ISSN: 1545-679X

Information Systems Education Journal

Volume 6, Number 33 http://isedj.org/6/33/ March 12, 2008

In this issue:

An Alternative Approach to Technology Infrastructure Presentation within the IS2002 Model Undergraduate Curriculum

Irv Englander
Bentley College
Waltham, MA 02452, USA

Abstract: Modern computer systems are characterized by distributed computing, with multiple computer facilities and other digital resources connected together and integrated using network and Internet technology. The IS2002 undergraduate curriculum treats computer technology and networking as separate entities within a three-course Technology Infrastructure area. In this paper, we consider the reorganization of the material in the IS2002 technology infrastructure courses into a sequence of two new courses that reflect modern computer system architectural design. In our reorganization, the new courses incorporate nearly all of the material from the original IS2002 computer technology and networking courses, plus selected material from the third course, along with new material reflecting recent developments that are covered sketchily or not at all in the IS2002 model. The material is to be presented with an emphasis on system architecture, integration, and interaction, with computer technology and network components present in both courses. The introductory course presents material suitable for a beginning IS/IT student with average computer literacy. This course also serves as preparation for a subsequent IS system design course. The advanced course uses the knowledge gained in the introductory course and other IS courses to offer deeper insight into the technology infrastructure of large integrated systems.

Keywords: system architecture, system integration, technology infrastructure, computer technology, networking, IS2002-4, IS2002-6

Recommended Citation: Englander (2008). An Alternative Approach to Technology Infrastructure Presentation within the IS2002 Model Undergraduate Curriculum. *Information Systems Education Journal, 6* (33). http://isedj.org/6/33/. ISSN: 1545-679X. (Updated from *The Proceedings of ISECON 2004:* §3415. ISSN: 1542-7382.)

This issue is on the Internet at **http://isedj.org/6/33/**

The **Information Systems Education Journal** (ISEDJ) is a peer-reviewed academic journal published by the Education Special Interest Group (EDSIG) of the Association of Information Technology Professionals (AITP, Chicago, Illinois). • ISSN: 1545-679X. • First issue: 8 Sep 2003. • Title: Information Systems Education Journal. Variants: IS Education Journal; ISEDJ. • Physical format: online. • Publishing frequency: irregular; as each article is approved, it is published immediately and constitutes a complete separate issue of the current volume. • Single issue price: free. • Subscription address: subscribe@isedj.org. • Subscription price: free. • Electronic access: http://isedj.org/ • Contact person: Don Colton (editor@isedj.org)

EDSIG activities include the publication of ISEDJ, the organization and execution of the annual ISECON conference held each fall, the publication of the Journal of Information Systems Education (JISE), and the designation and honoring of an IS Educator of the Year. • The Foundation for Information Technology Education has been the key sponsor of ISECON over the years. • The Association for Information Technology Professionals (AITP) provides the corporate umbrella under which EDSIG operates.

An Alternative Approach to Technology Infrastructure Presentation within the IS2002 Model Undergraduate Curriculum

Irv Englander
Computer Information Systems, Bentley College
Waltham, MA 02452, USA

ABSTRACT

Modern computer systems are characterized by distributed computing, with multiple computer facilities and other digital resources connected together and integrated using network and Internet technology. The IS2002 undergraduate curriculum treats computer technology and networking as separate entities within a three-course Technology Infrastructure area. In this paper, we consider the reorganization of the material in the IS2002 technology infrastructure courses into a sequence of two new courses that reflect modern computer system architectural design. In our reorganization, the new courses incorporate nearly all of the material from the original IS2002 computer technology and networking courses, plus selected material from the third course, along with new material reflecting recent developments that are covered sketchily or not at all in the IS2002 model. The material is to be presented with an emphasis on system architecture, integration, and interaction, with computer technology and network components present in both courses. The introductory course presents material suitable for a beginning IS/IT student with average computer literacy. This course also serves as preparation for a subsequent IS system design course. The advanced course uses the knowledge gained in the introductory course and other IS courses to offer deeper insight into the technology infrastructure of large integrated systems.

