Overview

Institutions of higher education face disruptive changes, and changes in information technology are at the heart of these disruptions. Institutions of higher education are responding to sweeping market changes, such as increased demand for lifelong learning, more knowledge workers, the need to reduce costs, and competition in a global market for education. At the same time, technology continues to be a catalyst in education—for example, increased online communication among learners and educators, automated evaluation of learners, access to information online, and the use of simulations. Finally, the parameters for how institutions implement information technology are changing, with a major shift under way from locally developed or implemented solutions to commodity cloud-based solutions.

The convergence of these changes has been called “education in the cloud,” referring both to profound changes in how learning and research take place and to the commoditization of information technology. An institution’s ability to adapt and thrive depends in part on its ability to rapidly obtain, adapt, and manage software services while both institutional needs and the technologies available to meet them are in flux. Service oriented architecture (SOA) provides a comprehensive methodology for embracing these changes. An approach based on SOA opens up the opportunity for greater agility in responding to changing needs by adapting existing services and incorporating new ones. SOA design principles include the following:

- Business requirements should be analyzed to identify the modular “building blocks” of software services needed to support them.
- Software services should be designed for future reuse, as when a new business process requires the same service or when the sequence of steps in a process changes.
- Software services should be standards-based so they can share data easily with other related services, across diverse software platforms.
- Software services should be independent so that each service is easy to replace without impacting the overall set of services.

In 2012, to find out how institutions are using SOA to prepare for changing software needs, members of the EDUCAUSE Enterprise, Business, and Technical Architects (ITANA) Constituent Group worked together to survey institutions. Architects from 7 institutions conducted surveys in March and October 2012 and analyzed responses from 27 institutions in the United States, the United Kingdom, Canada, and Australia. Two-thirds of the responding institutions fall within the ARWU top-100 ranked universities.
For the purposes of the survey and for this article, we characterized elements of SOA as either “strategic” or “tactical.” A comprehensive approach to SOA includes both. From a strategic perspective, SOA encompasses both business architecture and software architecture, including identifying institutional goals and the business processes that support them; analyzing business processes for capabilities that require software services; ensuring that business processes can be revised and software services replaced with minimal effort; defining and governing data models and master data; and creating standards for data exchange between organizations and systems.

We characterized as tactical the more technical and operational elements of SOA, including the use of web services technologies to integrate back-end systems or develop new services, perhaps combined with some concept of an enterprise service bus (ESB) or asynchronous messaging infrastructure. A service registry might be used to track existing services and service contracts, and of course web services should be part of an IT organization’s change management, portfolio management, and IT governance processes. These efforts address recurring integration, development, and maintenance issues.

**Highlights**

Applying SOA successfully to facilitate change is a major challenge, even for companies centered around information technology. Have institutions been able to use SOA strategically as part of a mature organization, or have they been using SOA-related technologies to solve tactical problems? Has their investment in SOA paid off?

**SOA Continues to Be a Compelling Architectural Paradigm**

The ITANA survey revealed numerous issues around the adoption and implementation of SOA. However, these issues notwithstanding, one overarching point emerged in the survey, namely, that SOA remains the preeminent and most compelling architectural paradigm for the Internet. This was clearly evidenced in the section of the survey that allowed respondents to report on SOA-related projects at their institutions. Nearly all respondents were actively engaged in one or more SOA-related projects, ranging from large-scale multi-institution integrations to more modest technology proofs of concept. Integration via web services was a constant and dominant theme. The range of examples included the following (for links to these and other projects, see the Where to Learn More section):

- Large-scale multicampus projects, such as University of California UCPath, which will integrate HR functions across 10 campuses and 5 medical centers; SOA is a key component of the data-integration strategy.
- The delivery of innovative new functionality, such as the University of Washington’s MyPlan, which integrates legacy services with the new Kuali Student curriculum module.
- More modest technical proof-of-concept projects, such as the University of Wisconsin–Madison “Integration Testbed” project, which is currently evaluating different ESBs.

