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REQUIREMENT SPECIFICATIONS FOR STANDARD LOCAL AREA NETWORKS AND APPLICATIONS FOR NAVAL AVIATION SQUADRONS

by

Laura E. Mason

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Thesis Advisor: Robert Knight

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by

Laura E. Mason
Lieutenant, United States Navy Reserve
B.A., Auburn University

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of the requirements for the degree of

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Author: Laura E. Mason

Approved by: Robert Knight, LCDR, USN, Thesis Advisor

Dr. Henry Smith, Second Reader

Professor David R. Whipple
Chairman, Department of Administrative Sciences

ABSTRACT

This thesis will address unique characteristics and requirements for implementing a Local Area Network (LAN) and standard applications at the Naval Aviation squadron level. The introduction will present the history and basic concept of LAN's at squadrons as well as defining the problem that exists. Examples of Local Area Networks are presented to provide a basic understanding of the technology involved. The organization of Naval Aviation squadrons is discussed to illustrate the high level functional requirements. Areas to be covered in the requirements specifications are then discussed to ensure completeness and the overall success of this concept. Performance, documentation, training, support and security are a few of the issues that are addressed. Complete specifications, a coordinated and well thought out plan and designation of a project manager are critical elements that cannot be ignored if the project is to succeed.

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CHAPTER I. INTRODUCTION

A. GENERAL

The advance of the microcomputer industry has greatly impacted U.S. Naval units, shore-based and afloat. Men and women in the armed forces prove efficiency of personal computers (PC's) in report writing, enhanced training and multiple database applications. Software programs are developed by outside organizations, NARDAC facilities and local experts at the different units each with varying standards. Two problems needing immediate attention are lack of standardization of these applications and underutilization and inefficient use of hardware and software in similar types of Naval units.

Resource reductions require more efficient use of each unit's assets. PC's have generally have been underutilized in Navy squadrons primarily due to lack of training. Squadron programmers develop applications that fit local needs but suffer from a lack of documentation and maintainability. When a programmer is transferred, the application software loses its value as the knowledge source leaves the squadron. Local Area Networks (LAN's) can capitalize on the use of PC's and improve communication throughout the squadron. For example, a database that is used by one department could be shared with other departments. By standardizing the applications, personnel could be trained in classes, thereby alleviating the problem of losing the expertise every few years. This thesis will focus on the unique characteristics and needs of a Naval Aviation squadron for developing standard applications and LAN's.

B. HISTORY

1. Local Area Networks

Local Area Networks became a reality in the late 1970's, as the emphasis changed from large centrally managed mainframes to distributed systems capable of supporting a number of users. LAN's proved to be a more convenient and cost effective way of supporting a number of PC's [Ref. 1, p.7], by sharing software programs, high quality printers and high capacity disks among many users.

As technology increased and improved user interfaces, LAN's gained in popularity and use. Workstations were less expensive to operate. Affordability, ease of installation and interconnectability are the primary strengths of LAN's. LAN's evolved almost overnight from a research curiosity to an attractive solution [Ref. 2, p. 10]. Although Local Area Networks provide a cost effective solution to most problems associated with distributed processing, there are disadvantages that should be addressed. Networks require management to ensure all workstations adhere to proper operating standards. This can be a difficult task. Another problem is that network software is more complex to develop and modify. High level and low level protocols are necessary for communication between computers on the LAN and from other network systems. Finally, security issues, always a concern in the Navy, multiply in LAN's.

2. Naval Aviation Squadrons

In the early 1980's, computers made their initial appearances at the squadron level. Naval personnel began to realize word processing capabilities as well as time savings. Preparing flight schedules and maintenance records suddenly became easier. Spreadsheet applications aided budget preparation and analysis. By the mid eighties, the Navy procured Xerox FLEETWORD II PC's, Zenith 120 and Zenith 248 computers to be used at the squadron level. Hardware and software proliferated. However, a lack of overall coordination created many problems and many assets were not being used.

Today, coordination is needed to standardize the applications throughout the Navy so that each squadron's five major departments (Administration, Operations, Maintenance Administration, Personnel and Maintenance Control) can maximize on the capabilities and minimize cost. Integrated data bases and shared applications and resources on the LAN's need to be managed by an effective network operating system that can interconnect different types of machines. With proper design and management, local area networks can provide: inexpensive communication between workstations and devices, distributed processing, rapid access to distributed data banks, and sharing of expensive devices and resources. [Ref. 3, p. 143]

Standardization is needed to correct the inequities and inconsistencies of microcomputer usage throughout the Navy. A thorough examination of applications common to all aviation squadrons would identify those applications which need to be standardized. LAN's already exist in various commands in the Navy, but have not as of yet been formally introduced or standardized in Aviation squadrons.

C. THE PROBLEM

The Gramm-Rudman-Hollings deficit reduction act forces the Navy to seek innovative cost-saving solutions. LAN's can provide cost savings in sharing ADP equipment as well as reducing paper requirements through E-mail software throughout an organization. The Navy has expended a significant amount of resources in providing Xerox Fleetword II, Zenith 120 and 248 PC's to most Naval Aviation squadrons. As Navy managers, we face a challenge to utilize all the resources and maximize the benefits.

Is it feasible for the Navy to spend over a hundred thousand dollars [Ref. 4] developing specific applications that are generic enough for all squadrons to use on a local area network? This question is currently being addressed by COMNAVAIRLANT, who is sponsoring a project by TASC (The Analytic Scientific Corporation). COMNAVAIRPAC has also been involved, and this project has become a high priority topic. Currently the contract is being negotiated in the Office of Naval Research.

Careful consideration needs to be taken when designing and developing LAN's and applications in an area as large as the entire realm of Naval Aviation squadrons. Users from all different types of squadrons need to be involved and be able to input ideas and their requirements for the applications if they are to be Navy-wide applications. The costs and benefits will be analyzed with the current requirements and future considerations for expansion.

General characteristics and components of Local Area Networks will be discussed in this thesis for basic understanding without presenting too much detail. Topology, media, protocols and operating system, are a few examples of the components that must interface to support the applications needed by all Naval Aviation squadrons. The main emphasis of the thesis will address high level functional and lower level squadron requirements for developing standarized LAN's and applications. Finally the conclusion will present an overall summary and recommendations for the success of this project.

CHAPTER II. LOCAL AREA NETWORKS

A. DEFINITION

Local area networks have been described as an interconnection medium that covers a limited geographical area where workstations on the network can communicate with other nodes and can exchange computer data, word processing and several forms of electronic messaging. Most LAN's reside in a single office or building and are usually under the control of one organization. A clearly significant attribute of LAN's has to be connectivity - the ability for any given point to communicate with any other point.

1. Connectivity

Connectivity is the driving concept behind local area networks. LAN's are a recognition of the need for people to use and pass data from one person to another. Connectivity allows sharing of software applications and peripherals such as expensive laser printers.

Each device on the LAN is addressed as an individual connection. Sessions occur when a circuit is established between connections. Network nodes are intelligent devices on a network and may support one or more connections. For future expansion, Local Area Networks can be connected to other networks through gateways which allow a user on one network to communicate with a user on another. An example is a user on a LAN at the Naval Postgraduate School connected to the DDN (Defense Data Network) that can communicate with another user on a LAN at the Pentagon.

2. Components

A LAN is composed of the following:

- FILE SERVER: File servers are dedicated computers, usually more powerful than the user computers, that serve the other nodes by providing a central data base, software applications and a coordination point for managing the network. There may exist one or more file servers depending on the needs of the organization.

- MASS STORAGE DEVICES: These are usually large capacity hard disks in or attached to the file server for the purposes of storing more data. A tape backup for small organization is typically 60 MB. There may exist more than one storage device, dependent on the needs of the organization.

- WORKSTATIONS: Intelligent workstations (personal computers with some memory) or dumb terminals (no memory) can number anywhere from 2 to 200 or more dependent on the size of the LAN or organizational needs.

- NETWORK INTERFACE CARD (NIC): A NIC is installed in each computer as well as the file server. These NIC's, sometimes referred to as network boards have built-in functions, such as controlling inter-application communication, which provide the logic for each type of LAN topology.

- CABLES: There are different types of connection cables but all provide the connection between the NIC in the workstations and the file server. Fiber optics, coaxial, and twisted pair are the most common types of cable.

- NETWORK OPERATING SYSTEM (NOS): The network operating system is installed in each file server to control access to common shared areas and devices. The NOS enables the LAN manager to guard security by assigning access rights and is indispensable in organizing multi-user applications such as the database.

3. Network Operating Systems

According to an article by Robert Lauriston in PC World magazine, "When you're serious about networking an office full of PC's, chances are you have more in mind than sharing printers, sending E-mail and exchanging files. That's because the mother lode of productivity lies in consolidating data with a multi-user application, usually a data base. And like it or not, multi-user software means buying a server plus a high-end, server-based network operating system to match." [Ref. 5, p. 88] Network operating systems (NOS) provide the integration between traditional operating systems executing on each individual workstation.

The NOS functions as a shell at each workstation to screen requests to access a file server or ensure that the local DOS is capable of executing the request. They perform basic yet important LAN management functions such as:

- enabling administrators to guard security by controlling user access to applications, data files, and network sources (printers, modems, and remote subdirectories).
- running multi-user applications.
- performing administration tasks such as assigning access rights to the network resources and rearranging the user configurations when necessary.

In 1984 IBM introduced its PC Network and the NETwork Basic Input Output System (NETBIOS). Most manufacturers of LAN software have announced or implemented support of NETBIOS and its operating environment, the PC-Network Program, which is noted for its low cost. Novell's NETWARE is a strong competitor, and "the current leader" in NOS's over NETBIUOS and has supported LAN development longer than IBM. [Ref. 6, p. 207] The primary advantage of NETWARE is its transparency while executing on a wide variety of network hardware. Network Operating Systems are the key element in overall manageability of LAN's and should be chosen with future expansion considerations in mind.

