An Integrated Educational Program in Information Networking Technologies – A Match for the Next Millennium

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Abstract

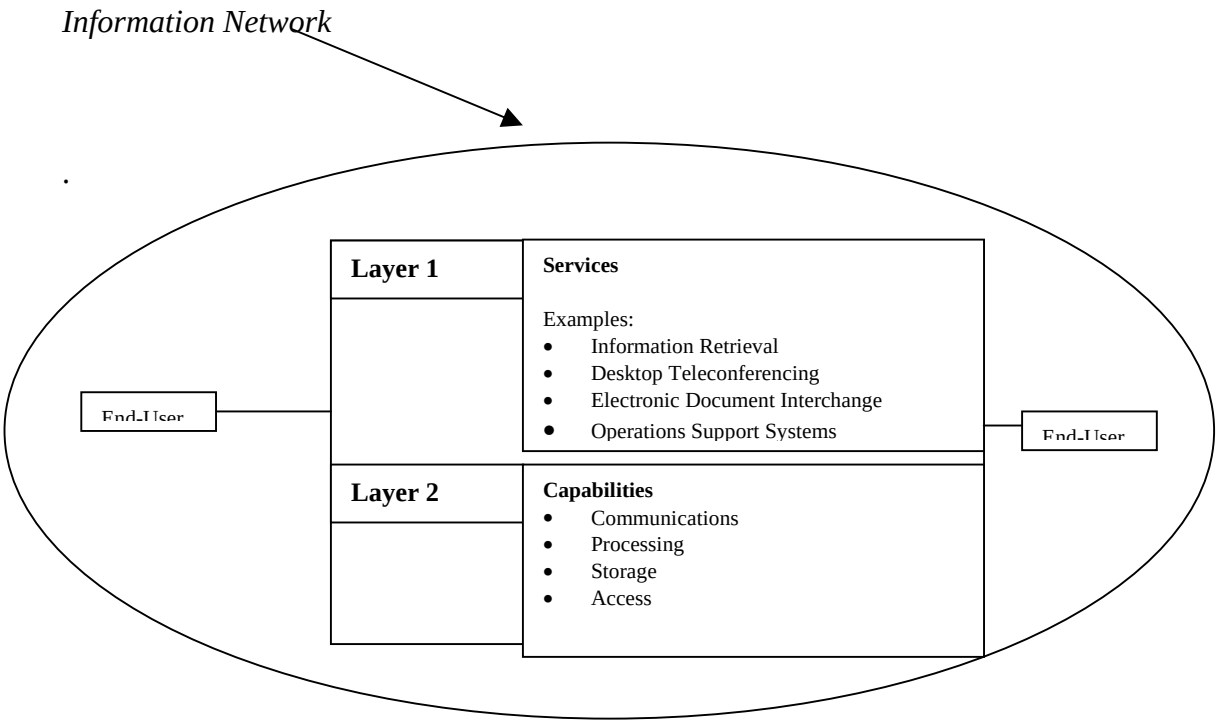
There is a vision being explored and brought to fruition by an unprecedented partnership of government, industry, and a wide range of institutions. It is a vision of a widely available and affordable access to lifelong educational opportunities, of improved and more cost effective health care, of essentially universal access to the best libraries and other sources of information, and of increasing productivity and competitiveness. The vision is of a national information infrastructure based on the powerful communications and computational capabilities that have emerged over the last several years. Models for information infrastructure already exist, although none have achieved the scale of the new one envisioned. The Internet, the universal telephone network and the vast bed of compatible videocassette recorders installed in America homes and businesses are examples of models for information infrastructure.

Information networking technology is a synergistic and rapidly growing field that is uniquely matched to the challenges of the evolving information era. This new discipline integrates the fields of computer science, telecommunications, policy, business management and psychology for the design of usable and even fun-to-use user interfaces.

Networking and information technology trends point to an increasingly strong coupling of here-to-fore separate disciplines. This paper will bring together a proposal for a new interdisciplinary program in information networking technologies that are well matched to the needs of the information era in the next millennium. The program architecture could be customized for a range of higher educational programs, spanning the Associate's degree to a graduate level Ph.D. program.

