THE NEXT-GENERATION INFRASTRUCTURE

By Ed Lightfoot and Weldon Ihrig

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Overview

The rate of technology adoption in higher education has been impressive. In contrast to the manual processes our institutions followed for decades, we now have applications for financial management, human resources, admissions, recruitment, payments, procurement, research databases, course management, online library reserves, classroom scheduling, patient records, grant and contracts management, and, of course, e-mail.

An open question is whether the systems have simplified or complicated life. There is a "system" for almost every function. In an attempt to become more user-friendly, these systems have evolved into a Web front-end, or in some cases, a portal. But all too often, the systems, Web sites, and portals are not interconnected, presenting the user with a fragmented view of the institution. Data from one system do not automatically transfer to another. Information in one database may need to be manually updated in another. Users must still register multiple times even though they are already affiliated with the institution. In some respects, the digital environment we have created replicates the offices on campus, but rather than walking from one place to another, the user must type in a different URL and log on to a different system. It may be faster and more efficient, but such fragmented approaches fall far short of the potential of the technology—and of the needs of users.

The number of systems we cope with is a reflection of the tremendous depth and breadth of our institutions. Colleges and universities have multiple constituencies, including parents, students, legislators, business and industry, and alumni. Higher education is also known for establishing strong relationships with individuals. But those relationships are no longer limited to four years or a term of employment—they are lifelong. If relationships define higher education, how do we move from fragmented systems and stop-and-go relationships to a vibrant lifelong continuum?

Expectations have changed, also. Our constituents expect around-the-clock customer service, convenience, personalization, and self-service. Institutions have adopted user-centered and learner-centered philosophies. In an attempt to integrate multiple systems and provide 24x7 access and personalized services, portals have proliferated. Yet we are challenged with how to manage multiple identities (e.g., a faculty member may also be a student parent; an alumnus may also be a medical center patient; a student may also be an employee) and lifelong relationships.

Expectations of campus personnel have changed as well. Administrators, faculty, and staff want information to be available for people who need to make decisions or take actions. As we have grown more accustomed to the Web, the notion that "work" is the equivalent of transmitting forms and getting multiple signatures has come under question by many. Pushing paper may not bring as much value as other tasks. Colleges and universities want to operate the institution in a more modern, productive way, where access to information is not defined by the "system" but by the individuals who need it.

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Although many institutional services and applications are available over the Web, we lack a holistic, integrated system that truly brings our institutions the full promise of the Internet. Called middleware by some, or an e-commerce infrastructure by others, this essential infrastructure that "glues" our current—and future—IT applications together is lacking in higher education. The purpose of this Research Bulletin is to provide higher education institutions and vendors with a framework for this "next-generation infrastructure."

Ten to fifteen years ago, colleges and universities invested in a network infrastructure that allows them to communicate across campus and around the world. Initially, that infrastructure was fragmented. Different departments often used different e-mail systems, meaning they could not send or receive e-mail among each other. Others used different protocols. We quickly identified the need for interconnectivity and gradually built the systems that made seamless communication possible. Today we have hundreds of applications (e.g., for e-mail, recruitment, admissions, classroom scheduling, enterprise resource planning [ERP], procurement, financial management, human resources), but the systems do not "work" together. They can't be "snapped together"; there is no end-to-end integration. As a result the user must make the connections manually. Higher education needs a next-generation infrastructure that will allow our institutions to be user-centered, to establish and maintain lifelong relationships with individuals, and to provide personalized, secure, seamless connections with all constituents.

The planning framework described in this Research Bulletin is the technical foundation necessary to support the Web-based relationships and applications an institution chooses. Designed by the University of Washington, the framework addresses needs

identified by many universities and has been modified by their input. Rather than representing a standardized approach, this foundation enables institutions to be unique. It defines a Web-based, layered framework that can deliver information, tools, and services to all of the college or university's constituents, anytime and anywhere.

