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Citation


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Introduction

Since 2014, EDUCAUSE has examined higher education’s top strategic technology priorities. This year, in addition to reviewing the overall list of strategic technologies, EDUCAUSE will publish nine separate reports examining in detail the technology domains we asked about and reviewing each domain’s component technologies and the trends associated with those technologies. This report covers the 20 technologies and 6 trends included in the research and scholarship domain.

As a core higher education mission, research and scholarship is woven throughout the 2017 top 10 issues. Although technology hasn’t always been wedded to research and scholarship, now it is integral. Academic research is often a source of funding for the institution. Superior research capabilities and high-quality research results are reflected in an institution’s reputation; serve as an enticement for researchers, faculty, and students alike; and can help drive development efforts. Perhaps most importantly, research and scholarship is a common good, making advances in areas as diverse as cancer research and environmental sciences and changing and improving our understanding of history, business, and culture. Support for research and scholarship is necessary for any strategic IT leader and should be a core consideration when funding and staffing IT, as well as in managing and governing data.

Computation has become critical to academic research, and the scale of academic research needs continues to grow. Not only does this dynamic result in an increased demand for IT and computational support for research projects, but the continued growth of research data (including big data) also necessitates a thoughtful approach to short- and long-term data storage, curation, access, and security needs. The deployment of strategic technologies to support these needs is crucial in enabling the IT organization to support research and scholarship. This year, only one research and scholarship–related technology is featured in the Top 10 Strategic Technologies—the blended data center—but multiple technology trends impact IT strategy in this space.

The focus of this report is the trends and strategic technologies associated with research and scholarship. Mature, commonly deployed technologies (such as financial information systems or networks) may be among the most mission-critical technologies, but they are generally more likely to receive operational rather than strategic attention. Strategic technologies, by contrast, are the relatively new technologies that institutions will be spending the most time implementing, planning for, and tracking in 2017. None of the 20 research and scholarship technologies analyzed in this research is currently in place in more than 30% of institutions.

Technologies are what IT organizations do. Trends, on the other hand, are widespread external factors that influence institutional and IT strategy and often spur the adoption of technologies. This report examines the trends that institutions are paying the most attention to and that are influencing emerging institutional IT strategy the most. This year’s trend list included six items closely associated with research and scholarship.
Covered in This Report

Trends

- Changing vendor-institution relationships (bypassing IT to work directly with business-area leaders)
- Cross-institutional and international research collaborations
- Cross-institutional partnerships and consortia
- Digitization of scholarly and research data (data management, visualization, discipline-specific tools, etc.)
- Institutional international strategies (international campuses and partnerships, internationalization of student body, etc.)
- IT as an agent of institutional transformation and innovation

Technologies

- Affective computing
- Blended data center*
- Cloud-based HPC
- Data center capacity planning and management tools
- Disciplinary repositories for research data
- ELNs (electronic lab notebooks)
- Flexible interactive platforms for descriptive and predictive analytics of institutional data
- High-precision location-sensing technologies
- Institutional repositories for research data
- IPv6
- Massively scalable database architectures and software
- Private-cloud computing
- Quantum computing
- Science DMZ
- Text/content analytics
- Tools to support cross-institutional and international collaborations
- Tools to support cross-institutional and international research data sharing
- Uses of in-memory computing
- Uses of the Internet of Things for research
- Virtual reality

*Part of the overall 2017 Top 10 Strategic Technologies
Findings and Recommendations

What do we know about the kind of progress higher education might make with research and scholarship technologies? What trends might influence this progress? While our data can never be a substitute for an institution’s own strategic plan or roadmap for research and scholarship, this report can inform an institution’s overall IT strategy and its deployment strategy for research and scholarship technologies.