B. CHARACTERISTICS OF LAN'S

1. Topology/Access Methods

LAN's may be organized in many different ways. Even after they have been designed, they remain in a constant state of growth and development. If the network has only one host computer doing all the data processing from one or more remote workstations, then it is a centralized network. If there are many remote workstations processing different jobs for different end users, then the network is considered distributed. Several characteristic network topologies, or network configurations, will be discussed: star, ring, bus and hierarchical. Figures 1-4 depict the different topologies.

a. Linear Bus Topology (Figure 1)

In bus topologies, a single communications circuit is shared by every workstation. However, the circuit is not joined together to form a loop. Each workstation uses the bus to communicate with every other node. The most common access method used by linear bus topologies is CSMA/CD. With this topology each node constantly monitors the common line, waiting for the bus to go idle, at which time the node can transmit. If another node sends a signal at the same time a collision occurs. Since the node is still monitoring, it knows the collision has occured (collision detection) and can execute a retransmission algorithm, usually based on time delay. The IEEE 802.3 protocol includes rules that determine how long the nodes will wait for another transmission.

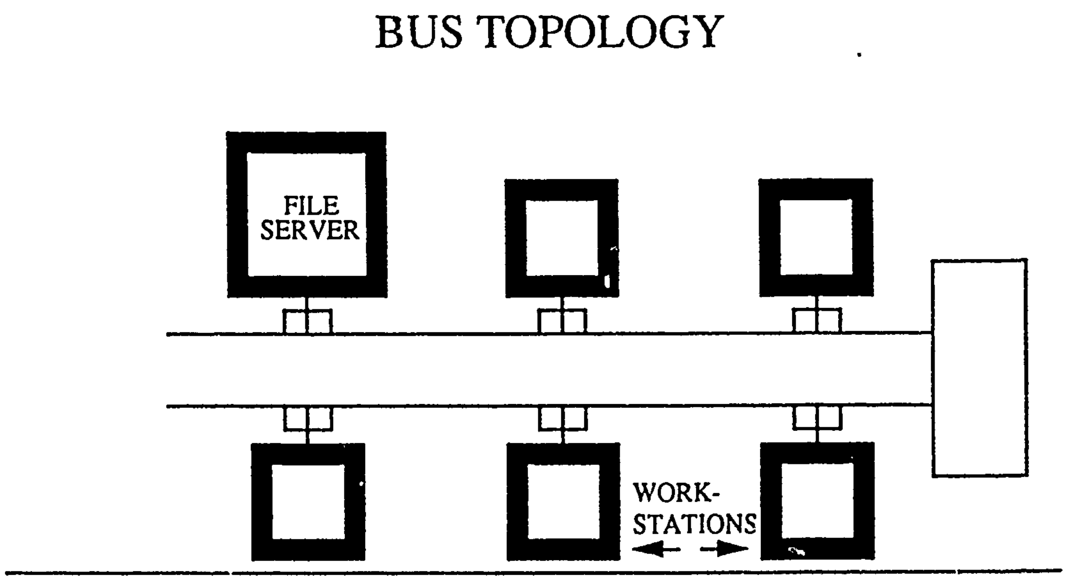

Figure 1 - Bus Topology

b. Centralized Star Network Topology (Figure 2)

In star topologies, the central controlling device is an intelligent computer, usually the file server.

The star network topology is similar to the local telephone system. The central controlling device in this case is the private telephone exchange which is usually an automatic device (a PABX - Private Automatic Branch Exchange) that allows any telephone to dial directly to another.

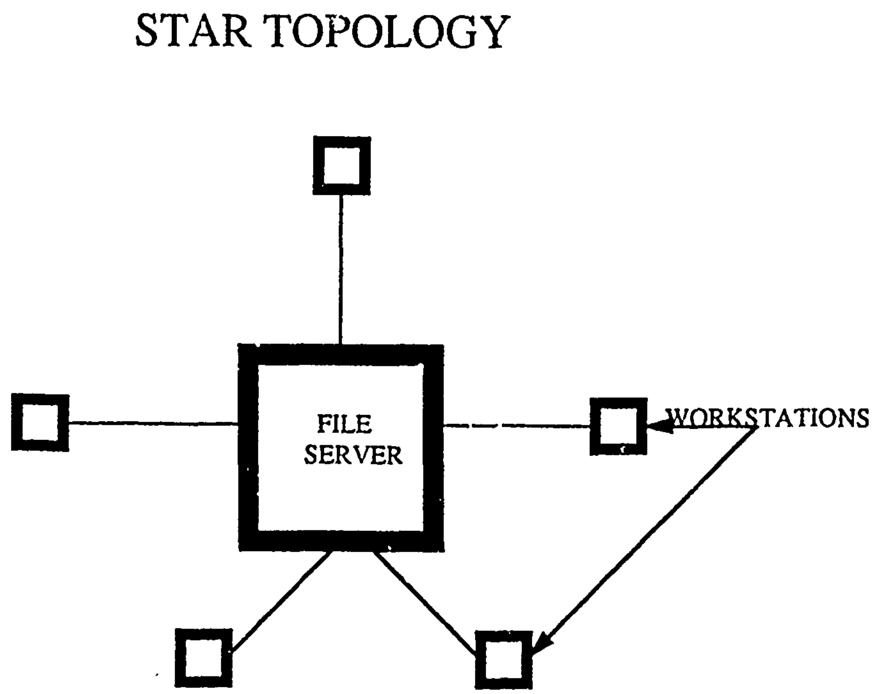

Figure 2 - Star Topology

The star topology commonly uses the polling protocol. It queries each node in a predefined sequence, querying for a request for network access. If such a request is made, the message is transmitted. If not, the central device moves on to poll the next node.

A star network is subject to failures of the central computing device. Reliable backups must exist to keep the network going. Also in a centralized network, "... the hub by virtue of the intelligence it requires to control even the simplest network will be quite a costly item itself." [Ref. 7, p. 17] On the other hand, the advantages of the star network are that it is ideal for many-to-one configurations meaning all the terminals need to access the central file server more than they need access to the other terminals. This topology provides easy fault detection and a higher level of security is possible because the central file server is able to determine the source of faults or security infractions.

c. Ring Network Topology (Figure 3)

In a ring network each workstation is connected to two other workstations. No single node exists with overall authority to control the order which nodes can send or receive messages. The rings consist of a series of repeaters or transceivers connected by the type of cabling medium chosen for the network. This topology eliminates the dependance on the central node while providing connectivity between all workstations on the network for high speed data transmission. Transmissions on a ring usually are in the same direction making the network design less complex. The cost of installing a ring network can be one of the lowest of LAN topologies. A few of the disadvantages are that reliability is dependant on the ring and the repeaters, routing can become complex having to be connected to the hub and it is difficult to add new workstations without bringing the whole network down.

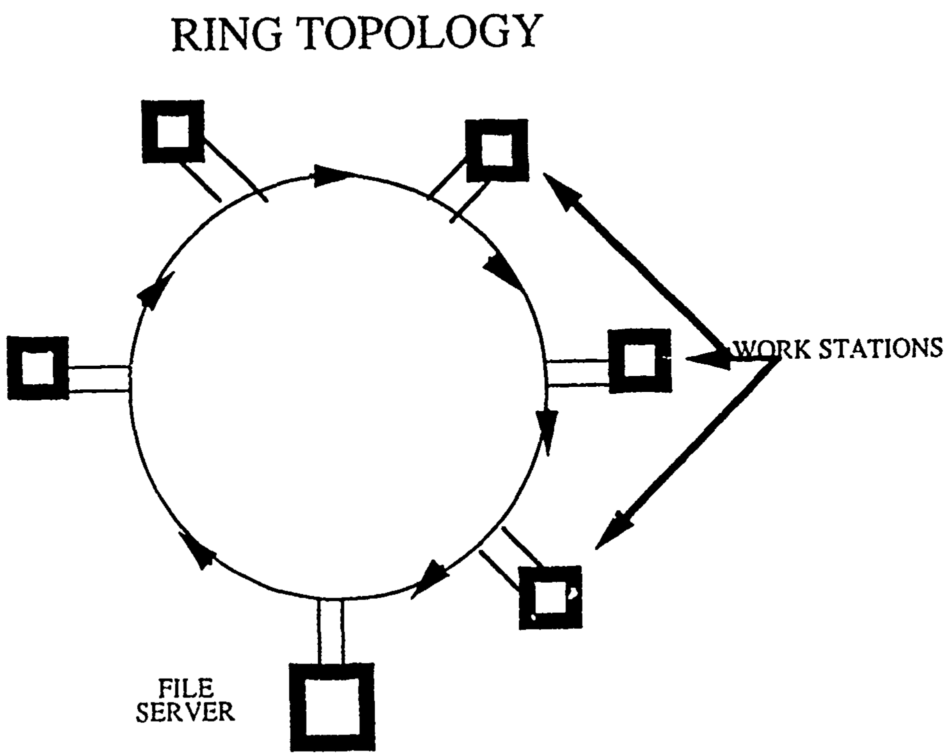

Figure 3 - Ring Topology

The token passing protocol is similar to polling but without a central controller and is associated with either the ring or the star wired bus topologies.

