Contrasting Computer Networking and Data Communication Curricula

Mohammad Shariat and Colin O. Benjamin
Florida A & M University

Abstract

Rapid changes in the telecommunication and computer industries have forced Computer and Management Science curriculum planners to redesign undergraduate programs. Many curriculum planners have added Data Communication or Computer Networking courses to Computer Science (CS), Computer Engineering (CE), and Management Science (CIS, IS, MIS) programs. Unfortunately, these courses do not always distinguish between the needs of CE/CS and CIS/IS/MIS students.

In this paper, we examine the computer degree programs at thirty universities and colleges and discuss the necessary distinctions between Computer Networking courses designed for CS and CE majors and Data Communication courses designed for IS, CIS, and MIS majors.

We propose that Information and Management Science students complete a business oriented Data Communications course that emphasizes the applications side of networks while Computer Science and Computer Engineering students be required to take engineering and physics oriented Computer Networking courses.

Introduction

Innovations in telecommunication technology have had a dramatic impact on how individuals and organizations communicate and conduct business. The role of the Information Technology specialist has shifted from one primarily concerned with machines, to one concerned with how employees interact with machines (Dahlbom & Mathiassen, 1997). Constant innovations in electronic communications and distributed computing environments make up-to-date information systems education difficult. Employers and universities are pressured to train workers on the innovative technologies. These technologies are popularly known as “bleeding edge” because they evolve so quickly that incorrect predictions on which way a technology is headed can bankrupt an organization.

To assist colleges and universities in remaining current with the IS and networking management needs of the computer industry, several professional associations, such as the Association of Computing Machinery (ACM), the Data Processing Management Association (DPMA), and The Institute of Electrical and Electronic Engineers (IEEE), have placed greater emphasis on computer networking and data communication in undergraduate curricula. These organizations suggest that Data Communications courses designed for Management Sciences (IS, CIS, MIS) focus on management of the computer network’s hardware/software and general use of the existing protocols (Fitzgerald, 1990; DPMA, 1991; Romos & Shroeder, 1994). The IEEE (1983) recommends that courses in Computer Networking focus on digital signaling, switching networks, effective and efficient transmission techniques, and new protocol development. These subjects are built upon the disciplines of advanced probability (Barnett, 1993) and electronic engineering (Stallings, 1988), and are appropriately placed in the Computer Science and Computer Engineering Curriculums (IEEE, 1983).

Computer Science students must possess the knowledge and skill to design, develop, and implement networking hardware and software solutions. In contrast, employers expect Information Science students to possess the knowledge and skill to use and manage networks and electronic communications systems. In other words, Information Science students must understand the applications side of networks. Although many schools and training programs have designed courses titled either Data Communications or Computer Networking, they often use these terms interchangeably, and make little distinction between the concepts of networking and electronic data communication. Because of this conflation of student needs and course content, information science majors are often required to complete a highly technical course that is beyond their abilities.

Literature Review

Walrand (1991) insists that the graduates of all fields, particularly graduates of Business Administration, must have sufficient understanding of fundamentals of data communication and computer networking. A comprehensive study of 104 Fortune 500 companies conducted by the training company Hill and Associates found that these are exactly the skill which businesses are most in need. The Hill and Associates (1997) study also found that Fortune 500 companies desire personnel qualified in groupware, wireless

communications, voice-over-IP, basic LAN and WAN technologies, and Intranets. Ninety-three percent of the employers surveyed by P. Davis (1997) expect recent graduates to possess email experience. Sixty-three percent of respondents desire new employees who are competent with online and Internet search techniques. Employers also valued a graduate's ability to create Internet documents and download files from a network. Twenty-two percent of the employers in the surveys valued the ability to create Internet documents, and 74.7% expected graduates to possess the skills to download files from a computer network.

Other studies argue, however, that many graduates do not possess even a basic understanding of electronic communications. Consequently, businesses are spending large sums of money to train recent graduate or are declining to hire them at all. According to Maglitta (1996), many new graduates of IS programs turn to outsourcing companies for employment. Nearly half of the 1996 IS graduates were employed by outsourcers and consultancies and not by corporations or private companies. Companies that specialize in outsourcing are more willing to expend the time and money necessary to train recent graduates in the technologies most needed by businesses.

Other research supports Maglitta's findings. Dishaw and Eierman (1996) also identified a shortage of adequately trained MIS professionals. Massetti, Abraham, and Goeller (1995) maintain that the differences between computer education programs make it difficult to determine just what qualifies a student as "adequately trained." Roth's and Duclos's (1995) survey of recently employed graduates supports the assertion that university programs are not providing their students with a sufficient grounding in the business applications of Information Sciences. They report a "strong plea" on the part of recent graduates for a more thorough integration of Information Science education with the Business Management curriculum. Two-thirds of the survey respondents indicated that their employers expected them to find new ways to apply information technology to increase personal and organizational productivity. Although these graduates felt comfortable using personal computers and information technology, many expressed the need for more formal training.

