Specializing in Telecommunications: Networking Curricula of IS Programs in the United States

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Executive Summary

Preparation for employment in the telecommunications area is not a major emphasis in most information system (IS) programs. The curricula of most programs include only one or two courses related to telecommunications. As a result, most do not provide much preparation for employment in this area. There may be, however, increasing employment opportunities in this area that could be met by IS graduates.

The current study investigates IS programs that allow students to develop their knowledge and skills in telecommunications. Not only is little known about the curricula of such programs, knowledge of their existence is relatively limited. The purpose of this study primarily is descriptive. A good place to start in understanding how networking curricula could be structured is to examine programs that are already in place. The specific telecommunications courses included in these programs and how they have been combined with more general IS courses provide examples that should be useful for understanding how IS programs can prepare students for working in the networking field.

A survey was conducted by examining fourteen IS programs in the United States that allow students to specialize in telecommunications. Data describing the general IS and the networking courses in these programs were gathered.

The results show that most networking specializations provided a broad IS education to some extent. That is, all programs were part of a comprehensive business program, and most of these also provided some preparation in typical IS courses such as Computer Programming, Database and Systems Analysis and Design along with some IS coursework beyond this. On average, the networking specializations required 5.21 IS courses outside of the telecommunications area.

Coursework specific to the telecommunications field was also analyzed to determine which courses were typically included as requirements and / or electives. The results show that on average, the specializations required 4.86 courses in telecommunications; 3.29 of these were specifically required courses with the remainder allowing students to choose among telecommunication electives. The foundation course in Networking and Telecommunications was required in all but one of the programs. Beyond this, there was considerable variation in what courses were required and offered as electives. The curricula tended to stress developing competencies in technical areas with much less attention being paid to tele-

communications management and policy issues.

Keywords: Telecommunications, networking, data communications, education, curriculum

Introduction

Telecommunications is not typically an area that receives much emphasis in IS curricula. Gambill and Maier's survey of IS programs (1998) indicates that systems development subjects such as programming, database, and systems analysis and design comprise the bulk of IS-specific coursework. This emphasis may be understandable given that many IS graduates start out in entry-level application development and support positions and see this as their initial career path.

An application development emphasis is also found in the IS 2002 model curriculum (Gorgone et al., 2002). Five out of the ten courses in the model curriculum relate directly to systems development skills and knowledge, while only two are telecommunications-related. These two courses are IS 2002.4 Information Technology Hardware and Software, and IS 2002.6 Networks and Telecommunications. IS 2002.4 is not a telecommunications course per se since it deals with the broader information technology (IT) infrastructure as well as telecommunications topics that serve as a prerequisite for IS 2002.6. Gambill and Maier's results (1998) showed, however, that only 78% of IS programs offered a data communications course and that only 38% included it as a program requirement. Even fewer (1.5 %) offered a course similar to IS 2002.4, with no program requiring it at all. Although this study predates the IS 2002 model curriculum by a few years, a similar level of coverage of the topics included in IS 2002.4 and IS 2002.6 existed in IS 1997, the prior version of the model curriculum.

Anecdotal evidence from our IS program over the years suggests that there is a sizable minority of students who prefer the computer networking area over application development. In some cases this may result from having strengths in technical areas besides programming. In others, students are simply drawn to the computer networking and IS technical infrastructure subjects. Additionally, some employers hire IS graduates into positions involving networking and infrastructure support. Experience with such students and employment opportunities for them led to an interest in investigating IS programs that allow students to specialize in telecommunications.

A number of similar terms are used to refer to this field. Telecommunications has broader connotations than computer networking or data communications. In addition to voice and data communications, telecommunications can also refer to broadcast telecommunications such as television and radio. The main emphasis here when the terms networking or telecommunications are used is on voice and data communications, which can of course include the use of telecommunication technologies for carrying video or audio data.

Employment Opportunities in the Networking Field

What opportunities exist for IS students who seek employment in the networking area? In discussing the future for American programmers, Mander (2001) notes that there is an undoubted skills shortage in the area of computer networking as this technology has increased in strategic importance during the 1990s. A study conducted in the late 1990's indicated that significant demand existed for IT graduates with skills in telecommunications and infrastructure support (Gonzenbach, 1998).

