Merging an e-Business Solution Framework with CIS Curriculum

Mayur R. Mehta
Jaymeen R. Shah
George W. Morgan
Department of Computer Information Systems
Texas State University – San Marcos
San Marcos, Texas 78666
mm07@txstate.edu js62@txstate.edu gm07@txstate.edu

ABSTRACT

Since corporations first started conducting business on the Internet in 1993, it has moved quickly from being a curious spectacle to a matter of survival for most businesses. To achieve successful results in this on-line business environment on a consistent basis, companies need to rely on two critical success factors. First, a robust framework to guide the design and implementation of e-Business strategy is crucial. Second, if companies are interested in e-Business applications that are robust, flexible, scalable, maintainable, and platform-independent then the development environment used to design, implement, and deploy such applications is more critical than ever before. These characteristics will gain importance as corporations begin migrating e-Business applications from the traditional Web-based environment to a wireless, mobile, hand-held, and pervasive computing paradigm. A consequence of such ongoing changes in the information technology field will require Computer Information Systems (CIS) departments to regularly update curriculum to ensure that students are imparted with the conceptual knowledge and technical skills expected by the IT industry. This paper describes an e-Business solution framework, and analyzes the impact of the technological and e-business evolution on an existing CIS curriculum in the College of Business at a university in the state of Texas. It discusses the new curriculum developed and implemented in response to these technology changes. Finally, the paper also describes some of the challenges of implementing the new model and the resultant impact.

Keywords: Computer Information Systems, Curriculum development, E-Business solution framework, J2EE

1. INTRODUCTION

Whereas fewer than 20 million consumers were connected to the Internet regularly in 1995, the numbers had more than doubled by end-1997. Today there are over 204 million Internet users in the U.S. and over 797 million Internet users around the world ("Home access to Web rises to nearly 75% in U.S.," 2004; InternetWorldStats.com, 2004). The Web is changing every aspect of our lives, but no area is undergoing as rapid and significant a change as the way businesses operate. The number of organizations conducting business using the Internet during the past several years has far exceeded most market projections and expectations (Murphy and Flemming, 1999, p.1). As businesses incorporate Internet technology into their core business processes they start to achieve real business value. Today, companies large and small are using the Web to communicate with their partners, to connect with their back-end data-systems, and to transact commerce, with both consumers and their trading partners. The scale of e-business in 1999 was about $145 billion, and it is expected to grow to approximately $12.8 trillion in 2006 ("E-commerce statistics and sources," 2004; Suh and Han, 2003). With such a growth in e-business, companies are likely to focus more on implementing technologies that support and enhance their e-business capabilities. A survey by Line 56 Media and consulting firm A. T. Kearney of companies with more than $250 million in revenue showed that companies are spending about 20.3% of their information technology budgets on e-business initiatives ("E-business spending tops 20%," 2003).

1.1 What is e-Business?

E-Business is defined as the transformation of key business processes through the use of Internet technologies ("Ready for e-business: A CIO's guide to e-business applications," 1999). While this definition applies to both business-to-consumer (B2C) and business-to-business (B2B) paradigms, the focus in this paper is on the B2B model. In e-Business, companies use the Web technologies (such as

HTTP/HTTPS, Web clients and servers, and business objects) to communicate with their partners, to connect with their back-end data-systems, and to transact commerce in such a way that it leverages the strength and reliability of traditional information technology in the Internet environment (Harkey et al., 1999a; Harkey et al., 1999b). This new Web + IT paradigm merges the standards, simplicity and connectivity of the Internet with the core processes that are the foundation of business ("Ready for e-business: A CIO's guide to e-business applications," 1999).

Successful e-Business applications have the following desirable properties ("IBM application framework for e-business: Web application programming model," 1999, p. 12; "Ready for e-business: A CIO's guide to e-business applications," 1999, p. 2; Harkey et al., 1999a):

- Application simplicity and reusability,
- Leveraging current developer skills, data and information,
- Robust security with good performance,
- Applications and systems manageability,
- Deployment flexibility and scalability to migrate to a variety of computing platforms including wireless, mobile, and hand-held devices.

Therefore, successful e-Business applications are based on standards that span multiple platforms. They are server-centric. They extend existing applications. They are scalable, easy to use, and they are built to be managed. To get applications with these characteristics, it is imperative that developers have a clear understanding of a robust solution framework. Furthermore, developers need to acquire an appreciation for the available application development tooling that leads to robust, secure, reliable, and scalable e-Business applications within the guidelines of this framework.

This paper describes in the following Section an e-Business solution framework as presented by one of the leading providers of enterprise-level e-Business application development tools ("IBM application framework for e-business: Web application programming model," 1999; Harkey et al., 1999a; Harkey et al., 1999b). Next, the paper presents discussion about how this solution framework was used as a template to metamorphose the CIS curriculum, which is followed by a discussion about the implementation of the revised curriculum.