This protocol is a more organized method of communicating on the network. Each node passes the token to the next assigned node giving it an opportunity to transmit its data. With token passing on a ring, the token is always passed in one direction, according to the way the network is cabled. Each node receives the token from the node on one side, and passes it on to the node on the other side in the physical ring sequence.

d. Tree/Hierarchical Network Topology (Figure 4)

The tree topology is basically a series of buses connected together. Usually there is a central

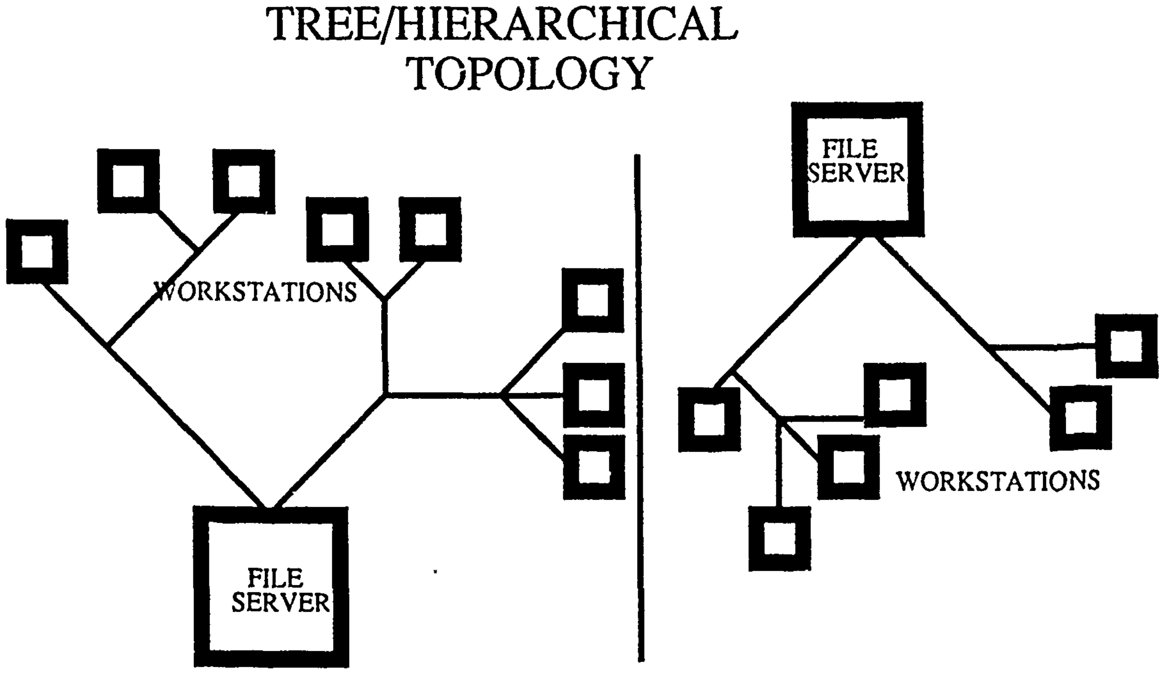

Figure 4 - Tree/Hierarchical Topology

backbone bus that has a number of smaller buses. Tree and hierarchical network topologies are fully distributed networks in that there are several layers in this topology. The workstations, used for remote devices, have independant processing capabilities and use resources at different levels as needed. ".... The tree network is best suited to the broadband method since the transmissions are modulated analogue signals - two frequency channels being used, one for transmissions and the other for receiving." [Ref. 8, p. 30]

e. Comparison of Topologies

Local area networks are usualy stars, rings, bus or tree networks because these offer the best compromise between cost, resilience and efficiency. Fully interconnected and mesh networks require too much cabling and are too complex to install and control. Table 1 shows an outline of the advantages and disadvantages of each of the networks.

CSMA/CD, or historically known as Ethernet, bus networks are used extensively in technical and office environments but the medium access control procedures are more complicated when compared to CSMA/CD. Complications arise mainly when faults in accessing data develop and are associated in the ring management procedures. The token bus network access method is deterministic in nature and has the ability to prioritize the transmission from the terminals. Therefore the token bus networks are primarily used in the manufacturing industry. The tree/hierarchical networks are used for remote devices that may have independent processing capabilities and require resources drawn from higher or lower levels. The most important factor that will determine the topology of network will be the requirements of the system. In other words what the user wants from the system. If users want centralization and high security the star topology would better fit the organization. A different organization might benefit from

TABLE 1 - COMPARISON OF TOPOLOGIES

[Ref. 9, pp. 2-11, 12]

COMPARISON OF TOPOLOGIES AND COMMUNICATION PROTOCOLS

ADVANTAGES	DISADVANTAGES
STAR/POLLING EASY TO MODIFY CABLE LAYOUT QUICK IDENTIFICATION OF FAULTY LINES NO DATA COLLISIONS SY TO ADD WORKSTATIONS	STAR/POLLING USES ALOT OF CABLE USUALLY MORE EXPENSIVE (CABLE COSTS) DEDICATED SERVER REQUIRED, SUBJECT TO SYSTEM FAILURES NOT SUITED FOR PEER-TO-PEER COMMUNICATIONS
LINEAR BUS/CSMA USES LEAST AMOUNT OF CABLE LOWEST PRICE	LINEAR BUS/CSMA BOTTLENECKS CAN OCCUR IN NETWORK COMMUNICATIONS H/W BUGS ARE DIFFICULT TO ISOLATE REQUIRES ADVANCED PLANNING FOR CABLE ROUTING
RING/TOKEN PASSING NETWORK CAN COVER GREAT DISTANCES EASILY ADAPTS TO FIBRE OPTICS BASIC SYSTEMS CAN COST LESS THAN STAR	RING/TOKEN PASSING COMPLICATED NETWORK CONFIGURATIONS EXPANDED SYSTEMS CAN BE COSTLY COMPLICATED CABLING SYSTEM

a bus topology if the network load was low and the budget did not allow for a more expensive design.

2. Connection Media

Many different types of media are used to provide LAN connectivity. The most common are twisted pair copper cables and coaxial cables (for either baseband or broadband). "As the engineering problems involved in using fiber optics disappear, this technology will become more important, possibly overtaking coax sometime in the 1990's." [Ref. 10, p. 63]. However, there are some LAN applications where flat multiconductor "ribbon" cables, infrared light transmitters and receivers, and microwave systems are being used but are beyond the scope of this thesis. There is no one best transmission medium. It all depends on what the organization wants to accomplish as well as what kind of budget they are working with.

a. Twisted Pair

In the past, electronic communications were accomplished with twisted pair cabling. The media of the telephone industry is logically based on twisted pairs of copper wires, hence the term "twisted pair." Many telephone systems today are using different forms of media today mainly because the electrical characteristics of copper wire introduce distortion that increases with speed and distance. The advantages of twisted pair cables are:

- it is a well understood technology
- minimal skill levels are needed to connect devices

- quick and easy installation
- there are minimal emanations of electrical or magnetic signals, thereby reducing security risks.

b. Coaxial Cable

Coaxial cable is composed of one wire (a conductor) that is surrounded by a shield that acts as the ground. Both are protected with an insulating jacket. Coaxial cable comes in a wide variety of types and thicknesses. Thicker cable carries signals longer distances but is more expensive and less flexible than thinner cable which can be used where space is a constraint.

The advantages of coaxial cable are:

- it supports both broadband and baseband
- it can transmit voice, video and data
- it is easily installed
- the technology is well understood
- there is a wide availability through pre-existing installations.

The coaxial cable that supports baseband and broadband bus networks differ in the way radio frequency (RF) signals are transmitted. The baseband signal is unmodulated and digital information is broadcast as a series of pulses that represent zeros and ones. These voltages of 0's and 1's are then applied directly to the medium. The line signal varies with time between the two levels as the data are transmitted. In the LAN environment, networks divide up the time interval between all the users so that at any given time only one node can transmit to the bus. In broadband bus networks the data is modulated onto carrier waves through the cable and demodulated when the data signal is received. RF modems are the devices that are used to modulate the digital information. Modem stands for MOdulation and DEModulation. A comparison of baseband and broadband demonstrates that where baseband is simple, inexpensive but limited in total length and capacity, broadband is overall more costly and more complex but can handle long distances, high speed traffic and can mix video, data, voice on one cable.

c. Fiber Optics

Fiber optic cable is used for high speed, high capacity communication applications, particularly when freedom from noise and electrical interference is important. A fiber optic cable is a very thin fiber made from two kinds of glass. There is an inner core and an outer layer that have different indexes for refraction. This means that transmitted light pulses are prevented from passing through the fiber's outer surface. It is protected by another layer to lend to structural integrity. Fiber optic cable does not have the environmental problems such as corrosion and electrical noise, inherent in twisted pair and coax. Also it can be submersed in water with no difficulties.

The main drawback of fiber optics is that devices for splicing and tapping cable are expensive and difficult to use. This form of media ma-e its success in network applications limited to smaller numbers of terminal connections. The advantages of fiber optic cable:

- best in applications that require high transmission rates
- it does not emanate electrical or magnetic signals
- it is immune to interference, cross talk, lightening and corrosion
- potentially less expensive medium
- can propagate a signal without boosting over a longer distance than copper wire
- for security purposes, it cannot be tapped.

3. Network Standards

Standards that pertain to Local area networks are those which deal with media, access and data transmission. The Open Systems Interconnection Model (Figure 5) was developed by the International Standards Organization (IS) in 1977 as a result of a study on the compatibility of network equipment. The next study was by the IEEE 802 project (The Institute of Electrical and Electronics Engineers Local Area Network project). In 1982 the IEEE 802 project summarized the definition of LAN's and provides the standards that can guide the manufacture of LAN components and software. Future standards of the project will define gateways and bridges.