Keywords: system architecture, system integration, technology infrastructure, computer technology, networking, IS2002-4, IS2002-6

1. INTRODUCTION

Many, perhaps most, college and university IS/IT departments design their undergraduate curricula with one eye focused on the standard IS2002 curriculum published jointly by the ACM, AIS, and AITP societies (IS2002, 2002) and the other on the rapidly changing and expanding curricular requirements needed to produce a student that can achieve both short- and long-term success in the IS marketplace. At the same time, the number of available teaching hours has not expanded, resulting in a number of conflicting demands in the design of the curriculum. It is no secret that the IS curriculum ages quickly and requires continual monitoring and tailoring to reflect the current state of the IS discipline.

In 2003-2004, the Bentley College CIS Department undertook an in-depth study to redesign its undergraduate curriculum. Every CIS track and individual course underwent thorough scrutiny. (More detail on this study and the resulting BSCIS'04 curriculum can be found in (Waguespack, 2004.)

The present author has a deep, long-standing, ongoing interest in the IS learning area concerned with the infrastructure technology that forms the bedrock of IS. This area includes hardware, software, data representation, networking and system interconnection, and system configuration, architecture, control, and administration. The author was a principal contributor to the design of IS'97-4, the computer technology component of the 1997 IS model curriculum,

which remained essentially intact through the IS2002 release. Thus, the curriculum study at Bentley provided an opportunity to examine and evaluate alternative approaches to computer and network technology in the context of modern computer systems, with the expectation that the results might contribute to forthcoming updates to the IS curriculum. This paper presents the results of a continuing evaluation of the curricular approach used to expose infrastructure technology to students, with specific reference to the approach that is currently implemented at Bentley College.

2. STATEMENT OF THE PROBLEM

Within the standard IS curriculum there has been little change to date in the approach to the teaching of computer technology since the studies leading up to publication of the model 1997 IS curriculum. The IS'97 curriculum technology infrastructure presentation area consisted of two architecture courses, IS'97-4, *Information Technology Hardware and Software*, and IS'97-6, *Networks and Telecommunication*, plus an additional course in computer programming, not considered here. The two architecture courses described in IS'97 were essentially independent of each other, and were only loosely tied pedagogically to other curriculum areas such as system analysis, modeling, design, and implementation courses.

The 2002 curriculum [IS2002] offered minor updates to these courses and added a new course, IS2002-2, *Electronic Business Strategy, Architecture, and Design* that replaced an IS'97 course in personal computer productivity. The personal productivity material is now assumed to be background knowledge that is typically part of an incoming student's standard computer literacy. IS2002-2 offers an E-business model as an example of system architecture. However, much of the material in IS2002-2 can easily be absorbed into other courses. The major feature of IS2002-2 is that it provides a context for system architecture, which offered a natural focal point for our redesign of the remaining two courses.

In observing CIS hiring patterns and anecdotal evidence of long-term success from alumni, the approach taken in IS'97 apparently proved itself to be adequate and appropriate for the time. Computers were relatively independent of each other. In most business applications, interconnectivity consisted predominantly of simple client-server operations: file, print, and application services and the like, and relatively straightforward networking technology. Widespread commercial use of the World Wide Web did not yet exist. Inter-enterprise value-chain based intercommunications were severely limited, both by the technology and by business practices of the day.

Today, computers are routinely interconnected into networks of varying complexity. Networking software is integrated into the operating system. Applications must communicate and integrate themselves across networks and internetworked structures made up of different computer systems and other digital devices, such as PDAs, network technology, system software, data formats, file systems, system interfaces, and application software. The applications themselves may be made up of objects distributed across network or Internet structures and other computing resources. Internet and Web technologies have transformed business practices and have resulted in systems that are far more sophisticated, complex, and versatile than in the past. The openness of the Internet requires security and control measures that are designed into the various system components. Understanding the architecture of a complete system is of vital interest to a modern system designer/analyst.

Thus, while IS2002 may adequately present the individual components in a technology infrastructure, it does not significantly address the important interaction and integration of components that is characteristic of a modern system.

