DEVELOPMENT OF A STANDARDS BASED OPEN ENVIRONMENT FOR THE WORLDWIDE MILITARY COMMAND AND CONTROL SYSTEM

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(Abstract)

The Worldwide Military Command and Control System (WWMCCS) is an operational multi-service/agency program that supports command and control functions for the National Command Authority and the Commanders of major unified and specified commands. These functions provide data processing capabilities including status of forces reporting, support requirements and contingency planning used in national security decision making.

For over 21 years WWMCCS users have been constrained to use only Honeywell Federal Systems, Incorporated (HFSI) proprietary hardware and software solutions. This constraint is the direct result of contractual agreements between HFSI and the government. As the demand for information, speed in which this information is accessed and transferred, and size of files processed increased the WWMCCS architecture became unable to effectively meet the user requirements. The cause for this deficiency in the

WWMCCS environment revolves around HFSI's proprietary solutions.

By following this philosophy the user's ability to obtain more capable solutions to the ever increasing demands has been limited. The users need the ability to connect whatever hardware and software solutions are available that satisfy their requirements. They need an environment that allows portability, interoperability, and scaleability. I call this "open systems" or for a better word, "openness." This openness can be achieved through vendor and user concurrence on a specific set of hardware and software solutions. Unfortunately, such specificity will only result in limited openness due to the speed in which technology is advancing. Needed is a "set of guidelines" that will give the vendors the ability to develop hardware and software solutions that will keep pace with technology. These guidelines can be developed from the formally and non formally accepted standards of today.

It should be stated, though that standards' development, implementation, and acceptance are not a very concise effort. Both vendors and users must be willing to invest their energies in understanding not only what standards are, but the positive uses of standards and ramifications if not used.

This project takes a Systems Engineering approach in which I describe a perceived problem and determine its validity through analysis. I develop three alternatives that could resolve this problem, analyze the alternatives, and decide the most acceptable
choice. I then apply this choice to WWMCCS by developing an evolutionary plan allowing implementation to coincide with available funding. This approach replaces proprietary solutions with formal and non formal accepted standard solutions allowing the user to connect whatever hardware and software solutions are available.

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CHAPTER 1

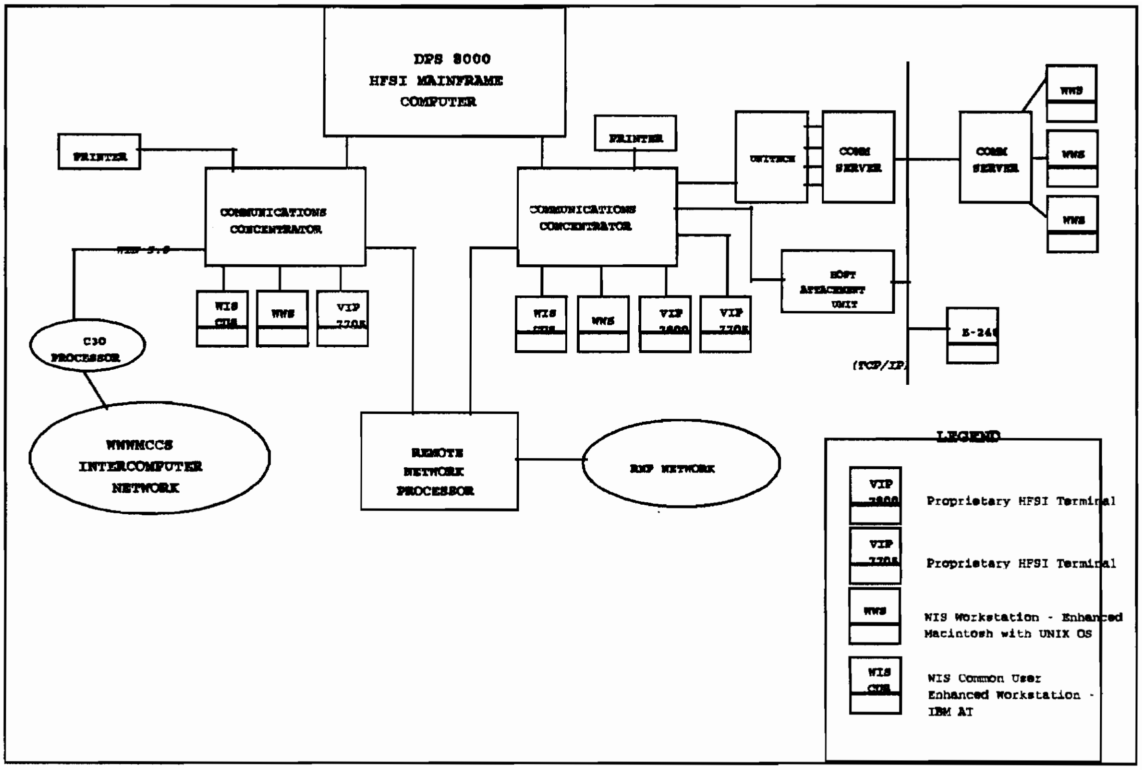
PROBLEM DEFINITION

1-1 System Description

The Department of Defense (DOD) has developed the Worldwide Command and Control System (WWMCCS) as the strategic level Command and Control (C^2) tool keeping senior decision makers informed of the status of all U.S. forces worldwide. This system has been in operation for over 21 years and currently in the maintenance phase of its Life Cycle. WWMCCS is based on Honeywell Federal Systems, Incorporated (HFSI) proprietary hardware running proprietary software and communication's protocols, figure 1-1.

1-2 User Requirements

WWMCCS users today operate numerous HFSI proprietary products that inhibit the efficient and effective transfer of information within the current environment. HFSI supported solutions have not advanced with technology, i.e., continued use of character based presentations and limited data throughput. The dependency on HFSI solutions has only exacerbated the user's efforts in satisfying their expanding requirements. These requirements are: near real time capability for decisions based on strategic status of friendly forces to include all personnel, equipment quantity and status, logistics, mobility readiness, force positions, planning contingencies, land/air/sea/sub-surface force structure, and enemy force composition; increased information distribution from 1.2 and 2.4KBps to 9.6, 19.2 and 56KBps via terrestrial and satellite communications worldwide; and access and input to WWMCCS data needs strict control. HFSI's use of their own "proprietary" standards and non-compliance to accepted standards have stifled progression toward meeting user requirements across the WWMCCS networks and it continues today. It should be noted though, proprietary solutions should not be eliminated from consideration without an analysis of their value to the effort. There are situations were the only solution is with proprietary hardware and software. These situations will be those in which you have a unique and limited environment that no standards already exist. WWMCCS is not such a system. Most any commercial off-the-shelf (COTS) hardware/software solutions will perform at a higher level of efficiency and effectiveness.



- HFSI proprietary mainframe computers running under the General Comprehensive Operating System (GCOS) proprietary operating system.
- TCP/IP connectivity via communication servers running HFSI proprietary protocols.
- HFSI proprietary front end processors and communication's concentrators running proprietary GRTS software.
- HFSI proprietary databases, predominantly IDS-1 BCD.
- HFSI proprietary terminal protocols limiting use to a few specific HFSI produced or enhanced terminals.

FIGURE 1-1

Current WWMCCS Architecture

1-3 Closed Environment

As new technologies emerged it became difficult for WWMCCS users to benefit from these non-HFSI supported technological advances. Benefits such as the ability to manipulate increased numbers and sizes of files and be able to support the increased speeds needed to transfer these files between the many WWMCCS sites worldwide. Being very inflexible and stagnate, HFSI's hardware and software solutions have not kept pace with technology. WWMCCS users have been constrained by contractual agreements to depend on HFSI solutions. The reality of this dependence on HFSI has made achieving these required operations almost unreachable. Any openness with other vendors' more capable systems has been severely limited and only accomplished, for the most part, using custom-developed and extremely expensive solutions.

1-4 Operational Impact

For over 21 years WWMCCS has been the only strategic command and control system used by senior national decision makers. The capabilities of WWMCCS were sufficient to satisfy the user requirements of twenty years ago. As the demands for greater data processing and transfer increased, user responsiveness decreased. This decreased responsiveness has jeopardized the senior national decision makers ability to act in a timely manner during critical phases of a national crisis situation. WWMCCS users today must operate in an environment where the transfer of a standard file of 10Mbits takes over an hour. If a new application is required, introduction of this new application is very expensive and time consuming. The users need to manipulate and transfer precessed data as near real time as possible. This requirement is not being met using todays WWMCCS architecture.

CHAPTER 2

PROJECT DESCRIPTION

2-1 Objective

The WWMCCS users have been unable to satisfy the increasing requirements placed on them. They have attempted numerous solutions to resolve these deficiencies, without success. They attempted costly fixes in the software along with modifications to existing user procedures. HFSI was approached for assistance, but their answer was one of additional funds for continued development of proprietary solutions. What is needed is an affordable and achievable solution. To resolve this problem a rational systematic approach needs to be undertaken. Such an approach can best be defined in the Systems Engineering process.

2-2 Methodology

In taking a Systems Engineering approach to this project I first needed to research a perceived problem and decide its validity. The problem researched was WWMCCS's inability to satisfy the requirements of the user. Their major complaint was the inability of interfacing with more advanced systems. These newer systems with advanced, more capable technologies are required to satisfy the increasing demands for WWMCCS information processing. Current HFSI solutions are ineffective in meeting these demands and therefore user requirements. There are no immediate capabilities available allowing connection of non-HFSI solutions to the current WWMCCS architecture.

Concluding that there is a valid problem my next step was to do a functional analysis developing a set of alternatives that could resolve this problem. My first recommendation was to continue with HFSI and their philosophy of using proprietary solutions. I decided against this approach for two reasons: (1) HFSI's lack of flexibility to the changing demands of DOD, and (2) the large amounts of capital and time required to modify contracts directing development of more capable solutions are unacceptable.

My second alternative was to start over with a new WWMCCS architecture. By doing this we could begin by using accepted standards as a foundation. This foundation would allow portability, interoperability, and scalability or for a better term, "openness," table 2-1. By following this approach the users could use whatever solutions available if they comply with accepted standards and satisfied requirements. I decided against this alternative for one very important reason, cost. The capital investment the users have in a system that has been in operations for over 21 years is exorbitant. Congress would disapprove any attempt to take this approach.

My third alternative is an evolutionary approach. This allows the users to go in a direction toward openness by using solutions that comply with accepted standards while phasing out older proprietary solutions. This is accomplished by the gradual introduction of solutions that comply with accepted standards at a rate commensurate to funding available. I chose this alternative as my solution to the stated problem.

Table 2-1

Open Systems Definition

PORTABILITY	The ability to access databases and execute application software on a variety of hardware and system architectures from different computer manufacturers.
INTEROPERABILITY	The ability to have different software applications, databases and computer systems operate together in a multivendor network.
SCALABILITY	The ability to use the same databases and software on all classes of computer from desk-top workstations to supercomputers.

CHAPTER 3

PROBLEM ANALYSIS

3-1 Proprietary Solutions

I have described a real problem within the WWMCCS environment. Through analysis I developed what I feel is the primary cause to this problem. The proprietary solutions of the past have only accelerated the users' dissatisfaction and inability to satisfy their requirements. Any custom developed solutions in the WWMCCS environment are only short term with a very high cost. If proprietary solutions are ineffective, we must look at other avenues that will allow portability, interoperability, and scalability of solutions. The only course to take is by using either de jure, de facto or alliance/vendor accepted standards. By following these standards the users can select whatever hardware and software solutions are available that comply with the accepted standards and satisfy their requirements.

3-2 Role of Standards

3-2.1 What are Standards

Before we can discuss standards further we must first understand them. A standard can be envisioned as a plan that represents the proposed activities of the industry in dealing with an issue.[1] The standard should represent the industry response to a real problem and should provide a valid solution. Deliberately or inadvertently, standards exist and have been used to control and organize much of humankind's activities throughout history. They are a powerful tool to stabilize and then promote growth. They can also, if misused, cause a culture to stagnate and wither.[2] Standards represent the acceptable behavior and mores of a society and culture.