More recent estimates provided by US Bureau of Labor Statistics (2004) of employment growth in different occupations from 2002-2012 suggests the networking field may offer increasing employment opportunities in the future. "Network and Computer Systems Administrators" and "Network Systems and Data Communications Analysts" are among the 30 occupations expected

to grow the fastest from 2002 to 2012, with predicted growth rates of 37% and 57% respectively. One of these, "Network Systems and Data Communications Analysts", is predicted to be the second fastest growing occupation in the USA during this period. Total 2012 employment for "Network and Computer Systems Administrators" and "Network Systems and Data Communications Analysts" is estimated to be 345,000 and 292,000 respectively with a combined employment of 637,000. Thus, there should continue to be good employment opportunities in this field for the foreseeable future.

One potential threat to future employment in the IS field is offshore outsourcing. Offshore outsourcing shifts jobs from domestic employees to foreign workers. Although employment opportunities overall in the IS field in the USA are still predicted to grow for the foreseeable future, one estimate indicates that there will be 246,000 fewer IT jobs in the USA in 2008 compared to the situation were none of this work to be done offshore (Information Technology Association of America, 2004).

Does offshore outsourcing affect all types of IS occupations equally? So far, the impact is the greatest in the software development area, with relatively little impact on demand for employees in the networking field (Gartner Group, 2003). US Bureau of Labor Statistics (2004) employment estimates provide some support for this; estimated growth in jobs for computer programmers is the lowest of all the IS occupations and the two networking occupations are both in the top 30 high growth areas. Carmel and Tjia (2005) note that one reason why certain IT activities such as networking do not lend themselves to being done offshore is simply the need for much of the work to be done in close proximity to the using-organization. Although there is nothing to guarantee that telecommunications won't eventually be affected, the networking field is relatively immune to the threat of being shipped offshore for the time being. Given all this, networking occupations may become a more important destination for IS graduates than they have been in the past.

All of this does not directly answer the question of what employment opportunities exist for IS students who specialize in networking since demand for employees in this area could be filled from other sources, such as by hiring computer science, electrical engineering or technical college graduates. The increasing demand in this area presumably could be met in part by IS graduates. Offering a specialization in telecommunications should better enable an IS program to meet the demands for IT talent in this area.

Prior Research on Networking Specializations

Shariat and Benjamin (1999) contrast the objectives of telecommunications curricula in computer science, computer engineering and IS. Computer science and computer engineering programs need more of a detailed, technical orientation than IS. IS, on the other hand, needs to be more concerned with the application of networks as a means to achieve organizational goals. Thompson (2003) also distinguishes between these three disciplines and notes that programs housed within a Business School may have somewhat technical courses in network management and telecommunications administration. Computer science programs, on the other hand, would go into greater technical detail on networks, protocols and distributed processes; and computer engineering programs would have greater emphasis on topics such as electronics, math, electromagnetic theory, and signal processing.

One study specifically addresses the issue of providing a networking specialization within a Business program (Minch & Tabor, 2003). Their view of the purpose of such a specialization is to produce "graduates who are not only technically proficient, but who understand the diverse business functions and organizational drivers that dictate technical solutions" (p. 52). The curriculum they describe provides an illustration of how one program accomplished this by combining a tra-

ditional foundation in business subjects, some courses that are typically found in IS programs (e.g. Programming, Database, and Systems Analysis and Design), as well as courses on telecommunications.

Snow and Lowman (2004) express a similar view regarding the scope of telecommunications programs as above. Without identifying which discipline would offer a telecommunications specialization, they note that curricula in this area need to go beyond developing technical competence and should pay some attention to telecommunications policy and management. This broad view of the field would seem especially appropriate for specializations within business-oriented IS programs.

Other literature on telecommunications education does not address the curricula of telecommunications specializations per se. Rather, it discusses how specific telecommunications courses could be structured and / or delivered. Examples are the IS 2002.6 networking and telecommunications course (Johnson, Stellar, and Tanner, 1999), computer and network security (Bergström, Grahn, Karlström, Pulkkis, & Åström, 2004; Steele, Stojkovic, & Zaveri, 2004), project management and requirements assessment for telecommunications (Snow & Lowman, 2004), and management of telecommunications services (Choi, Teer, & Teer, 2005). While these studies provide insight into the teaching of specific telecommunications courses, they do not describe the structure of telecommunications curricula where such courses might be found.

The main research question addressed by the current study is:

> *What are the curricula of IS programs that provide networking specializations?*

Specifically, how have these programs structured their IS curricula in general, as well as the courses within the telecommunications area? What telecommunications courses are typically offered in these specializations? This study will describe in some detail how this has been accomplished in a number of universities.

The following, adapted from Minch and Tabor (2003), provides a conceptual overview of what the structure of such programs was expected to look like in general.

