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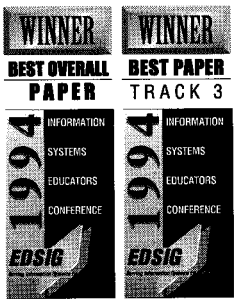
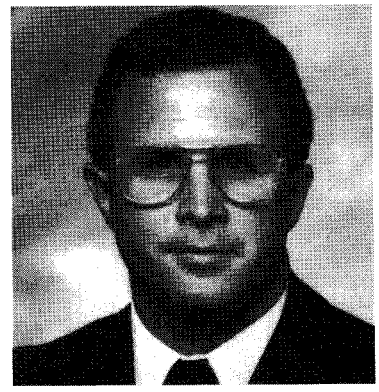


Design and Implementation of a Practical Business Oriented Undergraduate Data Communications Curriculum



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ABSTRACT: The content and orientation of undergraduate computer information systems curricula have historically been designed and implemented in response to the dominant systems architecture of the time and the associated skills required by professionals in support of that systems architecture. As the information systems architecture paradigm has shifted in recent years from a centralized mainframe/terminal focus to a distributed client/server orientation, the role of data communications and networking has shifted from an ancillary electrical engineering oriented specialty to a computer information systems oriented area of study at the very heart of distributed computing.

Changing business trends such as globalization, increased competition, enterprise partnerships and corporate downsizing have brought increased emphasis on the importance of corporate information networks as key contributors to the achievement of overall corporate strategic objectives. This increase in the importance of data communications and networking from both an information systems architecture as well as a business perspective has created a demand for practical business oriented data communications and networking courses within the undergraduate computer information systems curriculum.

Creating such a practical, business oriented undergraduate data communications curriculum presents a variety of challenges in terms of faculty background and experience, course content and orientation, laboratory establishment, and equipment acquisition. The proposed curriculum model describes a practical, business-oriented data communications and networking curriculum to be taught within the context of an undergraduate computer information systems program. Such an area of concentration within the C.I.S. curriculum produces graduates with practical hands-on experience in data communications and networking possessing complementary information systems and business analysis skills.

KEYWORDS: *Data Communications, Computer Information Systems, Curriculum Development, CIS, Networking*

INTRODUCTION

In order to fully understand the importance and relevance of a practical business oriented undergraduate data communications and networking curriculum, it is essential to first establish the current need and motivation for such a curriculum. To do so, it is required to examine both the information systems architecture of the recent past as well as the design of the undergraduate curricula which trained the people to support the infrastructure of these information systems. Only by understanding the relationship between systems architecture, people architecture, and computer information systems curricula, can the need for major innovation in data communications and networking education be fully appreciated.

Having gained an understanding of the skills required of people to support the new model of information systems infrastructure and established the need for innovation in the curricula which will provide these required skills, overall required characteristics and themes of such a curriculum must be established. A review of calls for innovation from a variety of business, industrial, and governmental sources provides both an understanding of required curriculum characteristics as well as an appreciation of the critical nature of the need for change.

The proposed undergraduate data communications and networking curriculum is analytically oriented according to the Top Down Model. Variations of such a model have been used previously in systems analysis and applications development curricula. Perhaps reflective of the strategically tighter integration of networking into the new distributed computing systems architecture, data communications and networking curricula are now more tightly integrated with models and methodologies previously used by other information systems areas of concentration.

Hands-on experience with data communications and networking technology in a problem-solving oriented laboratory is an essential component of the proposed curriculum. A systems-oriented approach with an eye towards business impact and cost/benefit analysis assures that this hands on laboratory experience is transferrable to the wide variety of data communications and networking challenges likely to be faced in the business world.

Finally, practical suggestions based upon the actual implementation of such a curriculum may offer insight to those individuals considering such curriculum innovation or alternative ideas for those who may have already undertaken such a venture.

HISTORICAL PERSPECTIVE

Systems Architecture

By focusing on the source of the processing power of information systems in any particular systems architecture throughout the history of computer information systems, one can identify at least three or four distinct periods or paradigms in the history of computer information systems. Chief among these are the following:

1. Age of the Mainframe
2. Introduction of the Minicomputer
3. Introduction of the Personal Computer and LANs
4. Dawn of Distributed Computing and Client/Server Architectures

Data communications and networking on these earlier paradigms was largely confined to single vendor, single protocol, turnkey networking solutions. Wide Area networking was usually limited to remote dial-up access or leased-line wide area networks, most often still limited to single vendor solutions. The major emphasis in terms of systems productivity in the earlier systems architectures was on optimizing the use of the precious and expensive processing resources. (Goldman, 1992)

People Architecture

As a result, the emphasis on required skills for information systems professionals in these earlier paradigms was on the ability to generate computer programs which would execute as efficiently as possible within the constraints of the hardware limitations of the day. Expertise in data communications or networking was most often left to a few engineering-oriented individuals. Human relations, personal communications skills or a thorough understanding of business processes were also of secondary importance to programming ability and productivity. All control of the programming and operation of the corporate information resources was centralized in the almighty M.I.S. (Management Information Systems) Department.

