Enterprise Systems Education: New Directions and Challenges for the Future

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ABSTRACT

Enterprise systems design, implementation, and integration are focal points for business and information technology (IT). Businesses of all sizes are looking to information technology to better integrate with business partners, reduce costs, and provide strategic advantage. These challenges require a new type of technical professional, one with the training and perspective of an enterprise architect with general technical expertise as well as business strategy and planning skills. This paper investigates the need for this new type of IT professional and the implications for higher education.

Keywords: enterprise systems, enterprise systems education, storage education, enterprise integration

INTRODUCTION

Enterprise systems design, implementation, and integration are focal points for business and information technology (IT). Businesses must change processes, environments, and technologies as organizations strive to become more integrated and break down traditional silos of information systems and responsibility. These challenges require a new type of technical professional, one with the training and perspective of an enterprise architect with general technical expertise as well as business strategy and planning skills.

Some college and university programs have risen to this challenge in recent years, and the joint ACM/Association for Information Systems Task Force developed the MSIS curriculum model to establish the fundamentals of enterprise information systems in response to the increasing demand for university-trained graduates in an information economy [Gorgone, 2000]. Recently, the Association for Open Group Enterprise Architects called for industry and academia to work together to craft new enterprise systems curricula that are relevant to today's global business environment and developed from the perspective of an enterprise architect.

Today's globally competitive environment requires technical professionals to move beyond technical expertise and contribute to the strategy and development of dynamic IT systems that are able to support changing business objectives. To prepare students to meet such expectations, IT students must have broad experience in the design, implementation, and integration of such systems. This education is typically offered in a layered fashion, teaching students about databases, networks, and applications in different courses devoted to single topics [Nickerson, 2006]. While this method allows universities to assign faculty with specific expertise to particular courses, it does not adequately prepare students for the work environment of the enterprise architect, where all of these different layers must be combined to support and align with business strategy. Students trained in a specific, narrow layer may fail to anticipate certain trends or requirements, such as a database designer overlooking the need for remote replication [ibid].

To meet this need, many information technology programs are incorporating enterprise systems curricula for senior students. These courses are often referred to as "capstones" in the curriculum, and must focus on a wide variety of educational goals; including, understanding the enterprise as a whole, understanding how technology can provide a competitive advantage, learning to design complex integrated systems, learning concepts underlying technical systems integration, learning how to assess requirements of an integrated system, and learning how enterprise architecture design is practiced as a profession.

DEMAND FOR ENTERPRISE SYSTEMS EDUCATION

Enterprise architecture education is particularly important when trying to meet current business objectives. Several prestigious consulting groups, including IBM and Forrester, have noted a major shift in most technology-centric businesses since 2005 toward service-oriented architectures [Boyle, 2006; Seethamraju, 2007]. A service-oriented architecture (SOA) is the practice of sequestering the core business functions into independent services that typically don't change frequently. These services then can be combined to create composite applications that can be easily reconfigured to meet the changing needs of the organization.

This new paradigm in enterprise systems development and integration highlights the demand for enterprise architects who can understand and align business goals with a technical strategy and architecture capable of supporting current and future needs. SOA does not represent the entire scope of responsibilities of the enterprise architect—it is simply one method of the overall goal of aligning the strategic vision of the business with its information technology infrastructure [Cannon, 2004; Davis, 2004; Mulder, 1997].

In spring 2007, the Information Technology Association of America (ITAA) identified the need to double the number of graduates in science, technology, engineering, and math over the next 10 years to maintain U.S. information technology competitiveness. Specifically, ITAA identified "a commitment to the use of information technology to solve real customer problems now and in the future" [ITAA, 2007] as a primary goal of the U.S. education system—higher education in particular. The organization is committed to enhancing IT education through better understanding of the IT workforce, and frequent assessment of the IT needs of industry.

The lack of well-educated IT workers is further emphasized when considering recent surveys predicting significant shortages in IT workers on the horizon. Despite the offshoring of certain technology jobs, a large number of organizations in the U.S. are currently deficient in properly trained IT workers. A survey of Washington Trade Group members (over 14,000 companies) indicated that 36% of member companies had open technology jobs—"open" meaning the position has been posted and unfilled for more than three months [Barrett, 2007].