1. University Core – The basic undergraduate requirements for all majors, e.g. Humanities and the Arts, Social Sciences, Science, etc.

2. Business Core: This would include foundation courses such as Math, Economics, Statistics, Oral or Written Communications, Legal Environment of Business, as well as courses in the Business functions such as Accounting, Marketing, Finance, Organizational Behavior or Theory, Operations Management, and Business Policy and Strategy.

3. IS Courses: Courses that are typically found in IS programs such as Computer Programming, Database, Systems Analysis and Design, and IS Policy and Strategy.

4. Telecommunications Courses: Courses specific to the networking area.

The first three categories describe how most IS programs are structured; Information Systems is embedded within the Business curriculum, which in turn assumes the broader education provided by the University Core. Telecommunications, the last category, provides more targeted IS coursework specific to the networking specialization. The emphasis of this study is on the latter two categories. That is, what general IS courses are in the curricula, and what are the telecommunications-specific courses?

Research Method

A survey was conducted to provide information on undergraduate IS programs that allowed students to specialize in telecommunications while obtaining a broader business education. If a program claimed that it offered a specialization in telecommunications, it was a candidate for inclusion in the sample. It was expected that any networking specialization would go beyond including just two telecommunications courses since this is the number of such courses in the IS 2002 model curriculum. Besides allowing students to specialize in telecommunications, the IS program had to be part of a broader Business curriculum to be included in the sample. That is, the program had to provide a preparation in the typical Business foundation and Business functional area courses

Besides IS, other names a program could go by include management information system, computer information systems (CIS), information technology, and telecommunications. In some cases the telecommunications specialization could be found within an IS curriculum that allowed students to concentrate in this field as a sub-specialty within a broader IS program, while in others, the networking specialization could itself be the IS program.

IS programs can either award a degree in IS or a Business degree where students concentrate in IS. Other terms that refer to the same thing as concentration are "track", "option" or "area of emphasis". The distinction between an IS concentration and an IS degree may not have too much significance in that no standard exists for defining how they differ. The IS and broader business curricula of two programs could be very similar, yet either program could award a Business degree with an IS concentration or an IS degree. This research will include programs going by either name. The primary interest is program content, not program name.

A number of approaches were used to locate programs to include in the sample. The main approach was to conduct web searches using various search engines to find the programs' web sites. Terms such as telecommunications, data communications or networking were used along with terms such as major, concentration, specialization, or track to identify these programs. Searches were normally limited to the *.edu domain since academic programs should be on a host within this domain. Promising hits from these searches were investigated further by examining the web sites to see if they met the above criteria. Eventually after performing several different searches, this approach converged on the same 10 qualifying programs.

Another approach was to use the attendee list from the Telecommunications and Information Technology conference held in Louisville, KY, April 1-3, 2004. Most attendees of this conference were involved in telecommunications programs in various disciplines, and had interest in teaching and curricular issues related to this field. An examination of attendees' web sites yielded three additional programs.

A third approach was to examine a random selection of AACSB accredited undergraduate programs of business (Association to Advance Collegiate Schools of Business, 2004), checking each for the existence of a telecommunication specialization. To obtain a random sample, the listing of accredited business programs was imported into a Microsoft Excel spreadsheet. A random number was assigned to each program and the resulting list was sorted in decreasing order of the assigned random number. Programs were then selected in first to last order from this sorted list. This ended up in the examination of a random sample of half (230) of the AACSB accredited undergraduate programs of business. This brute-force, time consuming effort yielded only one additional program that was not found using the first two approaches. Due to the low payoff for the effort, and with no expectation that the other half of the AACSB programs would provide better results, the remaining half of AACSB programs were not examined.

All three of the above methods for locating telecommunications programs would be expected to generate a sample that would primarily be located in the United States. Programs identified by the .edu domain are mostly within the US. All of the conference attendees and most of the AACSB accredited programs were located in the United States.

Data were collected by recording program requirements and course descriptions for general IS and telecommunications-specific courses into a document that described each program. These documents provided the raw data for creating the results tables.

Telecommunications builds on and is complementary with other areas such as technical infrastructure (hardware & operating systems), computer and network security, and the legal and regulatory environment of telecommunications. All these types of courses will be considered as part of telecommunications-specific coursework. Some courses had titles such as "network programming" or "internet programming" suggesting they were telecommunications courses. Courses with such titles sometimes turned out to be web-based application development courses (e.g. HTML, JavaScript, Active Server Pages). Unless there was some emphasis on networking issues per se, these courses were classified as web-development courses in the general IS curricula, and not included among the telecommunications-specific courses.

