology.

Addressing these opportunities with a compelling plan to invest in advanced networks can have a huge advantage to a campus. But which investments are best given the varied needs and responsibilities of a large university?

Universities investing in ADVANCED RESEARCH INFRASTRUCTURES receive more funding, are more competitive at recruiting top talent and are often at the forefront of some of the most impactful scientific breakthroughs.

RESEARCH AREAS THAT BENEFIT FROM ADVANCED NETWORKING

The following outlines some of the research areas across a higher education campus that would benefit from advanced networking. An additional benefit is that institutions that invest in infrastructure that supports research and science often receive more grant funding.

For instance, physicists from the University of Texas at Arlington were awarded a $2.5 million, three-year Department of Energy grant to continue physics research on scientific discoveries such as the Higgs boson particle.1 And the NSF’s Global Environment for Network Innovations (GENI) project awarded Indiana University $2.3 million to continue using its virtual laboratory to build, test and support innovative computer networks.2

**GENOMICS**: High-speed transfers of DNA sequence sets between national databases and virtual collaborators.

**TELEMEDICINE**: HD-quality videoconferencing for tele-surgery and surgical education, consulting with specialists, reviewing medical images and communicating with patients.

**HIGH-ENERGY PHYSICS**: Support for supercomputing collaborations and large data sets.

**ADVANCED MANUFACTURING**: Cloud-based simulations to design and build advanced manufacturing components.

**DISASTER RECOVERY**: Cooperative storage of digital archives, broadening access and protecting collections from digital disruption or loss.

**TECHNOLOGY ENGINEERING**: A virtual lab for research and development of new networking and distributed systems technologies.
TARGETING NEW IT INFRASTRUCTURE INVESTMENTS

New solutions in five technology areas support improved infrastructure capabilities for a university’s research, academic and business operations.

100 Gigabit Ethernet
A high-capacity connection from the university network to advanced networks like Internet2 is essential for accommodating high data volumes across research, academic and business applications. Today, 100 GbE is the baseline for high-performance networks; in most cases, 100 GbE investments also provide a platform for scaling up to 400 GbE in the future.

Cloud Computing Services
Higher education institutions are moving business applications from on-premises deployments to network-based “cloud” services where the applications run on a provider’s IT infrastructure. These services typically offer advantages of cost savings, simplicity and on-demand scalability.

A Science DMZ
Given the demands of high-bandwidth applications and huge data volumes, it makes sense to segment and optimize a portion of the university network specifically for moving the enormous scientific and engineering data sets among researchers. A science DMZ serves the performance and access needs of researchers without creating a negative impact on other institutional traffic.

Software-defined Networking (SDN)
With SDN technology, virtual networks can be configured dynamically to connect systems and applications within a campus or externally with regional, national or global networks. This responsive adaptability adds agility to dynamic and virtual research projects, enabling accelerated breakthroughs.

Integrated Identity & Access Management
Identity and access management, and particularly federated IAM among multiple institutions, has become part of the expected infrastructure, allowing secure, convenient and immediate access to collaboration applications and tools across the network and in the cloud.

Although it is possible to cobble together these solutions from a mix of service provider and vendor offerings, many universities look instead to services from an advanced IT infrastructure consortium, such as Internet2, that are designed specifically by, and for, multi-institution collaboration and research. The table to the right presents key capabilities to consider when evaluating a consortium infrastructure approach.

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OPPORTUNITIES FOR ENHANCING THE ACADEMIC MISSION
Keeping the network and IT infrastructure on the leading edge isn’t just important for research—it is also vital for innovation in the university’s core teaching and learning activities.

For Dr. James Hilton, Dean of Libraries and Vice Provost for Digital Education and Innovation at the University of Michigan, the IT infrastructure has become as essential as bricks-and-mortar buildings for advancing an institution’s academic mission. He notes that advanced infrastructures have allowed the scientific and discovery aspects of the academic mission to globalize through large, collaborative research teams. But this collaboration has yet to extend to other academic disciplines, where it could be applied to deliver teaching and learning across institutional boundaries.
UNIVERSITY OF UTAH
ADVANCING EDUCATION & ECONOMIC DEVELOPMENT STATEWIDE

Driving his view is increasing collaboration in the university’s research, teaching and learning, and operations that support those areas, as well as the need to stay ahead of traffic growth and features expected by users.

Another important factor for the university is extending advanced networking capabilities to the state’s K-12 districts and enabling local economic development. In a partnership with the Utah Education Network, the university’s BONFIRE network supports gigabit-speed Internet access for local schools. This network capacity enables remote teaching with HD videoconferencing as well as data access for hydrology field projects that help students understand the impact of climate change on the state’s economy.

The BONFIRE network also supports the University of Utah’s participation in CloudLab, an open testbed for cloud computing development funded by a National Science Foundation (NSF) grant. “Researchers are no longer confined to a physical campus. With facilities in multiple locations across the state, we need a network that will give us the greatest flexibility without the constraints of traditional circuits,” says Corbató. “We have also designed our network to take advantage of a 100 GbE connection to Internet2, which in the future will allow Cloud Lab to support researchers globally.”

CLEMSON UNIVERSITY
SUPPORTING COLLABORATIVE GENOMICS RESEARCH & BIG DATA

Collaboration with Clemson University technologists has helped Dr. Alex Feltus with his genomics research to develop new crop varieties that address population pressure, biofuels, pharmaceuticals and climate change. “When university IT professionals understand the type of data sets we use and how we use them, they can choose network services that deliver data faster, which helps us run our experiments and analyses faster,” says Dr. Feltus. “Because I don’t have to spend so much time downloading data, I can do more creative and exploratory experiments that weren’t possible before.”

Dr. Feltus notes that the interdependence of scientific research and the IT innovations that support it will continue to grow. “Soon the data sets will become too big for current networks to handle, and the lack of network capability will inhibit the potential for research innovations,” he says.

To quickly and easily deliver the leading-edge capabilities needed by researchers, Clemson leverages many components of Internet2’s consortium infrastructure for networking and cloud computing along with the support and resources Internet2 provides members to obtain funding. “The quality of a consortium service has already been validated by other institutions,” says CIO Jim Bottum. “Also, the consortium has negotiated contract terms that reduce costs and make it easier to adopt cloud services within the legal constraints faced by higher education institutions.”

READY FOR THE TECHNOLOGY FUTURE OF RESEARCH & EDUCATION (R&E)

Universities need a clear strategy for investing in and transitioning to more open and dynamic IT infrastructure. For research, a new infrastructure strategy opens areas of exploration, collaboration, development and commercialization. For academics, advanced capabilities support new creativity in teaching and learning. And for the institution as a whole, continued investments in advanced IT infrastructures help to sustain a competitive edge while also serving the research and academic mission.

1 www.uta.edu/news/releases/2014/05/HEP-funding.php
2 http://newsinfo.iu.edu/news-archive/20685.html
3 Center for Digital Education interview with Jim Bottum, 12.12.14
4 Center for Digital Education interview with Dr. Steve Corbató, 12.22.14
5 The Science DMZ model developed by the Department of Energy’s ESnet: fasterdata.es.net/science-dmz
6 Center for Digital Education interview with Dr. James Hilton, 12.10.14

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