Managers are constantly involved with the justification of standards and the perceived costs associated with there use. Others claim that there should be no need for justification, standardization should be accepted and supported based on its intrinsic value and its obvious contributions to the common good.

What managers are searching for are lower costs and greater profits in using standards. They expect a reduction in the number and variety of materials, parts, and assemblies

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[1]Cargill, p.13.

[2]Ibid.

manufactured or purchased. Management usually requires justification and re-justification. Since the basic language of management is money and most engineers have a natural tendency to concentrate on the technical aspects of a project, here lies the major dichotomy in standards. On one end we have the economic realities and on the other end we have the technical expectations.

We can approach this dichotomy by translating technical problems and accomplishments into terms that top management understands and appreciate. We can use return-on-investment (ROI). To management

ROI is:

$$\frac{\text{Total Revenues}}{\text{Total Investment Costs}}$$

Translating this into standardization we can re-write the ROI equation:

$$\frac{\text{Total Standardization Revenues}}{\text{Total Standardization Investment Costs}}$$

Measurements of standardization costs and benefits enable the manager to determine ROI, identify high payoff projects, set goals, and compare the standardization accomplishments of projects, factories, companies, and industries.

The benefits of using standards can be quantifiable. By minimizing the variety of items, processes and practices, standardization:

- Improves efficiency in design, development, material acquisition;
- Conserves money, manpower, time, facilities, natural resources;
- Enhances interchangeability, reliability, safety, maintainability.

The National Aerospace Standard (NAS) 1524 series, a compilation of accepted methods of calculating the costs and benefits of standardization, are used to justify the use of standards. NAS 1524 lists a number of specific benefits. Some are tangible and others are intangible. Some tangible benefits are improvements such as:

- Greater discounts from larger orders;
- Reducing time required for design;
- Processing fewer purchase orders;
- Reducing warehouse operating costs;

- Reducing capital investment;
- Decreasing stocks of spare parts;
- Operating farther down the learning curve;
- Reducing training time.

Some intangible benefits are:

- Reducing hazard of technical errors of judgement;
- Reducing need for minor supervisory decisions;
- Providing a common language between buyers and sellers;
- Improving quality control based on accepted and explicit specification;
- Improving user and customer confidence.

Intangible benefits usually cannot be stated in terms of money, manhours, or other resources. We know that the benefits exist and are significant, but development of elaborate formulas with constants and factors to accommodate various situation will be of questionable value. Tangibles can be measured and terms such as "savings," "cost reduction," and "cost avoidance" are used.

The standardization benefits derived by various departments in a company are usually far in excess of the cost they incur. For example, a project engineering department would ordinarily have the following standardization costs:

- an apportioned share of the cost of the standardization operation;

- direct costs of implementation such as engineering changes, preparation of lists of project preferred parts, materials and processes, and direct charges of standardization specialists that may be assigned to, or be called upon by, the project.

Benefits that the project engineering department realize include:

- avoiding the preparation of some drawings;
- eliminating some testing;
- reducing time spent searching for appropriate parts, materials and processes;
- determining costs more reliably and economically;
- improving product reliability by reuse of known items.

There are also peripheral benefits to be realized. These are not directly associated with standards development and implementation, but are a byproduct. Some examples include:

- providing better control of front end costs for the specification of parts, materials and equipment;

- assisting in the preparation of bids and proposals by having available a library of current standards and vendor information.

Standardization will reduce variety. Variety reduction through standardization is profitable not only for purchased products, but also for items manufactured within the company. Without standards or other constraining factors, varieties tend to proliferate continuously.

By not using standards four factors will account for about 80% of the total Life Cycle Cost. They are:

1. The cost of preparing a document that describes the nonstandard part, taking into account the labor charges, overhead, burden, and other changes related to document preparation.

2. The cost to test nonstandard parts which represent a major portion of the cost, and ranges from $5,000 to $75,000 for electronic parts.

3. The cost of managing a part in the inventory which includes the cost of provisioning meetings, computer layout sheets, etc.

4. The cost incurred in maintenance owing to the reliability or unreliability of a nonstandard part. This, to, is a major cost and is estimated conservatively at $300 for each maintenance action.

Appendix 1 describe examples of procedures endorsed by NAS.

3-2.2 A Brief History of Standards

Standards have been with us for over 2500 years. One of the first standards was the establishment of a guaranteed national coinage, "Lydian Stater." The main purpose for this particular standard was commerce and therefore economics, being able to trade using an accepted base for exchange.[3] The prosperity that this produced continued for a thousand years until around A.D. 500 with the fall of the Western Roman Empire, causing massive isolationism throughout civilized Europe.[4]

The drive for economic satisfaction surfaced again during the medieval period. Individual merchants created craft Guilds which established standards to maintain product quality. Local civil authority enforced these Guild produced standards since the more trade there was the more taxes received. The theme of economics continually prevails in the history of standards.[5]

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[3]Ibid., p.14.

[4]Ibid.

[5]Ibid., p. 15.

As the Nation-States grew increasingly interdependent and the advent of the Industrial Revolution, the importance of standards gained considerable importance throughout Europe. Standards became necessary to ensure that growth was not random and that a degree of commonality existed among nations.[6] Today we see this with EC 92, which has fueled the resurgence of standards throughout Europe. This is evident by the importance given to the various nations standards bodies in adopting a consensus on standards to be used with the aim of enhancing their economies.

In the first 100 years of the United States existence standards were imposed to protect the common good of the citizenry. The primary areas covered by these standards were commerce and safety. Few standards were technically driven, through. Indications of this can be seen with the introduction of the steam locomotive which brought on standards which were safety related not technical.[7] After the Civil War a fundamental change had occurred in the society of the U.S.; the commercial interdependence of the various sections of the country became more and more pronounced.

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[6] Ibid.

[7] Ibid., p. 16.

Maintainability, duplicability, and interchangeability constituted the three-part justification for standards from a consumers's viewpoint.[8] This three part justification becomes very important in a dispersed market, since services or products to be replicated or repaired where done at great distances from the original source. This was enhanced with development of the great rail system in the U.S., which increased the speed of industrialization throughout the country. This industrialization created a larger demand for standards to maintain itself: standards in metallurgy, information representation, in work units, in fasteners, in terminology, in education, in nearly every aspect of life.[9]

As we transition from being an industrial based society to one of service and information, the importance of standards and their correct use in Information Technology has become the key factor for future success.

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[8] Ibid.

[9] Ibid., p. 17.

3-3 The Challenge in Standards Development

3-3.1 Standards Development

There are two means of standards approval, the first being voluntary and the second regulatory. The purpose of voluntary standards is not to mandate change, but to cause the market to prefer a standard solution to a non-standard solution.[10] They are more for activities in volatile areas with competing technologies and application solutions; slower precess but hopefully preventing a single interest from dominating the standardization effort for self-serving ends.[11]

Regulation is a poor substitute for market action in either a dynamic society or a dynamic industry.[12] There are situations, though, where regulation is appropriate. In particular are standards developed by the Occupational Safety and Health Act (OSHA). These are government regulated standards concerning safety. Regulatory standards are more useful when only a single acceptable solution exists.

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[10] Ibid., p. 20.

[11] Ibid., p. 22.

[12] Ibid., p. 18.

The United States has over 400 groups devoted to doing standards. These groups are a mixture of formally recognized and sanctioned organizations and unofficial groups of professionals who have banded together informally to help their industry. These groups deal with hundreds of standards each year; producing them, reviewing them, recommending them for implementation, or obsoleting them. Unfortunately, the perception that a number of individuals have about these standards groups is that each group acts to protect and expand its area of influence, sometimes at the expense of other standard groups.[13]

Standards represent different things to groups and disciplines, to organizations, and to individuals, and these meanings vary with time and context.[14] This difference in rationales and goals for participating standards bodies is a major cause of confusion about standards and standardization in the Information Technology industry.[15]

There are three basic types of standards groups;

- Traditional standards groups: i.e., International

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[13]Ibid., p. 9.

[14]Ibid., p. 28.

[15]Ibid.

Organization of Standards (ISO), International Electrotechnical Commission (IEC)

- Vendor Consortia: i.e., Open Software Foundation (OSF), and Unix International Incorporated (UI) - cover multiplatform solutions in areas of Distributed Computing Architectures (DCA) and network management.

- User groups: i.e., SOS, Open User Recommended Solutions (OURS), and National Microcomputer Managers Association (NMMA).[16] These groups are relatively new, but have great potential. Example being a group of ten companies combining their assets of 15 billion/year to influence vendors in support of open systems. An example of one such group comprises American Airline, Du Pont, General Motors, Kodak, Motorola, 3M, Northrop, Merck, Unilever, McDonnell Douglas.

Many of these user groups are also involved with formal standards groups. The goals of this combined effort are to get vendors to produce the products that meet their needs and state publicly their commitment to, and plans for, support of open systems.[17]

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[16]Susan McGarry, "Open Systems: The User Reality," Computerworld, White Paper, Spring 1993, p. 20.

[17]Ibid., p. 14.

The primary standards body in the United States is the American National Standards Institute (ANSI) which represents both government and trade organizations.[18] ANSI is a non-profit, nongovernmental organization that coordinates voluntary standards activities in the United States, though it does not develop standards. ANSI is comprised of approximately 300 Standards Committees and almost 1000 company members representing virtually every facet of commerce, trade, and industry.[19] The members of ANSI are: professional societies; trade associations; governmental and regulatory bodies; industrial companies; consumer groups; and individual members.[20]

ANSI represents the United States in two international telecommunications and information related organizations; the International Organization of Standards (ISO) and the International Electrotechnical Commission (IEC). Both are independent of each other, though have many common members. Operating under the procedures of ANSI are a number of committees directly related to information processing and

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[18]Patricia B. Seybold, "The Alphabet Soup of Standards Bodies: A Primer on Setting Standards," Patricia Seybold's Office Computing Report, October 1992, v15, n10.

[19]McGarry, p.40.

[20]Sava I. Shear, "ANSI and Information Systems," Proceedings Computer Standards Conference 1986, May 1986, p. 12.

telecommunications.

ANSI provides coordination aimed at avoiding: duplication of effort and development of conflicting standards and arranges for: identification of needed standards, development of such standards by qualified organizations and verification of national consensus.[21] It is important to note that all ANSI recognized standards developing organizations are voluntary standards organizations working under consensus. Consensus is used to describe that which occurs when the developers and commentators of a standard merge on an agreement point. Consensus operates under the concept of "due process," which provides anyone with a directly or materially affected interest in the proposed standard an opportunity to participate in the consensus process, from its initiation through its completion.[22]

In addition, an important group of standards are developed by quasi-independent committees, known as Accredited Standards Committees, which are administered by ANSI member organizations. Among the significant ones related to Information Technology systems are the Computer and Business

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[21] Seybold, p. 3.

[22] Ibid., p. 2.

Equipment Manufactures Association (CBEMA), the Electronics Industries Association (EIA), and the Institute of Electrical and Electronic Engineers (IEEE) which does standards development in information processing, micro processors, computer languages, software engineering, buses, and other aspects of information processing. The IEEE society is peopled by engineers, have little or no knowledge of international procedures and organizations and little experience in working within the U.S. voluntary standards system.[23]

Primary work in international standardization is done by three voluntary groups. The first is the International Organization of Standards (ISO) which is a global, non-treaty organization that writes and approves international standards for products ranging from screw threads to computer communications software. There are some 90 countries represented in the ISO. A member body of ISO is the national body "most representative of standardization in its country."[24] ISO members include: (United States) ANSI, (UK) British Standards Institute (BSI), (Canada) Standards Council of Canada (SCC), (France) Association Francaise de

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[23]Shear, p. 13.

[24]Ruthowski, p. 86.

Normalisation (AFNOR), (Germany) Deutsches Institut fur Normung (DIN), (Italy) Ente Nazionale Italiana de Unificazione (UNI), and (Japan) Japanese Industrial Standards Committee (JISC).