Results

The institutions and the telecommunications specializations included in the sample are shown in Table 1. All programs were located in the United States. The most common type of specialization, found at seven of the fourteen sampled institutions, was to provide a bachelor's degree in IS with the option to complete a concentration in the telecommunications area. The next most common type of specialization, found at three institutions, was for the business program to directly offer a bachelor's degree in telecommunications or networking (Boise State, California State - Hayward, and Western Michigan). One program offered a telecommunications track within an IS concentration (California State – Long Beach). Another had a telecommunications concentration directly within the business degree (Golden Gate).

Two of the fourteen institutions included in the sample offered neither a telecommunications concentration nor a telecommunications degree. University of Mississippi provided a degree in IS and an interdisciplinary telecommunications minor. Requirements for the minor overlapped IS degree requirements in a way that allowed IS students to complete its requirements while simultaneously fulfilling the requirements of the IS degree. Finally, one program (Dakota State) made no mention of allowing IS students to specialize in telecommunications. Dakota State, however, offered a non-business CIS degree that had seven networking-related courses that could be taken by IS majors. IS majors were required to take four elective courses from CIS or computer science, so IS majors could put together a telecommunications specialization informally by choosing electives from these courses in the CIS program. In order to analyze Dakota State in the same manner as the other programs, it was assumed that students who informally specialized in telecommunications would take all four IS electives in the telecommunications area.

All the sampled programs were integrated within broader Business curricula. Ten were found in AACSB accredited programs, and four were not. Being in an AACSB accredited program guaranteed a solid grounding in Business core subjects. All specializations, however, required a broad education in Business core subjects as described earlier. No program had fewer than 33 credits in its required business core, and all institutions required additional foundation courses beyond this (e.g. Economics, Math, Statistics). The purpose of this paper, however, is not to document all requirements for graduation, but rather to confirm that the specializations were embedded in comprehensive Business programs instead of merely drawing upon a select, small group of Business courses designed to give a highly technical program a business-oriented flavor.

All but two programs expressed program requirements in terms of "credits" where one credit translated into 15 class hours for an academic term. Two quarter-based programs did not (University of California at Hayward, Milwaukee School of Engineering). The class hours of these two programs were converted into 15 hour per term credits using formulas provided on their websites. All credits shown in the results can therefore be interpreted in the same way. All other programs mostly offered 3 credit courses, with a few courses being one or two credits.

General Program Structure

Table 1 shows the IS curricula in the 14 specializations by identifying the general IS courses required in each program, and how many telecommunication courses were in the programs on a required and elective basis. The most common general IS courses were Computer Programming, Database and Systems Analysis and Design. Other frequently required courses were Web Development, E-commerce and IS Policy and Strategy. All programs of course also included networking courses. Some summary figures for the programs are as follows:

1. The 14 programs required 5.21 IS courses on average outside of the telecommunications area.

2. On average, the programs required 3.29 specifically designated telecommunication courses.

3. On average, the programs required an additional 1.57 elective courses in the telecommunications area.

4. Combining the required and elective courses, 4.86 telecommunications courses were required on average.

5. Adding the general IS and the telecommunications courses resulted with the requirement for students to take 10.07 courses on average in order to complete the specialization.

6. Finally, on average, the telecommunications courses represented 48.3 % of the courses in the overall IS curricula.

All of the specializations required three or more networking courses. There were no cases of programs claiming to offer a networking specialization that failed to meet this minimum threshold. Therefore, all specializations provided at least a little more in-depth coverage of networking topics than what is included in the IS 2002 model curriculum.

Golden State University had no specific telecommunications courses required. An examination of course prerequisites showed that only one telecommunications course had another telecommunications course as a prerequisite. So unless students wanted that course having the prerequisite, there were no restrictions on what networking courses they could take. Dakota State also had no specifically required telecommunications courses, so students could theoretically choose any 4 courses in this area. In practice though, taking 4 telecommunications courses required students to take one of the telecommunications courses due to prerequisites of the other courses.

Most of the curricula shown in Table 1 provided a well-rounded preparation in conventional IS topics, at least to some extent, by requiring several of the courses in the IS 2002 model curriculum. A few of the specializations, however, did not. Golden Gate University was the most extreme in this regard with the entire curriculum being comprised of networking courses. California State University, Hayward provided a single programming course and two web development courses that covered topics such as HTML, multimedia, JavaScript and the CGI Interface. Dakota State required three programming courses and one database course. All of the other programs required at least one programming and one database course along with one or more courses in areas

outside of telecommunications that typically included either Systems Analysis and Design or a system development field-project.