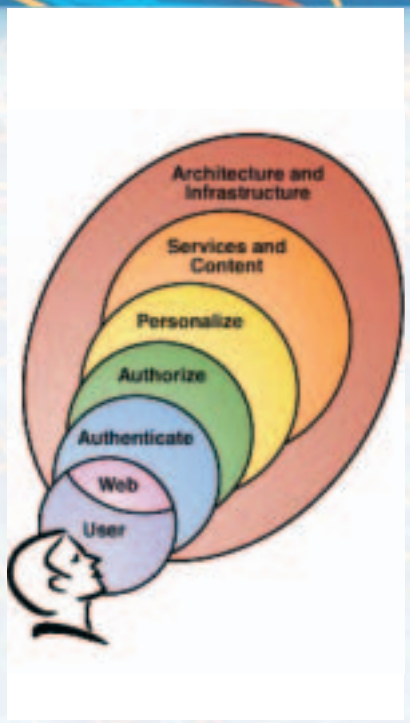
Highlights

Although some have called this the Information Age, many are now focused on making it the "informed age." Colleges and universities are "information organizations" that provide people with the resources they need to make decisions or take action (e.g., select a major, enroll for a course, procure supplies, register for a health program). In an information organization, the institution designs flexibility into the way it does business to meet the needs of its constituents; it does not ask its people to change the way they do business to suit the institution. The principles of the information organization allow institutions to streamline processes, eliminate duplication, and minimize routine tasks.

The information organization rests on a framework that starts with the users but expands to include the Web, authentication, authorization, and personalization, as well as services and content, while being supported by an underlying architecture and infrastructure.

User

The framework begins with the user. But who is the user? Users may include potential students, enrolled students, faculty, staff, alumni, and others. In addition to these groups a user may have more than one identity (e.g., faculty member and student parent). Plus, the "identity" of a user can change. A student becomes an alumnus. A staff member becomes a lifelong education student. And, these users may be on-campus or any place else in the world. All users want convenient, easy-to-use, personalized information and services made available to them over the Web.



Web

The Web is a contact point for the user and the institution. The Web is more than a static Web page that provides information that used to be published in a catalog. It is a dynamic environment that provides interactive resources and services that are customized for each individual.

Authenticate

Authentication allows a person to enter the network. A user ID and password provide authentication. The current challenge is that users typically need to authenticate themselves multiple times. For example, campuses have student IDs, employee IDs, and some have alumni IDs. An ID for accessing a library system may be different from one for event tickets. Multiple authentications are the Web equivalent of making students bounce from office to office to register for classes or requiring faculty to obtain multiple signatures to submit a grant proposal.

A next-generation infrastructure provides a single ID and password that authenticates a user. The user is no longer required to juggle multiple IDs and passwords because a single authentication provides access to the institution's resources.

Authorize

Although users may be logged on to the network, they do not necessarily have the authority to access specific applications. Authorization is the process by which the system determines what resources a user is permitted to access and the kinds of operations he or she is allowed to perform.

Although authorization is mediated by a computer, current processes that lead up to authorization are manual. For example, many institutions require that paper forms be submitted requesting authorization for an individual to view budget numbers or personnel files. These forms require a signature from a department representative and are passed to an office that logs the request. Although designed to ensure security, the authorization is usually implemented by someone who does not know the individual receiving authorization, does not recognize signatures (i.e., knowing if one is legitimate or forged), and may not even be required to cross-check the name against current employees or students. A next-generation authorization process occurs close to the user. It is automatically updated when a user's status changes, such as when an employee leaves, a faculty member is promoted, or a student graduates.

Workflow depends on having the appropriate authorizations in place. To truly streamline work, forms can be approved online, then automatically routed to the next person. Although redesign may eliminate some steps in the process, most institutions still require certain sign-offs. Authorization drives the routing and reviews associated with specific types of work. For example, one routing is appropriate

for grant applications while a different one may be needed for procurement decisions. Authorization is also a key link in the post-audit process. Some institutions automatically approve certain transactions; rather than requiring sign-offs in advance, specific transactions are selectively reviewed after-the-fact. Individuals might be authorized for post-audit approvals for different types of transactions or particular dollar amounts. Authorization is the critical step that streamlines these workflow processes.