The Trends

We characterized a trend as “influential” if it was already incorporated into IT strategy or exerting a major influence over emerging IT strategy. We used that characterization to classify the trends into four levels of influence, based on the prevalence of influence across institutions:

- **Most influential**: Trends that are influential in 61% or more of institutions
- **Taking hold**: Influential in 41–60% of institutions
- **Worth understanding**: Influential in 21–40% of institutions
- **Limited impact**: Influential in 20% or less of institutions

Understand how the most influential trends are affecting your institution.
None of the research and scholarship trends is influential at 61% or more of colleges and universities.

Review the trends that are taking hold and address them at your institution.
One research and scholarship trend is influential at 41–60% of institutions:

- *IT as an agent of institutional transformation and innovation*. Almost all projects involving innovation and transformation that are strategic in scope involve IT. IT has always had a dual role with respect to transformation and innovation: (1) IT can be the vehicle by which an innovation is realized, and (2) new breakthroughs in IT can open the door for a new set of innovations and opportunities that were scarcely imaginable before. There is no indication that IT will relinquish this dual role; indeed, if anything, the pace of such change only seems to be accelerating. Finally, the power of IT can greatly increase the scope and scale of current initiatives (e.g., the collection and analysis of greater amounts of data provide the basis for new directions for business modeling and technology-enabled student advising).
Understand these trends, and consider their possible role at your institution.

The influence of three research and scholarship trends (listed below from highest to lowest level of influence) is limited to 21–40% of institutions. Higher education is monitoring these trends with respect to emerging IT strategy and the deployment of research and scholarship strategic technologies:

- **Cross-institutional partnerships and consortia.** In an effort to be as efficient as possible with enterprise IT systems and services, many institutions look to cross-institutional partnerships and consortia as a way to possibly reduce costs or gain efficiency. Purchasing consortia are a good example. In a purchasing consortium, a group of institutions develops a contractual relationship that allows for collective cost savings and the opportunity to work more closely with system and software vendors. Other consortia are employing their collective strengths to develop applications, to purchase and produce educational content, and to build out and enhance data collection and analytics capabilities. Still others are combining their resources in service to a collective strategic goal, such as student success and the improvement of completion rates. The potential of higher education consortia to further the agenda of the next-generation digital learning environment was identified in the EDUCAUSE white paper on this topic.

- **Digitization of scholarly and research data (data management, visualization, discipline-specific tools, etc.).** Data today are typically produced in a digital format and increasingly are being used, manipulated, and studied in scholarship and research in digital ways. It is essential for data management practices to be updated so that they will work with digital data throughout its life cycle, as well as for higher education IT to be aware of and able to provide researchers with the necessary tools and resources to work with and manage these data, including discipline-specific tools and practices, data visualization, research support for both traditional and more nascent areas of study (such as digital humanities), interdisciplinary research support, and more.

- **Changing vendor-institution relationships (bypassing IT to work directly with business-area leaders).** As cloud-based services become increasingly common, individual departments often negotiate directly with vendors and bypass IT departments to select and purchase technology-related services. This practice makes it difficult for IT staff to maintain standards for architecture and integration, and it complicates concerns for information security, compliance, privacy, data management, and data governance. IT departments are responding in part by developing expertise in relationship-management skills, allowing them to communicate better with both campus stakeholders and the vendor community.
The remaining two trends were of limited impact in our research: institutional international strategies (international campuses and partnerships, internationalization of student body, etc.), and cross-institutional and international research collaborations.

The Technologies

The list of strategic technologies included in our survey was derived from the 2016 list and from several authoritative sources that annually identify emerging and maturing technologies in higher education. A total of 20 of the technologies in the survey pertain to research and scholarship. For each of those technologies, respondents selected one of six response options to indicate the level of activity for that technology at their institution in 2017:

- **Institution-wide deployment**: Full production-quality technical capability is in place, including ongoing maintenance, funding, etc., with deployment potentially supporting institution-wide access.

- **Expanding deployment**: In 2017, we will move from initial or partial to broader or even institution-wide deployment.

- **Planning, piloting, initial deployment**: This technology is not yet available to users; however, meaningful planning for deployment is either in development or in place. Staff are investing significant time (multiple person-weeks of effort) and resources in executing the plan to pilot or deploy this technology within a defined time frame.