When respondents were asked to describe the main drivers for SOA initiatives, the need for enterprise integration once again emerged as the main theme (see Table 1).
Anecdotal comments also testified to the continued appeal of the SOA paradigm. For example:

We have recently implemented an enterprise architecture focus area within the CIO’s office that will facilitate development of SOA service governance (among other tasks).

SOA is a good IT strategy, which must have top-level support and investment in order to produce efficiencies and cost savings. Our early entry into SOA has helped lead to many successes. Looking back, the three most important considerations would be campus-wide governance and understanding, consistent development and usage, and a well-supported service portfolio.

We leverage our SOA infrastructure for nearly all system level integrations, regardless if they are web services related or not. Through the use of commercial adapters we are able to standardize the integration patterns for legacy integrations as well, which allows us to manage the vast majority of our system integrations through one standardized management interface.

Most respondents reported increased understanding of SOA-related concepts among their IT and business leaders (94%) and improved collaboration with business units to define goals (72%) over the past five years.

In terms of project activity, SOA continues to be relevant for IT organizations. This may be because it addresses older and deeper concerns in software design (loose coupling and reusability) or due to widespread use of SOA-related technologies (web services). But the survey also suggests a gradual increase in maturity that keeps SOA relevant as a framework for responding to business needs with IT solutions.

**Tactical SOA Is More Mature Than Strategic SOA**

As discussed in the Overview, there are both tactical and strategic elements to preparing for change using SOA. To understand where institutions stand, our surveys asked respondents to rate both tactical and strategic changes around SOA.

Regarding changes over the past five years, most respondents indicated increased use of web services provided by vendors (94%) as well as projects that have increased the portfolio of available services (76%). Relatively few respondents agreed that services are currently tied to known business requirements (33%), have improved responsiveness to changing needs (24%), or have resulted in real cost savings (24%).

Respondents also indicated challenges in managing SOA within their IT organizations. Close to half (44%) indicated no improvement over the past five years, and none indicated major strides in the governance of services as they are proposed, developed, and changed. A similar 44% indicated no improvement in the operational management of services (SLAs, change

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**Table 1. The Leading Drivers for SOA Initiatives**

<table>
<thead>
<tr>
<th>Driver</th>
<th>Important</th>
<th>Very Important</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Need for enterprise integration</td>
<td>41%</td>
<td>33%</td>
<td>74%</td>
</tr>
<tr>
<td>Response to strategic demands</td>
<td>26%</td>
<td>30%</td>
<td>56%</td>
</tr>
<tr>
<td>Need for business agility</td>
<td>15%</td>
<td>33%</td>
<td>48%</td>
</tr>
</tbody>
</table>

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management). Only 6% agreed that SOA is currently supported by a strong IT governance and change management framework, and none strongly agreed.

Projects at the University of Washington (UW) and the University of Wisconsin–Madison (UW–M) provide evidence of the success of a tactical and pragmatic approach where there is a supportive and forward-looking IT culture.

- The UW Supplier Registration Form (SuRF) integrates workflow (Kuali Enterprise Workflow) and legacy systems through RESTful APIs to allow vendors doing business with the university to self-register.
- The UW–M Curricular Hub provides a standard set of services for access to curricular data across campus.

In both cases new functionality and value have been created through service orientation but without any explicit SOA governance mechanisms.

An example of a more top-down approach is the University of Toronto’s Student Contact Information project using IBM WebSphere: “We purchased IBM’s WebSphere Message Broker and established an SOA governance structure. We’re in the process of building an ‘Integration Team’ that will operate the ESB and develop message flows and services, and help the divisions build services too.”

A review of the projects described by the respondents suggests that they have been most successful where there is a well-defined business problem to be solved, combined with a good level of maturity in SOA-related infrastructure and skills.

The survey suggests a preponderance of tactical approaches. This appears to be true both for IT organizations (which often struggle with the governance and operational aspects of SOA) and for institutions (which often have not seen major gains in transparency or efficacy of services).

