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STRATEGIC PLANNING FOR COMPUTER INTEGRATION IN HIGHER EDUCATION THROUGH THE YEAR 2000

Joseph O. Esin

Professor & Director
Research, Planning & Management Information Systems
Paul Quinn College
Dallas, Texas, U.S.A.

Abstract

Strategic Planning is the process through which the institution's mission, goals and vision are articulated. The institution's mission and goals must focus on opportunities, limitations, constraints and provide directions for an institution to fulfill its vision. Colleges and universities embarking on computer integration in higher education must avouch their commitment to a quality education. They must also profess that every child in this technological age has access and an equal opportunity to acquire computer skills. Colleges and universities must develop academic programs that are internationally competitive and accountable for improved learning through the year 2000.

Preamble

In the early 1960s, few institutions had on-line integrated systems. The advent of integrated systems made network systems very essential to colleges and universities. A new class of network technologies has emerged and institutions of higher learning must be familiar with the cost and benefits of the new technologies. A network is a collection of compatible hardware and software arranged to communicate programs, data files and information from one

workstation to another.

For successful implementation of computer integration in higher education, colleges and universities must include in the regular budget the cost of implementation and compatible equipment such as the following:

1. File Server, computers for workstations or any input and output devices that send and receive data;
2. Protocols, a set of rules and procedures that regulate the transmission between the components in the network systems;
3. Communication Channels, for various communications such as telephone lines, fiber optic cable, coaxial cables and wireless transmission;
4. Communication Processors, such as MODulations-DEmodulation (Modem), multplexers and front-end processors, which provide support functions for data transmission and reception;
5. Communication Software, to control all input and output activities and manages other major functions of the network systems;
6. Network Topologies, the shape or configuration of a network system; and
7. Types of Networks, networks are classified by geographical scope into computer telecommunications network (CTN), private branch exchange (PBX), local area networks (LAN), wide area networks (WAN), and Value-Added networks (VAN).

File Server

In a small college or university, a file server is the heart of the network system. A more efficient microcomputer-based system usually consists of a 486 DX, PC/AT compatible; a hard disk of at

least 1.2 Gig; networks cables (twisted pair, coaxial or fiber optic); printers (attached to a workstation or to a file server); tape backups cartridges to provide reliable backup of programs and data files and security of information; uninterruptible power supply (UPS) to provide emergency power to bring the system down gracefully, surge protection to alert the network users of the power outages; a network interface board of at least 32 bits (server works better with larger boards) and network operating system.

Protocols

There are sets of rules and procedures that regulate transmission of data between two points in a network. The primary functions of protocols in a network system are to identify each device in the communication path, verify correct receipt of the transmitted message, however, it can not perform recovery when errors occur. Information travels through a network communication systems in the form of electromagnetic signals. Signals are represented in two ways; analog and digital. An analog signal, according to McLeod (1993) and Laudon and Laudon (1994) is represented by a continuous waveform that passes through a communication medium. Analog signals are used to handle voice communications and to reflect variations in pitch.

A digital signal is a discrete waveform. It transmits data coded into two discrete states; 1-bits and 0-bits, which are represented as on-off electrical pulses. Notably, all digital signals must be translated into analog signals before they can be transmitted in an analog system.

The device that performs the translation is called a modem. A modem translates the digital signals of a computer into analog form for transmission over ordinary telephone lines and translate analog signals back into digital form for reception by a computer.

Communication Channels

Communications channels are the means of transmitting data from one workstation to another. A channel consist of different type of transmission media such as twisted pair, coaxial cable, wireless, satellite or fiber optics.

A twisted Pair Cable consists of strands of copper wire of about 1 millimeter thick twisted together in a long helix, and are the most common widely used transmission channel. The purpose of twisting is to reduce the level of electrical interference. A twisted pair cable operates at a speed of 10 megabytes per second. This type of cable is very inexpensive and is relatively slow for transmitting data from one workstation to another. Most telephone systems in a building are connected to the local telephone company or the local Private Branch Exchange (PBX) through a twisted pair. In other words, twisted pair cables supports analog telephone conversations.

A coaxial Cable consists of a heavy copper wire at the center, surrounded by insulated material. Around the insulating material is a cylindrical conductor, which is often a woven braided mesh. Coaxial cable is noted for its ability to transmit a larger volume of data from one workstation to another. It is faster and provides a good combination of relatively high transmission speeds of 200 megabytes per second, low noise and interference-free channel. A coaxial cable is thick, hard to wire in most buildings, and cannot support analog telephone conversations. There are two types of coaxial cables ; a 50-ohm cable used for digital transmission called **Baseband Coax**, and a 75-ohm cable used for analog transmission called **Broadband Coax** (Martin, DeHayes, Hoffer and Perkins, 1994).