Key goals for the ISO are: (1) develop international standards; (2) facilitate the international exchange of goods and services; and (3) encourage cooperation in economic, intellectual, technological, and scientific endeavors.[25] Recent activity has been devoted to Information Technology and Open Systems Interconnection (OSI). Appendix 2 describes OSI in detail.

Second is the International Electrotechnical Commission (IEC), an analogous organization that focuses on electrical and electrotechnical standards. There are over 40 nations who participate. IEC membership is held by national committees representing their respective country.[26] ISO and IEC merged their information technology committees into a single Joint Technical Committee (JTC1) in 1987. The two goals of the JTC1 are: (1) develop a consistent strategy for Information Technology standards, rather than the project-

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[25] Ibid.

[26] Shear, p. 15.

by-project approach of the past, and (2) to accelerate the production of standards. Participants in the JTC1 are national delegations accredited from one of the national member bodies, such as: ANSI, AFNOR, BSI, CSA, DIN, and JISC. There are two components to the JTC1: an oversight committee and twenty plus subcommittees, plus many working groups.[27]

Thirdly, the International Telecommunications Union (ITU), comprising 160 members, is the main standards organization for telecommunications. The purpose of the ITU is to promote cooperation and development in the field of telecommunication. The critical difference between the three is that the ITU is a United Nations (UN) treaty organization, so the standards are binding on all UN signatories. Only administrations, i.e., national governments, may be ITU members. However, recognized private operating agencies (i.e. AT&T), scientific and industrial organizations can participate in most facets of ITU work.

The ITU has two major committees: The International Telegraph and Telephone Consultative Committee (CCITT) and

[27]Seybold, p. 2.

the International Radio Consultative Committee (CCIR). The CCITT is involved mainly with Information Technology. As a permanent subcommittee of the ITU, the CCITT consists of a Plenary Assembly that meets every four (4) years and numerous "study groups" established by the plenary. The study groups in turn have their own plenary meetings and divide their work among numerous working parties, working teams, and rapporteurs. The ultimate product of the CCITT is recommendations.

The Department of State gets indirectly involved in Information Technology standards largely because of the CCITT. They have chosen to discharge their representational responsibility in two ways: first is through two "public advisory committees," the United States Organization for the CCITT and a similar organization for the CCIR that "recommends" US policies and contributions. The State Department maintains approved charters defining the responsibilities and structures of both organizations. Second, representation in these forums is through the formation, accreditation, and conduct of delegations to many of the CCIR and CCITT meetings, or otherwise bestowing the title of "recognized private operating agency" or "scientific and industrial organization" upon US companies.[28]

A number of active regional standards organizations exist that are not represented in the formal international process, but whose input is increasingly vital to that process. Examples being the Asia-Oceania Workshop (AOW) and National Institute for Standards and Technology (NIST) which all work together to contribute to the development of draft international standards. Their main focus is on usability, interoperability, and conformance testing.[29] This level is a good place for customers who are relying increasingly on international standards to get involved in the standard process.

Next we have trade industry groups such as the European Computer Manufactures' Association (ECMA), involved in defining a framework and proposed international standards for Computer-Aided Software Engineering (CASE). Other organizations are the IEEE, which is best known for its development of the local area network standards and for its Portable Operating System Interface (POSIX) efforts.

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[28]Ruthowski, p. 92.

[29]Seybold, p. 2.

At the same level as the trade associations and feeding into the international standards process are national government organizations such as Britain's Central Computer and Telecommunications Agency (CCTA) and the U.S.'s NIST. The nationally approved standards such as the U.S. ANSI X3 (Information Technology), X12 (EDI), and T1 (Telecommunications) standards, feed into the process at this level.

The progress toward EC 92 full implementation presents a more agile standards-related organization chartered to rationalize standards across national boundaries. Such organizations are: Comite' European de Normalisation Eletrotechnique (CENELEC) which is the regional equivalent of the IEC. The European Telecommunications Standards Institute (ETSI) which is dedicated to the creation of Europe-wide telecommunications standards and the harmonization of existing standards. Another body is the Comite' European de Normalisation (CEN) which is the European equivalent of ISO. Its members include 16 national standards organizations from both the EC countries and the European Free Trade Association (EFTA).[30]

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[30]<u>Ibid</u>., p. 3.

There is yet another group of standards bodies which exists, consortiums. Consortiums are fairly new to the standards game. Included are the Corporation for Open Systems (COS), which is an industry group that is primarily funded by vendors interested in OSI. COS also includes the User Alliance for Open Systems (formally the Atlanta 17, and then the Houston 30), a group of North American end users concerned about the future of open systems. The Internet Engineering Task Force (IETF) represents the large Internet community. The Manufacturing Automation Protocol (MAP) group and the Technical Office Protocol (TOP) group are consortia that arose out of customer concerns and requirements to make progress in certain areas faster than the traditional standards process was moving.

The Standards and Promotion and Application Group (SPAG) selects and promotes ISO standards throughout Europe, and contributes to and reviews standards proposals through the European Working Group on Open Systems (EWOS). The Promoting Conference for OSI (POSI) is a policy-making standards group consisting primarily of Japanese corporations. X/Open, UniForum, Open Software Foundation (OSF), Unix International (UI), and the Object Management Group (OMG) are all international organizations with both users and systems suppliers as members. All these groups are attempting to develop and push ahead with industry standards in areas that are of critical concern to their members.

3-3.2 Standards Process

The dramatic increase in the speed with which new technical developments occur is placing a great deal of pressure on the traditional consensus-driven standards process.[31] There is a negative image associated with the standardization process. Many see this as slow work done by procrastinating committees that publish their documents long after the technology involved had become obsolete. The process takes too long. This slowness will not maintain the pace of technology, therefore we will always be behind in standard development unless another method is developed. The excess time needed for standard development/research/implementation only adds to the already immovable bureaucratic process.

Before a standard is approved as a standard, each standards proposal must pass through a similar number of stages. The stages are:

- New Work Item
- Working Draft

[31]Ibid.

- Committee Document (Draft Proposal/Standard)
- Final Standard

This phased implementation ensures that all technical considerations have been taken into account. What usually happens is system vendors begin implementing their product once the standard reaches the draft standard stage. If a positive response is noted the vendors will attempt to take advantage of the customers requiring standards-based implementations. These actions are only enhanced because all major government ADP acquisitions must comply to standards, both national and international.[32]

Finally, the political process must be handled carefully. Two years ago there was a meeting held by 14 standards and user groups from North, Central, and South America. The purpose of this meeting was to begin work towards developing an agreed upon set of standards which could be presented to the international standards committee in Europe. This effort was undertaken in hopes of boosting the strength of the standards bodies representing these countries in international negotiations.[33]

[32]Cargill, p. 45.

[33]Anita Taff, "Standards and User Groups Discuss Universal Approach," Network World, April 20, 1992, p. 53.

Since standards bodies are comprised of voluntary committees needing a consensus for each stage of the standards process before it can go to the next stage, the time involved to motion that a new standard is needed, assign to committee, do the research, send out to colleagues with similar background as the one the proposed standard is destined for, compile all inputs and resolve all questions is too costly.

3-3.3 Standards Implementation

In a recent study 69% of the CIO's polled said their number one problem is achieving enterprise integration, and the greatest barrier to that integration is the lack of Standards.[34] I would also add the lack of understanding standards. Considering the dynamics of Information Technology, solutions must evolve with the problems they solve. There are three distinct categories into which standard creation activities can fall: (1) Standards that plan to change the industry - conceptual; (2) Standards that reinforce existing industry patterns - implementation; (3) Standards that cause unplanned change - both.[35]

Conceptual standards are **revolutionary**, seeking to change

[34]McGarry, p. 45.

[35]Cargill, p. 29.

industry perceptions and direction, to encourage technology conversion or change, or to redefine an industry problem through a different perspective on the approach to a solution or a different perspective on the problem itself.[36] Example of a conceptual standard is IEEE 802.3, Ethernet Standard. This was initiated in response to a perceived market need to provide separate users access to computing facilities without degrading user performance or duplicating the centralized resources.[37]

An Implementation standard is intended to ensure that the evolution of an answer keeps slightly ahead of the evolution of the question. Example being COBOL, which has changed so that COBOL remains responsive to the current and future needs of the industry. These revisions are not new standards, but are **evolutionary** vice revolutionary. The intent is to reinforce the activities of the industry, not to change them.[38]

Standards can come into existence as a result of the free interplay of market forces (de facto), legislation (de jure)

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[36] Ibid, p. 30.

[37] Ibid.

[38] Ibid., p. 29.

or vendor confederations (Alliance).[39]

De facto standards do not codify technology, they are widely accepted market-driven standards usually based on a specific product. This product is almost always supplied by a single vendor with monopolistic objectives. Example: Microsoft's MS DOS and Windows.

De jure standards are established by a formal and independent standards body. It is often not associated with either a specific vendor or product. Unfortunately, it often trails leading edge technology due to the excessive time required to formally codify it. Example: IEEE's POSIX and Unix.

Alliance/Vendor standards are created when a collection of vendors form a confederation designed to advance a well defined product. The Common Operating System Environment (COSE) consortium is an excellent example of how a group of vendors can get together and influence industry. This particular group was formed by Hewlett-Packard, IBM, Unix Laboratories, Inc., Sun Microsystems, Inc., and the Santa

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[39]Michael B. Spring, "Education in Information Systems Standards," Bulletin of the American Society for Information Science, February/March 1990, p. 28.

Cruz Operation earlier this year. COSE is currently working on both a standardized framework and services for administering distributed Unix systems along with networking, graphics, multimedia, objects and system administration. The underlying goal of COSE is to provide a standardized Unix platform that can win out over Next's NT as the centerpiece of corporate users' client/server strategies.[40] Again we see economics as the driving forces behind this action. Other examples of alliances are OSF and UI.

3-3.4 Alternatives to Formal Standards

In areas that standards do not exist or are weakly represented, standards organizations and vendors compete by publishing new specifications and by offering newer technologies to standards organizations for their adoption. Sometimes these good intentions end up reducing the expected gains. Structured Query Language (SQL), used in relational database systems, is an example of software developed by IBM and then modified when it became an ANSI supported standard. IBM stuck with its original version with the intent on supporting its own customers; as a result, DB2 SQL is not ANSI compliant. Even within the ANSI supported SQL standard

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[40] Elisabeth Horwitt, "COSE Attacks Net Administration," Computerworld, August 9, 1993, p. 8.

there are many options which has allowed each database vendor to stay within the standards, but still remain incompatible with its competitors. The result, even relational database systems that comply to the ANSI-standard SQL cannot easily interoperate.

What has now appeared is a group called the SQL Access Group (SAG) comprised of SUN Microsystems Inc., Hewlett-Packard Co., Digital Equipment Corp., Tandem Computers Inc., and Ingres Corp. This group is dedicated in creating a single, widely compatible version of the query language called SQL Access. Even IBM has begun, though quietly, to work with SAG.

The Open Software Foundation (OSF) has been working with a number of vendors in developing its Distributed Computing Environment (DCE). Although OSF is best known for their version of Unix, DCE is independent of any one operating system; it works as well on Macs as it does on Unix platforms.[41] This action by OSF will allow noninteroperable systems to communicate and share information. For example, Sun Microsystems' SunOS will enjoy symbiosis with IBM's AIX and Systems Application Architecture (SAA). DEC's Ultrix,

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[41]Mary Hubley, "Distributed Open Environments," BYTE, November 1991, p. 230.

VMS, and Network Application Support (NAS), along with multiple architectures from Bull, Hewlett-Packard, and Siemens-Nixdorf will be among the first to incorporate DCE. OSF has successfully been running "live" test on 11 different systems demonstrating that their approach works.