Telecommunication Course Requirements

Course names and their descriptions were developed from the courses in the 14 programs. Descriptions of the courses that were considered to be examples of the same course were grouped together and compared with each other as well as contrasted with courses placed in other categories. The goal of this was to ensure that courses put into the same category were very similar in objective and topics included, as well as being different from the objectives and topics of other course categories. The results of this were reviewed by two colleagues who teach in the telecommunications area with some minor revisions being made as a result.

Table 2 shows the telecommunications courses that were required in two or more programs. For each course category, Table 2 shows how many different courses fit each category at an institution both as a requirement and as an elective. In a few cases, an institution offered or required more than one variation of the course. For instance, Arkansas State University required two different Local Area Network courses and Dakota State University provided 4 different Computer and Network Security courses as electives. The "other" category included courses that were required in only one program or that were offered only as electives. Ten courses are shown left to right in decreasing order of how many programs required them. The Appendix provides a brief description of the courses that were included in Table 2.

The most commonly required course was Networks and Telecommunications, the course that corresponds to the IS 2002.6 telecommunications course defined in the IS 2002 model curriculum. It was offered in all fourteen programs, and was required in all but one. Golden Gate University had no specific telecommunications courses required. Neither did Dakota State officially, but due to this course being a prerequisite for other networking courses, it would end up being a required course in practice for most students. This course served a similar role in all programs that required it in that it provided a foundation in the principles, standards, protocols and managerial issues related to telecommunications that subsequent courses built upon.

No other course came close to IS 2002.6 Networks and Telecommunications in being so widely required. The next most commonly required course, "Local Area Networks" was required in only 5 of the programs and offered in a sixth as an elective. This course emphasized standards and protocols relevant for LANs, LAN server administration as well as hands-on lab exercises related to the implementation and administration of LANs and LAN servers.

Following closely behind Local Area Networks were "Network Design" and "Networks and Telecommunications II" with each being required in four programs and offered in two as an elective. "Network Design" provided a systematic approach for defining network solutions to business needs, with additional content related to the implementation and administration of networks typically being included. Although the topics found in "Networks and Telecommunications II" overlapped those found in IS 2002.6 "Networks and Telecommunications", this second, follow-on course built on the foundation provided by the first course by providing practical application and extension of those concepts. It tended to provide more hands-on experiences such as setting up, configuring and administering networks and internetworking devices as well as providing more in-depth coverage of certain issues such as TCP/IP and security.

"Legal, and Regulatory Environment of Telecommunications" was a requirement in three programs and was offered as an elective in three others. "Information Technology and System Software" corresponds to IS 2002.4, the IT Infrastructure course defined in IS 2002. IS 2002.4 provides a foundation in broader IT infrastructure issues such as computer architecture, networking

technologies and system software. Although this course is recommended as a requirement for any IS degree (Gorgone et al., 2002), it was required in only in three of the sampled programs.

"Computer and Network Security" was offered more often as an elective than a required telecommunications course. Although not regarded as critical enough to merit a dedicated required course in most specializations, it apparently was viewed as important enough to be offered as an elective in more programs than any other telecommunications course. Dakota State went so far as to provide 4 courses on security. Students at Dakota State could select up to 3 of their 4 networking courses from among the security courses and could therefore develop a depth of knowledge in this area that was unique among the sampled programs. At Ball State University this course could be used as a general IS elective for all IS majors, but the networking specialization itself didn't specify telecommunication electives.

"Applied Operating Systems" had a very practical orientation by concentrating on specific administration skills along with some basic principals. In two programs the course was oriented mostly towards vendor certification. The program at Milwaukee School of Engineering went furthest in this regard by preparing students to certify in several courses within the Microsoft and Novell curricula.

The "Internetworking/WAN" course could be considered a complementary course to the local area networking course in that together they represented the range of networking issues from local to wide area networking, although only one program required both. The LAN course dealt with managing local networks without much emphasis on how LANs are connected, while the Internetworking course concentrated on the enterprise, wide area connectivity of networks, including LANs.

Finally, only "Management of Telecommunications" dealt substantially with softer managerial issues such as telecommunications planning and management of the telecommunications function. Despite use of the term "management" in the titles of some courses, there were only 4 institutions that offered courses that primarily dealt with management of telecommunication. Only two required it.