The most common explanation for the open positions among executives interviewed is a lack of "business literacy." In other words, applicants for the position are not sufficiently well-rounded in business and technology. Most of these unfilled positions seek an employee who can interact with various groups within the organization, manage technology projects, analyze business needs and translate those needs into a technical solution, and become an effective bridge between functional business units and the technologists. In short, thousands of U.S. companies are in need of employees with the background, skills, and perspective attributed to the enterprise architect.

The ITAA and Washington Trade Group expect this trend to increase, rather than simply continue. Given projected company growth and the currently dismal hiring numbers, the projected IT worker shortage in 2020 is expected to exceed 10 million [ibid]. In a separate survey, executives asserted that parents and teachers were largely to blame for the worker shortage, claiming that they promote four-year degrees as adequate training for the IT workforce, but do not ensure that the content of the programs meets current industry needs [ibid].

Other surveys have predicted comparable shortages in appropriately skilled technology workers [Survey, 2006; Trewyn, 2006]. Among other possible explanations of the predicted shortage, one survey of general corporate executives cited compliance with Sarbanes-Oxley requirements as a major contributor to hiring problems [Survey, 2006]. Specifically, Sarbanes-Oxley requires companies to retain more records of transactions and for greater lengths of time, in addition to general requirements of organization of documents. This drives the need for significant storage and information management purchases up, and thus increases the demand for properly trained enterprise architects to design, implement, and maintain those storage and information management systems.

With the advent of the technology era, industry-relevant content is developing at a greater rate than academia can hope to keep up with using traditional practices [Catanio, 2005; Dede, 1986; Dougherty, 2002; McGann, 2007]. The developmental rule of thumb in information technology is that computational capability will double at least every 18 months, while the average university course goes relatively unchanged for twice that time [Dougherty, 2002; Lynch, 2002]. Management Information Systems (MIS) and Information Technology (IT) curricula are finding it difficult to keep up with the shifting demand of the industry their students must populate, while industry advancements are often publicly well-known—allowing new crops of incoming students to have a better idea of what is missing or outdated in the content offerings of higher education institutions [Kruss, 2006].

To meet the needs established by industry, information technology curricula must produce well-rounded students who have a broad enterprise-wide understanding of a variety of IT concepts from databases to networks to data storage and management. IT firms are looking for employees who can engage the organization at a high level, define comprehensive requirements for large projects, design solutions, and be able to easily develop expertise in multiple areas of the company [Marshall, 2001; Sanders, 2004]. This is no small task, and necessitates a significant restructuring of many of the IT curricula in place today.

CHALLENGES TO ENTERPRISE SYSTEMS CURRICULA

Meeting the educational needs of enterprise systems-related courses is difficult enough, but faculty and administrators in higher education are also plagued with paperwork and committees when attempting to implement new courses, content tracks, and areas of study. From an administrative perspective, many deans and provosts are rooted in traditional academic thinking that avoids branching off in new directions for fear of being unable to promote unfamiliar academic tracks to new students [Alford, 2004]. Worse yet, many administrators fear the expense of starting up new academic tracks, concerned with their ability to market new curriculum to financial donors [ibid].

More significantly, university faculty are faced with a variety of concerns when attempting to produce and promote new curricular changes. On top of the challenge of mastering new content, many universities have an arduous approval process in place for any new class, making the task of linking a new course to an existing curriculum even more difficult [Helps, 2006]. Most significant of all, the delivery of pedagogically-sound content specific to information technology is problematic. Students must be prepared to engage rapidly developing equipment and practices by the completion of a degree, but ready access to equipment and content to meet these needs is extremely difficult. Universities cannot afford to adopt equipment at the same rate large companies are able to, making it difficult to offer a course on a topic like enterprise systems integration that will remain relevant and up-to-date [Davis, 2004; Prigge, 2005; Tompsett, 2005].

Additionally, while most institutions of higher education uphold strict standards for performance among their students, Light and Strayer [2000] have noted adjustments in the enforcement of standards. Over the past several years, school quality and student ability have undergone a shift. Faculty of lower-level courses often pass students on more lax guidelines than those teaching upper-level courses. Among the potential explanations are university/college interest in maintaining enrollment numbers as long as possible and "entrance to major" requirements (to which faculty of freshman and sophomore students are sympathetic) are met. Regardless of the cause, the passing of students in lower-level, foundational courses necessitates the re-teaching of core content in advanced classes. In a course such as enterprise systems integration, the number of foundational courses contributing to the topic is too great for a faculty member to re-teach them and still have time for the course itself. In addition, finding qualified faculty with the background, experience, and perspective of the enterprise architect is often a great challenge.