Authorization becomes an important process for identifying individuals as their relationships change over time. Typically, information systems manage the identities of students separately from employees, extension students separately from regular enrollments, and so on. Yet, students are often employees, sometimes employees become students, and other overlaps occur. To manage the identities of individuals and the type of relationship(s) they have with the institution, the next-generation infrastructure uses a database that allows the portal to present users with an appropriate view based on their current "identity" (e.g., student, employee, alumnus, athletic booster). This database is sometimes referred to as the person registry. When a person is authenticated, the portal checks the person registry and presents the individual with a view tailored to his or her current relationship, enhancing the level of personalization.

Personalize

Portals are used by many institutions to provide users with a personalized Web space. A portal is similar to a Web page, but rather than representing a view seen by all, it is customized by the individual. Portals allow individuals to select the elements that are displayed, reflecting the person's unique needs and preferences. A personalized student portal will likely be different from that of an administrator because the information, tools, and services each needs are unique. Moreover, portals allow individuals to change their preferences.

A portal relies on authentication and authorization to "know" what information can be provided to the user. As a result, rather than the user needing to move from Web site to Web site to find the information needed, the portal brings the information to the individual, making it user-centric.

Services and Content

Once the user has entered his or her portal, a range of services and content are available. The wealth of institutional resources, ranging from instruction to service to entertainment, are available at this point. The services and content are institution-specific; no two institutions will be the same. The services and content provided by the institution help create a unique image and relationship with the user.

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There are three common categories of services and content typically found at post-secondary institutions.

- Communication tools (e.g., e-mail, Web-based discussion groups)
- Information resources (e.g., institutional data, library resources)
- Transaction services (e.g., buying products, making appointments, paying tuition, registering for classes)

Architecture and Infrastructure

Supporting the services, content, authorization, authentication, personalization, and the Web is an architecture and infrastructure. There are underlying hardware and software systems that make this middleware viable. The infrastructure includes computers, servers, networks, and the wireplant (e.g., physical wire and wireless systems). The way the infrastructure is configured defines the architecture. The architecture gives the system its functional characteristics, such as the ability to operate a data warehouse, to use a physical or wireless network, or to archive video.

There is a set of capabilities that the architecture and infrastructure should provide. These include:

- Fast, reliable service that provides continuous operations
- Security and backup capabilities
- Rapid recovery in the event of an emergency or disaster
- Networking that manages traffic flow

What It Means to Higher Education

Implemented well, the next-generation infrastructure makes it possible for the entire institution to be at the users' fingertips. Our institutions have multiple departments, student services, administrative systems, alumni operations, and medical centers. Although each office is likely to have a Web presence, they are rarely linked and

sometimes not easy to find. Just as no one individual has a relationship with all parts of the institution, connections are likely to change over time. And, in an integrated system, the institution can suggest new connections to individuals, enriching their relationship with the institution.

For example, a potential student might be strongly attracted to the athletic program. That interest might be parlayed into an interest in enrolling. Once enrolled as a student, the individual may develop an interest in the arts. After graduation, the institution can leverage both the athletic and arts interests because it maintains a connection with the alumnus. As the alumnus ages, he or she may become more interested in health and wellness information or alternative career opportunities. The relationships our institutions have with constituents should change over time. But changing these relationships should not be onerous for users.

This middleware infrastructure makes it possible for institutions to cross-market products and to mass-customize services, to borrow two phrases from marketing. Mass-customization allows institutions to tailor material for large numbers of constituents. Cross-marketing enables the medical center, for example, to encourage patients to consider enrolling in continuing education programs. Or it can encourage those interested in athletic events to consider taking an alumni association cruise. Users can register their interests with the system, thereby tailoring the institutional contacts to their particular preferences.