1.0 Introduction

For the purposes of this document, we define an information network as being comprised of two distinct layers, as shown in the following diagram.



The higher layer is an entity that offers services to users. These are based on underlying capabilities in the second layer to communicate, process, store, and access information. Examples of information networks include:

- a personal computer running spreadsheet software for a single user.
- the hardware and software in a local exchange that interconnects data terminals and computing resources within a single building or campus like complex
- a large geographically distributed communication network of a corporation covering entire countries or, possibly, spanning the globe.

2.0 **Program Description**

The proposed program is made up of the following modules, some of which may be taught in parallel. In each module, there will be a mix of lectures, laboratory exercises, demonstrations, and case studies. Several business case studies will be included, which will expose students to the needs of actual businesses, as well as the potential for innovative solutions.

A) Overview of End User Systems
B) INT Principles
C) Technologies Shaping The Future
D) Advanced Technologies Services and Applications
E) Standards Affecting Information Networks
F) Information Networking for Leading Edge Companies

Section A-Overview of End User Systems

1.0 Applications of Information Technology

The primary objective of this first module is to develop the student's ability to assess the current use and flow of information within a business. This understanding is essential for evaluating both the implications of new technologies and the synthesis of new end-user applications.

The strong dependencies between the use of information and the organizational structure in a modern business will be analyzed and assessed from a number of different perspectives. First the dynamics and interrelationships of information flows within the organization will be studied through review and analysis of large and medium sized businesses. Subsequently, the inter-play between technology-based information networks and informal or "soft" communications networks (person-to-person exchanges of ideas and information) will be studied for several leading-edge companies, which depend on various forms of information networking to compete effectively on a national and/or international scale.

Illustrative examples will be used to demonstrate that there are no universal solutions to information networking problems. Information networks need to be matched to the way an organization make decisions, the firm's success factors, its daily operations, strategic directions, and the way the business differentiates itself from its competitors in the world market place.

Applications of information technology by leading-edge businesses will be assessed by considering issues such as-.

- The domain of information networking (internal Vs external) critical to the organization.
- The current information needs of the organization and how are they are met by the institute information systems.
- The components of the overall information system (i.e., personal computers, voice systems, combinations of mainframe and minicomputers, etc.).

- How this company could use its available information to gain a strategic advantage in the market place.

Section B-Review of Information Networking Principles

2.0 Information Systems Principles

Information Networking and information networks will be introduced, and the architecture and performance characteristics of the principle information network building blocks will be reviewed.

The module begins with a review of the "atomics" or building blocks of information networks, and how these building blocks can be organized to synthesize literally thousands of different kinds of information networks that enhance the ability of end users to communicate with each other. Information network atomics include Personal Computers (PC's), mainframe processors, storage media, transmission links, switch fabrics, and 1/0 devices. The partitioning, allocation and interconnection of these building blocks will be studied from the perspective of how they can be arranged and rearranged to form fundamentally different information networks architectures.

Layered system architectures will also be examined. The impact and dependencies of system architectures on the use of multi-vendor software and hardware elements will be analyzed from the perspective of how these types of heterogeneous elements can be integrated into an information network.

Examples will be used to illustrate how competing technologies can lead to a variety of information network architectures. The organization of mainframe computing environments with various mixes of smart and dumb terminals will be compared with local communication networks and personal communication environments built around high performance 16 and 32 bit processor-based computers. Synchronous and asynchronous communication environments, administrative tools, text processing, database systems and information retrieval systems will be analyzed to show how various mixes of information requirements can affect the choice and interconnection of basic information network elements.

Performance metrics of information networks, including throughput efficiency, response time, latency, and congestion, will be introduced. The performance implications of components such as software resources, memory elements and memory access techniques, system protocols, circuit and packet-based multi-stage switch fabrics, transmission media, and multiplexing strategies will be discussed within the context of overall end-to-end performance as seen by the end user.

3.0 Industry Structure and Regulation

This module explores the structure of the information and telecommunications industry. In this module we will cover elements of public policy in the current environment of deregulation within the telecommunications industry, especially as it affects and is affected by information networks. Although dynamic and changing, these "rules" of the telecommunications industry play a central role in the development of viable business/technical solutions for end-user

communications services. This module will also examine the increasing concerns for individual privacy that are influencing the design and implementation of modern open telecommunications network architectures.