2. E-BUSINESS SOLUTION FRAMEWORK

E-Business applications leverage Web clients (such as Web browsers running on PCs, PDA, and pervasive internet appliances), Web application servers, and standard Internet protocols. They also typically leverage existing applications and data from external non-Web services ("IBM application framework for e-business: Web application programming model," 1999, p. 1; Harkey et al., 1999a, p. 3). In a robust e-Business application the key processing requirements include interaction with user, executing and managing business logic, and application logic to control the interaction between user view and business logic. These key processing requirements can be easily mapped to the classical Model-View-Controller (MVC) paradigm, leading to a layered application architecture ("IBM application framework for e-business: Web application programming model," 1999, p. 5; Brown et al., 2001, p. 27-29). Figure 1 illustrates the MVC paradigm, which provides a framework for separating functional processing involved in typical computing-oriented transactions into three major components - Model, View, and Controller ("IBM application framework for e-business: Web application programming model," 1999, p. 4-6; Brown et al., 2001, p. 26; Habibulah and Xu, 2001; Harkey et al., 1999a; Harkey et al., 1999b).

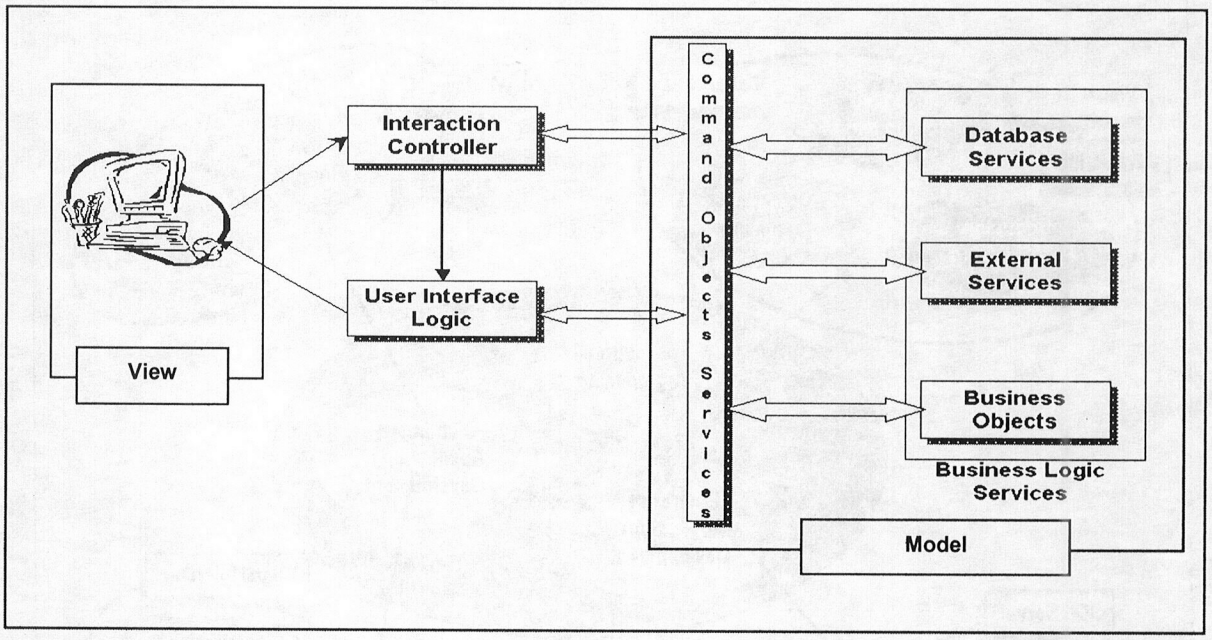
In the MVC paradigm, View (Presentation Layer in layered architecture) is the user interface (UI) logic part of the system. It is responsible for generating HTML pages that will be returned to the client. It includes objects defined to accept user inputs and to display formatted application output. Model (Domain and Data Access layer in layered architecture) is the business logic portion of the system. It comprises code that is ultimately responsible for satisfying client requests. Interaction Controller (Controller/Mediator layer in layered architecture) handles client-side input and validation, mapping of the request and session parameters to the business logic components, and logic flow to correctly chain the business logic.

As can be seen, the MVC paradigm and layered architecture provides a mechanism to decouple business logic implementation from presentation logic. Such a separation offers several advantages including ability to develop, modify, and manage business logic independent of form and style of resulting presentation. More importantly, this layered architecture suggests a possible framework that would lead to e-Business solutions that are server-centric, scalable, and platform independent (Brown et al., 2001). Consequently, this framework would support any client device, including the traditional desktop, handheld, set-top and other pervasive devices. Additionally, the framework fosters component-based application development as well as reuse of enterprise business objects (Brown et al., 2001).