3. DESIGN OF A NEW TECHNOLOGY INFRASTRUCTURE SEQUENCE

The distributed and interconnected nature of modern computing systems suggests that there are strong potential advantages in presenting computer technology and networking concepts in a more integrated fashion than that specified in IS2002. The ever-expanding need for course slots in the IS program also suggests that it is impractical to allocate more than two slots to the area of technology infrastructure. For the new Bentley IS curriculum we have created a

two-course sequence that integrates computer architecture, networking, and system architecture into each course, with basic technology presented in the first, introductory, course and expanded to a deeper level in the second, advanced, course. Ideally, students will take the courses in the sequence with a separation of a semester or more between the two courses. System analysis and design courses taken in the intervening semester will enable students to deepen their understanding of the implications of the technology that were presented in the introductory course of the sequence and thereby enhance learning in the advanced course.

Figure 1 shows the positioning of the new technology sequence within the overall structure of the Bentley BSCIS'04 curriculum. CS240, *Business Processing and Communications Infrastructure*, and CS440, *Advanced NetCentric Computing*, are the introductory and advanced courses of the new sequence. CS240 is a prerequisite for CS380, *Multi-tiered Application Development*. As can be seen from the figure, a student taking CS380 has already taken courses in programming, object-oriented application development, database management systems, and business systems analysis and modeling. Most students will take the advanced technology course concurrent with, or after the multi-tiered application development course. With this structure, it is expected that a student taking the advanced technology course will have considerable IS maturity as s/he enters the course.

The CS240/CS440 sequence presumes a number of advantages over the present component-based approach:

1. The introductory course presents a complete picture of the modern computing system, including the components that comprise an individual computer system and the network technologies that tie individual systems together. An E-business system example, similar to that suggested by the IS2002-2 model course, is included to provide context for the discussion. Of most importance, integration is a de facto part of the picture.
2. The introductory course draws upon prior student knowledge, but does not require technical depth and maturity. This can help to maintain interest and enhance mastery when students are in the early stages of the program. By the time students take the advanced course they are better prepared for the additional demands required by the more challenging material being offered.
3. The introductory course can easily be tailored to support the possibly-changing needs of the system design courses, giving students the background they need to understand issues and requirements of system architectural design and performance.
4. Because the advanced course is offered late in the student's undergraduate program, the opportunity exists for the course to explore and discuss new technology concepts and trends shortly before the student graduates and moves into graduate school or a career.

4. IMPLEMENTATION OF THE COURSE SEQUENCE

After polling the departmental faculty and comparing the results with the learning units defined in IS2002, we created a tentative list of topics for the two courses. Each topic was evaluated for position in one of the courses based on the criteria noted earlier: support for an ensuing course, student maturity level, basic or advanced material, and so on. This study resulted in creation of the following tentative syllabi. Each course is designated as 3 contact hours per week, taught over 13 weeks, plus exam periods:

Introductory Course Topics

(*Business Processing and Communications Infrastructure*)

- Introduction to the course and to system architecture; discussion of the components, linkages, interactions, and operational elements in a typical client-server Web exchange. (1 week)
- Data representation and manipulation: decimal and hexadecimal numbers, positive and negative integers, real numbers, alphanumeric data, bit-map and object graphics, images, sound (1½ weeks)

- Introduction to the CPU: a simple model (Little Man Computer), basic CPU organization, typical instruction sets, machine representation of simple high-level language constructs (1 week)
- Memory: the memory hierarchy, types of memory, performance issues, cache memory, RAM, introduction to virtual storage (1 week)
- I/O technology, program I/O, interrupt concepts, device controllers and controller operations; bus technology and performance (1 week)
- I/O peripheral device technology and operations: hard drives; CD- and DVD-ROM/RAM; display technology; network interfaces (1 week)
- Introduction to networking; network topologies; standards and protocols; introduction to OSI and TCP/IP layered models; data packet representations of data (1½ weeks)
- Network hardware and data link layers; LANs and WANs; Ethernet and switched Ethernet; network components; simple routing (1½ weeks)
- Examples of network applications: http, smtp, ftp, etc.; the differences between business applications and network applications (½ week)
- Introduction to operating system software: OS functionality, user interfaces; application program interface concept; multitasking and multithreading; file systems; simple internal organization; network interface and support (2 weeks)
- System architecture; interconnectivity and interfacing; clusters, client-server and peer-to-peer networking; n-level architectures; system integration; performance issues (1 week)