An equally powerful implication is that this middleware framework enables higher education to make institutions truly user-centered. Users can determine what their relationship will be with the institution and access resources appropriate to that relationship. Users will no longer need to bookmark multiple URLs, remember multiple IDs and passwords, or be required to close one application to use another. Navigating through the institution will be as easy from on-campus as from off, letting users determine whether they want to work from the library or from their homes.

When institutions are user-centered, they are also able to customize their offerings. Services can be personalized. Ultimately, a middleware infrastructure may enable academic programs to tailor individual educational programs for each learner. With the appropriate level of authorization and authentication, faculty can offer unique opportunities for students, tracking individual progress, culminating in a personalized, outcomes-oriented, self-managed educational experience.

The next-generation infrastructure has significant implications for administrative applications, reducing paper processing and enhancing decision-making capacity. The bulk of an institution's administrative processes are represented by paper flows today. With the next-generation infrastructure, many of these will be automated, with policies embedded into the processes. Education may also be embedded into processes. If an individual must process a travel requisition but has forgotten the process, that person may choose to view a quick tutorial before beginning the online process. Integration of systems will allow finance officers, department chairs, deans, and Principal Investigators (PIs) to receive up-to-date budget information, eliminating the need for multiple shadow systems. The systems will also be more useful for decision making because of the ability to do projections and examine trends from multiple perspectives.

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There are a number of benefits to institutions that create such a next-generation infrastructure. Efficiency is enhanced. Rather than generating multiple infrastructures for each office on campus, an enterprise-wide infrastructure allows for the production of a single system that can be replicated locally with greater efficiency. It also ensures that all systems will interact. Reduced duplication of hardware, software, and services will improve efficiency. And the collaboration and coordination required among units leads to additional efficiencies.

Security is also improved by an enterprise-wide middleware system. Today, authorizations are typically passed from individual units to a central office. The further away the decisions move from the individuals involved, the more likely the errors. A middleware infrastructure allows those decisions that affect security and privacy to be made locally.

While this next-generation infrastructure provides multiple opportunities, it also requires a new discipline on the part of institutions. If the institution is planning to purchase a new

system (e.g., financial system), it should ensure that the application will interface with the authentication, authorization, and Web infrastructure. Today, applications are purchased by institutions without regard to this new level of interoperability, resulting in IT staff having to devise work-arounds so that new applications integrate with the existing system. In some cases, it is impossible to integrate applications, the end result being our current multiple ID/password environment.

Higher education must proactively engage vendors in these discussions if they want companies to develop systems that will integrate with this new middleware infrastructure. Although vendors are aware of the need for end-to-end integration, in the absence of industry standards not much action is taken. For the next-generation infrastructure to be viable, higher education institutions must hold themselves and vendors accountable for a new level of integration and cooperation.

Moving to the next-generation infrastructure will be empowering for many but intimidating for some. Those who may have viewed their role in the institution as a processor or approver of forms will find themselves with a different task. Instead of being a processor, they may become the "help desk" for those who have questions about the process or policies.

While the perception may be that more work is being distributed to individual units, this type of work aligns more closely with the expectations of incoming workers. These workers are more independent, are used to information systems, and expect their positions to provide a challenge. And keeping work close to the unit or individual with the greatest knowledge ensures the best results.

Critical Success Factors

Many institutions have begun creating the next-generation infrastructure. Based on their experiences, several critical success factors have emerged.

For the next-generation infrastructure to be viable, higher education institutions must hold themselves and vendors accountable for a new level of integration and cooperation.

A top-down and bottom-up approach will be required. It is not sufficient for the president, provost, or CIO to declare a middleware initiative. It will require the support of those "in the trenches," from IT staff to functional employees (e.g., a cashier) to faculty. The degree of coordination and cooperation required to make an enterprise-wide initiative work is significant.

Time is another critical success factor. There must be sufficient time allowed for individuals at all levels of the institution to discuss what this new infrastructure means to them. It will take time for the technical components to be put in place. It will take time for vendors to modify their development plans. Creating the next-generation infrastructure is not a one-year project; it is likely a five- (or more) year journey. It will take both passion and persistence.