Another excellent example being pursued which would allow applications interoperability is the Portable Operating System Interface (POSIX), a family of specifications and set of interfaces defined by IEEE. POSIX is not an operating system, but a set of function calls or services that can be used by application programs to access system services. This is the single most critical standard today when we speak of open systems allowing users to obtain application portability.[42] POSIX works directly with the operating system - the critical point of contact between application software and hardware in every general-purpose computer today.[43] Furthermore, operating-system performance is becoming increasingly important with the continued advances in networking technologies such as client/server and cooperative computing. Also, the operating system is the

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[42]Rick Kittle, "Towards Open Computing: What Users Should Know and What Vendors are Doing," Manufacturing Systems, September 1992, p. 67.

[43]Ibid, p. 68.

place where backward and forward compatibility can merge, to the benefit of users who want to tie newer technologies to their existing systems. By implementing open-computing interfaces into existing operating systems, vendors can help users extend their use of proprietary systems into the foreseeable future.

Here is where vendor cooperation is required. Since no two operating systems are alike, POSIX attacks this problem in stages by mandating specifications for certain critical application program-to-program operating systems interfaces. To implement POSIX interface specifications, an operating system vendor must design a translation mechanism - usually a run-time library - that can take system calls to the POSIX interface and turn them into native operating system calls.[44]

Communicators Integrator from Covia Technologies is another entry into the world of applications interoperability. Covia's approach is to create a virtual network in which applications communicate via simple, standardized interfaces. A layered architecture is used to separate the communications aspects of an event, i.e. file transfer or

[44]Ibid.

database query, from the application itself. Schematically it has a protocol stack application program interface (PSAPI) at the bottom, followed by the Kernel of the integrator, and topped off by the application interface. PSAPI furnishes the interface between the network layer of the Communications Integrator and the network protocol stack. It supports a variety of network protocols: Netbios for DOS, Windows, OS/2, and Stratus VOS environments. Also, can run on a variety of platforms and operating systems.[45]

In taking a different approach, some vendors are earnestly trying to ensure standardization by investing into accepted procedures. Novell, Inc. will begin supporting TCP/IP on its upcoming release of NetWare 3.12. This is a change of heart for Novell since their past support to TCP/IP on NetWare was limited to encapsulating IPX, Novells' proprietary protocol, commands inside TCP/IP packets. This will allow Novell users to link its Novell servers to higher end systems that support TCP/IP, but not IPX.[46]

Another non-standard approach is Xpress Transfer Protocol

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[45]Salvatore Salamone, " An Easier Way to Build Distributed Applications," Data Communications, August 1992, p. 131.

[46]Horwitt, "Novell Preps Support for TCP/IP," Computerworld, August 23, 1993, p. 16.

(XTP), a new LAN protocol, that has been proposed to the ANSI committee overseeing OSI protocols. XTP addresses weaknesses common to all existing protocols. XTP is designed to allow individual workstations or PCs to transmit data at the high speeds that emerging, advanced local area networks support. These include: 100-Mbit/s Fiber Distributed Data Interface (FDDI), 16-Mbit/s token ring, and broadband ISDN. Benchmark tests have shown that existing protocols such as TCP/IP, OSI's Transport Protocol Class 4 (TP4) and Xreox's XNS require computers to devote five to ten times more processing power than XTP in order to attain equivalent transmission speeds. In addition to better supporting higher transmission speeds, XTP includes unique features that enable it to support emerging advanced distributed applications.[47] Northrop intends to use XTP to support military applications running on LANs installed in airplanes.

Yet another non-standards product is produced by Quarterdeck Office Systems Inc, "Desqview/X". It fulfills a promise of letting users run a UNIX or DOS application on any computer or terminal that runs the X window system. This may be the first glimpse into the era when operating systems will not

[47]Shear, p. 20.

matter to the users. "Desqview/X" makes DOS and UNIX workstations visually indistinguishable using X windows. "Desqview/X" is a full implementation to X on DOS, unlike X emulator products.[48]

Finally, but not the last, the triumph of TCP/IP and SNMP over ISO OSI transport level 4, and CMIS/CMIP in the U.S. market are victories for de facto over official standards. This shows that users prefer an available, inexpensive, multivendor solution over one that may be internationally blessed, but which is less accessible.[49]

3-3.5 Education on Standards

Without an understanding of standards as a separate discipline and market in themselves and not as a by-product of other processes, each new standards venture is pursued in isolation, re-creating the successes and failures of the past.[50]

Standards should result in economic and operational benefits to users and or procedures. To ensure a greater success,

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[48]Alan Southerton, Andrew D. Wolfe and David Granz, "DOS and Unix on a Two Way Street," Unixworld, August 1992, p. 51.

[49]McGarry, p. 46.

[50]Cargill, p. 29.

people must be educated in the details, philosophy, etc., of standards development. It is crucial that their be a cadre of personnel who know the world of standards. They will not only bring a widen picture of how other organizations actually operate, but also provide critical bridges of understanding among the people engaged at all levels, both staff and volunteers.[51]

In general there has been little support by universities to develop curriculum providing academic interaction in the problem of standards and standard formation and theory. A program of standards education in the Information Technology field needs to be developed providing an introduction to the field of standards.

The Department of Information Science at the University of Pittsburgh has developed such a curriculum specifically addressing standards and standardization, table 3-3.1. This curriculum addresses the participants, the processes and the politics of standardization. Goals of this course include defining the basic characteristics of standards; reviewing the impact of standards on the development of information systems; exploring the process by which standards are

[51] Ibid., p. 50.

developed; and examine the implications of standards for the interpretation and analysis of document creation, conversion and design.[52]

[52]Spring, p. 29.

Table 3-3

Information Technology Standards

Course Outline

A. Introduction

1. Purpose of standards
2. History of standards
3. Types of standards
4. Impact of standards
5. Description of standards
6. Terminal design
7. Character sets
8. Escape sequences and control characters
9. Communications interface
10. LAN cabling and protocols

B. Standards evolving from vendor/institutional success market

1. *De facto* and informal consensus standards
2. Construction industry (windows, studs, joists, stairs)
3. Electrical plug, electrical wiring, appliances
4. Underwriters Laboratory (UL)
5. Paper sizes, types, book sizes, bindings
6. PC-DOS, IBM PC, SNA Postscript
7. Evolution of selected standards
8. Costs/benefits of natural selection in standards

C. *De Jure* and client determined standards

1. *De jure* standards
   a. Safety standards - automobile
   b. National security standards - highways

Table 3-3 Continued

2. Impact of major clients on evolution of standards
   a. Military standards - DIF, DOD MIL-STD-188
   b. Unix OS in education
   c. General Motors and Boeing - MAP/TOP

D. Consensus standards: the standards bodies

1. International Standards Organization (ISO)
2. Consultative Committee on international Telegraph and Telephone (CCITT)
3. European computer Manufactures Association (ECMA)
4. American National Standards Institute (ANSI)

E. Consensus standards: the development process

1. Accreditation of a developer
2. Planning and coordination of standards
3. Designation, publication, maintenance and interpretation of standards
4. Procedures for development of a standard by committee
5. Role of associations

F. The ISO-OSI model and its implications

1. The seven-layer model
2. Standards suites

G. Consensus standards: examples

1. EIA RS-232C
2. X.25
3. CCITT V.24
4. SGML
5. Z39.2
6. Z39.59

H. Information display standards

1. Windowing system languages
2. Page description languages

Table 3-3 Continued

I. Information encoding standards

1. Z39.2
2. DCA/RTF/Interscript
3. SGML/Z39.59
4. ODA/ODIF

J. Mail and messaging standards

1. X.400
2. X.500

K. Standards validation organizations - the new UL

1. NBS lab
2. Corporation for Open Systems
3. SPAG
4. POSI

L. Ethical and legal issues in standards

1. Ethical issues
2. Liability of standards groups
3. Liability of the validating organization
4. Liability of the vendor

M. Political issues in standards development

1. Vendor participation
2. Professional associations
3. Responsibilities to insure vendors' adherence
4. National governments and international organizations
5. Disagreements

N. Economic issues in standards development

1. Impact on research and development
2. Impact on end user purchases
3. Cost of the standards themselves
4. Impact of technological developments

3-3.6 Guidelines for Standards Development

So why have standards and their use been so elusive? Although computer technology standards have been under development for over twenty-five years, all too often the results of these activities were overlooked, under utilized, and too little coordination achieved between standards developers, vendors, and end users. We have been constrained by the multitude of definitions defining standards. A process that is exponentially increasing in every dimension, scope, complexity, number of organizations and meetings, level of detail, and throughput.[53]

Is it in the best interest of the United States industrial base, DOD, and future global competitiveness to force standards so all will comply? Will standards alone be the keys in making this obtainable? What is the formula needed to develop standards that are not only usable, but acceptable to all? Table 3-3.2 gives a recommended approach to standards development. This approach will allow due process of standards development without sacrificing speed. This should not be considered a final format, but a basis for future improvements as the situations dictates.

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[53]A.M. Ruthowski, "An Overview of the Forums For Standards and Regulations," Telecommunications, October 1986, p. 84.

Table 3-3.2

Proposed Approach to the Standards Development Process

A. Getting Started

- Prepare a background document or justification of need paper at the beginning of the standard's development process.
- Develop a system of timetables and operating plans for all draft standards, with target dates and progression steps.
- Assign responsibilities, after defining goals, tasks, and schedules.
- Issue a schedule of steps to completion with target date.
- Obtain as much data in advance of any new standard's development and address at an early stage.

B. Staffing and Training

- Identify and involve likely participants in the development of a standard as early in the process as possible.
- Define qualifications of "expert" participation early in process.
- Assign someone with experience and knowledge of the standards development process to act as Chair of any new work group for the first series of meetings. The work group should elect the permanent Chair during that time.

Table 3-3.2 Continued

- Conduct training on due process and procedures.
- Develop team building within group.
- Separate "personal" from "company" position.

C. Meetings

- Schedule meetings on fixed days of the month. e.g., first Wednesday and Thursday of every other month.
- Increase the frequency of meetings to significantly affect progress.
- Make meeting durations to enhance progress.

D. Drafting documents

- Use word processors to write the first draft of the standard and to circulate draft standards via FAX electronic mail, bulletin boards or on discs, as appropriate.
- Develop detailed rationale statements during the development process to explain why the text is as stated.
- Have mechanism for editorial review; send draft standards at an early stage to editorial review. This reduces negatives/comments at later stages.
- Make sure a standard contains those provisions that make it suitable for certification, if a standard is to be used

Table 3-3.2 Continued

as the basis for product certification.

E. Balloting

- Maintain mailing lists that are up to date.
- Issue subcommittee letter ballot, without delay, when document is ready.
- Delegate authority to issue subcommittee letter ballot to a work group Chair.
- Expedite balloting of revisions of standards by submitting only the revised paragraphs. Do not open the entire document for review.
- Mail letter ballots immediately. Do not delay mailing in order to combine with other correspondence.
- Re ballot drafts during meetings when possible.
- Use subcommittees instead of work groups for new standard development, thereby reducing the number of balloting steps.
- Resolve issues over the phone.

F. Handling Negatives

- Contact every negative voter, preferably by phone, and discuss ways to resolve the negatives.
- Do not wait for a subcommittee meeting to start handling

Table 3-3.2 Continued

negatives. Work group that drafted standard should attempt right away to accommodate negatives in a revised draft.

- Obtain authority to accept editorial changes without re-balloting.
- Have the courage or wisdom to declare "those last few negatives" not persuasive, and convince those necessary to override them.

CHAPTER 4

RECOMMENDATIONS

4-1 WWMCCS Open System Migration

The previous sections have discussed in detail the various aspects of standards including historic, economic, and technical reasoning behind standard development. Also, discussed the many organizations and consortiums that make up this ever increasing body of standards makers. With this as a base I will develop, from my original WWMCCS example, a portable, interoperable, and scaleable architecture in which intelligent use of standards are the foundation for an effective and efficient Information Technology system.