A 1996 study conducted by *Computerworld* of 90 representative university IS programs found that only a few of the schools exposed students to the technologies most desired by organizations. Many of the participants report that their schools do not possess the technology or the qualified faculty to sufficiently educate students on the newest concepts and technologies (Maglitta 1996). A professor at the University of Colorado, for example, claims that schools are three years behind business in innovative technology. Another professor maintained that his students personally own better computing resources than does his college. The *Computerworld* survey also reported that more than 50% of the IS programs studied offer only four or five information science courses and only one client/server course. In addition, 48% of the programs do not evaluate students on their knowledge of TCP/IP, and 98% do not test students' understanding of the Internet. Only 8% of the schools evaluate network management skills (Maglitta 1996).

Current Developments

Many schools have addressed the inadequate training of students by introducing Networking and/or Data Communications courses into the curriculum. Little distinction has been made, however, between the skills required of Information Science students and those necessary to Computer Science majors. Designing an appropriate curriculum is not an easy task because networking and data communications are large fields that continue to expand daily. Still, curriculum planners must keep in mind that Information majors, once in the workforce, will be called upon by employers to manage networks and communications systems, not design them.

Students pursuing degrees in telecommunications, computer science, or computer engineering require much more technical information than do students pursuing management and information science degrees. The former will benefit from instruction in network architecture; communication lines such as fiber optics, copper, and coaxial cable; switching techniques like ATM or frame relay; Ethernet; and routing. These students must study algorithms and logic, and examine in detail the layers of the Open Systems Interface (OSI). Engineering oriented networking courses should also explore the development of protocols and the use of the protocols over LANs, WANs, Intranets, Extranets, and the Internet. These subjects require a high degree of understanding of physics (i.e., frequencies, wavelengths, electromagnetic disturbances) and electronics.

In contrast, the topics covered in a data communications course for information science majors or non-majors need not be concerned with detailed discussions of design, physics, or electronics. The purpose of a data communications course is instruction in the application of data networks. Information Science students need to be able to apply an organization's systems to cost reductions, efficient business processes, business tactics, and strategic decision making. Although IS students should possess a working knowledge of system structure, they will most likely be part of a team that includes a computer scientist or engineer. Application-oriented data communication courses should thus focus on the theory behind distributed systems, their uses in problem solving, and the value of these systems to the organization. Furthermore, Stewart (1994) suggests that courses on distributed environments include conceptual as well as practical material. Information science majors and non-majors would benefit from exploration of case studies and practical projects that require them to employ data communications in the solution of a problem. Such exercises would provide them with more practical skills than would lectures on the physics and engineering aspects of distributed computing environments.

According to Dahlbom and Mathiassen (Dahlbom & Mathiassen, 1997), computing students should understand the history of the discipline, in this case, the history and development of data communications. Instructors should expose students to the philosophical questions, technical problems, and aesthetic values of computing systems. In a course designed for the information science curriculum, the philosophical questions might explore intellectual property, cooperation between departments, responsibility for system content, or access rights. Aesthetic questions would highlight the cultural value of electronic communications in distributed environments and their impact on the work culture. Furthermore, Dahlbom and Mathiassen recommend that academicians devote considerable attention to the economic, commercial, ethical, and social aspects of computing. These topics are especially important for MIS students whose employers will most likely ask them to use data networks to reduce expenses or improve productivity.

Dahlbom and Mathiassen suggest curriculum planners design courses that encourage students to develop a "conscious and critical attitude as users of computer systems" (1997, p. 88). Computer applications students must develop critical thinking skills that allow them to compare the differences between operating systems, for example, or evaluate the scalability of network segments. They must be able to distinguish between data, information, and knowledge, particularly with regards to information available on the Internet and the World Wide Web. Finally, students must perceive their roles as facilitators of information rather than keepers of information or IS resources. The IS professional works with others to meet changing needs and requirements for data, information, and knowledge (Dahlbom & Mathiassen, 1997, p. 83). A Data Communications course designed for computer applications students should emphasize the role data networks play in operations, management, and organizational strategy.

Many of the specific topics that instructors should present in an IS data communications course also appear in a computer science oriented networking course. The difference between the two courses is not one of content per se, but focus. A data communications course in an IS program concentrates on applications and problem solving, while a networking course in an engineering or CS program concentrates on design and programming. For example, both courses include topics on FDDI (Fiber Distributed Data Interface), but the course designed for information science students would present the pros, cons, and economics of FDDI networks. The Networking course, on the other hand, would describe the electronics and photonics of such a network and how systems analysts design and implement a FDDI network. Other examples of overlapping content are datawarehouses and relational databases, protocols, open systems standards, network topologies, switching and routing, and transmission modes. Data Communication courses should introduce these topics, provide basic definitions and explanations, and demonstrate the use of these technologies. IS students must understand the value of these technologies to an organization and how an enterprise network might best utilize a particular type of technology efficiently and effectively. Conversely, Networking and Telecommunications students will need to understand how to design, implement, and troubleshoot a specific technology.