3.1 Industry Players

The impact of the current information policy environment will be studied from the perspectives of lccal exchange carriers, interexchange carriers, other common carriers, resale carriers, enhanced service providers, information providers, communication network equipment manufacturers, customer premises equipment (CPE) manufacturers, CATV operators and others. Case studies will be used to demonstrate the mutual role these entities can play and the potential couplings and cross-industry implications of the current information policy environment.

3.2 Policy Issues and Decisions

The formulation of public policy at the Congressional level through legislation and oversight of the FCC has set the parameters and boundary conditions for the provision of information services. This sub-module will review the major telecommunications policy issues faced by the nations telecommunications industry. It will begin with a review of key historical decisions including: challenges to the natural monopoly theory, introduction of toll competition, Computer Inquiry 11 and the deregulation of CPE, AT&T divestiture and the MFJ, MFJ restrictions on LEC's, access pricing and universal service issues. Current policy issues including, the "price cap" proposal, Computer Inquiry 111, Open Network Architecture and CATV/BCC competition will be reviewed, and the impact of alternative scenarios on each industry segment will be discussed.

4.0 Telecommunications Principles

This module will cover principles of telecommunications in terms of layered architectures, topologies, traffic types and characteristics. This approach will make it possible to dissect the many interlocking functions of a communication network, independently evaluate them one at a time, and assess the relative software and hardware impacts of each layer.

4.1 Traffic Types and Characteristics

This sub-module begins with a discussion of the characteristics of voice, data, video, and telemetry signals. Students will be introduced to the underlying statistics of the media signals, as they relate to bandwidth requirements, inherent burst characteristics, traffic symmetries, relative sensitivity to delay distortion, implications of signal compression and redundancy. The subjective performance of each of these media signals in the presence of random and burst errors will be discussed.

4.2 Medium Access

Here we discuss how different users with various mixes of media signals can share alternative transmission media. Access techniques including ALOHA, space and time division switching, hybrid space-time division switch fabrics, virtual circuit packet switching, CSMA/CD techniques, bus/ring token passing strategies will be reviewed. Critical comparisons will be made of these medium-access techniques for single bit-rate versus multi-rate and inherently bursty media signals. These comparisons will include choices of contention schemes, throughput as a function of available channel traffic, connection control, gate way routing strategies, etc.

4.3 Topology

Communication networks may be circuit switched or packet switched. However, at a high level, communication networks have the same general appearance - they consist of nodal switches interconnected by a transmission facility.

This sub-module will cover the topologies of interconnected communication networks associated with public traffic, interconnections of multiple private communication networks, and interconnections of public and private communication networks. The performance and cost implications of the following topologies will be investigated: tree, star, double star, bus and ring.

Examples will include conventional subscriber loop architectures and the use of rings in fiber-based subscriber loop feeders. Discussions will include cost and performance tradeoffs and the relative compatibilities of alternative switching, multiplexing and transmission techniques. For example, tradeoffs between centralized switching versus remote multiplexing and/or switching and issues of passive versus active remote electronics in fiber loops will be investigated.

4.4 Main questions addressed in this sub-module are the conditions under which one would use packet switching and the conditions under which one would use circuit switching. This sub-module will cover circuit and packet switching. Comparisons of circuit and packet switching will be made and the basic principles of queuing will be applied to traffic structures of different media signals (i.e., voice, video data.)

4.5 Protocols

This sub-module will deal with the general principles of layering associated with the Open System Interconnection (OSI) architecture. Topics will include:

- General Principle of Layering
- Standard Layering models

- Overview of the Seven Layers of the OSI model
- Identifiers
- Establishment and Release
- Data Transfer

Examples will be drawn from Dec Net, SNA, Signaling system 7, ISDN Q.931, X.25, X.400 and other standard protocols. The implications of packet size, addressing, routing, flow control, internal multiplexing of flows and error recovery, will also be reviewed in moderate depth.

This sub-module will also introduce the problem of interconnecting disparate communication networks with differing internal protocols, differing bit rates and packet handling capabilities, and different internal architectural constructs.