Some institutions have taken more long-term, strategic approaches to SOA. The anecdotal responses suggest that this is more likely when an institution has reached greater maturity in IT governance and in collaboration between IT and business units, in some cases through an enterprise architecture program. Institutions that are less centralized (especially with regard to their IT organization) probably have greater governance challenges to overcome and are likely to use SOA in a more tactical way.

Although our survey didn’t ask about funding models, our conversations with respondents suggest that this can also affect the type of SOA activity. In principle, numerous units in an institution could offer and use software services as part of a university-wide architecture, but in practice, decentralized units may not be able to do so in a sustainable or coordinated way. An institution with more centralized business processes and IT services may be in a better position to maintain a suite of services that provide reusability and agility.

**Technical Standards Are Easy and Industry Standards Are Hard**

One of the most compelling aspects of the SOA model is that it should be possible to orchestrate existing software services to provide new business functions. In order for services to be able to communicate effectively, they must be able to understand each other. That is why standards are so important. It is useful to distinguish between “vertical” industry-specific
standards (such as education, health, and retail) and “horizontal” technical standards (such as identity and communication protocols). At the 27 institutions surveyed we found a more or less ubiquitous adoption of horizontal standards. By contrast, the adoption of vertical standards appeared to be much slower.

Vertical standards in higher education cover a number of familiar business objects: student academic records, admissions applications, course registrations, etc. In North American higher education the two best known standards organizations are PESC (Postsecondary Education Standards Council) and IMS Global. PESC standards are primarily concerned with the exchange of information between institutions and organizations. The best-known PESC standard is the College Transcript, which allows for the electronic transfer of transcripts between institutions across North America. The IMS Global standards are more focused on the integration of student systems and learning technologies. These standards include Learning Tools Interoperability (LTI), which is a standard for integrating learning tools with a learning management system (LMS), and Learning Information Services (LIS), which provides, among other things, a standard for integrating a student information system and an LMS (see Table 2).

<table>
<thead>
<tr>
<th>Table 2. Adoption of Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard</strong></td>
</tr>
<tr>
<td>IMS Learning Tools Interoperability</td>
</tr>
<tr>
<td>IMS Learning Infrastructure Services</td>
</tr>
<tr>
<td>PESC College Transcript</td>
</tr>
</tbody>
</table>

One issue that emerged on several occasions was that of the size and complexity of some of the vertical standards. Two institutions had abandoned efforts to implement a standard, citing complexity and inflexibility as issues. In the words of one respondent,

> Where the standard is somewhat easy to understand and limited in scope and usage, its uptake is more broad. IMS Basic LTI is a good example—it is a standards-based approach to solve a fairly common, fairly well-understood challenge, and not surprisingly it leads in adoption. The more heavyweight and all-purpose the standard tries to be, covering a broad subject/service area with lots of interpretation required, the more complex the information model for the service becomes.

Some of the complexities and issues around the adoption of vertical standards are discussed in the section What It Means to Higher Education.

While PESC and IMS might be viewed as de jure standards, there are also de facto standards in the service contracts of various open-source and commercial products. In the survey results there were several examples of successful integrations using vendor-supplied service contracts (especially the PeopleSoft Integration Broker). Prominent among these is the aforementioned University of California system Path project (UCPath), which involves integrating payroll HRIS across 10 campuses and 5 medical centers. On the collaborative software front there were a number of successful integrations using Kuali Foundation software.

The survey results around horizontal technical standards were much more straightforward. The survey respondents indicate ubiquitous adoption of web services technical standards. Responses indicated more or less equal use of SOAP and REST when it came to the actual
transportation protocol for the web services. More than three-quarters of the respondents were using SOAP (81%), and 61% were using REST. There were also high adoption rates for web service security protocols and for web service Java binding technologies (60% of the respondents were using JAXB and JAX-WS). In short, the standards around the web service technologies of SOA appear to be well established.