A baseband cable system is a single digital transmission channel with data transmission rates ranging from 10 million bits per second (10 mbps), and up to 264 mbps, depending primarily on the intervals, in which a longer a cable means lower or slower data transmission rates. Assertively, broadband cable are widely use for local area network system. A broadband cable system utilizes analog amplifiers to boost the signals periodically and operates at higher trans-

mission speeds of 550 million bits per second (550 mbps) over much longer distances. Broadband cable systems are more difficult to install and considerably more expensive than baseband cable systems.

Wireless is a broadcast technology in which radio signals are sent into the air. A wireless communications system is used in a variety of circumstance, including cordless telephones, cellular telephones, wireless local area networks and transmission of voice and data.

A Satellite communications system is used for communications in large geographically distant institutions with two or three campuses that would be difficult to tie together through cabling channels. Satellite systems are used to relay signals over very long distances. Satellites move in stationary orbits of approximately 22,000 miles above the earth.

A Fiber Optics Cable is the newest transmission system. Fiber optics cabling operates with a much faster speed and less space requirements because they are very small in diameter. Martin, DeHayes, Hoffer and Perkins (1994) in their studies found that fiber optics are very secure because the cables are : highly reliable ; emit no radiation ; very difficult to tap ; not affected by power-line surges, electromagnetic interference ; not corrosive chemicals in the air ; and widely utilized by all leading telephone companies for their long-distance lines. Transmission speeds for fiber optics range up to 500 mbps for a large diameter fiber to as high as 30 billion bits per seconds (30 giga).

Communications Processors

Communications processors such as front-end, concentrator, controllers and multiplexes are used to support data transmission and reception in a network. **The front-end processor** is a computer dedicated to communication management, attached to the file server and responsible for formatting, editing, routing, speed, signal con-

versation, collecting and processing input and output data to and from the workstations. **A concentrator** is a programmable communications computer that collects and temporarily stores messages from the workstations until enough messages are ready to be sent to the file server.

A controller is a specialized device that supervises communications traffic between the central processing unit and peripheral devices such as workstations and printers. It routes output from the central processing unit to the appropriate peripherals device. **A multiplex** is a device that divides the communications channel so that it can be shared by multiple transmission devices.

Communication Software

Special communication software is required to control and support the activities of the network systems. This software resides in the file server, front-end processor and other processors in the network. The primary function of the communication software includes access control, transmission control, error detection, error correction and security (Laudon and Laudon, 1991).

The network control software routes messages, polls network workstations, determines transmission priorities, maintains a log-in, log-out, passwords, and various authorization procedures for preventing unauthorized access to a network and to check for errors.

Network Topologies

Topology is the technical acronym for network configuration. The four most widely used network topologies are :

1. Bus Topology : a network topology linking a number of workstations by a single circuit with all messages broadcast to the entire network ;
2. Ring Topology : a network topology in which all workstations are linked by a closed loop in a way that passes data in

one direction from one workstation to another ;

3. Token Ring Topology : a variant of the ring network topology ;
4. Star Topology : a network topology in which all workstations and other devices are connected to a fiber optics. All communication between devices must pass through the file server ; and
5. Hierarchial (tree topology) : is an extension of star network topology.

A bus network topology : a single length cable made of twisted wire, coaxial or fiber optic cable connected to a number of workstations. One of the bus network devices is a file server with a large data storage capacity. The disadvantage with the system is its single point failure quality. An obvious advantage of the bus network topology is the wiring simplicity. If one of the workstations in the network fails, none of the other components in the network is affected. Bus topology is commonly used for local area networks (LAN).

In a **Ring Network Topology**, two ends of the cable are connected and data are processed and transmitted from workstation to workstation flowing in a single direction through a closed loop. Each workstations operates independently so that if a particular workstation fails, the communication through the network is not interrupted. However, in Ring Topology, the connecting wires, the coaxial cable or the fiber optic cable forms a closed loop. However, the wiring for the ring network topology is slightly more complicated than the bus network topology. The distinct advantage of the ring topology is that it is not susceptible to failure.

The Token Ring network topology is a unidirectional predefined packet that allows data to flow in only one direction around the network system (Laudon and Laudon, 1991). In this topology, all devices communicate using a signal and each of the devices in the network is known as node. In a token ring network, only one compu-

ter can transmit a message at a time. Messages are transmitted from nodes in the network through relays in the hub on to the immediate active node. The potential problem in the use of the token ring topology is that a single break down anywhere in the network would disrupt communication in the entire systems. Nonetheless, the Token Ring configuration is most useful for transmitting large volumes of data between the file server (Madron, 1991 ; Martin, DeHayes, Hoffer and Perkins 1994).