4.6 Local Area Networks (LAN's)

This sub-module will deal with concepts, architectures and strategies for high-speed local area communication networks. Examples of existing LAN's will be reviewed from an end-user's perspective and the salient characteristics of emerging LAN architectures will be studied. Case studies of LAN applications and interworking issues will be drawn from university settings, office environments, and commercial banks and hospitals. Topics will include:

Broadband and baseband LAN's
Fiber optic LAN systems
Dynamic reconfiguration of LAN's
Programming languages for LAN's
Switching and statistical multiplexing
Interconnection of communication networks
LAN interconnects to geographically distributed wide-area communication networks.
Names, addresses, routes
Bridges Vs routers Vs transport relays
Interworking

4.7 Alternative Network Architectures

Communication network solutions for singular and mixed traffic types will be explored from an integrated systems perspective. Also, the system implications of common communication network architectures versus overlay communication networks will be explored in the context of solutions at the transmission level versus solutions at the switching level and the relative performance implications and overall system tradeoffs will be analyzed. Finally, hybrid

local/public communication networks and CO-based LAN's will be compared from the perspective of meeting the end-user's information networking service and performance needs.

5.0 End User Communication Networks

Using the facilities offered by public carriers, it is possible for enhanced service providers and end clients to build their own "private" communication networks. The requirements of these communication networks will be compared to the requirements of public communication networks. Typical institutional and private communication networks will be described and alternative architectures for CO-based corporate communication networks will be compared from an end client's perspective.

6.0 Operations Management

In an increasingly demanding and complex world, the services of the operations management systems that are used to control and manage a telecommunications network are nearly as important as the services of that network itself. Historically the communications carrier has focused on the management of the telecommunications network between the network terminating blocks at each end. The end user, however, is concerned with managing an information network which may be comprised of heterogeneous communication networks—both public and private and interconnected by gateways—value added communication networks, and the computer and software systems on the end user's premises which use the underlying transport. Networks.

In this module, we examine management and control functions. The management of today's communication networks will be studied within the context of both end user information networks, and carrier telecommunications networks. This module will cover basic elements (i.e., fault management, configuration management, performance management, security and service management) and the requirements posed by large information networks in the business environment. Study material will also include-. integrated management of heterogeneous communication networks, elements of distribution and redundancy for communication network reliability, the management of complexity as a function of the range of user services, security and access strategies, operational requirements (i.e., integrity and operational reports, communication network activity, reconfiguration and software attributes, etc.). Management systems for LAN's, WAN's, MAN's and ISDN-based communication networks will be discussed. The implications of system management associated with LAN's, WAN's, MAN's and ISDN based communication networks will be drawn from existing examples in practice. End user strategic opportunities of information network management will also be studied.

6.1 Telephone Operations Support Systems (OSS)

This sub-module provides a brief review of the current state of the art in telephone company operations support systems, as well as proposed standardized architectures for the future. Topics will include OSS concepts, protocols and standards, operations support communications architecture, and OSS software systems. In particular the implications of on the evolution of future OSS architectures will be discussed in some detail.

Module C-Technologies Shaping the Future

The following modules (7 through 22) will cover in moderate depth the underpinnings of software, distributed computing, optical transmission, high-speed switching, storage technologies, VLSI and emerging work station technologies that are providing the technology push and driving the evolution of tomorrow's information networks. The analysis of trends in both cost and performance will be stressed to provide a better understanding of how new technologies are influencing the evolution of tomorrow's information networks.

7.0 Trends in VLSI

The packing density and speed of devices on VLSI chips has experienced an exponential growth in recent years. This in turn is affecting the functionality of virtually every information network component, from high function workstations, to transmission and switching fabrics. This new functionality is already impacting traditional software architectures. Moreover, new optical/electronic devices are emerging which could have a fundamental impact on the way information networks are synthesized in the future.

This module will also review ways to employ LSI including custom LSI, catalog LSI and Programmable LSI. The relative trade-offs of cost, performance and functionality of each of these approaches will be reviewed.

Illustrations of how changes in VLSI are affecting information systems will be drawn from, e.g., multi-media workstations, smart cards, etc.