Advanced Course Topics:
(*Advanced NetCentric Computing*)

- Review of system concepts, basic system components, and system architecture (½ week)
- Internal CPU features, design, and implementation; the CPU fetch/execute cycle; CPU architectures (1½ weeks)
- Computer systems: multiprocessing; PC and mainframe design; virtual machine concept (1 week)
- Networks: detailed discussion of layered model; internetworking, routing, name resolution, etc.; alternative network models (e.g. ATM, SONET, frame relay); applications: VOIP, etc. (3 weeks)
- Wireless and mobile networking; alternative device technology (cell phone, PDA, etc.); operational issues; capability and performance issues; protocols and standards (1 week)
- Operating systems: kernel design; internal functions: process management; scheduling, memory management, priorities; network protocol stacks; security and privacy considerations (2½ weeks)
- Program translation and execution (½ week)
- Organization, operation, administration, comparison of Windows, Linux (1 week)
- System technology design: network options, considerations and choices; security; performance; administration and maintenance; backup and recovery (2 weeks)

Taken together, the two courses cover all of the technology infrastructure learning units proposed for inclusion in IS2002, currently updated to reflect the 2008 IS environment. The introductory course was offered at Bentley College for the first time in Fall, 2004. The advanced course was offered beginning in Fall, 2005. A similar course sequence is also offered at the Master's degree level with deeper coverage.

Course Materials

Although the material covered in the new course sequence is similar to that currently presented in IS2002-4 and IS2002-6, the order in which material is presented is considerably different. There is to date no single textbook presently available that meets the needs of either new course individually. Instead, we have opted to require two sepa-

rate textbooks, which are used together for both courses. For Fall 2008 we have selected Englander [2002] and Fitzgerald [2007] for the undergraduate classes and Englander and Forouzan [2007] for the graduate classes. In addition, the author has prepared detailed notes that supplement the textbook readings in areas that require more detail as well as areas that require integration and clarification between multiple sets of readings.

Several years ago, the author created course module outlines for each of the major topics addressed in a typical Computer System Concepts course. These outlines specify detailed learning expectations, readings, typical questions a student should be able to answer, and suggested approaches to learning. A typical module can be seen in [Englander, 1997]. Since the major topics are similar to those being offered in the new course sequence, these module outlines have been reorganized and updated and made available to the students in both courses as additional learning support.

5. CONCLUSION

The new course sequence design offers an alternative, and, we believe, preferable, implementation of the technology presentation area specified in IS2002. The sequence satisfies our stated criteria: it provides a fully integrated picture of the technology from the start, provides appropriate background knowledge for the system design course that follows, attempts to enhance learning by reducing the stress level for students entering the sequence, and offers the advanced material when students are more equipped to handle it effectively. Although the introductory course is being offered for the first time this Fall, with the advanced course to premiere a year later, we are confident that the sequence will meet its objectives. The coverage within the course pair is very similar to that previously offered, but we believe that the new organization, with its steady focus on the modern system as a whole, will substantially improve and deepen student learning and understanding, as well as the ability to teach and manage the course.

6. ADDENDUM — AN UPDATE (2008)

Although there was already substantial evidence of the oncoming convergence of computer infrastructure with network technology when this paper was first presented, continuing advances in technology, as well as related societal and business developments, make the case for integrating network and computer technology together within a two-course computer infrastructure sequence ever more compelling. A few brief examples of recent developments and trends that support this view:

- Pervasive computing assumes that nearly every computer-based device is seamlessly integrated with network technology. Thus, cell phones with global positioning systems become web browsers that offer services local to the user. Bluetooth can even extend this service to a nearby computer. This type of activity is already familiar to many students. and provides an instructive opportunity to view the infrastructure and architecture of systems of this type.