Educational Architecture

Required undergraduate education for employment in the early systems architectures was very often a B.S. in Computer Science. Emphasis, in general, remained on programming skills rather than on business analysis skills. With the encouragement and support of such organizations as DPMA, undergraduate degree programs in Computer Information Systems were established which began to emphasize business analysis and systems analysis and design skills in addition to the programming skills typically associated with Computer Science degrees. In many cases, a core of business courses and personal communications (verbal & written) were also required in order to complete a C.I.S. degree. (DPMA, 1990) The use of architectures, frameworks, or models for the organization of systems analysis and design methodologies was introduced in such best-selling texts as *Systems Analysis & Design Methods* by Whitten, Bentley and Barlow.

One such model is known as the **Top Down Model**. Although it may go by a variety of names, and may be comprised of a variety of different layers, its overall emphasis remains the same. By starting one's analysis with the people or business issues, one is more assured that the final computer application program and its associated data will meet the requirements of both end-users and management. (Whitten, et.al., 1989)

Data Communications was not considered an integral part of systems analysis and design for early systems architecture paradigms. This fact is borne out both by the lack of emphasis in systems analysis & design texts as well as the fact that the DPMA Curriculum outlines only a single concepts oriented elective course in data communications. This course amounts to data communications lit-

eracy for information systems professionals. (DPMA, 1990) The point here is not to find fault with texts or curriculum guidelines. The important conclusion to this analysis is that the computer information systems curriculum of any given information systems architecture paradigm is a product of the prioritized people skills required to maintain that systems architecture. As paradigms shift, and systems architectures change, it is inevitable that the required people skills and educational programs to provide those skills must change in a complementary fashion.

TODAY'S SYSTEMS ARCHITECTURE AND ITS ASSOCIATED PEOPLE ARCHITECTURE

Distributed Information Systems and Client/Server Architectures

As a result of a number of business factors such as corporate downsizing, enterprise partnerships, and business process re-engineering coupled with technological advances providing increased processing power at decreased prices, the older paradigm of centralized, mainframe-based processing power has shifted towards a more distributed processing paradigm which links multiple, smaller, powerful processors via networks in an arrangement often referred to as client-server computing. (Micossi,1993; Verity, 1992)

Networks are at the heart of the new information systems paradigm. Effective use of networking will allow companies to be more competitive. Networks can allow enterprise partners or multiple departments within an organization to work together efficiently and cost-effectively by improving cross-departmental communication. Industry sources often cite how effective networking actually allows companies to reduce costs through resource sharing and concurrent software licensing. Other firms are using networks to fight for greater shares of shrinking markets by having better access to better information than their competition. Increased efficiencies afforded by networks have improved revenues in declining markets. (Anderson, 1992; Dortch, 1992)

The New People Architecture & Required Skills

At the same time that networks have gained in strategic importance within the overall information systems architecture, networking personnel and management have had to become more business-oriented. Return on Investment justification is often employed as a method of networking technology evaluation. Networking personnel and management are being increasingly held accountable for both operational as well as financial performance as cost or profit centers and are no longer merely considered a part of overhead. (Brown, 1993)

The centralized organization of the M.I.S. Department is in a transitional state as well. Increasingly, client/server savvy experts are acting as consultants on end-user projects. Centralized M.I.S. Departments are shrinking as processing power is being distributed to end-user departments. Centralized infrastructure management is focusing more on the network which links corporate computing resources, rather than on the formerly centralized processing resources themselves. (Brown, 1993) At the heart of so-called client-server skills is an increased knowledge of multi-vendor networking solutions. The path to such solutions is through a new, more rigorous, hands-on orientation to data communications and networking education at the undergraduate level. (Brown, 1992; Eckerson, 1992)

REVIEW OF CALLS FROM INDUSTRY

The apparent shift in people architecture and its associated shift in educational requirements as a result of the shift to a distributed computing systems architecture is reinforced by numerous calls from industry and government sources for swift and significant change to undergraduate computer information systems education. These calls for change emphasize not only increased instruction in the concepts and technical aspects of data communications but also a fundamental shift in emphasis to a more practical, business-oriented, information systems approach to data communications.