Beyond the challenge of specific courses, the landscape of enterprise information systems instruction in higher education covers a wide variety of interpretations. With no parent organization to make decisions about what is appropriate content for an information technology curriculum, individual colleges and universities are freely creating very disparate curricula. A 2005 survey of IT programs in colleges and universities around the United States showed that while many institutions placed unique emphasis on different aspects of information technology, all offered courses on networking, database construction/management, and software applications (including operating systems) [Helps, 2006]. Each of these parent topics in IT could easily be a curriculum of its own.

With such wide ground to cover with respect to content areas in information technology, capstone courses within the discipline are extremely challenging. Student preparation entering into these courses is often widely varied. These courses often take the form of an enterprise systems integration topic, or some other closely related topic [Tetard, 2005; Suchan, 2006]. It is at this point in an educational program that students have developed a broad enough skill set to begin understanding the relationships between different areas of IT to one another and to the enterprise as a whole.

These capstone classes are often an ideal situation for academic-industry partnerships [Turk, 2005; Courte, 2005]. A few universities attempt to begin industry partnerships early in the academic program, but according to Courte (2005), partnerships involving more senior students tend to have higher rates of return (industry partners are interested in repeating the experience the following year) and more often lead to internships and job placements. Pedagogically, this industry interest in advanced students offers an opportunity to put students in situations that expose them to current technologies and problems within an industry setting.

The traditional method of teaching enterprise systems-related topics at the college level would almost certainly involve the use of case studies to articulate relationships between technologies and practices. These case studies are beneficial to a student because they offer significant context to a real-life problem and afford the student an "insider" perspective on the subject. While this seems ideal, case studies cannot be written at the rate at which industry moves forward, rendering a specific case study more meaningless and outdated each semester. Industry engagement allows students to work on projects designed with cooperating companies. Students receive the most "hands-on" training possible with relevant contexts and scenarios [Cameron, 2005; Harman, 2001].

No matter how educational institutions approach teaching information technology, and enterprise systems integration in particular, the associated costs of that education can be astronomical. The costs of information technology education fall into three categories: cost of equipment, cost of instructors, and cost of material. The cost of maintaining computer labs alone (and replacing the equipment in them frequently enough to preserve up-to-date status) is enormous. For a moderately-sized branch of the SUNY system, the cost of replacing campus computers is over $700,000 [SUNY, 2007]. This means an expense well above $2,000,000 every decade for a school with approximately 5,000 students, assuming the school replaces machines every three years (putting them one to two years behind industry at any given time). This expense means that information technology professors must adapt the teaching of cutting-edge content to accommodate somewhat outdated equipment. This is particularly problematic for a topic such as enterprise systems integration, which must rely on many foundational courses taught over several years.

Adaptation of a capstone course in enterprise systems curricula using campus technology is an ongoing task, often with students having learned core skills on disparate systems. Beyond standard computer labs, many of the courses supporting enterprise systems integration (as well as the enterprise systems integration courses themselves) require additional equipment to better prepare students. The materials for a networking lab that allows students to build networks to meet various specifications, for example, are both cost- and space-prohibitive. With a class size of 30, placing students in groups of six would still require the purchase of a large amount of equipment, as well as the dedication of considerable space for storage and instruction. The financial mechanics of these courses make information technology instruction, and enterprise systems integration instruction in particular, extremely difficult.

Furthermore, information technology instructors also often command above-average salaries in higher education. While many faculty commonly have specific areas of expertise within the technology domain [Helps, 2006], faculty with the necessary skills to teach the integration of systems at an enterprise level must often be "coaxed" away from industry, necessitating significant salaries to make the switch to academia appealing. In the same way that properly trained enterprise architects are very difficult to come by in industry, qualified faculty to train enterprise architects in higher education are in short supply.