To begin I have developed the following list of requirements that will lead WWMCCS toward an open system:

- Reduce the WWMCCS dependency on proprietary systems and protocols and increase its use of standard open systems;
- Implement and enforce DOD and government-wide standards and mandates, while still providing the interoperability and connectivity that are the practical outcome of adopting an open system;
- Minimize the operational and training impact of the WWMCCS migration from its current closed environment;

- Continue supporting the WWMCCS investment in legacy systems;
- Accomplish these actions realistically within budgetary and resource constraints that only promise to get tighter.

These requirements can be accomplished by:

- Increasing the connectivity and interoperability of WWMCCS proprietary systems by using available software/hardware solutions;
- Introducing open systems guaranteed to interoperate with legacy WWMCCS systems;
- Increasing evolutionary support of open systems.

To facilitate this, several technological elements will be required to effect the WWMCCS evolution to open systems, including:

- DOD compliant Portable Operating System Interface (POSIX) operating environment or available middleware allowing interoperability between different operating systems and platforms.
- Government Open Systems Interconnection Procedures (GOSIP) compliant Local Area Networks (LAN) and Wide Area Networks (WAN) technology to include use of bridges, routers, and gateways; (Appendix 2 and 3 give a detailed

discussion on Open Systems Interconnection (OSI) and LANs.)

- SQL based relational database technology with heterogeneous distributed database access;
- Programmatic interfaces to open systems resources such as LAN, Database management software and Peer-to-Peer software;
- Distributed computing;
- Transparent file sharing across systems.

4-2 WWMCCS Open Architecture

Figure 4-2 outlines my proposed WWMCCS architecture that will satisfy the stated requirements within a distributed environment. There will be no mainframe computers. I have made this decision not so much on technical rational, but funding considerations. Mainframes usually have the highest overhead charges than all other ADP components. Next, what was once only available in large, expensive machines can now be found in boxes that are smaller, lighter, and cheaper. A series of servers, running Unix (standard), will be used as databases, applications, and file type servers. Even if technology advances dramatically over the next two years, the price of these servers is relatively inexpensive, they could be disposed of and new one purchased.

POSIX and Unix System Five Revision Four (SVR4) (nonstandard) will be used allowing interoperability among the different variants of Unix. This will also permit a greater number of available platforms. If available, Desqview/X (nonstandard) could also be used allowing DOS platforms to be considered.

Transitioning from TCP/IP to GOSIP (standard) will be a gradual effort. Until all the legacy applications have been either modified or removed, we will be able to get GOSIP implementation through tunneling of the application over the OSI stack.

Distributed databases allowing almost transparent query between diverse database systems will be of primary importance. Replacement of non-relational databases can begin while still maintaining both relational and non-relational databases. One solution for this (to a certain extent, though) is with IBM's Distributed Relational Database Access (DRDA) (nonstandard) software. This will allow a certain amount of compatibility only if the Database Management System (DBMS) is DRDA compliant. If using SQL then SQL Access (nonstandard) software will be required. This will provide interoperability over all database environments using SQL Access.

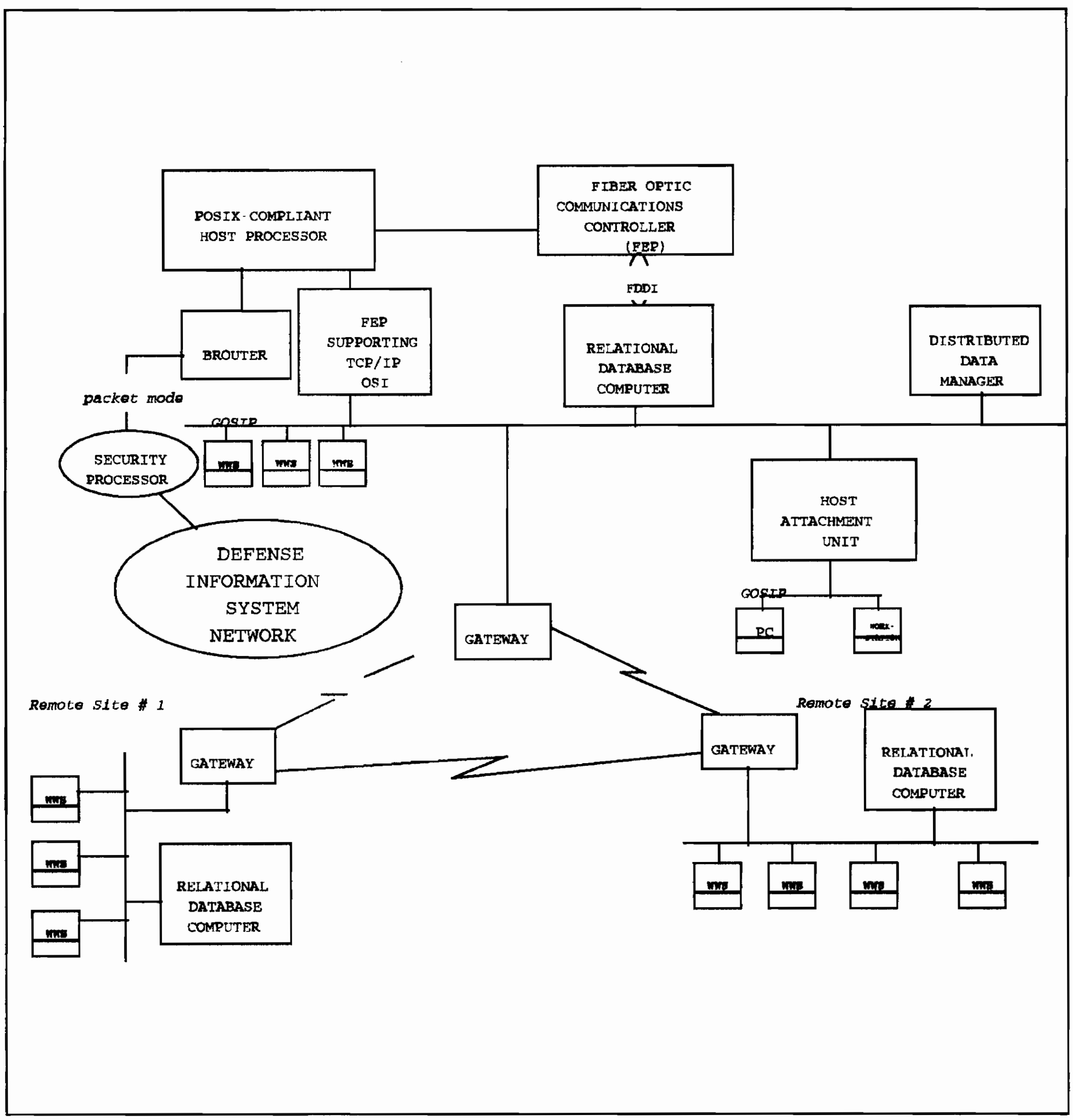

Figure 4-2

Proposed Open WWMCCS Environment

4-3 Implementation

The future of WWMCCS must not only depend upon a distributed open system based on client-server computing concepts, but also a system in which existing, proprietary elements can be sustained or phased out slowly as the user chooses. The challenge to this is that migrating to an open system involves more than installing new hardware and software.

To truly take advantage of open systems, WWMCCS developers must rethink how its operators use and interact with their information system. Initial planning and evaluation are crucial. Before an open system can be implemented, every business process must be evaluated to determine (1) how the WWMCCS does business (policies, procedures, and practices) and (2) why it does business that way (missions and methodologies). The importance of the users needs and requirements cannot be over stated.

Only by taking an **evolutionary** approach will this change to open systems be gradual and iterative - minimizing or eliminating the risk of catastrophic operational dislocations and failure.

CONCLUSION

Throughout history Standards were used to advance economic standings. From the establishment of "Lydian Stater" to economies of scale, this belief forms the foundation of standards' development and use, continues today and will continue if this basic philosophy is not changed. Information Technology is dynamic with technology advancing at an astonishing rate. Producers are developing Information Technology systems that meet their economic needs while not considering what is best for the end user. There is little cooperation between these two distinct, yet inherently integrated groups.

We cannot start over with one set of standards that all will follow. We must not only abandon the old way of creating standards, but how we think about and use standards. What is needed is to regain user confidence by not developing new technologies that will not work with legacy systems or develop new standards leaving current systems unusable. To eliminate stagnation and maintain growth we need to approach user requirements in an **evolutionary** manner.

The user must have the flexibility to integrate whatever system he has while benefiting from advances in technology.

The ability to rapidly integrate new technologies will be very important to the users as requirements change.

Strict compliance to standards is not the solution in achieving interoperability within WWMCCS. We must be able to integrate current and yet-to-be developed standards so that both producers and users can achieve their anticipated goals. We must approach standard's development with greater knowledge and understanding. We must be able to develop standard relationships relevant across all platforms, systems, and vendors. Vendors can no longer control users, nor can users control vendors. They must recognize their interdependence. An understanding of the advantages and disadvantages of available standards must be realized. We must allow networked groups to work together supporting components from multiple vendors and not depend on an all inclusive set of standards.

By taking this approach I have shown how a closed architecture such as WWMCCS is transformed to one of openness. This permits the user to interconnect whatever solutions are available that satisfies the needs.

Only by discarding the old way of creating standards and reduce the deep-rooted desire for profit will vendors and users begin to work together building the systems that will allow **Openness** to flourish.

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Appendix 1

NAS 1524 Examples

Standardization Savings From Increased Quality Purchases

NAS 1524-1

The savings attainable through standardization from increased quantity purchases may be estimated from the use of the equation:

Cost Savings = Purchase Cost Part 1 + Purchase Cost Part 2 + ...

$$S_{QB} = Q_1 \; C_1 + Q_2 \; C_2 + \ldots$$

Purchase Cost Other Parts − Total Quantity Replaced Parts x Cost of Standard Parts

$$Q_N \; C_N - (Q_1 + Q_2 + \ldots Q_N) \times C_S$$

where:

S_{QB} = The cost reduction resulting from a quantity purchase and discount.

Q_1 = The quantity of part 1 which would have to be purchased yearly if it were not replaced by standard part P_s.

C_1 = The unit cost, in dollars, of part 1 based on the actual purchase costs in dollars.

Q_2 = The quantity of part 2 which would have to be purchased yearly if it were not replaced by the same standard P_s.

C_2 = The unit cost, in dollars, of part 2 based on the actual purchase costs.

C_S = The unit cost, in dollars, of the standard part based on the increased quantities needed yearly.

Example: Yearly requirements for an aerospace program require 10,000 hose clamps costing $.60 each and 20,000 similar clamps costing $.70 each. Replacing these clamps with an industry standards costing $.50 each for the 30,000 required each year results in the following savings:

$$S_{QB} = 10{,}000 \times \$.60 + 20{,}000 \times \$.70 - (10{,}000 + 20{,}000) \times \$.50$$

$$= \$6{,}000 + \$14{,}000 - \$15{,}000$$

$$= \$5{,}000/\text{year}$$

Standardization Savings in Paperwork and Handling

NAS 1524-2

The savings attainable through standardization in paperwork and handling may be estimated through the use of the equation:

Cost		Reduction in		Cost To		Reduction In
Savings	=	Purchase Orders	x	Process P.O	+	Shipment
S_{PW}	=	$(N_1 - N_2)$	x	(K)	+	$(D_1 - D_2)$
	x	Cost of Paperwork and Inspection				
	x	(J + M)				

where:

S_{pw} = Cost avoidance resulting from reduction in paperwork and handling.

N_1 = Number of orders placed per year before standardization.

N_2 = Number of orders placed per year after standardization.

The most economical number of orders that could be placed can be derived from the economic order quantity formula. The most economical number of orders is expressed as:

$$N = \frac{IA}{2K}$$

where:

I = Inventory carrying cost in decimals.

A = Annual volume in dollars.

K = Purchase order average process costs.

D_1 = Number of yearly shipments before standardization.

D_2 = Number of yearly shipments after standardization.

J = Storage bin average cost (paperwork only)

M = Receiving inspection average cost.