There were a few commonalities in the courses included in the "Other" category. Four programs gave credit for a networking internship with one of them including it as a required course. Three programs offered a course on TCP/IP with one case of it being required. Besides this, other miscellaneous courses include IP telephony, wireless networking, network simulation, business web architecture, A+ certification, data center management and automated data capture.

Conclusion and Discussion

The analysis of programs with networking specializations provides models of how different Universities prepare students for work in this area. The results provide examples of telecommunications curricula that could be useful for other IS programs considering the creation of a networking specialization. For an institution that already offers such a specialization, the results could still be useful for suggesting other alternatives.

Most of the specializations are structured as sub-specialties within IS programs that to some extent provide a well-rounded background in IS. Most programs provide students some background in the courses traditionally found in IS programs such as Programming, Database, and Systems Analysis and Design, as well as some additional IS courses. Besides gaining a background for entry-level networking positions, the graduates of most specializations would therefore have some credentials to seek work in other IS areas. Even if graduates end up in a telecommunications position, the variety in IS coursework provided by most programs would help in understanding the broader IT function of their employers. This background would presumably be useful as

they rise through the telecommunications ranks and could make it easier for graduates to move into other functions within IS later on if they desired.

There were some programs, however, that provided only a limited number of IS courses outside the telecommunications area. Golden Gate University and California State University, Hayward are the leading examples of this. These specializations do not necessarily go into greater depth in telecommunications coursework, but rather allow students to complete the specialization with fewer courses overall within the combined general IS and telecommunications areas. The view implicit in these curricula apparently is that having a narrower focus on telecommunications provides acceptable preparation for work in this area.

The specializations provide a mixture of theory and conceptual learning along with hands-on experiential learning in a lab and/or field setting. "Networks and Telecommunications" tends to concentrate on theory and concepts while other courses such as "Local Area Networks", "Networks and Telecommunications II", "Applied Operating Systems" and "Internetworking/WANs" tend to provide significant hands-on experiences in addition to theory and concepts. "Network Design" more than other courses provides experiential learning via field projects.

Taken as a whole, the telecommunications-specific courses place much greater emphasis on technical than non-technical topics. The main courses featuring a substantial degree of non-technical content include "Network Design", "Legal, & Regulatory Environment of Telecommunications" and "Management of Telecommunications". These courses are required in seven of the specializations, with only two programs requiring more than one of them. Although other telecommunications courses include some content found in these three courses to a limited extent, seven of the specializations do not require any course that significantly emphasizes non-technical topics.

In discussing the educational requirements for the telecommunications discipline, Snow and Lowman (2004) suggest that programs should include "concepts in each of the three dimensions of telecommunications, namely; telecommunications *technology, policy, and management* … Although some educational programs might place particular emphasis on one of these dimensions, it is important to pass on to the student the core competencies of each" (p. 1). Many of the programs in the sample, however, concentrate on the development of technology competencies without much attention being paid to the others. Although technology competencies would likely be the most important for entry level positions, the importance of the others should increase as graduates advance into more senior positions in this field.

Besides being limited by the number of courses that can be required of students, one possible reason for this technical emphasis may be that other general IS courses include these issues to a certain extent. For instance, Systems Analysis and Design provides a problem solving approach that could be adapted for network design. Also, the broader Business curriculum provides education in topics relevant for policy and management in the telecommunications area. However, greater attention to the non-technical issues within the telecommunications courses themselves may still be warranted.

The discussion of networking curricula highlighted those courses that were designated as networking or infrastructure-related. Telecommunications however, would likely be included to some extent in other courses outside of these in most programs. For instance Electronic Business (IS 2002.2) and IS Policy and Strategy (IS 2002.4) would both pay some attention to networking and infrastructure issues. To the extent that computer networking content is embedded into these courses, the results presented here would tend to understate the coverage of these topics in the networking curricula. IS 2002.2, however, would probably include infrastructure and security issues at a relatively simple level due to its assumption of no prior computer networking background. The integration of networking and infrastructure topics into courses such as this would still provide a useful addition to the networking courses in that they would help students under-

stand how networking and infrastructure issues relate to other areas of IS. IS Policy and Strategy (IS 2002.4) would also provide a useful complement to the technically-oriented networking courses, especially if a program has no "Management of Telecommunications" course.

The relatively low emphasis given to proprietary knowledge such as teaching Windows, Net-Ware, or CISCO for the purpose of preparing students for certification is worth noting. Although many courses include these technologies, Milwaukee School of Engineering is the only specialization that offers several courses geared specifically towards vendor certification. Only a few other courses at other institutions were found related to Windows or CISCO certification.