**SOA Technology Infrastructure**

A number of infrastructure technology capabilities are associated with SOA. The capabilities include a service bus, business process management, messaging, and rules engine technology. Often these are integrated into a single suite as is the case with Oracle SOA suite, IBM WebSphere, and SAP NetWeaver. The institutions in the ITANA survey tended to take one of two approaches—either invest in a suite, or eschew the integrated suite approach and instead concentrate on individual capabilities that are included in the suite.

The only thing the survey revealed with respect to integrated SOA suites is that there is no clear trend in this area. The results were too sparse to support any trends (see Table 3).

**Table 3. Uptake of SOA Suites among Survey Respondents**

<table>
<thead>
<tr>
<th>SOA Suite</th>
<th>Exploring</th>
<th>Implemented</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oracle SOA suite</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>IBM WebSphere</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>SAP NetWeaver</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Microsoft BizTalk</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Maybe this lack of obvious commitment is, in itself, revealing. These technologies tend to be very complex, and they do not return immediate business value. Interestingly, the community-source product Kuali Rice has many of the same capabilities as the heavyweight SOA suites: business process management (Kuali Enterprise Workflow), business rules management (Kuali Rules Management System), and a bus (Kuali Service Bus). Although it is not a self-styled SOA suite, it is used in this way by adopters. This relatively lightweight approach is more likely to return business value for a more modest technology investment and has had great success with schools implementing Kuali products.

In general, a piecemeal and empirical approach to SOA technologies seems to be more successful. An ESB is often seen as the core SOA technology. Among the survey respondents, 56% had either implemented or were in the process of implementing a service bus, and 59% of the respondents had implemented some kind of ERP integration via web services.

**What It Means to Higher Education**

In response to disruptive changes in higher education, institutions will need to manage an increasing number of software services to meet expanded requirements. These services will be required to work more closely together and change more often; they will also be used more heavily while their reliability becomes more business critical. What can higher education, institutions, and IT departments do to prepare for these changes?
Implications for Higher Education

To our knowledge, no institution of higher education has applied SOA comprehensively to its operations and technologies in the manner of Google, Amazon, or Facebook. Unlike these companies, however, colleges and universities are primarily consumers rather than creators of IT commodities. We think that for any single institution, applying SOA comprehensively is a “boil the ocean” goal that will likely fail. This makes it all the more important for higher education as an industry to work together to improve the technology ecosystem for all institutions. Ideally, an institution should be able to obtain commonly used software services as commodities and focus its energies on orchestrating services (or in some cases creating unique services) and managing data to meet its unique needs.

Institutions will increasingly look to cloud solutions for large swaths of software services. Higher education can collaborate to make commonly used commercial cloud services easier for everyone to discover and select, faster to contract for, and more affordable. Internet2’s NET+ Services is currently the leading example.\(^1\) By speaking with one voice on commonly used services, higher education can exercise greater leverage with vendors to lower costs and improve functionality in products that would otherwise be designed without much higher education perspective. For example, greater modularity and interoperability (based on SOA principles) may be of particular interest to higher education.

There is, arguably, a natural synergy between collaborative, open-source projects and the pursuit of industry standards. Higher education institutions have unique needs in identity management that are often an obstacle to integrating cloud-based software services. These needs are more likely to be met by software providers if agreement can be reached on a set of standards. The leading current example is the CIFER (Community Identity Framework for Education and Research) project,\(^1\) which brings together a number of well-established open-source projects in the identity and access management space (Shibboleth, CAS, Grouper, and Kuali Identity management) and provides higher education with a standard roadmap for identity projects.\(^1\)

Implications for Institutions

SOA represents a different challenge for each institution. For example, large or decentralized universities with potentially the greatest need and potential for SOA often also face the greatest challenges in governance, preventing strategic SOA approaches from gaining traction. We believe that the current climate of disruptive changes, including cloud, mobile, and pervasive computing, is a good time to revisit SOA strategy at the institutional level (not just within IT organizations).