Example:

By applying the principle of standardization on an aerospace program the variety of electrical connectors is significantly reduced resulting in increased quantity purchases of the preferred varieties with a resultant decrease in annual cost from $100,000 to $70,000. Savings in paperwork and handling can be estimated conservatively by assuming that the most economical number of orders will be placed and each order will be delivered as a dingle shipment.

$$N_1 = \frac{.18 \times \$100{,}000}{2 \times \$35} = 256 = 16$$

$$N_2 = \frac{.18 \times \$70{,}000}{2 \times \$35} = 180 = 13$$

$$S_{pw} = (16 - 13)\$35 + (16 - 13)\ (16 + 32)$$

$$= \$105 + \$144$$

$$= \$249/\text{Year}$$

Standardization Savings from Reduced Engineering Search Time

NAS 1524-4

The savings in engineering search time as a result of the ready availability of standards manuals and similar aids may be estimated from the use of the equation:

Cost Savings	=	Cost to Search W/O Standards Manuals	-	Cost to Search Standards Manuals With Success	-
S_{ys}	=	$N\ T_{ef}\ R_e$	-	$N\ R_e\ R_s\ T_{sm}$	

Cost to Search for Items Not In Standards.	After First Looking in Manuals	+ Search in Engineering Standards Manuals Files, etc.
$R_e\ (N - N\ R_s)$	$(T_{am}$	$+\ T_{ef})$

\- Cost to prepare and maintain Standards. Manuals

\- C_{os}

which can be simplified to:

$S_{ys} = N\ R_e\ (T_{ef}\ R_s - T_{sm}) - C_{os}$

where:

S_{ys} = Approximate cost avoidance resulting from reduced search time as the result of standardization.

N = Annual number of searches for data that could be expected to be included in Standards Manuals, Preferred Lists of Parts, Materials, and Processes. etc.

R_e = Engineering rate per hour including overhead.

T_{ef} = Time to accomplish search using engineers files, library, DODISS, etc.; include travel time. A typical average is 1.25 hours per search.

R_s = Success rate in finding data in Standards Manuals and similar standardization documents.

T_{sm} = Time to accomplish search in Standards Manuals; include travel time.

C_{os} = Annual cost to develop, publish and maintain standardization documents.

Example:

A survey of an organization of 3000 design engineers reveals an average of four searches per week for data on parts and materials. Reviews of preferred parts lists for new designs and spot checks with engineers on various design projects indicates that 60 percent of the required data for parts and materials were found in the standards manuals or project preferred parts lists, after a search averaging six minutes. A staff of ten provides standardization services including project preferred parts lists at an annual cost of $200,000 including overhead. The salary rate for design engineers in this organization average $10 /hour including overhead.

S_{ys} = 600,000 x $10 (1.25 x .60 - .10) - $200,000

= $3,900,000 - $200,000

= $3,700,000

Other NAS 1524 procedures are: Standardization Savings from Reduced Storage Requirements, NAS 1524-3; Standardization Savings from Using a Stocked Standard Part in lieu of Establishing a New Standard, NAS 1524-5; Standardization Savings from Using a Stocked Standard Part in lieu of a New Design, NAS 1524-6; Standardization Savings from Control and Reduction of the Number of Items in Inventory Through Simplification or Use of a Supersedure Procedure Whereby Inventories of Interchangeable Items are Consolidated, NAS 1524-7; Standardization Savings from Using a Stocked Standard Part in lieu of a Nonstocked Part, NAS 1524-8; and Standardization Savings from Using a Design Standard in Lieu of Detailing the Data Completely on Each Drawing, NAS 1524-9.

Appendix 2

Open Systems Interconnection (OSI)

One way to describe a LAN architecture is to organize the functions that the LAN performs into a set of functional "layers". A network architecture can then be defined in terms of the services provided by each layer and the interfaces between layers. The International Organization for Standards has developed a seven layer reference model for computer networking called the Open Systems Interconnection (OSI) model. This standard forms the basis for evolving standards for computer networking. The United States Government, with some slight modifications developed by the National Institute of Standards and Technology (NIST), has adopted the OSI model under the name of "Government Open Systems Interconnections Protocol (GOSIP)" and issued a GOSIP Standard publication called FIPS Pub 146.

You can think of the OSI model as a layer cake, figure Appendix 2-1. At the bottom, holding everything up, is the physical layer. It's the wiring and cables. The higher in the OSI model you go, the more meaningful the communication is to the end user.

PHYSICAL LAYER - The physical layer furnishes electrical connections and signaling. Subsequent layers talk through the physical layer. Twisted-pair wiring, RS-232C cable, fiber-optic strands, and coaxial cable are all part of the physical. The physical layer carries the signals for all the higher layers.

DATA-LINK LAYER - Once you make the physical and electrical connections, you must control the data stream between your system and the one on the other end. The data-link layer of the OSI model works like the foreman of a railroad yard putting together cars to make up a train. This functional level strings characters together into messages and then checks them before putting them on the track. It may also exchange an "arrived safely" message with the foreman in the other yard, or work with the other yard to reconstitute a message when a data disaster strikes.

The data-link layer uses many protocols, including High-Level Data Link Control (HDLC), bisynchronous, and Advanced Data Communications Control Procedures (ADCCP).

NETWORK LAYER - Large networks typically offer a number of ways to move a string of characters (put together by the data-link layer) from one geographic point to another. The network layer decides which physical pathway the data should take based on network conditions, priorities of service, and other factors.

The network-layer software usually resides in switches out in the network, and the interface card inside the computer must put the train together in a way that the network software can recognize and route.

TRANSPORT LAYER - The transport layer does many of the same job as the network layer, but it does them locally. Drivers in the networking software perform their transport layer's tasks. This layer is the railroad yard dispatcher who takes over if there is a wreck out in the system. If the network goes down, the transport-layer software will look for alternate routes or perhaps save the transmitted data until the network connection is reestablished. It handles quality control by making sure that the data received is in the right format and in the correct order. This formatting and ordering capability becomes important when transport-layer programs implement connections among dissimilar computers.

The data-link layer can count boxcars to see if they are all there. The transport layer opens them up to see if anything is missing or broken. If both these layers are doing their jobs right, linking and prioritizing doesn't have much to do.

SESSION LAYER - The session layer performs the functions that enable two applications (or pieces of the same application) to communicate across the network, performing security, name recognition, logging, administration, and other similar functions. The primary applications that make use of session layer communications are network gateway programs.

PRESENTATION LAYER - When you use blinking characters, reverse video, special data entry formats, graphics, and other features on the screen, you get into the presentation layer. This layer may also handle encryption and some special file formatting. It formats screens and files so that the final product looks the way the programmer intended.

The presentation layer is the home of control codes, special graphics, and character sets. Its software controls printers, plotters, and other peripherals. For microcomputers, this layer is the home of terminal emulators that make an IBM PC think it is a DEC VT-100 or IBM 3278 terminal.

APPLICATION LAYER - The application layer is where the network operating system and application programs reside, everything from file sharing, print job spooling, and electronic mail to database management and accounting. The standards for this top layer are few, and they usually apply only within a particular line of software products. Yet this layer is the most important one because the user controls it directly.

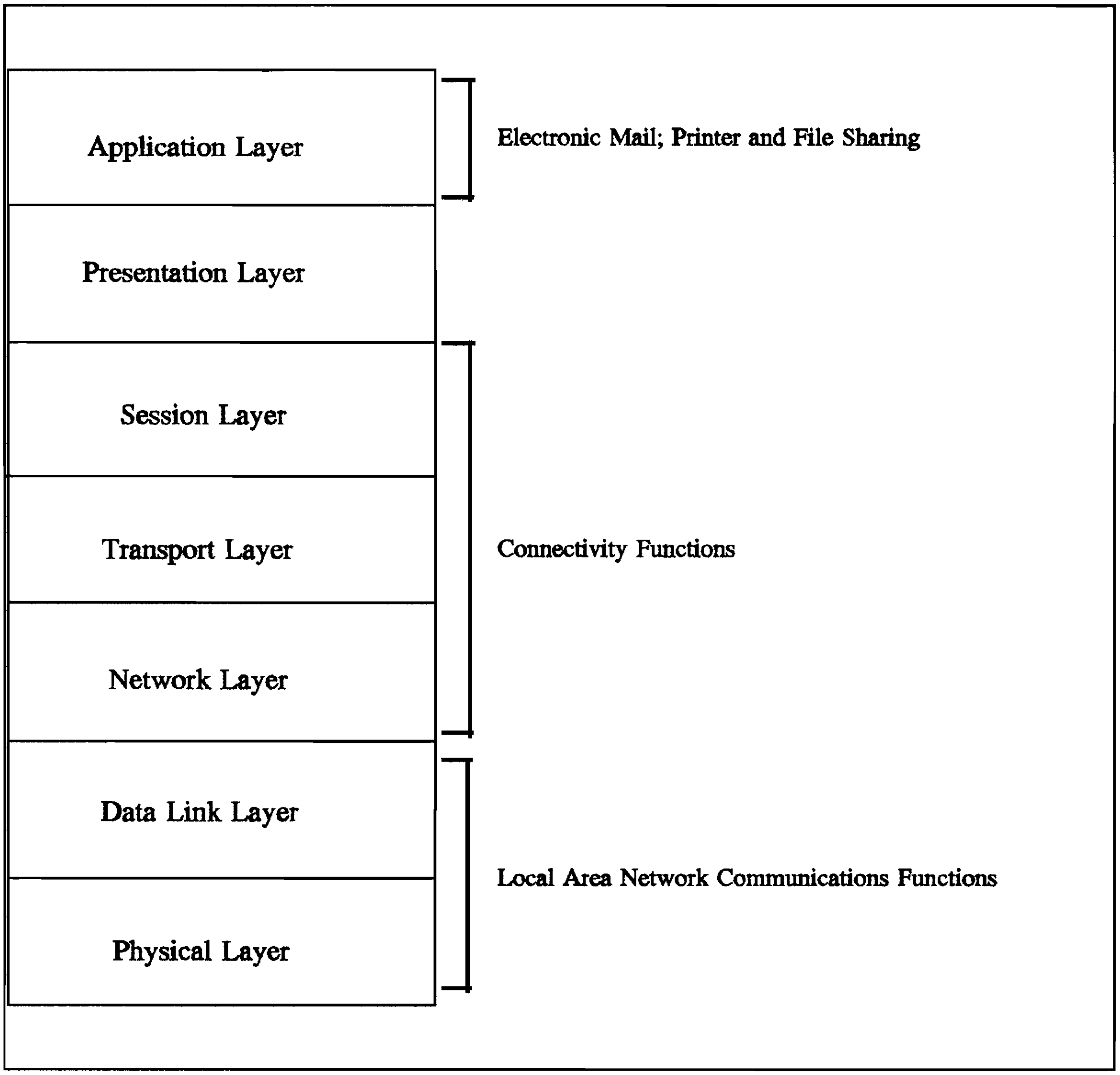

Figure Appendix 2-1

Networked Layers

APPENDIX 3

Local Area Network (LAN)

Local Area Networks (LANs) enable computer users to transfer files, manipulate data, and share resources with the same office or building. Multiple LANs can be interconnected among buildings in close geographic proximity to form metropolitan-area networks (MANs) or over larger geographic spans, wide-area networks (MANs).

When considering implementation of a network some issues need to be addressed. Some include LAN topology, transmission methods, media, information access, and network security and management. Appraisal of network installation factors begins with analyzing the proposed LAN applications.

LAN applications are typically classified as resource sharing or communications. Both applications involve a number of subcategories, and both require some type of network management. Successfully sharing resources among network users depends, to a large degree, on the concept of transparency - permitting users to access network resources with the same command syntax as they would if the resources were local.

Hardware Components

Servers. Most networks incorporate a stand-alone terminal device or workstation that functions as a file, applications, or print server for the other nodes on the network. Although most servers can also perform additional processing functions, such an arrangement can overextend the server capabilities and cause network traffic problems. Some LANs use multiple servers, with one server managing gateway communications and others acting as print or file severs, storing and distributing public and private files to other nodes on the network.