The cost of instructional content for information technology, and enterprise systems integration in particular, can also be expensive. Technology and computer science textbooks are often among the most expensive materials for college-level classes. They are made even more expensive by the inability to reuse texts for more than two or three years. Unlike the $100 biology textbook that can be resold year-to-year for several years to help defray the cost, technology textbooks have very short shelf lives. For enterprise systems integration in particular, no comprehensive academic textbook currently exists, and course content must be assembled by each instructor—as no parent organization currently offers specific curricular material for teaching the topic. This content assembly becomes very expensive with respect to faculty time, in addition to the cost of whatever additional resources a faculty member may require.

THE PILLARS OF INFORMATION TECHNOLOGY

Helps' survey of information technology curriculum content identified three major areas of focus for most institutions: networking, databases, and applications. Presumably a fully comprehensive education would offer a student significant training in all three areas. These areas map reasonably to industry definitions of information technology architecture, as laid out by the five pillars of the modern IT architectural components suggested by EMC Corporation [Van Sickle et al, 2007], but not completely. Van Sickle et al's five pillars include databases, networking, software applications, operating systems (which many universities and colleges include under the umbrella of applications), and storage.

Van Sickle et al (2007), argue that storage is a fifth pillar to the modern enterprise systems architecture that higher education has, for the most part, been missed in curricular designs. The reasons for this lack of appreciation for the importance of this topic in modern IT & MIS curriculums are many, but mainly stem from a general lack of appreciation for the importance of storage-related topics in the modern corporate technology architecture. Storage as a topical area of study encompasses a wide range of concepts, topics, and issues including technologies and protocols, evaluating technical options based on business requirements, architectural design, systems management and governance, performance considerations, information management, data recovery, security, and emerging issues and technologies.

Furthermore, in modern enterprise architecture, each of the five pillars is interrelated with other pillars of IT. The enterprise architect can not consider one pillar without at least some consideration of the other pillars. For example, databases require an expertise of their own, but some degree of expertise in networking allows a database administrator to better plan a database through knowledge of how users will access it. Likewise, expertise in storage allows the database administrator to better utilize resources by understanding the storage environment where the database resides. Network specialists can improve throughput with some expertise in storage technologies and through knowledge of the storage demands and capabilities of existing systems. Storage experts can customize their systems for better performance with expertise in the databases and applications stored on these systems.

This partial mapping shows that higher education is generally on the right track with IT education, but is often not doing a complete job. Several pillars of IT are commonplace in information technology curricula (databases, applications, networking), but these are often taught within their own curricular tracks or simply as independent courses of varying complexity—expecting that a student will take lower-level courses in each topic, but then choose a specific pillar (for example, networking) to specialize in through advanced coursework.

The enterprise systems architect must be well versed in all of the pillars of IT and higher education must develop curricula that foster this perspective in students. [Catanio, 2005; McGann, 2007]. This means curriculum to support comprehensive courses on enterprise systems design, implementation, and integration that teaches students to architect systems encompassing networking, storage, databases, and applications (including operating systems or devoting a lower-level course specifically to operating systems) all in the context of alignment with business objectives and corporate strategy.

IMPORTANCE OF THE STORAGE PILLAR

While storage spending in industry (and in higher education, for that matter) continues to skyrocket, with respect to both spending and information production/retention [Gantz, 2007; Sun, 2005; VUB, 2006], colleges and universities lag woefully behind in curriculum implementation. This can be due to several factors including the rapidly changing landscape of the storage industry (making it difficult to keep up with in an academic setting), to an absence of instructional materials on the subject, or to a lack of appreciation on the part of faculty of the importance of the topic in industry today. At the time of writing, there are a plethora of practitioner-focused articles on storage-related topics, but no adequate textbooks or other instructional materials commercially available. Companies are forced to train storage professionals on the job, rather than being able to hire university graduates with relevant knowledge and skills [ChannelTimes, 2005; Van Sickle, 2007].

In the mid-late 1990s, when universities began deciphering what content would be appropriate for an information technology curriculum, industry spending was predominantly on network equipment and software applications [McDonald, 2001]. This was quickly followed by interest in databases [Lynch, 2002], and the early information technology curricula were framed. It has been a decade since those content areas were selected for IT in higher education, and most universities still hold tightly to them today. Industry definitions of core competencies for information technologists have evolved in that time. While many universities have begun teaching operating systems from an experiential standpoint or as part of their application content, storage remains relatively ignored.