Consider some foreseeable changes in how institutions manage software.\(^1\) Instead of designing their own software services, institutions will increasingly be subscribing to cloud-based packages of software services. Similarly, instead of integrating individual software services, institutions will increasingly be using integrations built into cloud-based solutions.\(^1\) To orchestrate services from multiple cloud offerings, institutions will increasingly use cloud-based integration services to create and manage customized integrations, rather than maintaining their own integration infrastructure. And instead of expanding internal operations in response to change, institutions will increasingly be outsourcing operations.\(^1\)
These changes suggest that institutions should shift their emphasis from tactical to strategic approaches to SOA. The technology-centric details of SOA-based software design will increasingly take place outside the institution, but to take advantage of cloud offerings and partnerships, institutions will need to know their goals, business processes, and data. For example, an institution may find it has greater need for business analysts conversant with SOA principles, perhaps located in administrative offices, rather than for programmers able to implement web services standards, traditionally located in IT organizations.

We expect to see institutions spending more time on strategic SOA activities, such as:

- Understanding institutional business processes and identifying the common capabilities and software services needed to support them
- Evaluating cloud offerings based on their ability to provide software services that are adaptable, reusable, and interoperable with other software used by the institution
- Evaluating and responding to changes in already implemented cloud offerings
- Understanding institutional data and defining master data that are expected to be consistent across software services in diverse platforms
- Managing the flow of data across vendor and partner applications in terms of consistency, access controls, information security, and governance
- Evaluating and using standards for data exchange between applications and with partner organizations
- Working with vendors to develop specific services needed for higher education
- Managing a multitude of vendor relationships and contracts, and tracking an expanding portfolio of software services

Our interpretation of the survey results is that many institutions are not highly prepared for these activities. While IT organizations are important in this shift, a great deal of responsibility lies with institutional leadership to define goals, business processes, and data models so that IT can facilitate the rapid implementation of software services.

**Implications for IT Organizations**

We found a substantial level of SOA activity at the institutions surveyed, suggesting that IT organizations view SOA as relevant both as a set of technologies and as an architecture. Nearly all respondents reported an active SOA-related project, and most had implemented or are implementing a set of ERP web services, an ESB, an integrated SOA suite, and/or a service registry. Most respondents indicated an increase in understanding of SOA-related concepts and the skills to act on them, as well as progress on surrounding infrastructure such as identity management.

There appear to be several challenges around SOA for higher education IT organizations. Many respondents reported little or no progress on IT governance and IT operations related to SOA. Few respondents indicated that their services are tied to known business requirements or that they could demonstrate a return on their SOA investment. We also found limited response to industry-specific XML schemas such as PESC or IMS.
The survey suggests to us several considerations for CIOs and IT directors.

- In light of changes in higher education and changing technologies, there could be a shift in what types of SOA skills and infrastructure remain relevant for IT organizations. Technical SOA solutions may be more focused on integrating legacy systems and managing transitions to cloud-based services, while the bulk of software services and related integrations may shift to the cloud.

- IT organizations will increasingly be called upon to support more strategic SOA efforts, such as evaluating business processes and data models. IT organizations and IT leaders play an especially important role in decentralized institutions, where they can help business leaders identify shared solutions for diverse goals and processes.

- Given traditional IT funding models, a major challenge for CIOs and IT directors is to free up resources for new activities, such as working more strategically and responding more rapidly to address changing needs with off-the-shelf solutions.

- Some tactical SOA goals do remain relevant, especially as increased user demand puts more stress on important legacy software services that must be maintained locally.

- Cloud-based solutions may be implemented by business units within an institution without central IT involvement, but institutions will probably still rely heavily on IT organizations to understand where data are housed and how they are secured.

**Key Questions to Ask**

- How can your institution participate in industry-wide efforts to make cloud-based software services more accessible and better designed for all institutions?\(^1^6\)

- How can your institution participate in standards processes that facilitate communication between institutions and partners and make software services more interchangeable (for example, PESC and IMS)?\(^1^7\)

- How should your institution participate in industry-wide efforts to manage individual identities and data across institutions and software services (for example, CIFER)?