8.0 Storage Technologies

The key parameters of storage devices (i.e., access time, volatility, dynamic or static memory capabilities, controllability, media dependencies, etc.) will be reviewed. The implications on existing and new services, including voice, data, and video, will be discussed.

Storage technologies to be covered include optical storage (e.g., CD-ROM), erasable optical storage, magneto-optic storage, vertical magnetic recording, and silicon memory (64 MB RAM).

9.0 Computer Architecture

This module will examine generalized computer architectures as hardware structures driven by software programs. It will begin with basic concepts and then discuss alternatives to traditional computer architectures.

9.1 Basic Concepts

This segment will include an overview of the functional subsystems of a computer, including CPU and control unit, memory elements, and 1/0. CPU instruction sets will be discussed in a "layered context" in terms of functional groups, including: data transfer, branching, stack and machine control, and arithmetic functions. Discussion of memory will include caching, segmentation, direct access, and paging. In the areas of buses and program controlled 1/0, several topics will be covered: isolated 1/0, memory mapped 1/0, program controlled parallel transfer of information, synchronous and asynchronous transfer of information, and standards for 1/0 control. These topics are likely candidates for lab/modeling exercises using Processor/Memory/Switch (PMS) analysis.

9.2 Alternative Computer Architectures

Parallel and distributed computer architectures will be compared with traditional, single-thread, centralized architectures in terms of their key differences at the system and architectural level. Performance benchmarks for each of these alternatives will be reviewed. The nature and implications of massively parallel systems and evolving RISC architectures will also be presented.

Loosely and tightly coupled systems will be compared from the standpoint of serial transfer and/or bus operating speeds, interface issues, local and remote memory management, etc.

Specialized processors, including microprocessors and digital signal processors (DSP's) will be described in terms of why and how these subsystems are used in modern telecommunications networks.

9.3 Application Implications

The relationship between computer architecture and the applications it can support will be discussed. A topic of special concern is that of the interface between a computer and a communication network, such as an ISDN or LAN based system.

1 0.0 Computers—small, medium and large

Today there is a vast spectrum of microcomputers, minicomputers, and large centralized computers. This module will discuss some of the underlying architectural and performance differences of small, m6dium, and large computing complexes.

The evolution of computer applications and functionality in a world with powerful chips will be traced and projected.

11.0 Operating Systems

We assume that incoming students have knowledge of at least one programming language. We assume, however, they do not have any systematic background in operating system concepts.

The first part of this module will be devoted to a motivation for operating systems based on the needs of the applications that a computer system must be able to support. The module then covers operating system basics and presents issues surrounding distributed operating systems. The module ends with a review of important commercially supported operating systems.

1 1.1 Motivation for Operating Systems

A computer system must be able to support a variety of applications. At an elementary level this includes support for software development, including compilers, assemblers, and test systems. At a slightly higher level, they must also be able to support word processing and document preparation. More complex applications involving large databases (megabytes of data), including administrative programs for telephone company trunks and lines, and traffic measurement and record keeping will be discussed.

It will be shown that, without operating system software, the computer architectures discussed in the previous sub-module will provide very poor support for these applications, and that one or more layers of operating system software can significantly improve the effectiveness of application development on computer systems.

11.2 Basic Operating Systems

This sub-module will begin with a review of the basic concepts of a software operating system including the fundamental ideas of a process and of computer resource management. This will be followed by a more in-depth discussion of process management, memory management, device management, file management, attributes of kernels and device drivers, concurrency, scheduling, security, and communication paradigms.

The effect of operating system design alternatives in each of these areas will be examined in terms of application program portability, system use by non-programmers in an office environment, real-time capabilities (e.g., process context switching, and system calls), etc.

The more specialized topics of database management systems and user interfaces, both

closely related to operating system design, are each treated later in separate modules.

1 1 .3 Distributed Operating Systems

The motivation for distributed operating systems will be presented, including the relationship between a telecommunications network and a distributed system. Then fundamental distributed system design and implementation strategies will be reviewed, including client-server models, remote procedure calls (RPC), and programming across heterogeneous systems. File system and security issues particular to a distributed implementation will be discussed.