A key concern of industry in today's highly competitive business climate is the expense which must be borne by corporations to provide hand-on, practical training in network analysis, design, implementation, and management for recent college graduates possessing only conceptual or theoretical understanding of data communications and networking. Of equal or greater importance than the hands-on experience itself is the manner in which this experience is provided. Given the rapid rate at which data communications and networking technology changes, it is essential that laboratory experiences be structured in an atmosphere promoting problem solving, creative thinking, flexibility, and a sound business perspective. (Welch, 1991; Carlini, 1992)

This call for hands-on, practical education in data communications and networking has been echoed by government agencies such as the National Science Foundation as well. Among the significant findings of the 1992 report *Research Priorities in Networking and Communications* were the following:

- The fields of networking and communications are developing rapidly and their importance is increasing.
- Funding levels are still well short of the needs of the field relative to its national importance.
- There exists an urgent need for educational programs to produce

students with a background in both hands-on experience and systems integration. (NSF, 1992)

In order to accomplish this redesign of data communications and networking curricula, colleges and universities must form partnerships with key networking industry leaders in order to fully understand the curricular changes necessary. The Bellcore Forum on Information Networking Education held in March 1992 brought together representatives from the telecommunications industry and higher education. Among the industry perspectives of the competencies which the properly educated networking professional must be able to exhibit were the following:

- Creation of proposals for information networking applications
- Development of technical strategic directions
- Interaction with end users of sophisticated information technologies
- Planning and design of evolving communications networks
- Research and creation of future information services (Bellcore, 1992)

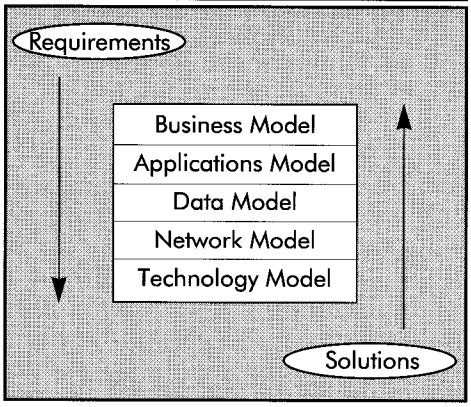
In other words, colleges and universities must produce graduates who have done networking in a practical, business-oriented environment and not merely studied networking in a conceptual setting.

PROPOSED DATA COMMUNICATIONS & NETWORKING CURRICULUM MODEL

Business Orientation

By adopting the Top Down Model for network analysis and design, data communications and networking curricula can not only inject a business orientation to courses but can also more tightly integrate networking courses with other computer information systems courses. This tighter course integration is reflective of the tighter integration of networking with data management and application development required by the deployment of emerging client/server information systems.

Figure 1. TOP DOWN DESIGN APPROACH
BUSINESS DATA COMMUNICATIONS ANALYSIS



The Top Down Model

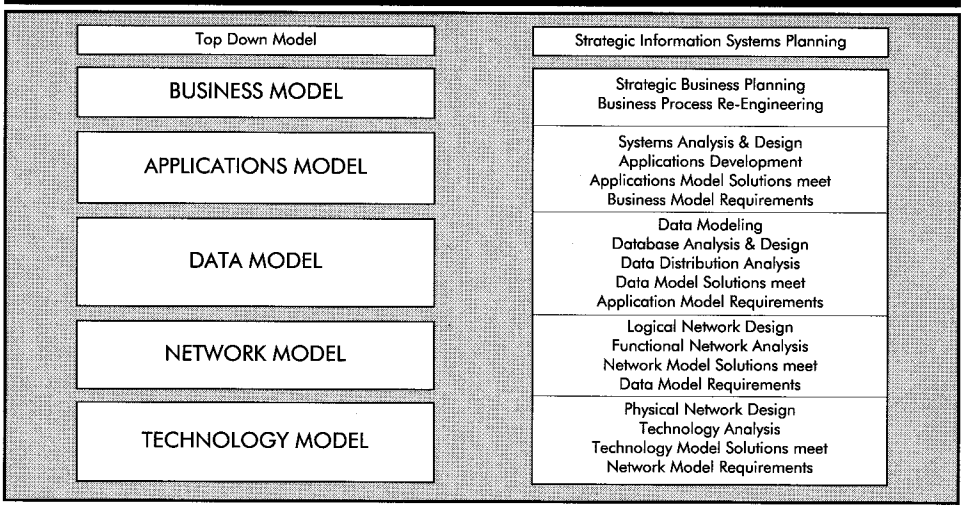
Figure 1 illustrates key features of the Top Down Model as it applies to data communications and networking while Figure 2 illustrates how the Top Down Model integrates data communications and networking skills and coursework within the context of an overall information systems architecture