- How will your institution engage in strategic SOA challenges, knowing that these span traditional organizational boundaries and budget silos?

- How will your IT organization increase its ability to respond to and partner with university units through the changes they are undergoing?

**Where to Learn More**

- The raw data collected for this survey, as well as summary analysis of the questions, are available on the ITANA website at [https://spaces.internet2.edu/display/itana/SOA+Survey+2012](https://spaces.internet2.edu/display/itana/SOA+Survey+2012).

- Respondents provided a wealth of data about specific SOA projects. Here are some of the highlights:
The University of Washington Supplier Registration, SOA integration of administrative systems: http://f2.washington.edu/fm/ps/how-to-pay/department-responsibilities/supplier-registration

The University of Washington MyPlan, SOA integration of student systems (course catalogue, degree audit, registration): https://depts.washington.edu/myplan/

The University of California UCPath project: http://ucpath.universityofcalifornia.edu/ (The ITANA survey used data from the UC Irvine team: http://www.ucpath.uci.edu/about/about_index.html)

The University of Michigan mobile initiative (using Kuali Mobility): http://mobileapps.its.umich.edu/

The University of Toronto Next Generation System is heavily invested in SOA: http://www.ngsis.utoronto.ca/

The University of Wisconsin–Madison web services integration of course information: https://wiki.doit.wisc.edu/confluence/display/CHUB/Home

For an excellent overview of the disruptive changes that are sweeping higher education, see Diana G. Oblinger, ed., Game Changers: Education and Information Technologies (Louisville, CO: EDUCAUSE, 2012), http://www.educause.edu/research-publications/books/game-changers-education-and-information-technologies.

A cursory survey of Amazon revealed over 50 titles on SOA since 2003. More recent titles have, understandably, concentrated on SOA and the cloud. Among the books the authors are familiar with include:


About the Authors

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Citation for This Work

Notes


4. The working group was led by Leo Fernig (University of British Columbia), and its participants were Glenn Donaldson (The Ohio State University), Scott Fullerton (University of Wisconsin–Madison), Keith Hazeltone (University of Wisconsin–Madison), Piet Niederhausen (Georgetown University), Dave Perhne (University of Michigan), Philip Robinson (Cornell University), and Richmond Stevenson (University of Maryland University College). See https://spaces.internet2.edu/display/itana/SOA+Working+Group.

5. For the complete survey data and summary analysis of survey questions, see https://spaces.internet2.edu/display/itana/SOA+Survey+2012.

6. Throughout this article the term “web services” is used to cover both REST and SOAP. Some IT professionals use the term “web services” in the more narrow sense of SOAP and WS* standards supported by W3C.

7. For example, see David Rubinstein, “SOA (the term) is dead, but SOA (the architecture) lives on,” Software Development Times, April 25, 2012, http://sdt.bz/36566.

8. See IMS Global (http://www.imsglobal.org/) and Postsecondary Education Standards Council (http://www.pesc.org/).

9. See the project website at http://ucpath.universityofcalifornia.edu/.

10. See the Internet2 NET+ website at http://www.internet2.edu/netplus/.

11. See the CIFER website at http://ciferproject.org/.

12. The memorandum of agreement between PESC and Kuali Student is also evidence of opportunities for the alignment of standards. Collaborative projects provide an opportunity to get involved and make changes.

13. For any particular institution, some of these changes may of course be more important or imminent than others.

14. For example, a cloud-based ERP solution will likely include existing integrations with business partners (such as benefits vendors) or with collaboration tools (such as instant messaging).

15. For example, for its online courses, an institution may work with a partner to outsource the design of course materials, marketing, admissions, and/or some student administration and support.


17. The memorandum of agreement between PESC and Kuali Student is an example of the kinds of opportunities that can be pursued. See http://www.pesc.org/interior.php?page_id=213.