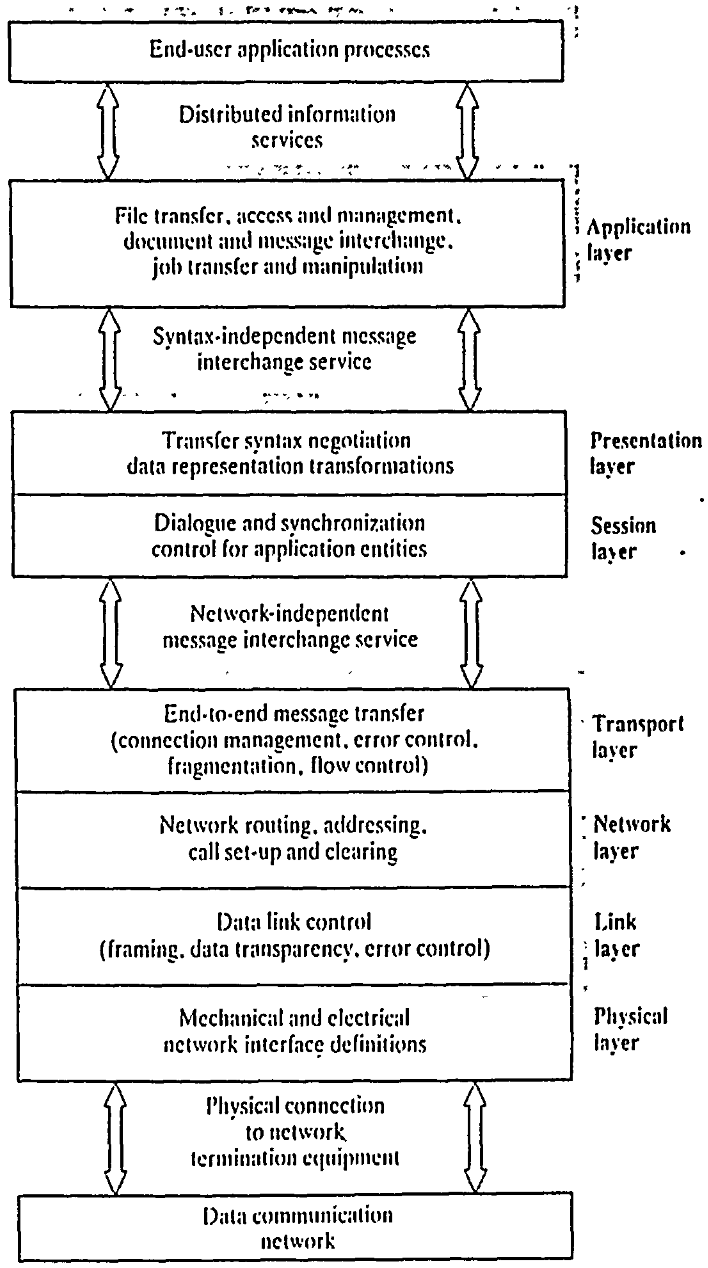

Figure 5 - OSI Model

[Ref. 11, p. 210]

a. International Standard Organization's Open Systems Interconnection (OSI) Model

The OSI model divides network issues into seven functional layers. This provides a common framework to address networking problems and opportunities. Compatibility of equipment can be defined in each layer or lower-level implementations can be used to achieve this compatibility at some higher level. This is accomplished by well-defined functions of each layer in communicating both user data and additional control messages. The purpose of the model is to ensure information flow among systems and also to allow variation in basic communications technology. This allows two different machines to communicate regardless of type.

The seven layers and their functions are:

- Layer 1: Physical Link - provides the hardware base for the network.
- Layer 2: Data Link - defines the access strategy for sharing the physical medium (the type of cable chosen.)
- Layer 3: Network Layer - is responsible for starting and ending connections between two transport layer protocol entities. Network routing and occasionally flow control are accomplished in this layer.
- Layer 4: Transport Layer - provides an additional, yet lower level, of connection than the session layer. This layer provides the interface between the higher application-oriented layers and the underlying network-dependant protocol layers.

- Layer 5: Session Layer - provides for the establishment and termination of streams of data from two or more LAN connections or nodes.

- Layer 6: Presentation Layer - translates the information for use by the seventh layer. Services such as protocol conversion, translation and encryption are accomplished in this layer.

- Layer 7: Application Layer provides services for network users such as initiation and reliability of data transfers as well as general network access, flow control and error recovery.

The OSI model, as developed, promises to make new networks easier and less expensive to operate by standardizing the functions of each of the layers. More manufacturers are following these standards. The U.S. Department of Defense has reviewed OSI protocols for suitability for its requirements but currently supports its own Transport Control Protocol/Internet Protocol (TCP/IP). Although the OSI implementation in the DOD and DON has been delayed, they still remain committed to OSI for future requirements.

b. IEEE 802 Project

The IEEE local network reference model is comprised of three sublayers that illustrates the complexity issue of LAN's.

The three sublayers are:

- Physical - dealing with the nature of the transmission medium, electrical signaling and device attachment.

- Medium access control - regulates access to the connection medium.

- Logical link control - establishes, maintains and terminates the logical link between devices.

The IEEE is using a strategy that provides for a more flexible framework for LAN's. The 802 Standards Committee is producing a family of standards for LAN's. As of this writing they are as follows:

- 1. ANSI/IEEE Std. 802.3 - an ethernet bus using Carrier Sense Multiple-Access (CSMA/CD) as the access method. CSMA/CD is used mainly on bus networks and operates in a manner where each terminal monitors the cable for other transmissions. The terminal can detect collisions when the transmitted and the monitored signals are different. Both terminals involved in the collision then wait for a short period of time and then retransmit the signal. Figure 6 illustrates the cable layout and the node interface of the CSMA/CD bus network components.

- 2. ANSI/IEEE Std 802.4 - a bus using token passing as the access method. Token passing is another way of controlling access to a medium by passing the token around to each terminal by a predefined set of rules. A terminal may transmit when it has possession of the token and then releases it when it is done. Figure 7 illustrates principles of the token passing access method.

- 3. ANSI/IEEE Std 802.5 - a ring using token passing as the access method. In a token ring network the token passing is the same access method as the token bus but differs in the way that terminals are ordered on the network. Figure 7 also illustrates the token ring.

Figure 8 shows an overall comparison between the DOD TCP/IP and the OSI model. The OSI standards largely determine what manufacturers are developing.

The DOD TCP/IP provides the basis for future integration of different DOD equipment on the same LAN or

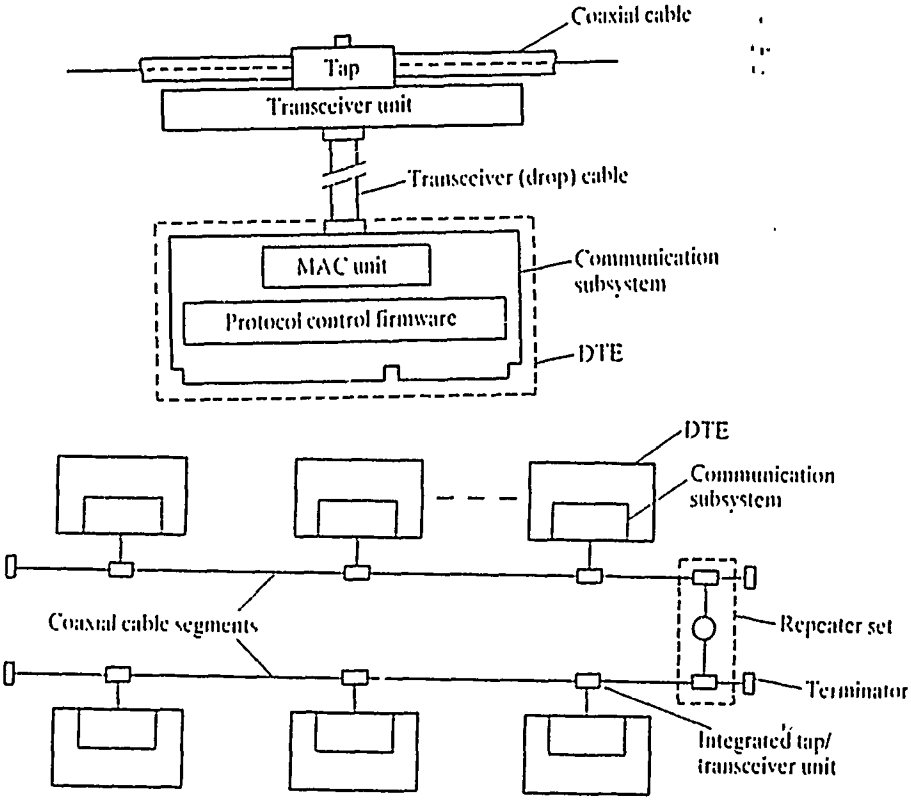

Figure 6 - CSMA/CD

[Ref. 12, p. 326]

WAN. The DOD based their TCP/IP model on the OSI model and packet switching features of the International Telegraph

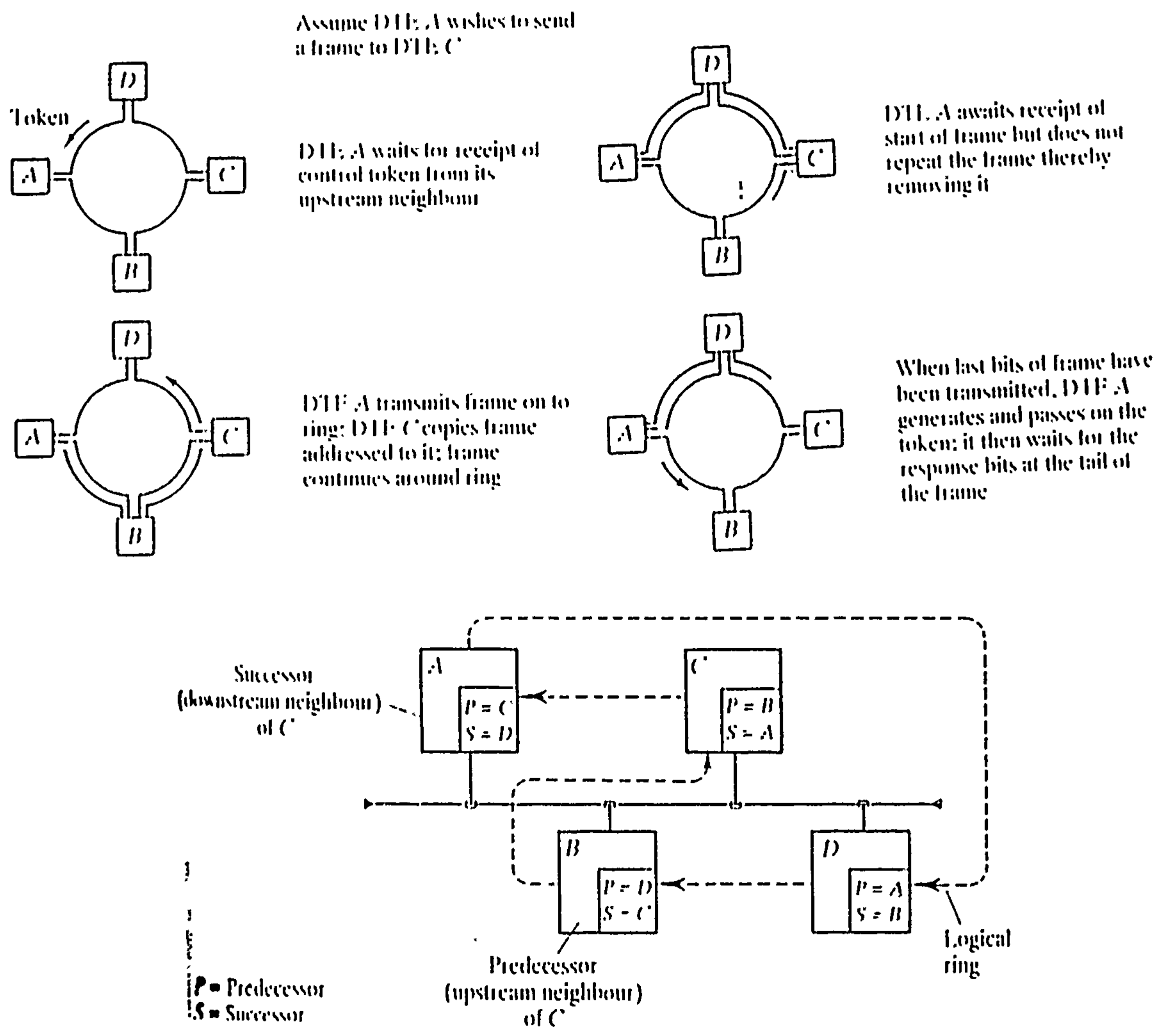

Figure 7 - Token Passing (Ring and Bus)