- **Tracking**: Multiple person-days of effort will be assigned but restricted to monitoring and understanding this technology (much more than just reading articles).

- **No deployment**: None of this technology is in place, and no work will be under way or resources committed for this technology in 2017.

- **Don’t know**: I don’t know what this technology is.

We assigned attention scores to the responses, and the scores were weighted to highlight responses indicative of higher levels of activity (expanding deployment; planning, piloting, initial deployment; and tracking) over responses that suggest little or no activity of that kind (institution-wide deployment, no deployment, and don’t know).

Understanding what peer institutions (both current and aspirational) are doing can help you gauge whether your institution’s current approach is on track or might warrant reconsideration. Some technologies are more relevant for some types of institutions than others. We looked at broad demographic categories, including Carnegie class, institutional size, and approach to technology adoption, and found differences in attention score based on those factors. In figure 1, the
U.S. mean is the average attention score for an item from all U.S. respondents. The minimums and maximums are the lowest and highest average attention scores among all groups within the categories of Carnegie class, institution size, and timing of technology adoption, with labels indicating which group or groups returned that score. In the event of a tie, all tied groups are represented.

Figure 1. Attention score averages and differences
Looking beyond attention scores, we sought to understand the kind of effort that the largest proportion of institutions is devoting to each technology. We created four attention categories by combining adjacent responses:

- Expanding deployment and institution-wide deployment, combined as **deploy and maintain**
- Planning, piloting, initial deployment and expanding deployment, combined as **pilot and deploy**
- Tracking and planning, piloting, initial deployment, combined as **decide and plan**
- No deployment and tracking, combined as **track and learn**

Although nearly every technology was represented to some degree in each attention category, we assigned each technology to the attention category with the greatest amount of institutional activity for that technology in 2017.

**Complete initial deployment and maintain these technologies.**
Our research shows although many institutions are expanding deployment or already have some strategic research and scholarship technologies in place, the bulk of the activity in 2017 will be at other levels. As a result, no technology was assigned to the **deploy and maintain** attention category.

**Pilot and start deploying these technologies.**
Similarly, no technology was assigned to the **pilot and deploy** attention category because larger proportions of institutions are devoting a different kind of attention this year.

**Decide when these technologies fit your strategy, and start planning.**
Institutions are watching the following research and scholarship strategic technology carefully, **deciding and planning** for potential future deployment:

- **Blended data center.** As institutions move services to the cloud, they usually move into a blended environment where they continue to maintain an on-premises data center while also managing a set of services that may run the gamut from software as a service to infrastructure as a service. While cloud-based solutions offer advantages related to agility, performance, and scalability, the blended environment requires a shift in strategy to one that encompasses both environments.

**Learn about and track these technologies.**
Institutions are **tracking and learning** about the following research and scholarship strategic technologies (listed below from highest to lowest attention):
- **Private-cloud computing.** Private-cloud computing refers to cloud infrastructure operating for a single institution and closed to other use. Institutions have used virtualization technologies to run parts of the environment on private cloud virtualized platforms for some time.

- **Flexible interactive platforms for descriptive and predictive analytics of institutional data.** Flexible interactive analytics platforms reflect a shift away from IT-centric analytics solutions to ones that do not require advanced technical or data-science skills. These platforms allow a wider range of users to perform interactive analysis of institutional data. In implementing these solutions, it is important to consider data governance implications because end users will have more direct access to institutional data.

- **Tools to support cross-institutional and international collaborations.** Collaborating with colleagues beyond the institution is getting easier through a variety of options that include enterprise-level collaboration tools as well as free web-based tools. Enterprise tools offer more assurance of privacy and security through the institution’s identity management system.

- **Institutional repositories for research data.** The management and curation of research data—including to provide continued access to this data—is an important role for many institutions. In addition, publisher or grant-agency guidelines may require the depositing of data in a repository. Institutional repositories help enable local, ongoing management and access and also serve as a place to host and share data where appropriate discipline-specific or national repositories are not available.