The key development and deployment issue is obviously how to implement this framework. What technology is available to build applications to these specifications so that resulting solutions are platform independent, scalable, easy to develop, and can be deployed to a variety of clients without much reprogramming? The answer to this question will also lead to the determination of technology skill-set that students in CIS should be prepared to acquire if they wish to be competitive in today's global IT environment.

Java 2 Enterprise Edition (J2EE) architecture has been strongly promoted by the proponents of this framework and e-Business developer community as one of the leading and, perhaps, the only technology currently available that accomplishes the above ("IBM application framework for e-business- Understanding technology choices," 2002; Brown et al., 2001; Grehan, 2002; Harkey et al., 1999a; Harkey et

Figure 1. Model-View-Controller (MVC) Paradigm



al., 1999b). The primary force behind this widespread adoption of J2EE is the fact that Java-based applications can be delivered over any network, operating system, and hardware.

To prepare students for designing, developing, and maintaining e-Business applications based on this framework it is critical that they become proficient in J2EE architecture. It is essential to introduce object-oriented (OO) programming using java programming language and technologies such as servlets, JSPs, and JavaBeans in the curriculum. In addition to the J2EE specifications based technologies students should also be imparted knowledge in other related IT areas such as systems analysis and design (with OO emphasis), database design, SQL, and networking and distributed environment. Such a curriculum will provide students with knowledge in all major IT skill categories, namely, contemporary programming language, Web-based development, database, and networking. Liu et al. (2003) analyzed IT skills required by three-hundred jobs advertised on Monster.com and HotJobs.com. They found that programming language, Web development, and database skills accounted for over 95% of the job skills required for these jobs. These results suggest that integrating contemporary programming language such as java, Web-based enterprise application development, and database design and implementation in the CIS curriculum is not only important but should form the core of a CIS curriculum that is designed to prepare graduates for the e-Business paradigm. Such an integrated curriculum is more likely to meet the needs of IT industry and enhance graduates' attractiveness to potential employers.