The primary problem with the disregard for storage is that the topic remains critical to enterprise systems education whether curricula support it or not. As a result of the absence of storage courses in higher education, enterprise architects must either go into the workforce with no understanding of storage (and thus, significantly unprepared to meet a growing industry need), or enterprise systems integration instructors must abandon weeks of their course to cover storage—thereby undermining the students' training in the integration of the five pillars of information technology.

Storage is of significant importance to industry because the value of information (and the virtual space it consumes) continues to climb. We have moved on from bookkeeping and asset-management tasks to business-to-business multimedia, video-on-demand, and voice/data integration. The number of e-mail messages alone has grown from 9.7 billion per day in 2000 to more than 35 billion messages per day today in 2007. Within those e-mails we embed a variety of media and file types, forcing a focus on information sharing rather than server-centric data storage. Material has to be shared via storage networking environments to meet current information needs [Datamonitor, 2006; Mesabi, 2006]. In addition, the increased storage and information management demands related to the Health Insurance Portability and Accountability Act (HIPAA), Sarbanes-Oxley, and other government mandated regulations has created an enormous demand for enterprise storage and information management solutions.

This overall 50% annual increase in data creation is coupled with increased interest in retaining digital, rather than physical, copies of material, so storage requirements are also extending across time. Business' information technology budgets are responding to storage demands, spending an estimated 40% on storage-related needs in large organizations [Hecker, 2004; Nisbet, 2006]. The increase in data creation proliferates in professional and private lives. While business data for inventories, pricing structures, sales numbers, shipping details, or health care-related information grows, so do the number of documents, photos, music, and video files kept at home. This information is currently stored anywhere, from MP3 players and USB drives to industrial disk arrays and off-site libraries.

The information being saved provides a variety of values to a business. It yields buying/spending patterns, reduced costs, new products and services, or targeted marketing campaigns. With the potential competitive advantage gained from analysis and access to all of a company's data, information availability becomes critically important. Retail industries can lose over $1 million per hour of downtime, while brokerages stand to lose more than $6.5 million per hour [Agami, 2006].

To meet growing storage needs, the industry has introduced a selection of storage solution alternatives, each addressing specific data storage and management needs [Duplessie, 2006]. Direct attached storage (DAS) systems attach storage drives directly to servers, network attached storage (NAS) environments are made up of specialized servers dedicated to storage, storage area networks (SANs) are highly scalable and allow hosts to implement their own storage file systems, and content addressable storage (CAS) systems are a mechanism for storing and retrieving information based on content rather than location. Because the storage needs of all organizations are growing exponentially today, huge investment are made each year in storage-related hardware, software, and skilled employees to design and navigate through these complex enterprise solutions.

CHALLENGES OF TEACHING STORAGE

The rapidly increasing need for storage professionals calls for an innovative capstone component in information technology education, drawing together the many aspects of storage technology and linking them to core information technology concepts. Students must be able to design, build, and manage storage architectures, as well as strategically plan for an organization's storage and information management needs.

Understanding the landscape of storage requires a broad skill set. Storage is not simply hard drives with data on them. Design and development of storage technologies requires understanding of technologies from legacy systems to emerging technologies, knowledge management, disaster recovery, data replication, application-aware resource management, as well as the business needs that storage networking addresses. Clearly, storage is a complex topic, and highlights the relationships between each of Van Sickle et al's five pillars of IT—while each is unique, they go hand-in-hand, such as storage and networking, or storage and databases, etc.

As with most areas of information technology, a significant hurdle in storage education is access to relevant equipment [Tompsett, 2005]. Just as access to a 4-port HUB does not scale to an understanding of complex networked systems, access to a hard drive does not scale to understanding of a storage area network. Many successful networking courses have overcome this problem through the use of theoretical constructs of network technology and simulations of networks. Successful database classes follow much of the same suit by employing any of a wide array of entity relationship diagramming tools and simulated environments. Successful instruction in storage technologies will need to follow a similar path.