[Ref. 13, pp. 331, 351]

and Telephone Consultive Committee (CCITT) X.25. X.25 is the standard device independant interface between packet networks and user devices operating in the packet mode. The Defense Data Network's TCP/IP supports the OSI concept but uses different features such as reliability and special DOD security requirements.

ISO/OSI	DOD-TCP/IP
APPLICATION	APPLICATION
PRESENTATION	PRESENTATION
SESSION	SESSION
TRANSPORT	TRANSPORT(TCP)
NETWORK	INTERNET(IP)
LINK	LINK
PHYSICAL	PHYSICAL

Figure 8 - Comparison of OSI and TCP/IP
[Ref. 14, p. 44]

4. Higher Level Protocol Architectures

A protocol is defined as "a formal set of conventions governing the format and relative timing of message exchange in a communications network." [Ref. 15, p. 535] A number of proprietary protocol architectures developed prior to the establishment of IEEE 802 standards continue to exist. These include the U.S. Department of Defense's protocol architecture, IBM's system network architecture and the DEC distributed network architecture. They will be discussed for future expansion considerations such as LAN to LAN or LAN to Wide Area Network (WAN). Figure 9 shows a comparison of these proprietary protocol architectures.

a. DARPA (TCP/IP) Protocol Architecture

The Defense Advanced Research Project Agency (DARPA) developed a protocol architecture from 1969 to 73, similar to the OSI model. The main emphasis of the early stages in development of the DOD architecture was to allow terminals to communicate over multiple networks. The internet layer, whose main function is routing, makes this possible through the internet protocol (IP). The transmission control protocol (TCP) supports both connectionless and connection oriented service. It does not have the same levels of functionality in that all end-user and application specific software is considered as a process. The goal of this architecture was to provide a means whereby such terminals on different networks can interact with one another.

The network access layer holds the protocols that are required to communicate with the network being used. For example the 802.3 standard would exist in the network access layer if it were a Ethernet LAN or X.25 if it were a packet switching network. The internet layer of the DOD architecture is where protocols are held for communication of multiple networks.

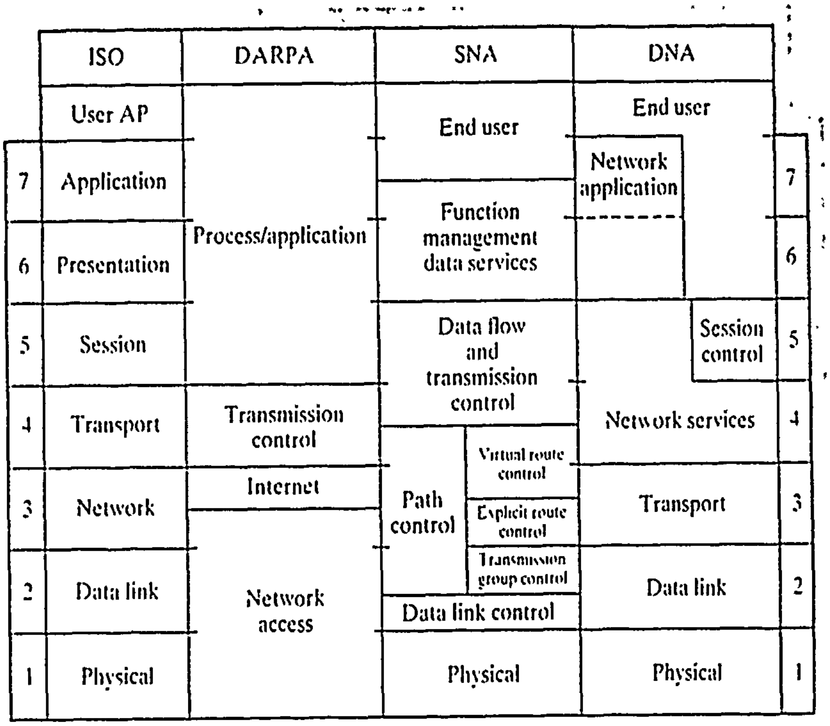

Figure 9 - Comparison of Proprietary Architectures

[Ref. 16, p. 519]

The Defense Data Network (DDN) TCP/IP is a most complex protocol. Proponents of the system are attempting to convince standards orgranizations that it should be the official network protocol standard. Another point is that the TCP/IP protocol will eventually be mandatory on all DOD LAN's [Ref. 17].

b. Systems Network Architecture

Systems network architecture (SNA) is the protocol architecture of IBM. In SNA networks, the end users communicate through logical units. One of the main differences between SNA and OSI architecture is that SNA networks do not require the end users to have network identifiers, but require network addresses. Another difference is that end users can transfer messages directly or within the same layer because messages carry protocol information. Both OSI and SNA require connection establishment before sessions can take place. There are more similarities and differences as can be seen as Figure 9 illustrates the layers of SNA and how they compare with OSI.

c. Distributed Network Architecture

The Digital Equipment Corporation (DEC) employs a unique architecture known as Distributed Network Architecture (DNA). Of the three discussed thus far, the DNA architecture most closely compares to the OSI model. One of the main differences is in the network application layer. The Data Access Protocol (DAP) provides for an initial exchange of preliminary messages establishing the operating system, type of file and organization information whereas SNA and OSI assume a virtual file structure. [Ref. 18, p. 523]

C. EXAMPLES OF MAJOR NETWORKS

A few examples of today's LAN market will be discussed in order to present the types of LAN technology being used today. All the combinations of topology, access methods or cabling medium cannot be addressed in this thesis. Many are not feasible due to difficulty of implementation, expense or logically do not make sense for implementation in the squadron environment.

Xerox's ETHERNET, the first commerical LAN, was developed as an experimental system in the early 1970's. During the same time frame, the Computer Laboratory at the University of Cambridge was working on the Cambridge ring, modelled after the Hasler ring of Hasler's Berne Research Laboratories. The second LAN developed from this early research was the IBM TOKEN RING network by Texas Instruments (TI). IBM also markets PC NETWORK, a token bus system originally developed by Sytek, Inc.

1. ETHERNET

Developed at Xerox's Palo Alto Research Center, ETHERNET's primary purpose is to connect office workstations to other peripheral devices to facilitate sharing expensive devices in an entire organization. The medium is coaxial cable, the topology is a tree structure and the contention or access control system is CSMA. The key to the ETHERNET system is the way each workstation gains access to the network, performs collision detection and shares transmission capacity with others. Earlier systems suffered from collisions in transmissions. Carrier Sense Multiple Access with collision detection (CSMA/CD) was developed to handle the collisions. CSMA/CD basically is a "listen before talking/listen while talking" procedure.

ETHERNET with CSMA/CD is among the most stable, reliable and versatile technologies currently being used for LAN's. Not only can it be used as a single bus network which is standard ETHERNET but CSMA/CD can be used in other network designs.

The economical aspect of ETHERNET was a significant influence on the design. The network was designed with the idea of simplicity in concept and operation thereby reducing total cost. ETHERNET is especially well suited for systems that use a small portion of the total network traffic capacity and whose individual devices transmit information in short bursts. One drawback is that long periods of continuous transmission from one device can upset the pattern of use in the network by keeping the network busy so that other workstations cannot gain access. The success and growth of the 802.3 standard in commercial environments has demonstrated good performance overall in two LAN's, Boeing Technical Office Protocol and General Motors Corporation's Manufacturers Automation Protocol.

2. IBM Token Ring

The token ring, originally known as the Newhall ring, was proposed in 1969. [Ref. 19, p. 160] The IEEE 802.5 standard that applies to token ring LAN's was an outgrowth of research conducted by IBM and TI. In IBM's implementation of the Token Ring Network for PC's, the token ring logic and medium access control is contained on a board inserted into the PC. The connection to the board is from a wiring concentrator that can be "daisy chained" together in a ring. The topology is a ring but is contained in the wiring concentrators so that it is actually a star configuration. The preferred medium used by IBM is twisted pair cables and is also recommended in the IEEE 802.3 standard.

With the token ring, collisions on the network are not possible. The token, a packet of control codes which is passed between stations to indicate the station that is currently in control of the medium, is either free or busy. Studies by IEEE have indicated good performance at moderate or high loads because every active node must react to each token and frame. Conversely, the CSMA/CD is expected to "out-perform" the Token Ring Network at low to moderate loads. Matt Kramer stated in a PC Week article that "IBM's Token Ring Network does not have adequate network management or inter-networking capabilities for extensive

Wide Area Network (WAN) configurations, according to corporate network managers tying to implement the LAN to connect systems dispersed over a wide area." [Ref. 20, p. C1] This is an important consideration if geographic expansion is a future consideration in the design of the LAN.