- **Data center capacity planning and management tools.** Data center capacity planning is a strategy that allows IT to meet the institution’s evolving needs for data center resources such as storage, power load, and cooling capacity. Some vendors provide tools for capacity planning. IT service management frameworks such as ITIL describe subprocesses for capacity management that include business capacity management, service capacity management, and component capacity management.

- **IPv6.** Internet Protocol version 6 (IPv6)\(^3\) is designed to address several problems of IP version 4, the most pressing of which is the exhaustion of IPv4 addresses. In addition to simply providing more addresses, however, IPv6 also allows for greater efficiency of IT systems, streamlined systems administration, and security improvements. IPv6 is not backward compatible, and institutions should do a thorough compatibility review of their IT systems and develop a plan for ensuring alignment with IPv6.

- **Tools to support cross-institutional and international research data sharing.** A core mission of higher education is research, and researchers...
are increasingly working with colleagues from other institutions and internationally in order to do their work. Understanding the issues of sharing research data with these colleagues is tantamount for IT to be prepared to provide the tools and support to enable this sharing. Tools in this space may address issues ranging from metadata to data access and usage rights to file format interoperability.

- **Disciplinary repositories for research data.** Many discipline-specific data repositories exist to assist with data retention and access. These repositories bring together research data for a particular subject area, regardless of institutional affiliation, and are often international in nature.

- **Uses of the Internet of Things for research.** The Internet of Things (IoT) is generating—and will continue to generate—vast new amounts of data from a multitude of potentially intersecting IoT devices. Growth in this area will necessarily influence how research is conducted and identify new areas of research.

- **Virtual reality.** Augmented reality (AR) and virtual reality (VR) are experiencing a renaissance in higher education. Both technologies have been around for some time; AR first appeared in the *Horizon Report* in 2005. Along with blockchain, virtual and augmented reality are the buzz technologies in the domain of teaching and learning. This renewed interest is being driven by reduced cost of the hardware (such as headsets) and by the fact that some of the headsets can be driven by mobile devices. Hence the digital divide for this technology has appreciably narrowed, making it possible to imagine its use in more academic disciplines. This new round of experimentation has two pedagogical dimensions: first as an experience consumed by the learner (e.g., anatomy in medical education) and second as a programming exercise whereby the learner creates AR and VR experiences.

- **Cloud-based HPC.** “Traditional high-performance computing workloads are characterized by tightly coupled scientific applications for which substantial processing capability, high-speed and low-latency interconnects, and performance parallel input/output are required. That is, they require high performance.” When these characteristics are provided by cloud vendors, as they now are, additional characteristics typical of cloud are inherited: ability to scale up and down quickly on demand in a pay-as-you-go environment.

- **Science DMZ.** According to the EDUCAUSE Technology Spotlight on the topic, Science DMZ provides a network-architecture approach that is optimized for high-performance scientific applications and the transfer of large research data sets over high-speed wide-area networks.
It supports big-data movement by improving security, cost-effectiveness, and the nimble handling of large (mostly) scientific data sets. Beyond issues of network design, the Science DMZ addresses issues of systematic performance monitoring and file transfer and also serves to simplify the use of software-defined networking (SDN) over wide-area network paths.

- **Text/content analytics.** Text/content analytics is a set of techniques and processes that analyze unstructured, text-based information to discern themes and patterns that can be used as data for analysis and decision making.

- **Massively scalable database architectures and software.** Massively scalable database architectures, such as NoSQL and Hadoop, allow for the distributed processing of very large data sets by dividing the work across computer clusters. Large data sets can be broken into pieces for cheaper storage on readily available commodity hardware, allowing for faster parallel processing. This type of technology approaches data storage and retrieval in a nonrelational way, allowing for high performance and highly scalable data management that can handle massive data.

- **High-precision location-sensing technologies.** These technologies enable applications to use precise indoor location, allowing systems to know an individual’s location to within a few meters. This precise location sensing, combined with the Internet of Things and mobile apps, will make possible more personalized services and information.