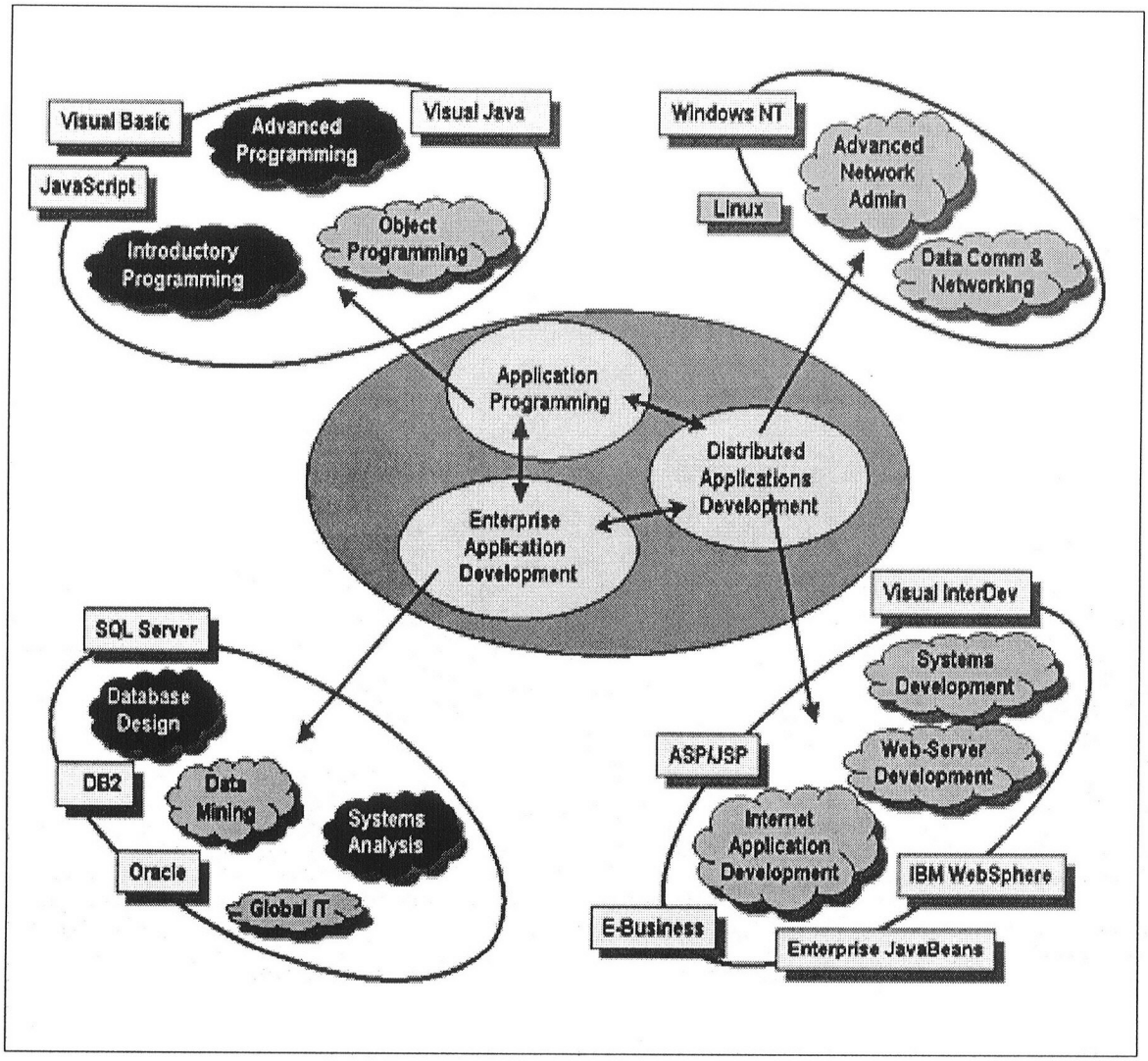
3. CIS CURRICULUM DEVELOPMENT

The strategic movement towards e-Business architecture has changed the technical competencies required of fresh CIS graduates to be successfully recruited. Companies are recruiting techno-savvy students capable of using current and emerging technologies to harness the tremendous potential of information technology to exploit e-Business opportunities in the networked business environment. The industry expects IT professionals to possess skill-set required to support the development, implementation, and maintenance of e-business solutions (Hawking et al., 2004).

The CIS department faculty recognized this conceptual and technological paradigm shift. To ensure that the CIS curriculum is aligned with these paradigm shifts, existing CIS curriculum content was compared with the IT industry's expectations for CIS graduates and with the major components of the e-Business solution framework discussed in earlier section of the paper. Information regarding industry needs is consistently gathered by the department from the following sources: (1) interaction with recruiters that come for campus interviews, (2) feedback from the department's industry advisory council comprising of senior IT professionals from fifteen companies in four major industries, (3) input from the CIS faculty, and (4) interaction with department's alumni. Ongoing dialogue with these entities provides the information and impetus for adapting the curriculum to keep it abreast with the changing needs of the IT industry.

An analysis of the CIS curriculum, as presented in the 2000 – 2002 catalog, in light of the industry needs and e-Business

Figure 2. New CIS Curriculum Model



curriculum was aligned with legacy, mainframe, and to a solution framework revealed a significant gap between the existing curriculum and the needs and expectations of IT industry. The industry was demanding graduates with proficiency in J2EE-based e-Business framework, our lesser extent, client-server computing paradigms. Recognition of shortcomings in the existing curriculum led the CIS faculty to initiate the process of making major revisions in the curriculum. Right from the beginning of this curriculum revision process conscious effort was made to not just sprinkle new courses on top of the existing curriculum, rather to focus on developing a well integrated curriculum. Critical analysis and synthesis of information related to existing curriculum, industry needs, and components of the e-Business solution framework led to the development of the new curriculum model presented in Figure 2. This curriculum model was used as the blueprint for revising existing courses and developing new courses to develop a thoroughly integrated CIS curriculum that meet the IT industry's needs. The new curriculum model recognizes the need to equip students with knowledge in three important areas, which form the core of the new curriculum model. These areas are application programming, distributed applications development, and enterprise application development. The model also details technologies that students should be proficient in to support each of the three core competencies.

Although CIS department's faculty have consistently revised the curriculum every two years to ensure that courses in the curriculum cover the core CIS topics and current technologies. The curriculum revision of 2002 – 2004 required significant structure changes. Substantial changes were made in the contents of existing courses, and several new courses were added in the curriculum. CIS curriculums after the last two revisions are presented in