3. IBM's PC Network

In 1983, token passing, which was originally used for ring topologies, became available on general purpose systems using bus structures. 3M Corporation introduced its broadband bus topology LAN using token passing as did TOKEN/NET from Concord Data Systems. 3M used an ARCNET chip set from Datapoint, a proprietary token bus network developed in the 1970's. ARCNET predates the development of token bus standards and contains some inconsistencies with the rest of the data communications environment. The standard eventually was published in 1985.

A token bus system such as PC NETWORK is often described as a logical ring since some or all nodes on a token bus LAN must be logically addressed as a ring. This token passing scheme can degenerate under heavy loads, as opposed to the the token ring. The token must pass every node in either the physical or logical ring before returning to any given connection. [Ref. 21, p. 136] Another drawback is that maintenance functions, such as ring initialization, lost token recovery and other general housekeeping of the logical ring, exist at each workstation of a token passing system and require considerably more management overhead than CSMA/CD systems.

In determining LAN specifications, such as access methods, topology and medium, the major factors that will influence the choice will be load on the network and type of user. The amount of "traffic" or "load on the network" must be defined by the user. The number of nodes on the network is part of the definition. The number of frames or size of network sessions is another. In CSMA/CD access methods, the number of nodes is not a factor, but the length of the sessions is. Smaller numbers of workstations with longer sessions is better suited for the token ring access method. In the squadrons, there is some variation in size but generally there will be a small number of users, usually less than ten. The load on the network will be slow until the users become familiar with the system. The next two chapters will address these specifications.

CHAPTER III. NAVAL AVIATION SQUADRON REQUIREMENTS

A. GENERAL

This chapter will outline a squadron's organization and define its functional requirements of a LAN. High level functional requirements will be discussed as well as each major department. The main emphasis is the user's point of view. Specifications will be drawn from assumptions made in this chapter.

1. Squadron Organization

Figure 10 illustrates a typical squadron organization chart. The commanding officer (CO) is responsible for all personnel, equipment and the accomplishment of the mission of the squadron. "Maintaining a squadron of today's fleet aircraft, training maintenance personnel and maximizing the aircrew training per dollar of aviation fuel requires close, efficient management of every aspect of squadron operations." [Ref. 22] The Administration, Operations, Maintenance Administration, Maintenance Control and Personnel departments will be discussed to present their major functions and overall contributions to the management of a fleet squadron.

a. Administration Department

The Administration (Admin) department operates in close proximity to the Commanding Officer (CO) and the Executive Officer (XO). Admin performs officer personnel

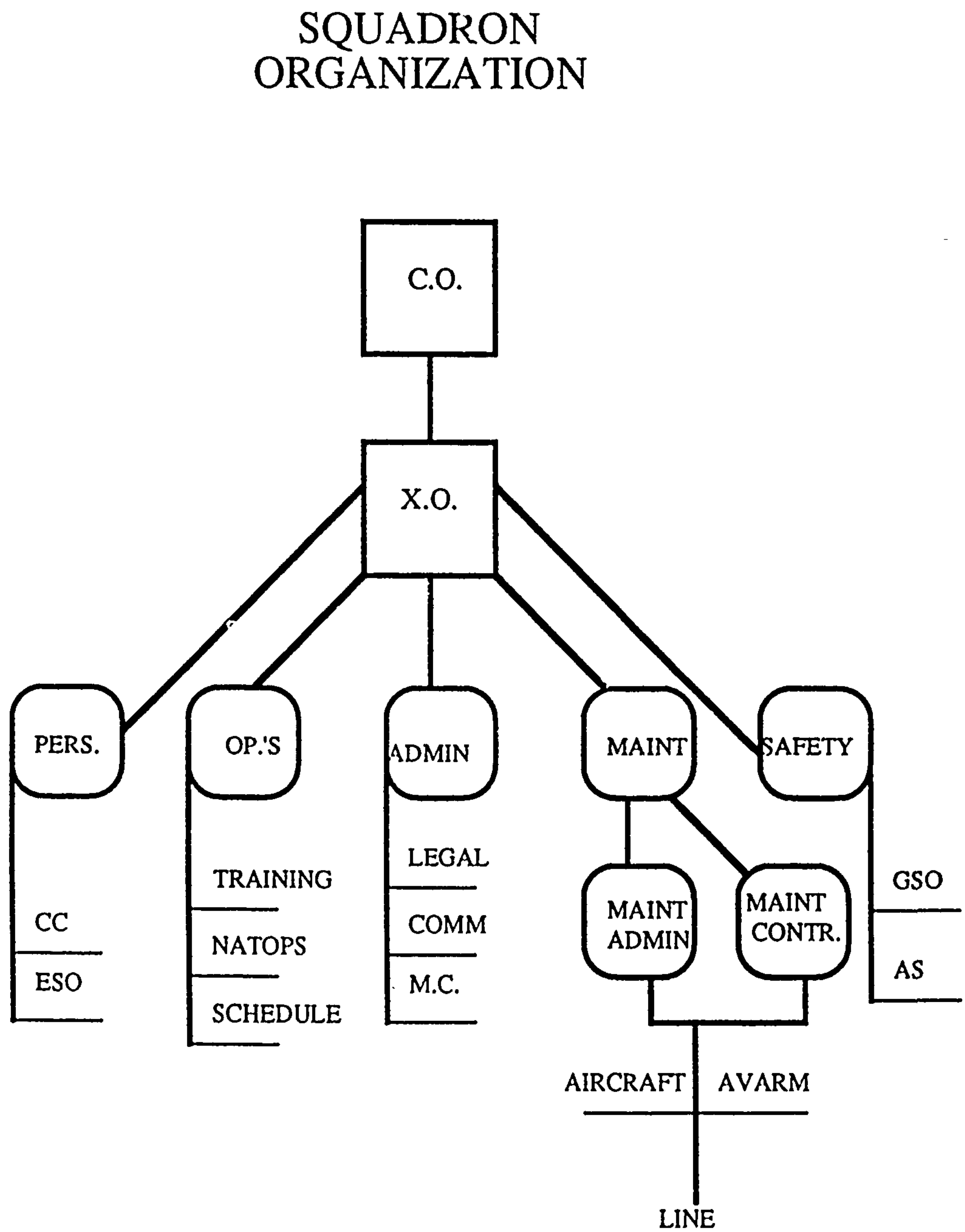

Figure 10 - Squadron Organization

management, ensures timeliness in the submission of recurring reports, tracks instructions, prepares the Plan of the Day (POD) and handles numerous protocol issues. Personnel perform check in or check out of the squadron procedures in Admin. Admin screens material, appointments and reports for the CO and XO. This department has major responsibilities in the appearance of the squadron to senior and other outside activities.

b. Operations Department

The Operations Department's (Op's) major function is preparing the daily flight schedule. This department is also responsible for processing aircrew data and tracking classified publications. Operations works closely with the Maintenance Department in processing maintenance forms such as "yellow sheets" and scheduling certain aircraft. Operations is also a major contributor in planning the squadron's budget for fuel costs and flight hours.

c. Personnel Department

The Personnel department manages the squadron's enlisted personnel. This department handles various manning levels, personnel qualifications and advancement, evaluations and official records. The squadron's Career Counselor and Educational Services Officer are Primary members of the personnel department. These two functions are critical in the overall morale and retention in the

Navy in that they are there to support and help in the advancement of enlisted personnel.

d. Maintenance Administration

Maintenance Administration supports the Maintenance Officer in managing aircraft, tools, training and people. This department also works closely with the Personnel department in the management of the enlisted personnel in the squadron. They track the technical publications library, maintenance instructions, and produce the monthly maintenance plan. Maintenance Admin keep records on the Quality Assurance (QA) and Collateral Duty Inspectors (CDIs) who are critical in ensuring the quality of maintenance on aircraft.

e. Maintenance Control

Maintenance Control provides central coordination of maintenance activities that are accomplished on the aircraft. Personnel in this department work closely with the Operations department in accomplishing the goals put forward on the daily flight schedule. Maintenance Control processes aircraft logbooks, maintenance records and tracks the Monthly Maintenance Plan. Their interface with the Supply department is critical in tracking parts and supplies needed to complete maintenance. The squadron's operating budget is another part of Maintenance Control's responsibility. The entire Maintenance Department is the center of the squadron but Maintenance Control provides the coordination.

Each squadron in the Navy is similar to an outside organization which relies on the smooth cooperation and communication of its major departments. Advances in technology can be seen in the aircraft of the squadrons but similar advances in information systems need to be made in the way personnel, aircraft, consumables and support equipment are managed. The hardware purchased over the last decade has made some improvements but only in the area of word processing. Each of the departments has applications and information that could be shared internally and externally.

B. HIGH LEVEL FUNCTIONAL REQUIREMENTS

The higher echelons in Naval Aviation, such as COMNAVAIRLANT and COMNAVAIRPAC, have certain functional requirements for a project this broad-reaching. For example, there must be cost savings and benefits that will justify the cost of developing the standard applications. There are training, security, support and maintainability requirements that also must be satisfied to gain the support needed by key figures in the Navy.