The effort required to locate the 14 specializations in the sample suggests that not too many undergraduate IS programs provide the telecommunications option in the United States. Perhaps future research using other search strategies could uncover more programs that provide a specialization in this area. The sample could be expanded by attempting to locate programs outside of the United States. Limiting internet searches to the .edu domain in this study was done to avoid having a result set that was so large that it would be difficult to find qualifying networking programs. The result, however, was that the programs uncovered were all in the United States. Use of domain names that identify institutions of higher education elsewhere could help internationalize the sample in future studies. It would be useful to investigate the similarities and differences of networking programs found in other countries with those in the United States.

Networking specializations offered by undergraduate IS programs face a challenge in needing to meet so many requirements, particularly if a broad background in non-telecommunications IS topics is to be provided. Can the relatively limited number of courses in the telecommunications area really provide adequate credentials for work in this area? The fourteen programs examined by this study apparently believe so.

The current study is descriptive in nature; it describes what has been done but does not go too far in evaluating the suitability of the curricula for preparing graduates for work in the networking field. More research is needed on the occupations and career paths of telecommunications professionals and what education and experience is needed to prepare students for this work. The results of this should shed light on how networking curricula could be structured to meet these needs, as well as the types of positions that graduates of IS programs fill versus graduates from other types of programs such as technical colleges, or 4-year computer science or electrical engineering programs.

Table 1. Structure of Telecommunications Programs

Institution	Degree / specialization name	AACSB Accredited?	General IS Course Requirements									Telecommunications Courses			Total IS courses / (credits)
			Programming	Database	SA & Design	Web Development	E-commerce	IS Policy & Strategy	Other	IS Elective	Total Non-telecom courses / (credits)	Required Telecom Courses	Telecom Electives	Total Telecom courses / (credits) required	
Arkansas State Univ. - Jonesboro	MIS degree with Networking Emphasis	Y	1	1	1						3 (9 cr.)	6		6 (18 cr.)	9 (27 cr.)
Auburn Univ. - Montgomery	BSBA in IS with Data Communications Option	Y	1	1					1	1	4 (12 cr.)	4		4 (12 cr.)	8 (24 cr.)
Ball State Univ.	Bachelors IS with Network Management option	Y	1	1	1				2	2	7 (18 cr.)	3		3 (9 cr.)	10 (27 cr.)
Boise State Univ.	BBA Networking & Telecommunications	Y	1	1	1	1	1	1			6 (18 cr.)	4	2	6 (18 cr.)	12 (36 cr.)
California State Univ. - Hayward	BS Telecommunications Management	Y	1			2					3 (8 cr.)	4		4 (10.7 cr.)	7 (18.7 cr.)
California State Univ. - Long Beach	IS option in the BSBA degree. Telecommunications track	Y	1	1					1		3 (9 cr.)	2	1	3 (9 cr.)	6 (18 cr.)
Dakota State University	Bachelors MIS, up to 4 Telecom electives	N	3	1							4 (12 cr.)	1	3	4 (12 cr.)	8 (24 cr.)
Eastern Illinois University	CIS Major with Telecom Concentration	Y	2	1	1		1			1	6 (18 cr.)	3		3 (9 cr.)	9 (27 cr.)
Golden Gate University	BBA with Concentration In Telecom Management	N									0 (0 cr.)	0	5	5 (15 cr.)	5 (15 cr.)
Our Lady of the Lake University	BBA in CIS and Security - Web/Network Admin. Track	N	2	1	1	1	1		1		7 (21 cr.)	5		5 (15 cr.)	12 (36 cr.)
Milwaukee School of Engineering	BBA MIS with Computer System Infrastructure Concentration	N	4	1	1	1	1		1		9 (19.3 cr.)	5	8	13 (26.7-32 cr.)	22 (46-51.3 cr.)
University of Mississippi	BBA MIS - with telecom minor	Y	4	2	2			1	2		11 (33 cr.)	3		3 (9 cr.)	14 (42 cr.)
Univ. of Wisconsin - Parkside	BS in MIS with telecom track	Y	2	1	1	1		1			6 (16 cr.)	3	1	4 (10-11 cr.)	10 (26-27 cr.)
Western Michigan University	BBA Telecommunications & Information Management	Y	1	1	1				1		4 (12 cr.)	4	2	6 (18 cr.)	10 (30 cr.)