The Top Down Model as illustrated in Figure 1 illustrates a frame of reference to data communications analysis and design. It implies an understanding of the fact that networks are designed and implemented to meet clearly defined business objectives by supporting the applications and data which, in turn, support the critical business processes of a corporation. This frame of reference or attitude transcends an entire data communications and networking curriculum. It is not taught in a vacuum in a particular course and then forgotten.

It is embodied by a key network evaluation question: "Does the network make good business sense?" This same question is asked whether the network in question is a LAN, WAN, or Internetwork, regardless of the course or laboratory in which a student may be enrolled. A business-orientation must be a curriculum wide attitude, not merely a chapter in a text. Without a thorough understanding of all elements of the Top Down Model which led to the eventual implementation of a networking solution, one cannot effectively answer this critical question.

Figure 2 illustrates how the logical and physical network design located on the network and technology model layers, respectively, are related to, and dependent upon, other business and information systems analysis processes. This model helps students, and curriculum designers, understand

Figure 2. NETWORK ANALYSIS & DESIGN - AN INTEGRATED TOP-DOWN APPROACH

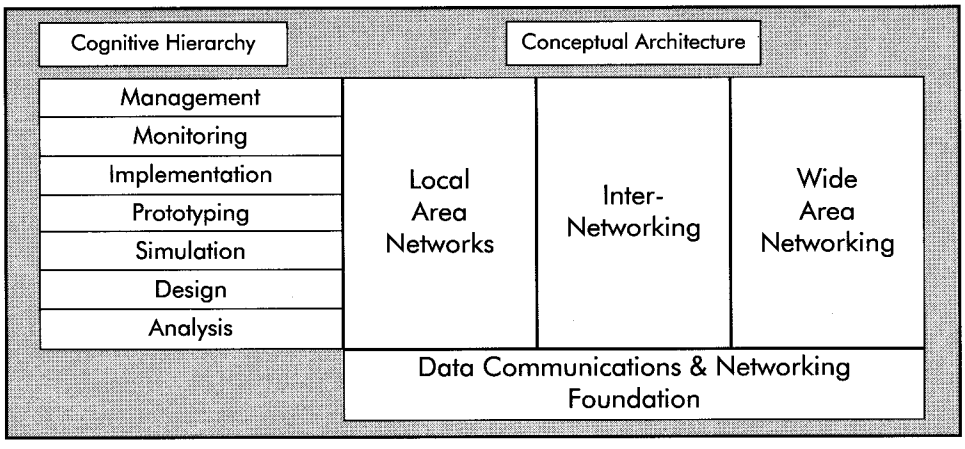


"the big picture" by illustrating how data communications and network courses must complement other course offerings in a computer information systems curriculum.

more detailed conceptual architectures should be used as desired.

The key outcome which this Curriculum Development Framework delivers is the combination or inter-

Figure 3. DATA COMMUNICATIONS & NETWORKING CURRICULUM DEVELOPMENT FRAMEWORK



A Curriculum Design Framework

Figure 3 represents a curriculum design framework incorporating both the conceptual spectrum of data communications technology and knowledge as well as the cognitive hierarchy or level of understanding/mastery associated with the stages of the Network Development Life Cycle. (Goldman, 1994)

Figure 3 can be used as a matrix in which to organize possible course offerings. As can be seen, a particular conceptual or technological area of study (LANs, Internetworking, WANs) can be taught at a variety of different cognitive levels. How many courses it takes to cover the entire cognitive hierarchy for all conceptual topics is up to the discretion of individual curriculum designers. Some course offerings may only be appropriate for advanced or graduate study. All coursework above the Data Communications and Networking Foundation implies the inclusion of a hands-on or laboratory component in order to delivery real-world experience in the particular cognitive hierarchy skill to be achieved. Additional or

section of the **practical** skills outlined in the cognitive hierarchy and the conceptual material outlined in the conceptual architecture. Data Communications concepts are no longer taught in a vacuum but in the context of using this knowledge in a practical application of some phase or phases of the Network Development Life Cycle.