Figure 3. CIS curriculum for 2002 – 2004 and 2000 – 2002 periods

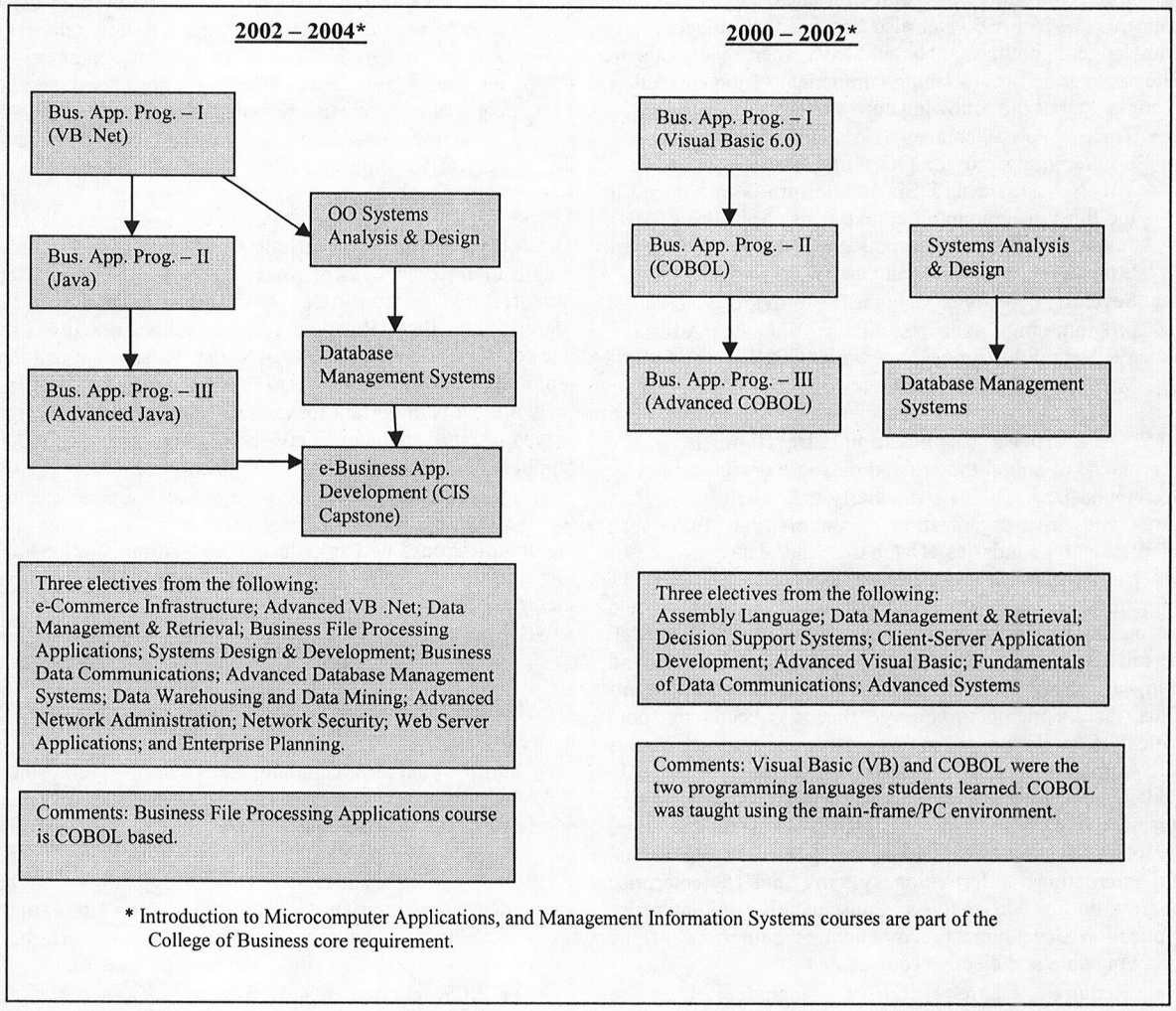


Figure 3 (Note – University and College of Business curriculums after the last two revisions are presented in Figure 3 (Note – University and College of Business requirements are not shown in the figure). Arrows in the diagram represent the course sequence and prerequisite requirements.

3.1 Changes Implemented in the Curriculum Revision Cycle of 2002 – 2004

The next logical step in the curriculum development process after developing the new curriculum model was to identify and develop courses for each of the three core areas, namely, application programming, enterprise application development, and distributed applications development. Courses for these core areas were developed with the intent of ensuring that students gain basic IT knowledge, and the technical skills necessary to be successful in the distributed e-Business computing environment. Note that communication and team skills are emphasized throughout the entire College of Business curriculum. The set of courses that were developed for each of the three core areas and the rationale for their development is presented below.