- **ELNs (electronic lab notebooks).** According to the EDUCAUSE Technology Spotlight on the topic, ELNs are electronic software intended to replace paper laboratory notebooks. ELNs move the lab notebook into the digital world and, in doing so, offer additional benefits, including easier search, better organization, and the ability to link to content and data. In addition, backing-up and sharing data with other researchers (including in cases of collaborative work) are simplified with electronic notebooks. ELN usage ranges from the very specific (e.g., for specific disciplines or “with specific applications, scientific instrumentation, or data types”) to more generalized, cross-disciplinary activities. Many ELNs are cloud based.

- **Uses of in-memory computing.** According to the EDUCAUSE Technology Spotlight on the topic, in-memory computing helps make big-data analytics possible by keeping data in a server’s RAM rather than removing it to databases on separate disk drives. Keeping it at the cached layer means not only that it can be retained in its original format but also that it can be searched, found, retrieved, and processed at much higher rates than data kept on disks, particularly when dealing with large amounts of data.
- **Affective computing.** According to the ELI 7 Things issue on the subject, the term *affective computing* “refers to IT systems and devices designed to discern human emotions, respond to the user on the basis of what they perceive, and, in some cases, represent human emotion to users. Unlike ‘conventional’ computing, in which computers only ‘know what they are told,’ affective computing strives to ‘infer’ or ‘read’ a user’s emotional state, adding a qualitative component to interactions between humans and computers.”

- **Quantum computing.** Quantum computing uses quantum bits (also known as qubits) as opposed to the binary digits (bits) that are used in current computing. The ability for a quantum bit to be in a superposition of states—that is, it could represent a one, a zero, or a sum of two or more distinct states—enables these bits to use quantum algorithms to solve problems more quickly than traditional computing.
Preparing for the Future

Understanding the technologies that are most relevant for your institution and how fast a certain strategic technology may be growing is critical to institutional IT strategy. We estimated the pace of growth based on the percentage of institutions we predict will implement each technology over the next five years (by 2022). Figure 2 positions each technology in one of 12 cells based on institutional intentions (the “recommendation for today”) and the expected pace of growth of that technology. Reflecting what was noted above, the figure shows that most of the technologies we tracked are still being explored—rather than deployed—by most institutions.

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Figure 2. Plans for 2017 and pace of growth for research and scholarship strategic technologies
Conclusion

The technologies discussed in this report are relatively new and typically have not yet achieved widespread operational implementation. Further, despite the integral nature of technology and research, the role of the IT organization in supporting research isn’t a simple one. Support for research and scholarship takes place across the institution, not only in IT but also in departments, research organizations, and libraries, to name a few. Funding for research technologies often comes from disparate sources as well, including the frequent use of grant funds to support research projects. As a result, it can be difficult to truly track implementation of research and scholarship technologies within the institution. That said, the importance of research data to the institution is clear, which may be one reason why institutions are currently looking at and starting to make decisions and plans around future deployment of research technologies or blended data centers.

As central IT becomes more service oriented and continues to reach across the campus to support the core institutional missions and goals, understanding what research and scholarship strategic technologies should be tracked, assessed, and deployed will only grow in importance.
Notes

1. EDUCAUSE tracks these types of established technologies in the Core Data Service because they are widespread enough to enable institution-level benchmarking.

2. Primary sources were The Horizon Report, Gartner’s Top 10 Strategic Technology Trends for 2014, and multiple 2014 Gartner Hype Cycles (education, big data, cloud computing, cloud security, enterprise architecture, enterprise information management, GRC, identity and access management, IT operations management, privacy, business intelligence and analytics, and emerging technologies). We augmented those with several additional technologies, most notably in analytics.

3. For more on IPv6, see Guy Almes, Celeste Anderson, Michael Mundrane, and Valerie Polichar, Transitioning to IPv6, working group paper (Louisville, CO: EDUCAUSE, October 2013).