Workstations. Virtually all LANs rely on standard terminals, CPUs or compatible microcomputers or Apple Macintosh system for internetwork communication. Additionally, many vendors offer products designed specifically to connect multivendor LAN environments and thereby ensure interoperability.

Interface Devices. Network interface hardware products establish the intermediary connection between similar and dissimilar networking systems. Network devices include media attachment units (MAUs); attachment unit interface (AUI); LAN interface cards; line amplifiers, splitters, taps, and connectors; frequency agile modems; repeaters;

gateways; bridges; and routers. Table Appendix 3-1 lists the functions of these interface device.

Network Design. An efficient, well-designed LAN enables users to share resources effortlessly and transparently. Several aspects of network design contribute to efficient LAN operation, specifically the processing environment, topology, transmission, media, and access control.

The processing environment refers to the manner in which processing responsibilities are allocated to workstations and/or host computers within the network. Topology deals with the actual configuration of the network, as well as such related factors as network traffic, potential for downtime, and network overload. Transmission addresses the manner in which information is transferred, as well as then cabling media used during the transfer. Access and control provisions refer to the manner in which uses contend for available LAN resources. Virtually all networks adhere to one of the following four processing environments: centralized, distributed, client/server, or peer-to-peer. Although centralized processing offers some advantages in network security, network performance is unacceptable for many applications because each node must spend time contending for available host resources. The more recent

Table A3-1
Network Interface Devices

PRODUCT	FUNCTION
Media Attachment Units (MAUs)	Transmit and receive data and detect collisions via digital transmission. Contain all of the electronic components to send, receive, and manage the workstation's encoded data via a cable.
Attachment Unit Interface (AUI) Cable	Connects the computer interface board and MAU device.
LAN Interface Boards	Provide a connection between the user workstation and the network; the AUI cable connects this board to the MAU. The adapter often acts in conjunction with a communications protocol, which frames the data between network nodes.
Line Amplifiers	Receive, amplify, and retransmit incoming data signals. Function much like a line transceiver in conjunction with some systems.
Splitters	Generally function as passive devices that split an incoming transmission line into two or more outgoing lines, or recombine two lines into a single line.
Taps and Connectors	Typically marketed as electronic interfaces that provide outlets for four to eight links, or as Vampire

Table A3-1 Continued

	taps, which tap into a coaxial cable through a special clamping process.
Frequency Agile Modems	Broadband or carrierband compatible devices that modulate the workstation digital signal onto the LAN link. Frequency agile implies that the modem has the ability to vary its output frequency to conform to channel assignments for the network.
Repeaters	Repeat a signal by amplifying it, then restoring its original shape and strength while resynchronizing the data. Repeaters can also extend the length of a single network segment to lengthen the distance capacity of a network.
Gateways	Permit network users to exchange information via a single access port. Gateways, typically LAN workstations equipped with appropriate software, also provide protocol conversion, electrical connections, end-to-end translations, network routing, security, and error detection/correction for data packets being transferred between dissimilar networks.
Bridges	Interconnect similar LAN environments, such as Ethernet or Token-Ring networks. Many bridges also include security, error detection and correction, and address validation capabilities.

Table A3-1 Continued

Routers	Connect networks running the same higher-level protocol, typically operating at the network layer of the OSI reference model.

peer-to-peer, distributed, and client/server environment offload some processing responsibilities to one or more network nodes. In a client/server environment a sophisticated LAN workstation functions as the file or applications server, from which the other nodes on the network obtain information. In a distributed or peer-to-peer processing environment each node on the network assumes some degree of responsibility for data processing. Generally, distributed environments offer productivity improvements over conventional centralized networks and promote efficiency by sharing the burden of information processing.

The network topology determines the way in which local or remote network users send and receive data. The most common LAN topologies are: bus, ring, and star configurations.

- **Bus**. The bus topology offers the advantages of reliability and ease of expansion. Uses cable interfaces, or taps, to connect all network nodes to the same cable. Each node on the network has a unique address that differentiates it from others on the network. The target node must recognize its own address embedded within the message to receive a message specifically addressed to it.

Figure Appendix 3-1a.

- **Ring**. Ring networks provide connectivity by using point-to-point links that create a continuous, unbroken chain typically depicted in a circular arrangement. Cable links connect each adjacent pair of nodes, and all messages pass from one node to the next around the ring. Ring networks, like buss-based networks, can use centralized or distributed control. Though typically a distributed architecture that provides each node with equal access to network resources is used. Figure Appendix 3-1b.

- **Star**. In a Star topology, all nodes connect directly with an intelligent central node that supports interfaces for a large number of remote nodes. A peripheral node can control communications, though messages must still pass through the central switching node prior to reaching their target destination. Figure Appendix 3-1c.

In a distributed star topology, all peripheral nodes assume some degree of control, and access/allocation protocols in each node must process communications to other nodes. If the central node in a star network fails, the entire network goes out of service (if there are no redundancy provisions in place). Failure of a single peripheral node, however, does not pose any major problems.

Network Transmission. LANs typically transmit analog or digital information via baseband or broadband communication techniques, although some LANs support both methodologies.