Table 2. Required and Elective Telecommunications Courses

	Rq	El	Rq	El	Rq	El	Rq	El	Rq	El	Rq	El	Rq	El	Rq	El	Rq	El	Rq	El	Rq	El
Arkansas State University	1		2		1																2	
Auburn University - Montgomery	1				1		1										1					
Ball State University	1		1										1	1								
Boise State University	1						1		1	1	1								1			5
California State Univ. - Hayward	1				1			1								1						
California State Univ. - Long Beach	1		1															1				1
Dakota State University	1			1										4		2						1
Eastern Illinois University	1		1													1						
Golden Gate University		1				1				1				1				1		1		2
Our Lady of the Lake University	1				1		1				1											
Milwaukee School of Engineering	1							1					1	4		9	2					4
University of Mississippi	1						1	1														
University of Wisconsin - Parkside	1										1			1		1					1	
Western Michigan University	1		1				1		1	1										1		5
Number of programs that require the course / Number of programs that offer the course as an elective	13	1	5	1	4	2	4	2	3	3	3	0	2	6	2	4	2	3	2	2	2	6

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Appendix: Description of Networking Courses

1. Networks and Telecommunications

This course corresponds to IS 2002.6 and provides a foundation in the technical and management aspects of business data communication and networking. Among the topics included are layered network models, network hardware and transmission media, standards and protocols, network design and management, local area and wide area networking

2. Local Area Networks

Topics pertinent to the setup, configuration and administration of local area networks (LAN), characterized by standards and protocols relevant for LANs and LAN planning and installation. LAN server administration, including topics such as user and group administration, file and print sharing, and server security.

3. Network Design

Identification of local, metropolitan and wide area solutions to match business needs. Provides methodology and tools for analyzing needs, capacity planning, identifying solutions, site planning, and designing the network infrastructure. Network setup and testing, troubleshooting methods and diagnostic tools, and network management tools. Typically uses case studies or a field project.

4. Networks and Telecommunications II

This course is similar in breadth to IS 2002.6 Networks and Telecommunications, and included many topics in common with those found in the first Networks and Telecommunications course. Since this course is a follow-on course to the first course, it covered these topics at a more advanced level. Other differences found are greater emphasis on hands-on experience with the installation, configuration, performance tuning, and troubleshooting of a network, internetworking devices, client and server operating systems, as well as more in-depth treatment of specific topics such as TCP/IP, wireless networking or security.

5. Legal & Regulatory Environment of Telecommunications

Overview of laws, regulations, governing bodies and the industry and political environment of telecommunications. Telecommunications contracting and preparing an RFP. Social and ethical issues related to telecommunications.

6. Information Technology and System Software

This course corresponds to IS 2002.4 and provides a basic foundation in the principles and application of computer hardware, networking technologies and system software. Example topics include computer architecture, principals and functions of operating systems, networking hardware media and standards, configuration of hardware and system software, understanding tradeoffs in architecture choices

7. Computer and Network Security

Overview of computer and network security. Securing computers and networks against hacking techniques or known vulnerabilities. Topics include security risk assessment, tools and techniques used by security violators, tools and techniques used to protect against security violator (e.g. cryptography, firewalls, file system security, user authentication, non-repudiation), policies, procedures and training to improve security

8. Applied Operating Systems

This course typically allowed students to learn the fundamentals and how to administer a single operating system, including Windows, UNIX, NetWare, or IBM Mainframe OS. In two cases, the course introduced operating system principles and provided an introduction to Windows, UNIX and NetWare. In two programs (MSOE and Golden Gate University) the Windows or NetWare courses prepared students for vendor certification exams.

9. Internetworking / WANs

Internetworking concepts, internetwork design, security, and administration. Technologies and protocols for internetworking; switches, routers, and gateways. Issues for enterprise networking, wide area networking.

10. Management of Telecommunications

Courses were included in this category only if they emphasized the planning and management of telecommunications and telecommunications services. A few courses were named using terms such as "Network Administration" or "Management of Telecommunications" turned out on closer inspection to primarily cover technical aspects of networking and network administration. These were not counted in this category. Some of the courses included in "Management of Telecommunications" category included technical administration issues (e.g. diagnostic, monitoring and management tools) but included these among a broader set of non-technical management issues.

Biography

Stephen Hawk is an Associate Professor of MIS in the School of Business at Technology at the University of Wisconsin, Parkside. His has conducted research on offshore software development, skill needs in the IT workforce, e-commerce in developing countries, the offshore software development industry in Russia, and networking courses in IT programs. His recent publications have appeared in MIS Quarterly Executive, Electronic Commerce Research, Information Technology for Development, International Journal of Information Technology and Communication Education, and Management Decision. His Ph.D. is from the University of Wisconsin-Madison.