Several recent curricular models support the view that Data Communications courses for Information Science students need not revolve around technical specifications. The IS95 and IS97 Model Curricula emphasize communications, problem solving, project management, and information management skills. As methods to teach these skills, the curricula recommend instruction in email, online searching and browsing, online databases, electronic bulletin boards, USENET and other electronic discussion groups, and development of home pages (Khosrowpour, 1996; G. B. Davis, et al. 1997). The Data Processing Management Association's (DPMA, 1991) Undergraduate Computer Information Systems curriculum suggests that data communications and distributed processing courses for computer applications programs include material on communications lines and network services, media speeds, and modems. The model curriculum also recommends that students explore the advantages and disadvantages of online and real-time transmission, and the distinctions between centralized and decentralized networks. The courses should present the material from the perspective of both the user and the manager. CIS, IS, and MIS students should learn to discern the impact of data communications and distributed processing on the business enterprise.

The ACM (1983; 1991) model curricula for information systems programs indicates that computer application students possess knowledge of the following specific topics:

Basic communication concepts (senders, receivers)
Types of communication in organizations
Communication functions (transmission, interface, etc.)
Forms of communication (data, messages, voice, image)
Transmission media (wire, optic, microwave, etc.)
Analogue vs. digital communication
Packet switching
Communication devices
Line options (dial-up, direct connections, T1, ISDN, etc.)
Basic network topologies
Common carrier services
Tariffs, regulatory agencies, and history

Network pricing
Satellite and wireless communications
Integrated voice and data
LANs
WANs
Internet

Although this list appears lengthy, the ACM suggests that students gain knowledge of most of these topics through self-study or lectures. Interdisciplinary courses need only survey these topics and present the material from an introductory perspective. Courses designed for information science majors might include case study projects that encourage students to research many of these topics on their own. They might then be required to choose the best technologies to solve the case problem.

Analysis of Programs

In the fall of 1997, thirty university degree programs were downloaded from the Internet. Twenty-two universities offered Computer Science degrees (CE, CS) and/or Computer Applications degrees (CIS, IS, MIS), and eight universities did not offer any computer-related degree programs. The twenty-two computer-related programs were analyzed with regard to the correlation between CE or CS programs and a required Computer Networking course, and the correlation between CIS, IS, and MIS programs and a required Data Communication course. Of these twenty-two schools, twelve offered only computer application degrees. Six institutions offered only Computer Science/Engineering programs. Four schools offered both computer applications degrees and Computer Science/Engineering degrees. The survey data is presented below in Table 1.

As we have argued, CS and CE students should complete courses in Computer Networking, and CIS, IS, and MIS students should study Data Communications. Table 1 reveals that few of the universities make this distinction. Only four of the universities studied offer a Computer Networking course designed for CS students and a Data Communications course designed for CIS, IS, and MIS students. Row 1 of Table 1 indicates that four out of nine colleges offering computer application degrees require students to complete a Computer Networking course rather than a Data Communication course. Row 2 shows that two out of six Computer Science programs require students to complete a Data Communication course instead of a Computer Networking course.

Furthermore, the survey supports our assertion that colleges and universities must revise their curricula to reflect the importance of distributed computing environments in business. Section II demonstrated that all computer application majors should complete an applications oriented Data Communication course, but less than half of the CIS, IS, or MIS programs require Data Communications. Four require a Computer Networking course, which should be required of CE or CS students only, and three do not offer any networking-related courses at all. CE and CS curriculum developers appear to better understand the differences between networking and data communications. Eight of ten CE and/or CS programs make a Networking course available.

	1	2	3	4	5
	Degree Types	Number of Coll./Univ.	No Data Comm. or Networking Course	Data Communic. Course	Computer Networking Course	Course for Non-majors
1	CIS, IS, MIS	12	3	5	4	0
2	CE and/or CS	6	0	2	4	0
3	CE, CS, CIS, IS, MIS	4	0	4	4	1
4	No computer degrees offered	8	N/A	N/A	N/A	N/A
	Total	30	3	11	12	1

Table 1: Computer Networking and Data Communication courses in Computer Degree Programs.

Conclusion

As the survey data demonstrate, several colleges and universities offer courses that explore data networks. More research is needed, however, to determine the specific focus of courses labeled Computer Networking and Data Communications, and the extent to which these courses prepare students for the workforce. The literature review supports the conclusion that curricular revisions are not meeting the needs of employers. Contributing to the discrepancy of skills taught and those needed by the industry may be the lack of a clear distinction between data communications and computer networking. Curriculum planners often apply these terms interchangeably and do not realize the differences the titles imply. To understand more fully the implications of course titles and content orientation, future researchers should keep in mind the argument we make here that Data Communications and Computer Networking are indeed two different courses, intended for two different audiences.

In our view, instructors with business backgrounds rather than engineering or science backgrounds should teach Data Communication courses. CIS, IS, or MIS students must receive instruction in the business and organizational aspects of data networks and communications so they may contribute to the strategic application of information systems once they enter the workforce. Their courses should expose them to the history and theory behind communication networks, basic topologies, types of networks, and the economic advantages of centralized and decentralized computing networks. Additionally, since the IS professional's role is increasingly one of support rather than control, Computer Applications curricula should include methods to evaluate students on their abilities to distinguish between these functions. Information Science students should approach data communications from the perspective of one who must apply the technology to solve common organizational problems.

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