3.1.1 Application programming: Java and object-oriented modeling are widely used for application development. Java has become the language of choice for e-Business and Web-based application development. Thus, object-oriented programming and Java were introduced at the core of the curriculum. Liu et al. (2003) tracking of job skills revealed that Java programming skills are in demand. Out of the 163 jobs that required programming skills, thirty-six percent required C/C++ skills, thirty-four percent required Java skills, twenty-five percent required VB programming skills, and only four percent required COBOL skills. Although the use of Java and VB .Net is increasing, companies that recruit our graduates use COBOL and even surveys have shown that COBOL is being used by companies (Carr and Kizior, 2000; Wenger, 2003). Thus, it was decided to offer COBOL as an elective instead of eliminating it from the curriculum. VB .Net is used in the first programming course

because of its user-interface friendliness and simplicity in teaching introductory object-oriented programming concepts. Use of VB .Net also ensures that students have knowledge of both, VB .Net and Java when they graduate. The application programming component of the curriculum is comprised of the following core and elective courses:

- Three core courses in business application programming provide OO programming foundation in VB .Net and Java. J2EE architecture is introduced in the third programming course (Bus. App. Prog. – III). Java development is introduced via IBM's WebSphere Studio Application Developer.
- Several elective courses provide advanced programming concepts. These include Advanced VB.Net, File Processing with COBOL, and Data Management and Retrieval.

3.1.2. Enterprise Application Development: The importance of sound system and database design cannot be overemphasized. This is particularly true when it comes to intra- and inter-organizational systems that may span international boundaries. Databases and data warehouses are core components of most large organizations' IT infrastructure. Many organizations use data mining to aid the business decision making process. Further, almost all organizations are involved in some form of e-Business, and many are using international, inter-organizational systems Thus, faculty members believed that it is becoming more critical to introduce several key topics in support of this core component. Key topical areas include: (1) database management, (2) data warehousing and data mining, (3) e-Business infrastructure design, (4) technical and organizational issues in implementing inter-organizational and international information systems, and (5) enterprise systems design and analysis. Consequently, the enterprise application development component is comprised of the following core and elective courses:

- Required core courses include Database Management, and Systems Analysis and Design. The Systems Analysis and Design course was substantially revised from its incarnation under the previous curriculum to provide coverage of object-oriented analysis and design concepts as well as introduced the use of UML and MS-Visio in design methodology. Using MS-Access as the primary database tool, the Database course continues its strong focus on design and SQL.
- Several elective courses are now available to support advanced preparation in this area. Advanced Database Management Systems focuses on development of enterprise-level databases and database-driven applications using Oracle products The course in data mining and data warehousing, which is currently under development, will cover theoretical and practical issues related to the design, implementation, and maintenance of data warehouses as well as selection and use of appropriate data mining methodologies. Toolset used in this course include Oracle products and SQL server's Analytical and Reporting Services. Topics related to the technical and organizational issues related to e-Business and inter-organizational systems are introduced in the e-commerce infrastructure course. Issues related to systems integration and mergers at the international level will be addressed by a proposed sequence of courses in enterprise resource planning. A course on managing information technology projects, which is currently being developed, rounds out this core component.

3.1.3 Distributed Applications Development: Distributed application development has become the de facto architecture for business application development as described in the e-Business solution framework discussed earlier. As components of distributed applications communicate with each other across wired and wireless networks, it is important for companies to be able to design, develop, and maintain networks. Thus, the distributed application development component of the revised curriculum comprises of one required and several elective courses that provide coverage of critical topics in data communications, network design and administration, and distributed application design and development. A brief description is presented below:

- One required course in e-Business application development prepares students for e-Business application design, development, testing, and deployment. In addition to learning advanced concepts of J2EE and n-tier architecture, projects in this course simulate real-world e-business applications that require students to integrate concepts learned in CIS core courses. Students use IBM WebSphere Studio Application Developer, DB2 and Oracle databases, Java (J2EE platform), SQL, and service-oriented architecture for designing, developing, testing, and deploying robust e-Business applications. This is the CIS capstone course.
- Elective courses in networks, security, and service-oriented architecture provide students with an opportunity for advanced preparation in enterprise application development. Courses in business data communications, network administration and security provide both a conceptual overview of the technologies used for secure transmission of data, voice, and video across the wired and wireless networks as well as design, installation, and administration of secure Linux- and Windows 2003 Server-based networks.

Students learn to develop, test, and deploy enterprise business objects and Web services that are consumed by applications running on desktop and wireless devices in our Web Server Applications course. IBM WebSphere Studio Application Developer, ASP .Net, and J2EE and .NET frameworks are used. One of the objectives of this course is to expose students to the competing technologies for services-oriented architecture, and their strengths and weaknesses.

Finally, Systems Design and Development is a project

oriented elective course that provides students with real world experience. Students work in teams on client projects to design and develop business applications for small/medium businesses. Most projects involve development of a system based on e-Business solutions framework discussed earlier. Development tools used by student teams are determined by the requirements of the client companies.

3.2 Challenges in Implementing the New Curriculum Model

The revised CIS curriculum model required a major overhaul of the existing curriculum. Some of the challenges encountered in implementing the revised (2002 – 2004) curriculum are discussed below.