11.4 Commercial Operating Systems

We will consider trends in commercial operating systems and attempt to help the student understand the significant differences among commercially important operating systems and the market trends for these systems. Systems reviewed will include DOS, OS/2, UNIX and their variants, and alternative implementations such as POSIX, the efforts of the Open Software Foundation (OSF), and Unix International.

12.0 Database Management Systems

The fundamental concepts of database management systems will be treated in this module. Topics to be treated include the entity-relationship model, front-end/back-end models, fourth generation languages, atomic transactions, data security, distributed databases, and relationships between database systems and file systems, both traditional and distributed.

13.0 User Interfaces

User interface design is increasingly critical to the success of information networks. In this module we begin with the conceptual bases in cognitive psychology for evaluating user interfaces and proceed to consider popular user interface paradigms and their implementations.

13.1 Conceptual Basis for User Interface Design

In this sub-module we will present the conceptual basis for user interface design that has emerged over the past decades based on principles of cognitive psychology and extensive practical experience.

13.2 User Interface Paradigms

Paradigm examples will include WIMP (windows, icons, mouse, pointing), Hypermedia, and natural language interfaces. Examples of new high function and multi-media workstations will be demonstrated.

13.2 User Interface Implementation

Window managers are a major extension to traditional operating system interfaces, which were stream-oriented or record-oriented. In this sub-module we review the concept of window managers and compare such popular window manager paradigms as Presentation Manager, X-Windows, and Motif.

Lower level implementation topics will focus on 1/0 for workstations, image capture, pointing devices, smart cards, and alternative media such as audio 1/0. Hardware requirements for Postscript, image windowing, and hands-free voice interfaces will also be reviewed.

14.0 Other Software Issues

This module will consist of a number of short presentations on a range of subjects. Topics will be covered at a relatively high level, with the focus on recent trends and implications for practice.

14.1 Programming Languages

This sub-module will focuses on the latest thinking about programming languages and program specification. It will begin with a review of some fundamental concepts in programming languages: expressions, statements, procedures, declarations, compiling, and interpreting. It will then introduce and assess procedural, functional, and object oriented languages. Issues in selecting a particular language for a particular application will also be discussed.

14.2 Software Engineering

This sub-module deals with issues in the design and construction of large software systems and the latest ideas about specification, design and testing, and tools for software construction.

14.3 AI & Expert Systems

Although still an area whose results are still largely in the domain of research, some results of artificial intelligence (AI) are contributing to effective use of computer systems in industry. This is particularly the case in the development and application of expert systems. This sub-module

will review the current status of AI applications and suggest where the next practical applications can be expected.

14.4 Software Portability

End-users are increasingly demanding standardized “environments’ for application construction that increase the potential for software portability across multiple hardware and operating system platforms. This sub-module will review trends toward emerging standards in operating systems, programming languages, windowing environments, database interfaces, and user interfaces. IBM’s SAA, OSF’s Motif, Microsoft Presentation Manager, etc.

15.0 Light Wave Systems

A major focus in this module is on the characteristics of fiber optics systems and the implications for communication network design. Use of fiber in the local loop and in new communication network architectures will be discussed in the context of emerging fiber technologies. This module will include a discussion of the many choices of light wave systems including the type of light source, fiber and detector, as well as the operating conditions. Examples of existing light wave systems will be discussed from the perspective of power budget, rise-time requirements, link budgets, etc.

15.1 Media Access

Conventional single channel approaches based on star, ring and bus topologies will be discussed along with parallel channel approaches, which achieve very high capacity through wavelength, time, and space division multiplexing techniques. The design of very high capacity communication networks with practical optoelectronic devices will be illustrated through examples of existing systems.

16.0 Portable Access Systems

This module discusses systems that provide portable access to information networks, both radio-based systems and free-space optical transmission systems. It will begin by describing the fundamentally different impairment and performance issues associated with these systems. This will be followed by a systems review of packet radio, and the IBM/Motorolla packet radio system will be reviewed in the context of a case study. Furthermore, the system architecture and performance of analog and digital cellular systems will be compared. Implications of public and regulatory policy on system design will be stressed- regulatory policy advantages of mobile satellite service, spread spectrum, and low-power portable systems will also be discussed. Most of the material in this module will be given by outside lectures.