If people and time are required, funds must be invested. The creation of this middleware infrastructure will enable the institution to reach more constituents in more powerful ways. Ensuring that opportunity, however, will require stable, long-term funding. An initiative this complex cannot be sustained on end-of-the-year or one-time money. Since more work is done online than manually, funds may need to be shifted to support the IT infrastructure (e.g., networks and servers).

Personnel will be heavily involved in multiple parts of such an initiative. Certainly, many IT staff will be involved. But individuals from every part of campus will be involved, as well—the medical center, athletics, student services, administrative offices, alumni affairs, and academic programs. Without the involvement of end-users, the system cannot attain its true potential.

A new management structure will be required. Traditional management structures are de-emphasized by this approach, while a focus on the end user is strengthened. The needs of end-users rarely match the historic management structures of the institution. While the management structure need not change, a shift in the relationships across multiple units will be necessary. It will also require the continual integration of a technological perspective and a strategic view. Few institutions have had successful enterprise-wide initiatives without adapting their management structure.

Because the fundamental impact of the next-generation infrastructure is on the image and brand of the institution, another critical success factor revolves around brand management. Higher education institutions have powerful brands. Without active management, the brand can be diluted, miscommunicated, or diminished. After all, the infrastructure is needed

to promote the brand, not the other way around.

Be clear about who your users are. Colleges and universities have very broad constituencies; it is natural to focus on faculty, staff, and students, yet this misses other groups such as media, legislators, patients, farmers, or food processors. To design a system that serves users, you must first know who they are, as well as their characteristics and common needs. At that point it is much easier to design systems to serve them.

Articulate a clear vision—multiple times. For the organization to support a long-term program such as developing the middleware infrastructure, individuals must understand the vision as well as their role in making that vision happen. Although an initiative may be well communicated initially, effective communication must be ongoing. One of the common failings of technology initiatives is to undercommunicate the vision and what the initiative means to individuals.

Key Questions to Ask

As institutions begin to pursue the development of the next-generation infrastructure, a series of key questions should be asked. Answering these questions will require a collaborative effort involving individuals from administration, academic affairs, and information technology. The answers will be enhanced if students, faculty, staff, and those external to the institution are involved in some way.

- Who are the college/university's constituents?
- What kind of relationship do we want them to have with the institution? How will that relationship change over time?
- What kind of experience do we want users to have (e.g., self-service, fragmented)?
- Do we have an integrated approach to establishing our Web presence for these constituencies?
- How do we manage the institution's brand (and sub-brands) via the Web?
- Do we have an IT organization that has the size, scope, and talent to deal with the next-generation infrastructure?
- How do we manage the creation and maintenance of the middleware infrastructure? How are decisions made? Based on what criteria?
- Are applications being built so that they integrate and work with the authentication, authorization, and personalization system?

A Necessary Step in Transformation

We often say that information technology is transforming higher education, breaking down barriers and making it possible for people to interact with the institution anytime and anyplace. In-

formation technology tools offer institutions the potential to transform how students learn, how we manage our institutions, and how we reach out to our constituents.

Transformation relies on rethinking what we do and how it is accomplished. It also relies on a solid infrastructure.

Creating middleware or the next-generation infrastructure is not just something for technologists. There are a host of technological implications to the process, but the most significant changes will be in how we regard our users and our work as well as how we define service. Just as we would not have achieved the technological revolution without a solid IT infrastructure, our next revolution/evolution relies on the next-generation infrastructure. This new infrastructure will require the same kind of design, management, investment, and precision execution as our current infrastructure. If we are successful, it will be transparent to users. Within ten years, a world of multiple logons will be a thing of the past.

Where to Learn More

- EDUCAUSE Information Resources Library section on middleware: http://www.educause.edu/asp/doclib/subject_docs.asp?Term_ID=285
- Internet2 information on middleware: http://middleware.internet2.edu/
- Higher Education PKI Summit Meeting. August, 2001: http://www.educause.edu/netatedu/events/pki01/
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