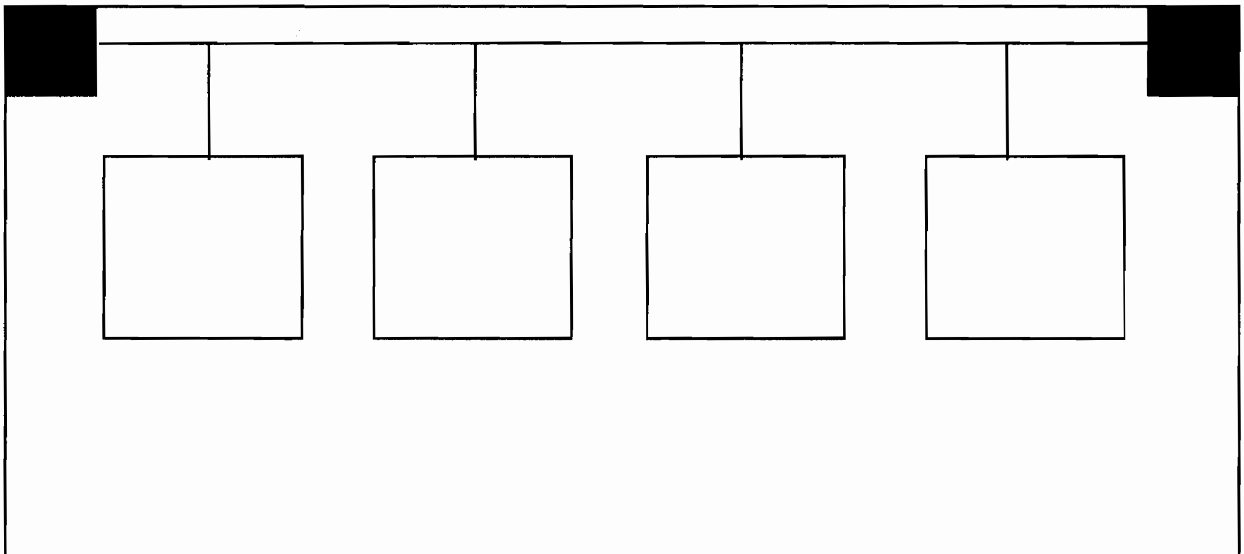

Figure A3-1a
Bus Topology

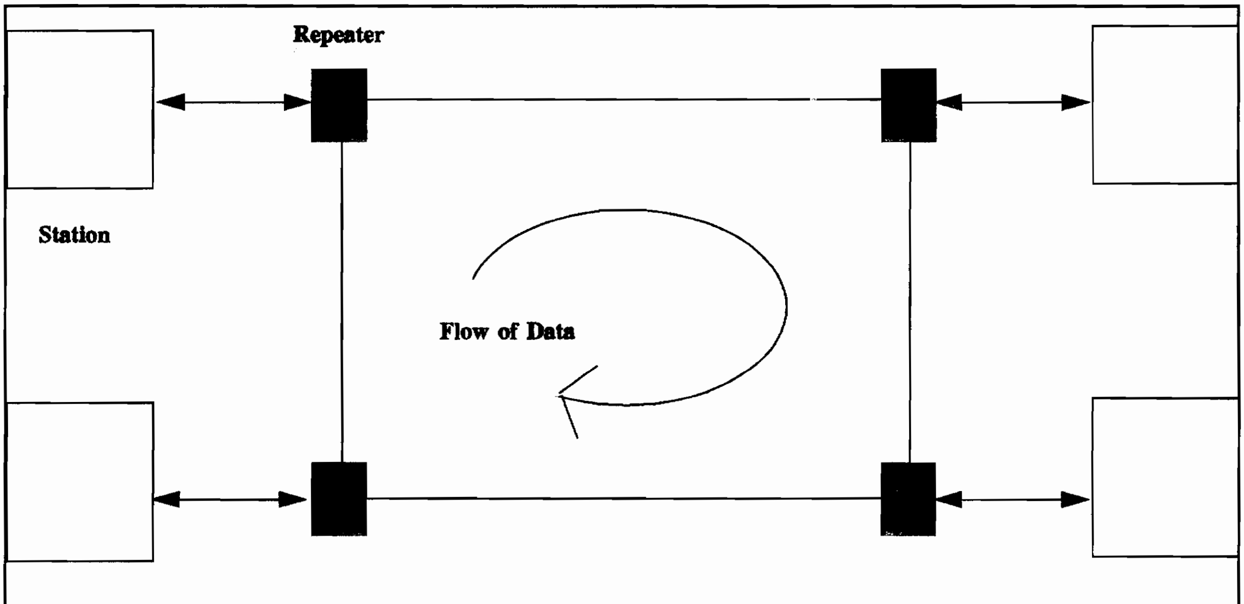

Figure A3-1b
Ring Topology

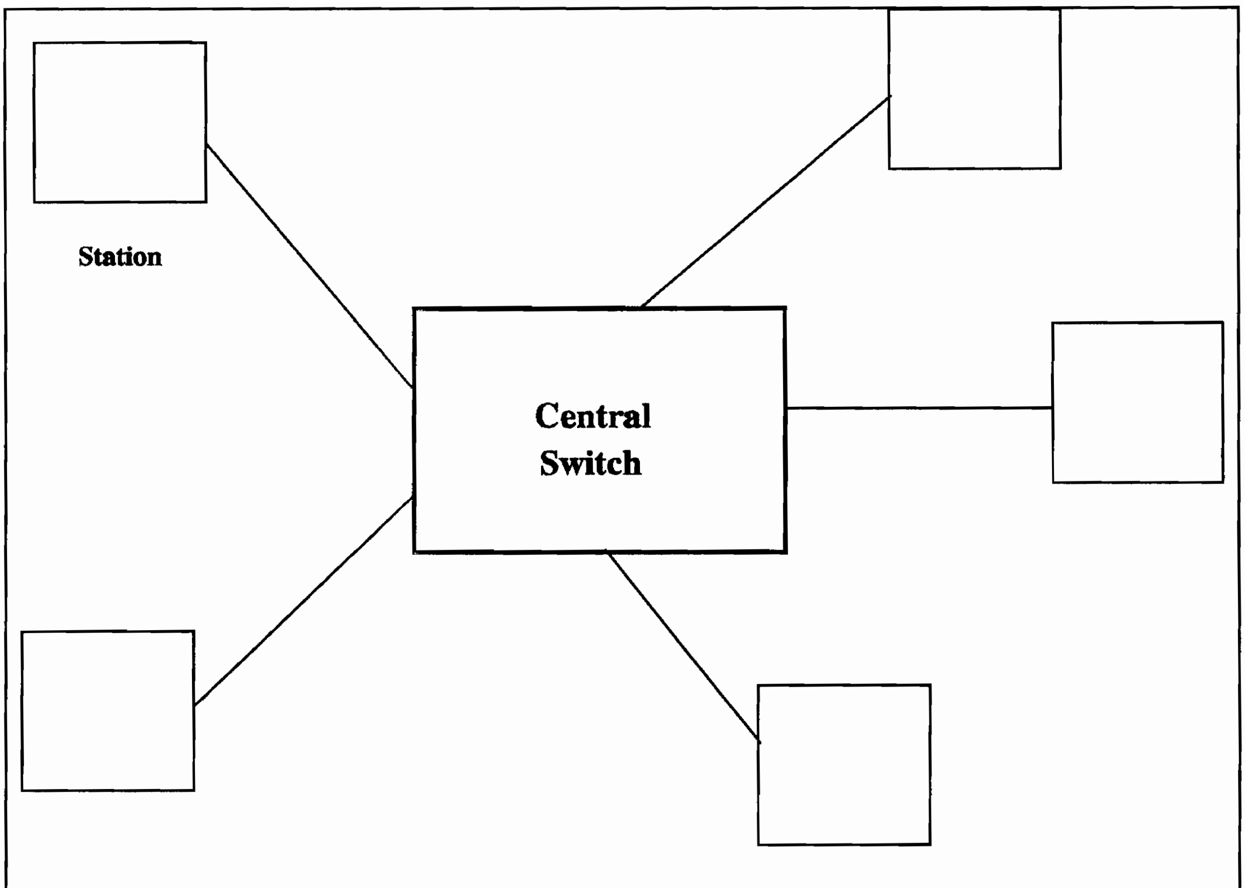

Figure A3-1c
Star Topology

- **Baseband.** Baseband communication is a single-channel transmission method that is used primarily for digital communications. Because baseband transmission uses the entire cable bandwidth to transmit a digital signal, it supports transmission from only one device at a time. Time-division multiplexing (TDM) is one method of allocating specific time intervals to multiple devices transmitting over the same cable, enabling them to transmit messages simultaneously.

- **Broadband.** Broadband uses analog signals providing multiple-channel capabilities across the entire cable bandwidth. With broadband transmission, the various channels can be modulated to represent the information they carry. Broadband techniques also support several transmission sources, including data, voice, and video applications simultaneously by dividing and allocating the available bandwidth to support separate functions.

- **Network Media.** A LAN requires a communication path, or medium, to transmit messages across the network. Using circuit and packet switching techniques, data is placed on the medium by the LAN node for transmission to the target destination using either centralized or decentralized control. Coaxial cable, twisted-pair wiring, and fiber-optic cabling are the most commonly used LAN delivery media.

- **Twisted-Pair Wiring.** Uses strands of copper wire to transmit analog or digital signals, is the most-widely used LAN medium. Although bandwidth varies depending on wire quality, signaling technique, and distance, speeds of up to 16 Mbps are possible with network repeaters. Similarly, although it can extend over distances as long as 10 kilometers, most network applications limit the use of twisted-pair wiring to a single building because repeaters are necessary to regenerate weak signals and ensure successful transmission over longer distances.

- **Coaxial Cable.** Coaxial cable offers advantages of wide bandwidth, low error rates, and high data transmission rates with considerable immunity to noise distortion.

- **Fiber-Optic Cable.** Fiber-optic cabling offers high-speed LAN connectivity, along with the advantages of durability and immunity to noise and electrical interference. The cables high transmission capacity enables a single fiber strand to carry traffic that would require many wires using conventional media.

In addition to the actual cable, a fiber-optic link includes a transmitter, which accepts analog or digital input and projects it along the cable in the form of light pulses, and a receiver, which accepts the light input and converts it back to its original form.

Fiber-optic cabling uses baseband transmission techniques and supports point-to-point configurations. It can achieve bandwidth rates of up to 50 Mbps over a distance of 10 kilometers or 140 Mbps at six to eight kilometers (without repeaters).

Access Control Methods

LAN access control methods determine the manner in which stations access a channel and move data from the sending node to the target node. Network topology, transmission method, and media, along with the specific hardware and software, all help to determine the appropriate LAN access method.

A data path through the LAN medium can be divided by space, time, or frequency multiplexing to ensure efficient utilization of the available bandwidth. In general, bus-based LANs require considerably more attention to allocation methods because such configurations are contention-based (i.e., stations must compete for a channel).

Because broadband LANs support a variety of signal types, (video, voice, and data) they require multiplexing to transmit data over multiple channels. While baseband LANs generally use time-division multiplexing (TDM), broadband LANs generally use frequency-division multiplexing (FDM). Regardless of the LAN configuration, workstations on the LAN either receive a permanent channel assignment, request the use of a channel from a central control node, or share a channel with other nodes using TDM.

LAN media access control (MAC) can be either centralized or decentralized; if the MAC is centralized, a central controller uses polling techniques to determine when access and transmission can occur. Workstations transmit data when requested to do so or when the central controller honors a service request. Disadvantages of centralized control, however, include the overhead associated with polling (which decreases the network throughput) and the disruption of the entire network if the central controller experiences a malfunction. Network node failures, however, have minimal impact on overall network operation and fault diagnosis.

Decentralized media access control permits each node to take responsibility for its own access to network facilities and for resolving contention and collision issues. Most centrally controlled LANs use deterministic access control, while decentralized environments use nondeterministic access control, also referred to as random or contention access.

- **Token Ring**. The most widely used deterministic access method, token passing, continuously circulates a special bit pattern throughout the network. Control of the network at any time rests with the node that has the token, which can require other nodes on the network to respond to its request for data. After transmitting data, the node passes the token to the next adjacent node in a predefined order and prescribed time frame.

Token passing is most commonly used in ring-based LANs, and somewhat less frequently in bus networks. In both topologies, the message size (number of bytes of data) and number of devices on the network determine throughput. The token's availability is represented by either a binary 0 (free) or 1 (busy). Because the token is typically eight bits long, the remaining seven bits represent related network activities such as monitoring, reservation schemes, and prioritization.

A node gains access to the ring when it has an empty token. The node then marks the token as active and appends data behind it. If a station has more information to transmit than a token's data packet can accommodate, segmentation and reassembly occur in the node network interface. In this case, the sending device's interface stores the data in a buffer and transmits it in separate packets using a sequence number.

In a bus network, token passing occurs by establishing a logical ring structure, with each interface unit directly attached to the bus. The token is passed from device to device using an addressing scheme established during network implementation. In logical rings, the token carries the address of the next device in a defined logical sequence. A node possessing the token can use the bus for a specified maximum hold time. When this time expires and the current transmission is completed, or the device has no data to send, the token passes to the next device.

Carrier Sense and Collision Detection (CSCD). In a nondeterministic or contention environment, network nodes compete for access and control of the media. If two or more terminals contend for the media simultaneously, the resulting collisions invalidate the transmitted data and require retransmission. With CSCD, however, collision detection and retransmission control functions are based on timing algorithms and are relatively straightforward. CSCD is, however, really effective only in LANs with low-traffic volume.

Carrier Sense Multiple Access (CSMA) and Carrier Sense Multiple Access with Collision Detection (CSMA/CD) are the most commonly used access methods in a contention environment. Bus-oriented LANs such as Ethernet typically utilize CSMA, which allows nodes to monitor the network for active transmissions prior to sending a message. The method by which a node does this is referred to as Listen Before Talking (LBT). If the bus is free (i.e. no activity on the network), the node can proceed with its transmission. If, however, two or more nodes test the availability of an otherwise clear network at the same time and receive notice to proceed, a collision will occur.

To resolve some of these problems with CSMA, non-persistent CSMA was developed which requires a station to monitor the network medium and transmit only when there is no other activity; if the medium is busy, the node waits a random amount of time (calculated from a probability algorithm) before testing again. If the node encounters a busy condition on the next attempt, it repeats the testing cycle until the medium is available, then proceeds with the transmission. The random testing sequence, which is controlled through the station interface to the LAN, reduces the possibility of a collision.

If, however, several stations are trying to send data, the random waiting sequence can result in idle time on the channel following transmissions. Another variation of CSMA, Persistent CSMA, is intended to avoid this situation. With this technique, a station continually listens to the bus and transmits when it is idle. If the station determines that a collision occurred due to lack of acknowledgment, it repeats the cycle. The chances of a collision increase, with 1-persistent, however, because more than one device may try to transmit at the same time. Another alternative that attempts to reduce both collisions and idle time is referred to as P-Persistent CSMA. With this technique, a network node transmits when the bus free, with the probability of a variable (P) plus one time unit equal to the propagation delay time. Each network node uses a different P value and spaces the transmission attempts progressively farther apart to maximize channel utilization at the cost of message delay.

A major disadvantage of CSMA is the inability of the medium to transmit after a collision occurs; this instability is particularly troublesome when long data strings collide. The solution to the problem is yet another variation of CSMA, CSMA with Collision Detection (CSMA/CD), in which the sending node continues to monitor the channel after initiating transmission in order to detect a collision. Because LANs typically operate over relatively limited geographic areas, feedback occurs quickly, permitting the sending node to abort transmission and alert other network nodes via a jamming signal. The sending node then retransmits after waiting a random amount of time.

A variation of CSMA/CD, CSMA with Collision Avoidance (CSMA/CA) uses a priority scheme to safeguard the data communications requirements of high-priority network nodes. This technique imposes a delay, corresponding to the priority level of the node, after each data transmission. High-priority nodes, thus experience shorter delays. Using a priority technique of this type usually avoids, but does not completely eliminate, collisions.

LAN Software

Network software includes tow major subcategories; input/output software and the network operating system. The network operating system controls access to shared resources, maintains the integrity of the network, provides security, and supports such common functions as electronic mail and print server functions across the network. Input/output software, on the other hand, provides the foundation for local area network access between workstations on the network. NetBIOS (Network Basic Input Output System) continues to be the most widely used network I/O software, and is now bundled into the software configuration of many LAN products. NetBIOS, which originated with IBM's PC Network consists of an extended set of primitive LAN communications routines that represent the portals through which LAN software accesses the physical LAN adapters as well as providing application program communication through the LAN.

In addition, numerous application programs are specifically designed to take advantage of LAN capabilities. Applications that are particularly well suited to LAN operation include word processing, desktop publishing, data base management, computer-aided design (CAD), and accounting products. Similarly, many software vendors offer communications programs that facilitate interconnection between LANs and host computers.

Network Management

As LANs continue to expand their geographic and functional boundaries, the need for centralized management of the entire network becomes increasingly critical, both to ensure optimal performance of the network and its various resources, and to safeguard network data and resources from intentional or accidental misuse. Ideally, a network management system enables a network administrator to monitor all components of a network to maintain a level of performance that is consistent with the information distribution and application access requirements of the network users. A comprehensive network management system involves a complex arrangement of software tools (e.g. LAN resource control, network performance tuning and load measurement, and diagnostics) along with dedicated hardware devices such as protocol analyzers and line monitors.

Technology and Applications

LAN technology is changing rapidly, driven by the increasing sophistication and a shift in traditional office orientation. Although the majority of existing LAN installations are still intended primarily for communication among geographically dispersed workstation, industry analysts predict that the majority of LAN installations during the next five years will focus on high-level resource-sharing applications such as CAD/CAE and massive data base sharing.

The current trend toward decentralization, along with long awaited network standards, is fueling the LAN market growth. As companies downsize and disperse their data processing facilities, there is an increasing need to shift information storage and processing responsibilities from a host computer to network nodes. Such decentralization creates a need for network products that address distributed or cooperative processing environments, whether they utilize a client/server or peer-to-peer architecture. Similarly, user demands and the increasingly competitive nature of the LAN market itself, are pressuring LAN vendors to continually enhance their offerings to support emerging industry standards, integrate efficiently with a range of other hardware and software platforms, and take advantage of recent technological capabilities such as fiber optics and increasingly-powerful servers based on high-speed microprocessors. Ongoing improvements in LAN transport media and access methods, along with new software capabilities that enable uses to efficiently share resources such as application files, are also likely to have a substantial affect on the future of LANs.