As important as how storage courses are taught is when they are taught. Storage is one of the five pillars of information technology, and universities would do well to treat it as such. Courses and modules on enterprise storage-related topics throughout an educational curriculum are needed today in order to properly develop the enterprise architect demanded by industry [Channeltimes, 2005]. The implication of adding storage to the existing curriculum is significant. Additional classes on any topic are always a challenge for a solid curriculum, as it usually means other classes must be dropped or modified to "make space" in the overall credit-load. Capstone courses, such as systems integration, must also be changed to model the realistic expectations of a systems integration professional in industry.

An integration architect must plan and coordinate all aspects of the information architecture for an organization—which includes storage as an independent item of consideration. Information storage architecture is a unique pillar of IT because it has unique requirements and attributes related to but not found in the other, more traditional pillars. Likewise, a capstone enterprise systems integration course should seek to bring all five pillars of IT together for students, making distinct courses in networking, databases, applications, operating systems, and storage prerequisites for such a capstone course.

SUGGESTIONS FOR CHANGES TO ENTERPRISE SYSTEMS CURRICULA

Given the clear demand for graduates with the perspective of the enterprise architect in industry today and for the foreseeable future, and the rapidly growing demands for storage over that same time period, enterprise systems curricula clearly need to make adjustments to accommodate courses on enterprise systems integration, as well as redesigning or creating necessary supporting courses.

Enterprise systems curricula must reflect comprehensive, broad education in relevant topics to prepare students for occupations in IT. This means introductory courses on networking, databases, applications, and storage, necessitating a minimum of four independent courses. Students will also require training on organizations and business processes, project management, and systems design. At an advanced level, enterprise systems curricula will need courses specific to enterprise integration (people, processes, and technology), teaching students to connect in relevant, meaningful ways what they have learned in the supporting courses.

Unfortunately, it is not enough to simply put courses on these topics in place—each course must be designed to support the courses that follow it, and faculty in the advanced courses must be able to rely on students entering advanced courses with adequate knowledge of content from the preceding courses. As noted earlier, this is often a challenge in higher education. To enhance the content of each of these courses, it is important for institutions and faculty to partner, whenever possible, with corporations invested in enhancing the quality of the forthcoming workforce. These partnerships can often supplement course content, direct curricula to reflect industry needs, and potentially foster professional relationships for the institution and the students.

CORPORATIONS LEADING THE CHARGE FOR STORAGE EDUCATION

The need for storage education has been publicized for several years [Morgenstern, 2003; Ruddlesden, 2005; Trelwyn, 2004]. With virtually no institutions of higher education hearing the call, corporations have begun leading the charge for storage education. Hewlett-Packard and McData are among industry leaders actively encouraging colleges and universities to include storage education in their curriculum [Trelwyn, 2004]. Professional organizations, such as the Storage Networking Industry Association (SNIA), are also encouraging storage education, offering course requirement suggestions and certifications.

EMC Corporation has recently launched an Academic Alliance Program [Van Sickle et al, 2007] to partner in a variety of ways with academia. The company is teaming up with university faculty to determine how to best create courses to educate students in storage-related topics within the context of a larger curriculum in information technology or related areas. The company also offers course content for storage education, as well as simulation materials and a current industry perspective on storage. To date, EMC is the only corporation stepping up in such an organized manner to work with academia to address the industry need for the inclusion of storage and information management topics and courses in IT, MIS, and other technology curriculums.

CONCLUSION

With the clear importance of the enterprise architect's perspective in industry, and the subsequent increase in demand for skilled enterprise systems graduates, colleges and universities wishing to remain competitive in their educational offerings will have to make significant overhauls to their IT curriculum to accommodate these demands. Despite the difficulty of incorporating a compliment of foundational courses in the five areas that comprise the modern enterprise IT architecture, IT and MIS curriculums must strive to meet the increasing demand for employees that can address information systems and technologies at an organizational-wide level. With IT budgets increasingly being spent on storage-related projects and components, a competitive educational institution must offer foundational education in all of the five areas suggested by Van Sickle et al (2007).

While the challenges to implementing new curricula are significant, and the development of storage-specific courses is especially difficult due to lack of instructional materials, academic partnerships with industry can help a college or university make significant progress toward completely supporting enterprise systems education. In addition to the creation of appropriate, relevant instructional content, these alliances also afford students industry engagements that are both highly effective for learning and help to ensure skill sets that will help information technology students be better prepared for the business environment they will face upon graduation.

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