AN EXAMPLE OF A DATA COMMUNICATIONS & NETWORKING CURRICULUM

Figure 4 illustrates how the Curriculum Development Framework can be used to map current and/or proposed course offerings. The courses listed are either being currently taught or are under development in the Department of Computer Information Systems & Technology at Purdue University in West Lafayette, IN where the author serves as Data Communications & Networking Course Sequence Coordinator.

Curriculum Details

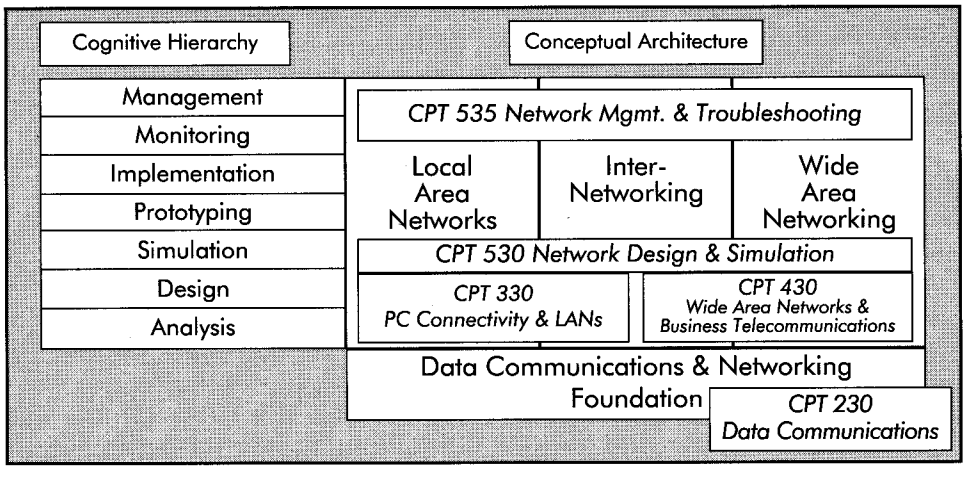
CPT 230 Data Communications

Lecture only. Introduction to a wide variety of topics in the voice and data communications field. Vocabulary, hardware, concepts, issues, trends, and decision making as well as the link between business needs and the data communications field are stressed. Proper application of business data communications technology is a primary theme of the course.

CPT 330 PC Connectivity & Local Area Networks

2 hr. Lecture, 2 hr. Lab. Exploration of PC Connectivity alternatives and the decision making process for designing cost-effective local area networking solutions for a given application. Emphasis is on the use of these local area networking solutions in client/server architectures. Alternatives to media sharing LANs are also explored.

Figure 4. DATA COMMUNICATIONS & NETWORKING CURRICULUM DEVELOPMENT FRAMEWORK



CPT 430 Wide Area Networks & Business Telecommunications

2 hr. Lecture, 2 Hr. Lab. Alternatives available for connecting LANs as well as providing remote access to/from users not connected to LANs. Emphasis is on the effect of telecommunications systems and networking decisions on business performance. Integration of internetworks and micro to mainframe connectivity into client/server and client/host architectures is emphasized.

CPT 530 Network Design & Simulation

Lab-based course. Advanced topics in network design, optimization, and simulation using software tools. Two current software tools are Synergis Neustar from Network Design Technologies and ComnetIII from CACI Products.

CPT 535 Network Management & Troubleshooting

Currently under development. Lab-based course emphasizing hands on skills with network management and troubleshooting technology such as protocol analyzers and multivendor enterprise network management systems.

CONCLUSION

As the systems architectures of computer information systems have changed throughout the history of the industry, the skills which industry professionals must possess have evolved as well. In turn, the computer information systems curricula which train (and re-train) information systems professionals must evolve. The emergence of information networks as a strategic corporate resource to be leveraged to competitive advantage has elevated the need for inclusion of practical, business-oriented data communications and networking courses within the computer information systems curricula of colleges and universities. Through the use of key models such as the Top Down Model and Curriculum Development Framework, educators can develop these important courses in a structured manner.

AUTHOR'S BIOGRAPHY

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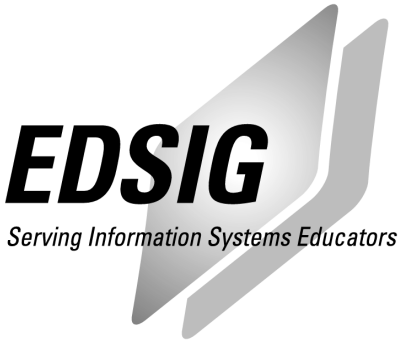

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