- Current bus and network technology concepts have evolved to overlap substantially. For example, PCI-Express is rapidly supplanting the PCI and AGP buses as an interface between the CPU and various I/O modules in personal computers. PCI-Express is a multiple lane, switched packet network-like technology [pcisig.com, 2008]. USB and FireWire also have many network-like qualities. It would appear that bus technology based on network concepts is poised to replace traditional bus design almost entirely in the near future.

- Network technology, itself, is being used as a replacement interface for computer-I/O communications. For example, it is now possible to use Ethernet or TCP/IP as a medium to carry "messages" that represent the SATA or SCSI interface signals between a disk controller and a computer. [Huang, 2003], [wikipedia, 2008]. As another example, a recent flash memory card contains a built-in wireless controller that can automatically send photographs from a digital camera to a computer when it detects a wireless connection within range [Pogue, D., 2007].

- Distributed file systems, network attached storage, storage area networks

and other related methodologies continue to grow in importance. Understanding these systems requires an understanding of both file system concepts and network concepts.

Each of these examples, and many others, suggests that it is no longer appropriate or effective to discuss networking as though it were separate and independent from the remaining components of a system. Instead, it is important to include network technology within each system technical infrastructure course as a fourth fundamental component, together with computer hardware, operating system software, and data concepts.

This was the conclusion tentatively reached in 2004, and expressed in the original conclusion to this paper. We now have considerable experience in the delivery of this material, organized as we proposed then.

Various aspects of the Bentley College CIS curriculum have been upgraded in the intervening years between 2004 and present; however, we believe that the decision to merge the technology infrastructure courses as described in this paper has been continually positive and successful in the face of rapidly evolving fundamental changes in the information system field. We do not plan any major modification of these two courses. The faculty teaching these courses agree that integrating all four components in each course has made it easier to explain new concepts as they arise. Informal feedback from recent alumni and the successes of students in internships and job placements also support this view.

A final note: as discussions go forward on a future upgrade or replacement for IS2002, we offer this work as a basis for creative discussion on the role and format of technical infrastructure in the IS curriculum. There is an open discussion forum for this purpose at http://blogsandwikis.bentley.edu/iscurriculum

7. REFERENCES

Englander, I., 2002, The Architecture of Computer Hardware and System Software, 3rd Edition. J Wiley & Sons, Hackensack, NJ.

Englander, I., 1997, "Rethinking Computer Architecture in the Undergraduate IS Curriculum: A Cognitive–Based Approach." ISECON '97 Proceedings, November, Orlando, FL.

Fitzgerald, J. & Dennis, A., 2007, Business Data Communications and Networking, 9th Edition, J Wiley & Sons, Hackensack, NJ

Forouzan, B., 2007, Data Communications and Networking, 4th Edition, McGraw Hill, New York.

Gorgone, John T., Gordon B. Davis, Joseph S. Valacich, Heikki Topi, David L. Feinstein, and Herbert E. Longenecker, Jr., 2002, IS2002 Model Curriculum and Guidelines for Undergraduate Degree Programs in Information Systems. Association for Computing Machinery (ACM), Association for Information Systems (AIS), Association of Information Technology Professionals (AITP).

Huang, S., 2003, "How Advanced iSCSI Architectures Can Extend the Functionality of SATA for IP Storage", Computer Technology Review, June 2003, (at www.wwpi.com).

pcisig.com, 2008

Pogue, D., 2007, "Gems in the Back of a Closet: Eye-Fi", New York Times, Dec. 20, 2007.

Waguespack, L., 2004, An Implementation of IS2002: BSCIS'04-Bentley College. ISECON 2004 Proceedings, November, Newport, RI.

wikipedia.org, 2008, "ATA over Ethernet".

wikipedia.org, 2008, "iSCSI (SCSI over TCP/IP)".

FIGURE 1 BENTLEY CURRICULUM BSCIS'04 [ADAPTED FROM WAGUESPACK, 2004]