A Star Network Topology consists of a central file server that is connected to a number of workstations. The central file server is the controller for all workstations in the network. The major disadvantage of the star network topology is its vulnerability. In other words, if the central file server stops functioning, communication in the network will definitely come to a standstill. However, this topology is essential in a centralized processing systems.

A Hierarchial Topology (Tree Network Topology) is a sample configuration of a very large computer system with mainframe computer as a controller connected to a numbers of workstations through data channels. According to Martin, DeHayes, Hoffer and Perkins (1994) the Tree Topology has the same primary disadvantages as the star network topology. If the central device fails, the entire network goes down. An advantage of the tree network topology is its flexibility.

Types of Networks

Networks are classified by their geographical scope and the type of services provided. The four vastly used networks include computer telecommunications networks (CTNs), private branch exchange networks (PBXs), local area networks (LANs), wide area networks (WANs) and Value-added networks (VANs).

A Computer Telecommunication Network (CTN) is a network emanating from a single channel or a group of closely linked work-

stations. The configuration of CTNs is organized a tree with coaxial cable and twisted pair media. For almost two decades, this type of network was widely used by colleges and universities with large campuses and several group of buildings. A CTN is controlled by the central file server with a number of workstations and other devices which exert tremendous communication burden on the network. For institutions that are still using CTNs, it is imperative for the campus network administrators to consider adding a front-end processor or communication controller to the network. A front-end processor or communications controller is a computer with specially designed hardware and software to handle all aspects of telecommunications, including error control, editing, controlling, speed and signal conversion.

Private Branch Exchange Networks (PBXs), are special-purpose network systems. PBXs have extensive capabilities that are not possessed by computer telecommunications networks (CTNs). The first-generation PBXs were switchboards run by human operators to operate an internal telephone system within the institution or organizations. Notably, the second-generation PBXs use electrochemical relays to perform the switching rather than human operators.

Today's third-generation PBXs consist of a digital switch operated by a built-in computer and have the capability of simultaneously handling communications with internal analog telephones, digital microcomputers, workstations, mainframe computers and the external telephone network. The potential advantage of digital PBXs is that they utilize existing telephone lines, and do not require additional wiring. Equipment can be moved when necessary with little worry about having to rewire the entire building. A workstation connected to a network by telephone can simply be plugged anywhere in the building, utilizing the existing telephone lines.

The primary disadvantage of PBXs is that they are limited to telephone lines and cannot easily handle very large volumes of

data. However, PBX system has several advantages. For example, it can connect all telecommunication devices in a building or campus ; has the capability to use existing telephone wiring ; is able to carry voice and data over the same network ; it can be connected in a transparent way to an external telephone network and has a potential of over 500 mbps (Beckham, 1989 ; Stephenson, 1990 ; Martin, DeHayes, Hoffer and Perkins, 1994).

Local Area Networks (LANs), were the first and most widely used network system. LANs are presumably owned by every college and university in the United States and abroad. They operate within an area not more than two or three miles in diameter. LANs have higher transmission capacities than PBXs, using bus network or ring network topologies, and transmit at a rate of 256 kilobits per second to over 100 megabytes per second. LANs systems are recommended for applications requiring high volumes of data and high transmission speeds. LANs, according to Laudon and Laudon (1994) are totally controlled, maintained and operated by end users. This capability enhances their productivity because the users are no longer dependent upon a centralized computer or p· ıter to complete their assignment.

LAN's three specific standards developed by the Institute for Electrical and Electronic Engineers (IEEE) and subsequently adopted by both national and international standards organizations are officially designated as IEEE 802.3 (co.ıtention bus topology), IEEE 802.4 (token bus topology), and IEEE 802.5 (token ring topology). LANs technology consists of cabling such as twisted pair , coaxial cable or fiber optic cable, compatible computers, network interface cards and software to control the LANs activities. The LANs network interface cards define the data transmission rate, the size of message units, the addressing information attached to each message and compatibility of network topology.

The four widely used LANs technologies are Ethernet, developed by Xerox, Digital Equipment Corporation and Intel, Apple-

talk from Apple Computer Incorporated ; Token Ring, developed by IBM and Texas Instruments ; and ARCnet, developed by Datapoint. LANs utilize either a baseband or broadband channel technology (Laudon and Laudon, 1994).