1. High Level Organization

Figure 11 depicts the overall structure of Naval Aviation and the appropriate chains of command for the east and west coast. In developing standard Naval Aviation LAN's, it is strategically important to the success of the project to get high level support early because "They will

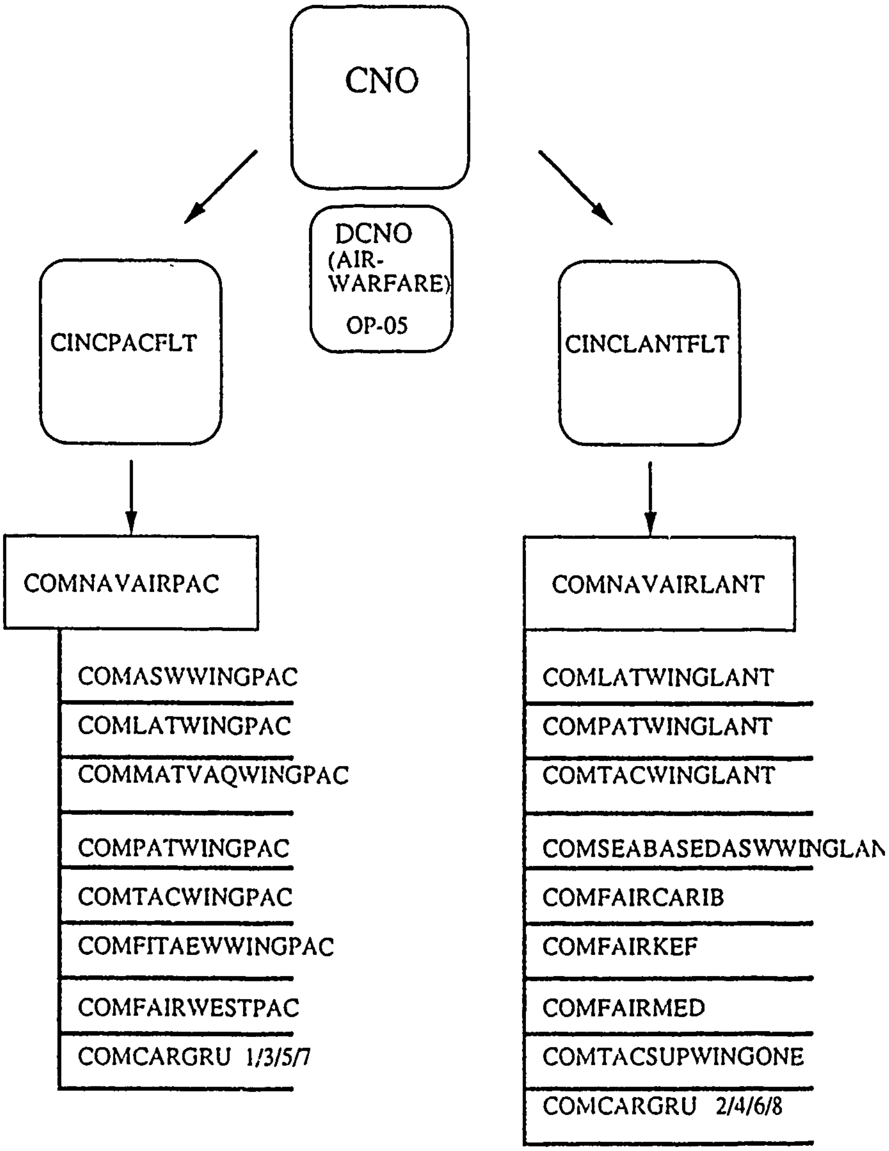

Figure 11 - Naval Aviation Organization

authorize funds, promulgate policy, settle disputes and encourage use of the system." [Ref. 23, p. 10]

An example of the importance of this strategy can be seen in the TASC project that has gained the support of COMNAVAIRLANT. Users from a squadron on the east coast suggested the idea of a standard applications and LAN's at the squadrons. The proposal was well presented and received at COMNAVAIRLANT headquarters and now the TASC personnel are working closely with the prototype squadron on the east coast, VF-31. The project is being proposed to COMNAVAIRPAC who has already designated a prototype squadron on the west coast, VF-1. With continued support and well-planned coordination efforts, the squadrons may soon be able to use this technology.

2. Cost/Benefit Analysis

Total costs associated with developing this system depend on whether the system is developed by a Navy software development facility or contracted out to an outside software development company. Regardless of how the project is funded there are two separate areas - the LAN and the software.

LAN costs will include: cabling medium, network boards, the network operating system and other costs dependent on the type of network developed. An example of typical hardware costs associated with networks is illustrated in Table 2. These costs were associated with

TABLE 2 - TYPICAL LAN HARDWARE COSTS

[Ref. 24, p. 52]

HARDWARE EQUIPMENT COSTS

3COM Etherlink Adapter Board Model 3C 501 Quantity 1 @ $340	340
Thin Ethernet (Coaxial) Cable With BNC Connectors Quantity 1 60-FT cable @ $40	40
Uninterruptible Power Supply GTSI Part # 820-800 CONUS Version 115v Quantity 1 @ $708	708
Zenith Z-248 Advanced System Model ID ZWX-248-62 Quantity 1 @ $1,628	1,628
Zenith Memory Expansion 512K to 1.1M Model ID Z-405-A Quantity 1 @ $120	120
Zenith Monochrome Monitor Model ID ZVM-1470-G Quantity 1 @ $116	116
Tape Backup, 60 MB Emerald Systems RAP060-9000 Quantity 1 @ $1,795	1,795
EMSAVE Application Kit Includes 5 60MB tapes Part # APK060-2610D Quantity 1 @ $395	395
Total Equipment Costs	$ 5,142

an ETHERNET LAN that had three workstations and one file server.

The software costs can be divided into modules for each of the major departments. Figure 12 illustrates each module and their components as illustrated by a user from the prototype squadron.

One point to consider is that the costs of the LAN hardware will be relatively minor when compared to development costs of application software. A comparison between Table 2 and proposal from the TASC corporation that amounted to over one hundred thousand up to three hundred fifty thousand dollars per module can be used to support this fact. [Ref. 25] Another point is that a major portion of the cost of hardware has already been expended with the purchases of the Desktop Three contract. Al squadrons on the west coast have a minimum of one Zenith 120 and will soon have 5 Zenith 248 PC's [Ref. 26] The east coast squadrons have comparable numbers of PC's with Fleetword II and Zenith 248 PC's.

Developing the modules separately is advantageous in that upon completion, each can be tested for squadron acceptance and can be prototyped more rapidly. The overall success of this project will largely depend on the timeliness of development. The ever-changing dynamic environment of the ADP world requires quick development or the applications will already be outdated. This does not imply that once developed the applications will not change.

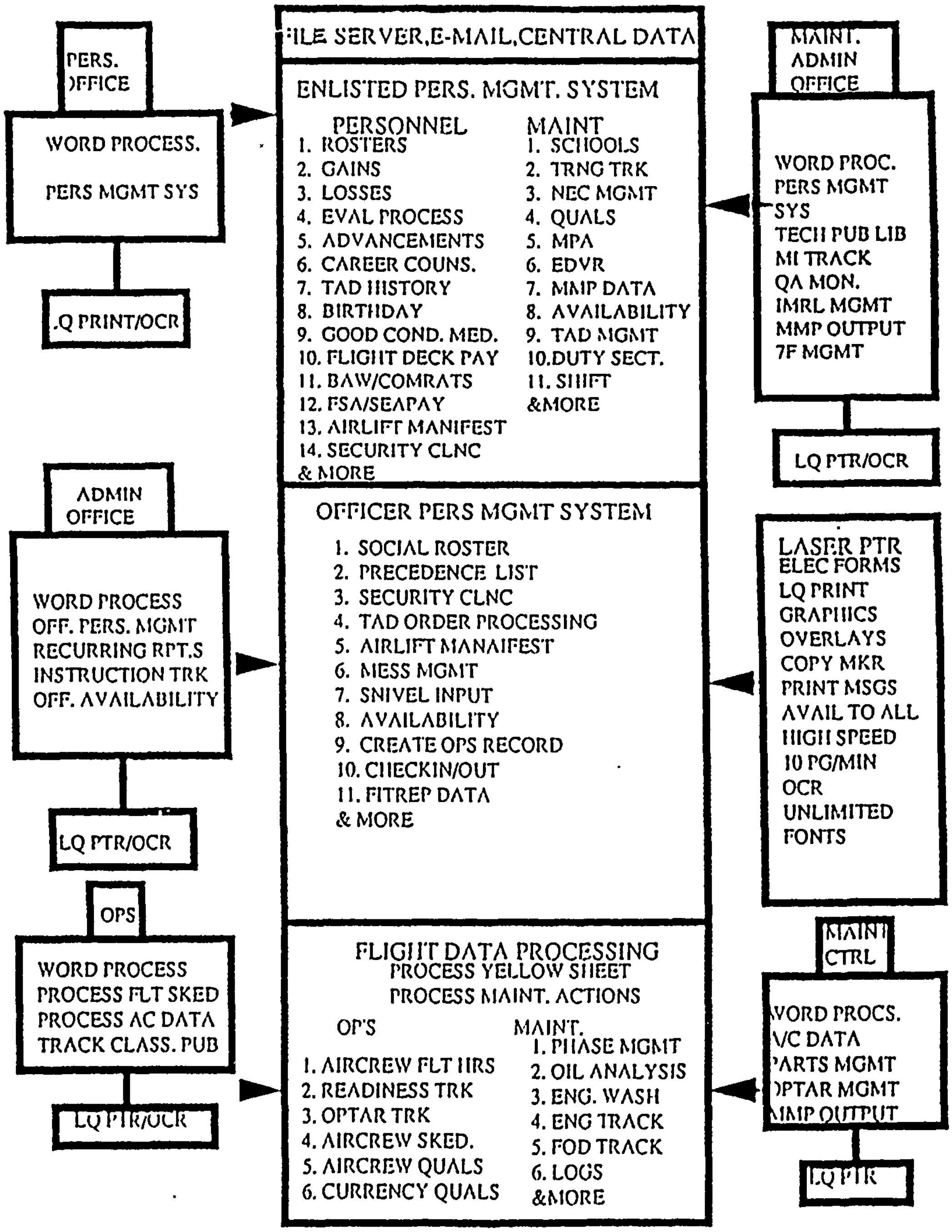

Figure 12 - User's Hardware/Software Concept

[Ref. 27]

Software development is an iterative process and new versions will continue to be developed to keep up with today and tomorrow's technology.

There are other costs besides development that are important to consider. Training Navy personnel to operate and maintain the LAN and the applications will be a factor in the overall cost. Also future support for new or improved versions from the developing company are integral to the project's success. Table 3 lists out typical costs and benefits of LAN's.

The benefits that will be realized from this system, though difficult to quantify, are numerous.