Signal Processing 17.0

This module will provide an introduction to the fundamentals of processing signals by digital techniques and their applications to practical problems. A discussion of practical applications will include: bandwidth/data compression and speech and video compression. The qualitative aspects of various inter-frame and intra-frame coding algorithms for transmitting compressed video will be discussed in some detail.

18.0 Multiplexing and Switching

This module will deal with the interleaving of several media signals and/or several traffic streams as they flow through one path. The module will begin with a review of the North American Tl standard frame format and its relationship to various high and lower multiplexing formats will be shown. New trends which allow multi-media transmission (e.g., extended quality voice and data) will be reviewed in the context of an ISDN environment. This module will also discuss the formats and architectural implications of SONET and will treat specialized circuit switched network architectures built around Digital Access Cross Connects.

19.0 PSDN (public and private) networks. New topics in connection oriented (virtual circuit) switching systems; connectionless modes of operation (data-gram), integrated circuit and packet switching fabrics will be covered.

20.0 Signaling and Control

This module will build on students' knowledge of signaling and control in the public switched telephone network. It will describe how these functions are handled in ISDN and in the equal access environment. The ways advanced signaling and control techniques make possible advanced services like Custom Calling I and 11, Private Virtual Network, and Advanced Intelligent Network will be explained.

21.0 Communication Network Architectures

This module will focus on topologies, performance, flexibility and cost tradeoffs of various communications network architectures. Studies of metropolitan area networks, WAN/LAN interconnection, and issues regarding interconnections to public communication networks will be reviewed in detail. Examples of existing LAN/WAN service applications will be drawn from current practice. The operation of enhanced service provides in an **ONA** environment will be described.

Section D-Advanced Telecommunications Services and Applications

21.1 Advanced Services

Examples of advanced services will be used to illustrate how the technical subsystems, which have been previously described, come together in information networks to deliver these new services. Examples will be drawn from both *communications and distribution* services. Communications services include dialog services such as real-time interpersonal communications, messaging services, and retrieval services.

Distribution services are mainly comprised of broadcasting services such as CATV, with subcategories including multi-casting, narrowcasting and interactive user access. Advanced services topics will include. -

Video Entertainment Services - The delivery of individually selected video material including a movie, ordered by a subscriber, and delivered by a service provider over a public switched network.

Information search and delivery services - The accessing of large blocks of information in various media, from distributed databases, and delivered through broadband communications networks.

Electronic Document Interchange Services - The conversion of many business forms and documents to their electronic counter parts with capabilities for “digital signatures”, encryption and time stamps to provide authentication and safeguard proprietary business information and individual privacy.

Personalized Desktop Teleconferencing - The ability to use multimedia and real-time communication services using a high-function desktop terminal. This service would provide interactive communications in a variety of media including, extended quality voice, video, graphics and data. This service capability could enable knowledge workers to collaborate at a distance and interactively share information in a variety of media and add value to a communications session in real time.

Additional end-user services, which may be studied in this module, include electronic publication services, transaction services for retail businesses, and high-resolution image networking for hospital service applications.

Section E-Standards Affecting Information Networks

23.0 Standards

The dissemination of any new technology is strongly affected by the availability of standards that permit its propagation and interworking with existing technologies. This module will discuss

some of the key standards impacting information networking. Also, this module will cover the standards making process and some specific standards developments from a commercial perspective.

The standard's bodies - CCITT, ISO, ISO/IEC, JTC1, ANSI, ECSA, and IEEE - as well as the relationship between standards and product competition will be covered.

Section F-information Networking for Leading Edge Corporations

24.0 End User Information Network Planning

In this module we describe three information network-planning models for end users of information technology. The first model is requirement-driven, the second is technology- or infra-structure-driven, and the third is strategy-driven.

24.1 Requirement-Driven Planning

Here we introduce a planning model for use in planning end user information networks. The model, which is requirement-driven, starts with an examination of a user's business requirements and proceeds to the development of an information network solution and a plan for the implementation of the information network. The first task in the development of the plan is to inventory, or document, the user's existing network. This documentation includes hardware, services, and costs. Next, the user's present and future (e.g., five year planning horizon) communication requirements must be determined. These will be expressed quantitatively to the extent possible. Future business applications will be given major consideration. Then several information network alternatives will be proposed and compared with respect to both cost and performance (i.e., ability to meet requirements).