LANs capabilities are specified by the network operating system. The network operating system can reside in single designated file server for all the applications on the network, or it can reside in every workstation in the network. The leading network operating systems include Novell's Netware, Microsoft's LAN Manager, and IBM's Personal Computer LAN. The primary disadvantages of LANs are that : they are very expensive to implement, inflexible, require new wiring each time the LAN is relocated, and require specially trained staff to manage and operate the network.

Wide Area Networks (WANs) Unlike CTNs, PBXs and and LANs span much greater geographical distances, ranging from several miles to across entire continents. WANs are usually owned by organizations licensed by the government to provide communications services to the public, such as AT&T, MCI, Sprint, Southwestern Bell, Pacific Bell, GTE, etc,. The Common carrier determines the transmission rates and interconnections between lines, but the customer is responsible for telecommunications contents and establishing the most efficient routing of messages, checking error, editing, protocols and management.

WANs consist of a combination of switch and dedicated lines, and satellites communications. Switched lines are telephone lines that the consumers can access from independent workstations to transmit data to the designated destination. The potential advantage in switched lines is that they are less expensive, and are very appropriate for low-volume applications requiring only occasional transmission. Dedicated lines (non-switched lines) are continuously available for transmission of data at higher speeds and are more appropriate for higher-volume transmissions.

Some institutions and organizations maintain their own Wide

Area Network (WANs). For instance, the United States International University, at San Diego, California use WAN to tie together its main campus in San Diego, Mexico, London and Kenya. Example of other organizations that use WAN include Hewlett-Packard Corporation (HP). HP has a WAN that ties together its facilities in the United States, Britain, France, Switzerland, Venezuela, Australia, Japan, India, Hong Kong and Singapore.

Value-Added Networks (VANs) are data-only, private, multipath and non-regulated networks that are used by multiple organizations on a subscription basis. The phrase Value-Added refers to extra "charge" added to communications by telecommunications and computing services to the consumers. The prominent advantage is that customers do not have to invest in network hardware, software or perform their own checking, editing, routing, and protocol conversion. The resulting charges are less than if the end users had adopted and implemented LANs or WANs. VANs are attractive for institutions or organizations like the United States International University (USIU) and Hewlett-Parkard (HP) because they provide special services such as electronic mail and data-access to their facilities in foreign countries.

The leading international VANs are GE Information Services (GEIS), Infonet, Telenet, and Tymnet. Assertively, VANs are not for all institutions and organizations. VANs function effectively at moderate-speed, high-volume, frequent long-distance communications. VANs, according to Laudon and Laudon (1994) do raise security problems because institutional or organizational data can be mixed in with data from other institutions or organizations.

Plan of Action and Decisions

The starting point for computer integration in higher education is to understand the need of the institution. Computer integration is very likely to succeed only if it advances one of the most important institutional goals. Computer integration has enormous potential

for academic advancement, but the institution, according to Laudon and Laudon (1994) must :

1. identify priorities for amelioration ; the Board of Trustees, President, Planning Council, unit Vice Presidents, directors, division chairpersons and department heads need to determine exactly how the institution's mission and vision could be strengthened by computer integration. Administrators, faculty, staff and students need to know how the integration can reduce institution's expenses by increasing the scale of student enrollment, attract quality faculty, improve instructional and learning process, and increasing the scope of operations without additional management cost ;

2. exemplify an analysis of precisely how computer integration will contribute to the specific five-year-goals and objectives, and to its longer-range strategies ; and

3. identify how computer integration will support the institution's day-today operations and provide directions for colleges/universities to fulfill its mission.

Implementation of the Plan

Once the institution embarks on planning for computer integration, it must determine the scope of the project and decide which technology to adopt and under what circumstances. Eight specific elements such as distance ; range of services ; security ; single or multiple access ; utilization ; cost of implementation ; installation and connectivity must be taken into consideration when considering computer intergration.

Distance : If the communication will be largely local and entirely in a single building, LAN is very appropriate for such a campus. LAN is strongly recommended for institutions with a single campus.

Range of Services : The institution must consider various options, whether the support services will be extended from the transmission of programs and data files to include electronic mail, voice mail, video conferencing, etc,.

Security : Unlike CTNs, PBXs, LANs and WANs, VAN is the only network system that raises security problems and is recommended for institutions with distant campuses in the United States and abroad.

Multiple Access System : If the institution has up to a thousand or more users, PBX network is recommended. However, if access is restricted to a hundred or less users, a high speed, more exotic technology like a fiber optic or broadband system is recommended.

Utilization : For a high-volume transmission and communications, LAN is recommended. Low-frequency and low-volume transmission and communications suggest the use of a traditional modem.