3.2.1 Selection of the e-Business Application Development Framework: The e-Business application development framework is defined by most vendors as a set of e-Business deployment tools, suites, and vertical business applications. Some of the architectural elements which are common to almost all e-Business application frameworks include server-centricity, scalability, use of Java-based tools and services, and common Web-oriented industry standards. CIS Department's faculty evaluated seven e-Business application development frameworks on each of the following six dimensions: (1) logical level of architecture, (2) range of applications deployed, (3) built-in business functionality, (4) integration capabilities, (5) vertical applications support, and (6) systems management tools included. The seven e-Business application development tools that were evaluated included the following: (1) Commerce Exchange (Interworld), (2) GenTran (Sterling Commerce), (3) IBM e-Business Application Framework, (4) Java Corporate Express, (5) OpenEC (Softcare Electronic Commerce), (6) Oracle.com Suite, and (7) .NET (Microsoft). IBM's e-Business application development tool was selected because it scored high on all six dimensions used for evaluating the e-Business application development frameworks.

3.2.2 Additional Faculty Requirement: In the new curriculum several new technologies and methodologies were introduced, which required revising existing courses, and developing several new core and elective courses. This made it essential for the department to offer more electives each semester to enable students to enroll in electives of their choice. Although current faculty members dedicated significant time and effort for developing new courses, it seemed almost impossible for the department to offer the core courses and new elective courses with the existing number of faculty. University and College of Business administrators supported implementation of the new CIS curriculum by providing two new faculty positions.

3.2.3 Faculty Training: IBM's e-Business application development tools were introduced in the curriculum for teaching e-Business (n-tier) application development. These include WebSphere Studio Application Developer, DB2, and Rational XDE. IBM provided free training for faculty as well as access to on-line training material through a special academic initiative. Students were also provided access to free software and on-line resources.

3.2.4 Funding for Technology Infrastructure (software and hardware): Software required to implement the new state-of-the-art curriculum were mainly obtained by forging alliances with IBM (WebSphere Studio Application Developer and DB2), Microsoft (Visual Studio .Net, Windows Server), and Oracle (Oracle 9i, Oracle Forms/Reports, and 9i Application Server). A new computer lab for teaching network administration and network security courses was set-up via university's curriculum development grants. And, existing CIS computer lab was upgraded through the university's computer refresh cycle and funds from course fees.

3.2.5 Development of Informal Tracks: Implementation of the new curriculum model resulted in extensive changes in the CIS curriculum. Review of the list of new courses introduced in the curriculum and the University, College, and AACSB requirements[1] revealed that it is not possible to require students to take advanced courses in all three core areas of the new curriculum model due to the twenty-seven hours (nine courses) limit on major courses. This realization culminated into the idea of developing tracks within the CIS curriculum. To provide greatest flexibility to students, the CIS faculty opted against implementing formal tracks; instead, faculty members volunteer to conduct career advising sessions during which they assist students in selecting electives based upon student's interest in professional career path. During these advising sessions students are explained the course contents of each elective course, and how electives are related to each other to provide advanced preparation in one of three core components discussed earlier.

3.2.6 Course Scheduling and Prerequisites: Careful attention was paid in designing the course sequence to minimize student logjams at any particular point in the curriculum due to course prerequisites. Most of the new application development and networking related courses were introduced as electives. Students are encouraged to enroll for these courses after they have successfully completed their CIS core requirements in application programming and enterprise application development. The current course sequencing structure allows students to graduate within four years, even if they have to take three electives that are a three course sequence. However, this has complicated course scheduling as the department has to schedule several electives every semester along with the required CIS core courses. This increase in the number of courses required to be offered every semester made it

[1] The College of Business is accredited by the AACSB. University, College, and Accreditation requirements limit major courses to twenty-seven hours (nine courses). This restricts the department from developing a CIS degree program that requires CIS majors to take more than nine CIS courses.

necessary for the department to recruit new faculty members to ensure that faculty members are not overloaded with course preparations, which could result in faculty burnout and turnover.

3.3 Impact of Merging e-Business Solution Framework with CIS Curriculum

The primary objective of revising the CIS curriculum was to align course requirements with IT industry's needs and expectations. Since its inception almost three years ago, the new curriculum has had a tremendous impact on the students and faculty morale, student recruitment efforts, and job placement.

The primary impact has been on the job placement and enrollment. The introduction of curriculum based on e-Business solution framework has attracted several new companies and government agencies for recruitment on campus. The number of companies (including government agencies) recruiting our graduates has almost doubled. Many of these companies had never recruited on campus before, while several returned after a significant absence. A majority of companies were interested in hiring graduates with a strong foundation in e-Business applications development. Consequently, a larger percentage (from approximately 70% before the change to 85% after the change) of the students have job offers in the field within two months after graduation. Additionally, the starting salary offer has increased by at least 10%.