The selected alternative is then "fleshed out" with more detail to become a functional design. Finally, a plan is developed for the implementation of the selected alternative. The plan includes task plans, timeliness, and budgets. This model will be illustrated with a case study: e.g., that of a large manufacturing company.

24.2 Technology/infrastructure-Driven Planning

Here we study the idea of introducing a technology into an environment without a specific understanding of all of the ways in which the technology can be used. We will first consider situations in which this approach may be appropriate, e.g., an educational/research environment. Then modifications are introduced to the requirement-driven planning model to accommodate a

technology-driven situation. This model will also be illustrated with a case study: e.g., the Andrew system at CMU, Manufacturer's Hanover system, the Sabre system.

24.3 Strategy-Driven Planning

The approach here is to develop a strategic plan, i.e. goals, objectives and strategies. The planning model is reviewed in the light of critical success factors of the business and involves participation by corporate management.

24.4 Mini-projects Students will work on small-scale information network planning projects, using the principles covered in the previous sub-modules.

25.0 Strategic Uses Of Information Technology

Here we look in moderate depth at past and potential future scenarios of strategic use of Information technology. Each application is analyzed from the following perspectives:

- strategic planning by end user's
- network performance requirements implications
- technology requirements
- standards issues
- application software issues
- organizational issues
- public policy issues

25.3 Scenario 3: American Express's use of image processing for customer transactions.

25.4 Scenario 4: A large manufacturing company and its use of a "just-in-time" inventory system to dramatically reduce its supply of parts on hand.

25.5 Scenario 5: The development of a basic telecommunication network in rural Alaska and its effect on the economic, social, and educational status of rural residents.

25.6 Scenario 6-. The future use of Electronic Document Interchange to dramatically change the nature of the relationship between a manufacturer and its retailers.

25.7 Scenario 7: The future use of ISDN to make telemarketing more efficient and

related privacy issues.

25.8 Scenario 8: The future use of fiber optic cable to the home to make possible video-on-demand services and video program origination from the home. Related copyright issues will be addressed.

26.0 Management of Product Innovation in an Information Technology Company

In this module students will learn how to manage and facilitate the product innovation process. Through the use of case studies, competitor analysis and the interface between a company's R&D and marketing organizations will be discussed. Elements of entrepreneurial and teaming activities within a company will also be explored. Successful techniques for recruiting, nurturing, and managing innovative knowledge workers will be described knowledge workers will be described. Furthermore, the new product development cycles and processes will be studied from the perspective of competitive analyses and the influences of lead user analysis on product development and product life cycles. Also, the critical interfaces between product development and marketing organizations will be examined to show how complementary expertise in technical and marketing areas can be effectively used to obtain a winning market position.

3.0 Summary and Conclusions

Information networking technology is a synergistic and rapidly growing field that is uniquely matched to the challenges of the evolving information era. This new discipline integrated the fields of computer science, telecommunications, policy, business management and psychology for the design of usable and even fun-to-use user interfaces.

Networking and information technology trends point to an increasing strong coupling of here-to-fore separate disciplines. This paper brings together for the first time a proposal for a new interdisciplinary program in information networking technologies that are well matched to the needs of the information era in the next millennium.

Biographical Information

Dr. Addeo has wide experience in multimedia telecommunications research projects at Bellcore where he served as the Executive Director of the Multimedia Communications Department.

In 1994, Dr. Addeo was inducted into the New Jersey Inventors Hall of Fame for key patents that led to the widespread use of cellular telephone communications systems.

He was named to New Jersey Institute of Technology's achievement honor roll in recognition for a series of achievements that have exhibited "superior dedication, vision, courage and originality." Dr. Addeo is the author or co-author of more than 60 technical papers given at IEEE Communications Society conferences and meetings held all over the world. He is the recipient of ten US. Patents.

Dr. Addeo is the current chair of the Telecommunications Management Department