Cost : Planners should by no means underestimate the cost of implementing the network system. They should take into consideration the cost of equipment compatibility, software, performance criteria, vendor selection, labor, wire and cable specification. Uncontrollable cost are always the cause of the network failure in higher education settings.

For network Installation, specific attention must be paid to the status of the building. In some instances, campus buildings have inadequate wiring channels underneath the floors, which makes installation of fiber optic cable extremely difficult. Connectivity requires that all components of the network communicate with each other.

Summary

Many institutions that have moved to computer integration have found that the type of savings they expected did not materialize because of unexpected cost. Therefore, colleges and universities embarking on computer integration should take into consideration the cost of compatible hardware, protocol, network topology, performance criteria, wire and cable specification, vendor selection, labor and communication software to control and support the activities of the network. Institutions should also determine transmission priorities, maintains a login and logout, passwords, and various authorization procedures for preventing unauthorized access to the network.

References

Beckham, Bonnie. "Networking Brown University," *Journal of Technological Horizons in Education.* 16 : 8 (April 1991), pp. 62–68.

Bright, George W. "Using a Local Area Network in a College of Education," *Journal of Technological Horizons in Education.* 15 : 8 (May 1988), pp. 90–93.

Brookshear, J. Glenn. *Computer Science : An Overview.* California : The Benjamin & Cummings Publishing Company, Inc. 1993.

Brumbaugh, Ken & Hart, Nick. "FTP : The Educator's Key to Multi-Platform File Transfers," *Journal of Technological Horizons in Education.* 20 : 10 (May 1993), pp. 65–69.

Brum, Penn. *The Micro to Mainframe Connection.* Pennsylvania : Tabs Books Inc., 1988.

Charp, Sylvia & Hines, I.J. "The Basic Principles of Networking," *Journal of Technological Horizons in Education.* 15 : 8 (May 1988), pp. 94–98.

Conway, Paul. "Voice Networking : Big Technology on Campus," *Journal of Technological Horizons in Education.* 17 : 8 (April 1990), pp. 67–68.

Gillay, Carolyn Z. *DOS 5 Fundamentals.* Oregon : Franklin, Beedle & Associates, Inc., 1992.

Hannu, R.W. "Interactive Television Networking," *Journal of Technological Horizons in Education.* 17 : 8 (April 1990), pp. 60–62.

Heier, Jeffrey L. "American School 2000 : Westfield's Technology Initiative," *Journal of Technological Horizons in Education.* 20 : 10 (May 1993), pp. 83–86.

Laudon, Kenneth C. & Laudon, Jane P. *Management Information Systems : Organization and Technology.* New York : Macmillian Publishing Company, 1994.

Madron, Thomas W. "Enterprise Computing in Higher Education," *Journal of Technological Horizons in Education.* 18 : 11 (June 1991), pp. 60–65.

Malfitano, Rocco. "Network for a School of the Future," *Journal of Technological Horizons in Education.* 20 : 10 (May 1993), pp. 70–74.

Montgomery, D.L. "Crafts, Commitments and Computer Connection," *Journal of Technological Horizons in Education.* 20 : 10 (May 1993), pp. 79–82.

Martin, E. Wainwright, DeHayes, Daniel W., Hoffer, Jeffrey A. & Perkins, William C. *Managing Information Technology.* New York : Macmillian Publishing Company, 1994.

McLeod, Raymond. *Information Systems Concepts.* New York : Macmillian Publishing Company, 1994.

McLeod, Raymond. *Management Information Systems.* New York : Macmillian Publishing Company, 1993.

Mielke, Angela, Phelps, Sandra D. & Schwartz, David. "Teaching at the Speed of Light : The Fiber-Optic Connection," *Journal of Technological Horizons in Education.* 16 : 8 (April 1991), pp. 77–78.

Krueger, M. Thomas. "Technology Transference : Using Dow Jones News-Retrieval Across Two Universities," *Journal of Technological Horizons in Education.* 19 : 10 (May 1991), pp.

63–65.

Segun, Armand. "Networking Educators Across the Expanses of Alaska," *Journal of Technological Horizons in Education.* 15 : 8 (May 1988), pp. 81–84.

Schrum, Lynne. "Introducing Teachers to Telecommunications : California (ESTTI)," *Journal of Technological Horizons in Education.* 15 : 8 (May 1988), pp. 85–89.

Sirc, Geoffrey M. "Learning to Write on a LAN," *Journal of Technological Horizons in Education.* 15 : 8 (May 1988), pp. 99–104.

Winston, Patrick H. *Artificial Intelligence.* California : Addison-Wesley Publishing Company, 1992.