While there has been a decline in the enrollment of new students as a result of the dot-com failures and recent off-shoring of IT jobs, it has not been as significant as those faced by CIS programs at many other universities. Compared to a nationwide average decline of 35%-45%, the enrollment in the program has declined less than 20%. In addition, the quality of students coming into the program is considerably better than before. We believe that all of this is largely due to a program that is strongly aligned with industry needs and is in demand.

The new curriculum also has had a consequential impact on students and faculty morale, as well as support the department receives from the College and University. Students and faculty take pride in being associated with an integrated, applied program that is gaining respect among our recruiters and major high-tech companies in the region. The College and University see the willingness to quickly respond to market demands as a sign of a progressive department. As a result, the CIS curriculum has been the beneficiary of additional capital resources and tenure-track faculty lines in spite of tight budgetary constraints.

5. SUMMARY

Implementing a successful e-Business solution requires careful planning, both from strategic and technological perspectives. It requires that information technology professionals have clear understanding of the key design issues as well as a solution framework that guides the design and implementation of e-Business solution. This paper examined an e-Business solution framework, based on the Model-View-Controller (MVC) paradigm, as presented by one of the leading providers of enterprise-level e-Business application development tools. The role of J2EE architecture as applied to this e-Business solution framework was briefly examined. Finally, the paper discussed the development and implementation of the CIS curriculum based on the e-Business solution framework presented in the paper, and inputs from the department's industry advisory council, faculty, and alumni. This curriculum revision was imperative to ensure that graduates possessed the skill-set expected by the IT industry. Implementation of the revised curriculum has allowed the department to fulfill one of its primary objectives, which is to prepare students for IT careers by teaching them concepts and tangible skills required in the business world. Successful implementation of the revised curriculum required significant concerted efforts from faculty, administrators, and industry partners. This combined effort made it possible to overcome some of the known causes of the gaps betweenCIS departments' curricula and industry needs, such as the rapid changes in IT skills requirement, focus on traditional programming, lack of ongoing interaction between educators and practitioners, and lack of resources to regularly update the curriculum and offer adequate number of courses (Kim, 1998; Lee et al., 1995; Liu et al., 2003; Maier et al., 1998).

The pace at which information technology is evolving is accelerating, which will make it challenging for CIS departments to maintain currency of their curriculum. Maier and Gambill (1996) indicated that CIS departments can no longer have curriculum redesign cycles of four years, if up-to-date curriculum is to be maintained to ensure that graduates acquire the skill-set necessary to enter the job market. This is the third academic year after implementing the new curriculum (2002 – 2004), and efforts are underway since Summer 2004 to modify the curriculum structure and develop new courses in the areas of pervasive computing, enterprise resource planning (using SAP), and project management. This curriculum changes are being implemented based on the analysis of the inputs received from the CIS advisory council, recruiters, alumni, and faculty. If educators do not consistently update CIS curriculum, IT innovations and frequent changes in information technologies may make it obsolete. Based on our department's experience, to maintain a state-of-the-art curriculum CIS departments' will require the following: (1) critical mass of dedicated faculty willing to invest time and effort required to remain current in the discipline by continuously advancing their skills; (2) adequate faculty size to preclude too many new preparations every year. This will allow faculty member to devote time in learning about emerging technologies and develop expertise in certain areas; (3) support from software/hardware vendors in terms of faculty training, software, hardware, and access to their learning resources; (4) support from the College and University in terms of training support, monetary support, and development leave to ensure that faculty members can devote time and attend training seminars to learn about emerging technologies; and (5) adequate technical and

monetary support to develop and maintain excellent computing resources required for the program, including full-time technical staff to maintain computer laboratories.

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AUTHOR BIOGRAPHIES

Mayur Mehta is a Professor and Chair of Computer Information Systems in the McCoy College of Business Administration at Texas State University-San Marcos. His research focuses on e-business application development, service-oriented architecture, and infusion of new technology into information systems curriculum. He is the author of many papers on curriculum development based on e-business, J2EE and Services-Oriented Architecture.

Jaymeen Shah is an Assistant Professor of Computer Information Systems in the McCoy College of Business Administration at Texas State University-San Marcos. His current research interests include information systems education, e-business, virtual communication, and applications of emerging information technology. His publications have appeared in journals such as Omega, Journal of Systems and Software, European Journal of Operational Research, Journal of Information and Optimization Sciences, and Journal of Internet Commerce.

George Morgan is Professor Emeritus of Computer Information Systems in the McCoy College of Business Administration at Texas State University-San Marcos. He has authored research articles in the areas of systems analysis and design, database management, Web- and Object-Oriented application development, e-Commerce, and curriculum development.retired in 2004 and now concentrates on art for his creative pursuits.