- The emphasis on paper reduction throughout the Navy can be realized with the LAN.
- Electronic mail will save numerous interdepartmental messages that always seem to get lost.
- An integrated database will increase the overall integrity and reduce duplication of personnel data that all the departments frequently need.
- Sharing peripheral devices such as laser printers, letter quality printers and software programs between the departments wil reduce costs in hardware and software.
- The time savings that will ensue from the applications will allow more time for professional development. An example of the potential time savings was discussed during interviews with the users at the prototype squadron in the manifesting procedure. Manifesting personnel on airlifts for training exercises used to take eight to ten hours. With the application developed, it now can be accomplished in under two.
- Finally, the loss of expertise, when personnel are transferred, of their "home-grown" applications and

TABLE 3 - COSTS AND BENEFITS OF LAN'S

[Ref. 28, pp. 197-198]

COSTS	BENEFITS
MATERIALS PURCHASES INCLUDING THE ACQUISITION AND INSTALLATION OF CABLING AND ASSOCIATED EQUIPMENT.	DIRECT, IMMEDIATE COMMUNICATION,
	TRANSFER OF FILES
	ELECTRONIC MAIL
SOFTWARE PUCHASES, INCLUDING THE NOS AND APPROPRIATE MULTI-USER SOFTWARE	MULTIPLE CONCURRENT ACCESS TO A COMMON DATABASE
MANAGEMENT, INCLUDING OVERSIGHT OF S/W INSTALLATIONS, ADDING NEW STATIONS, BACKUP, MAINT.,IMPROVING USER INTERFACE	CENTRAL FILING OF ORGANIZATIONS DATA AND DOCUMENTS
	CONCURRENT AUTHORING OF SINGLE TEXT DOCUMENTS USING A MULTI-USER WORD PROCESSOR
COORDINATION OF ESTABLISHING BRIDGES AND GATEWAYS TO OTHER NETWORKS, S/W AND H/W COSTS	COMMON ORGANIZATIONAL CALENDAR FOR MORE EFFICIENT SCHEDULING OF MEETINGS
ONGOING TRAINING OF USERS AND LAN MANAGEM;ENT PERSONELL, NEVER-ENDING PROCESS WITH HIGH TURNOVER RATES	EFFICIENT SHARING OF FILES FOR MULTIPLE REVIEWS PRIOR TO FINAL PUBLICATION OF REPORTS, PROPOSALS AND OTHER DOCUMENTS

the time spent relearning new applications for various tasks throughout the squadron will no longer be a problem.

3. Specific Requirements

The justification and development of standardized Local Area Networks and applications for all Navy squadrons will require many hours spent with different users to determine specific requirements that will suit all types of squadrons. For a successful development and implementation, Thomas Madron developed the following list of considerations to remember when designing and installing LAN's in his chapter on "Making it Work."

- LAN's are installed to increase people productivity.
- LAN's are installed to promote a cooperative work environment for both people and machines.
- LAN's will not operate themselves - they need management.
- LAN's are not yet all things to all people.

While these considerations are important, there are more specific requirements that the success of this Naval Aviation-wide program depends on.

- The LAN and applications must be suited to the knowledge level of the users, must be easily and quickly learned and it must maintain a high level of user friendliness.
- The overall benefits must outweigh the cost.
- There must be adequate training for the users as well as documentation and future support of the LAN and applications.
- The system should meet security requirements for the level being used.
- The performance capabilities of the system should allow for future updates and expansion.

- There should be training for collateral duty LAN managers to manage and maintain the system.
- Indoctrinations and presentations to Commanding Officers and other key personnel will lead to a better understanding of the system capabilities and enhance user participation.

C. SQUADRON/DEPARTMENTAL REQUIREMENTS

High level functional requirements deal with the requirements that Naval Aviation, as a whole, needs for the success of the standard LAN and applications. The squadron and departmental requirements are related to the actual tasks of each department and the squadron as a whole.

Figure 12 illustrates a proposed hardware and software concept of the LAN and applications for each of the major departments by a user at a fighter squadron on the east coast. The concept is accurate in the number of nodes but negates the advantages of sharing peripheral devices. Most aviation squadrons will have five workstations. Admin would require the laser printer and one letter quality printer but the other departments should be able to use those resources instead of needing redundant assets. The file server should be the only workstation that requires a tape backup. Other departments should be able to keep backup copies on floppy discs. The applications, such as word processors and spread sheets, can reside on the server. The server itself should have at least a 40 MB hard disk and have a 80286 microprocessor. The other workstations do not need these capabilities, thereby savings can be realized by using an 8088 microprocessor.

1. The Squadron Requirements

The squadron as a whole will require a LAN manager. One of the most overlooked problems in successfully implementing LAN's is the absence of an administrator. With a small network such as that of a squadron, maintaining the integrity of the network may only require ten to fifteen percent of a local departmental person's time. Therefore training and instructions must be developed to give to prospective LAN managers of this system.

Another requirement for the system is that it provides connectivity between the departments. This will aid in paper reduction and increase overall integrity of communication between all departments. Electronic Mail (E-Mail) is a method of sending and receiving data and messages to and from other users on the network. E-mail is a software package supported by the network operating system.

The departments will share an integrated data base containing information on personnel, instructions and standard operating procedures. This will aid in the integrity of the data and reduce duplicate information that would otherwise simply take up space in memory. One consideration is to place a hard disk, not as large of capacity as the file server, on each department's computer for data and applications that other departments do not need. This would reduce traffic on the network and decrease access time for that department.

In addition to shared data, the squadron will also share resources such as laser printers, letter quality printers and applications such as spreadsheet and word processing programs. This allows all departments to have the same capabilities and reduce the costs of duplicating these capabilities. Access to these expensive peripherals leads to many economics of scale.

Even though the LAN will be designed to avoid failures, it is almost inevitable that it will fail at some point. Backup considerations are important measures to consider in the design. The cost of a day or an hour of down time on the network must be weighed against the cost of providing redundant systems. A manual backup method may be a less costly alternative than providing another file server or data base. For the squadron LAN, a tape backup of the database and applications in the file server would be sufficient. Each department could also have backup disks for their particular data and applications.

2. The Departmental Requirements

Each department uses a word processor on a regular basis. Most will also use a spreadsheet for occassional departmental analyses. Table 4 lists hardware and software as each department requires.

TABLE 4 - HARDWARE AND SOFTWARE REQUIRED IN SQUADRON LAN

[Ref. 29]

HARDWARE	SOFTWARE
ADMIN -PC, LQ PRINTER,TAPE BACKUP, NETWORK EQUIP	-WORD PROCESSOR, OFFICER PERSONNEL MNG. APP., FORMS MNG., INSTRUCTION & REPORT TRACKER, NETWORK S/W
PERSONNEL -PC, LQ PRINTER, TAPE BACKUP NETWORK EQUIP	-WORD PROCESSOR, FORMS MNG ENLISTED PERS MNG.,NETWORKS/W
MAINTENANCE ADMIN -PC, LQ PRINTER, TAPE BACKUP NETWORK EQUIP	-WORD PROCESSOR, OPS DATA MNG., FLIGHT SCHEDULER, FLIGHT LOGS CLASSIFIED PUBS MNG., NETWORKS/W
MAINTENANCE CONTROL -PC, TAPE BACKUP, NETWORK EQUIP.	-WORD PROCESSOR, ENLISTED PERS. MNG., TECHNICAL PUBS TRACKER, IMRL MGMT, 7FMNG, NETWORK S/W
FILE SERVER -PC, 40MB HARD DISK, LASER PRINTER TAPE BACKUP, NETWORK EQUIP	-WORDPROCESSOR, A/C DATA, OPTAR MNG, PARTS MNG, NETWORK S/W -WORD PROCESSOR, NOS, E-MAIL

Each department should have a designated person who will use the network most often. The following documentation should exist to support the user:

- messages and codes for the operating system as well as all hardware (printers, graphic computers ...)
- operators guide for all equipment available to users.
- problem determination guides
- network configuration data for users and equipment.

The goal is to ease users frustration and to keep the network in use.

Each department will require a certain level of security. Privacy act information is a security consideration for the data base that all departments will require access. Leave information, fitness report and enlisted evaluations need access restrictions.

Although the LAN should be designed with expansion in mind, each department will initially require a certain period of time to adjust and get used to the LAN. Eventually as more LAN's proliferate in the Navy, departments in squadrons will want to connect to outside organizations. An example of this is the Maintenance department searching for parts from the Navy Supply system or the Administration department dealing with new assignments for personnel with the Navy Military Personnel Command in Washington, D.C. While these are not current departmental requirements, they should be kept in mind for future growth in regards to the compatibility and type of equipment and protocols that will be used on the LAN.

CHAPTER IV. SQUADRON LOCAL AREA NETWORK/APPLICATION PERFORMANCE SPECIFICATIONS

A. GENERAL

A well-coordinated and cooperative relationship between users, network designers and contracting agents is critical to prooperly define LAN specifications. The only way the Navy will be able to identify requirements of LAN's and standard applications is through a well defined and completely detailed requirements specification. Inadequate specifications give most commercial software and LAN design companies an opportunity to submit "an abundance of detail on the features of his own system without ever having to translate those features into required operational performance capabilities." [Ref. 30, p. 93] LAN and software application specifications should satisfy user requirements.

When developers meet with users and submit proposals, the following questions should be among those answered in the specifications:

- What types of applications are needed by each department in the squadron and what types of services will be provided?
- [Personnel Management System, Technical Publications Library Management, Maintenance Instruction Tracker, Monthly Maintenance Plan and others listed in Figure 12.]
- What are the transmission types and throughput requirements for each type of user on the LAN?
- [Most departments' transmission types will be bursty in the sense that the length of sessions will be

short and frequent. This will change after users become used to the network and then they will tend to use longer sessions. The prototype LAN has not been in use long enough to test these parameters but this should be looked at now.]

- What type of hardware is already in place that could be incorporated on the LAN and what kinds of file server capabilities and other devices (printers, print spoolers, modems and disk drives, etc.) will be required?

- [The FLEETWORD II, Z-120 and Z-248 are the PC's placed in the squadrons today. The Z-248 should be used as the file server because it has a larger memory and faster microprocessor. Letter quality printers are already in place at most squadrons. A laser printer would provide additional capabilities to the Admin department. A tape backup unit should be used with the file server and a modem located in Op's or Admin would prove useful in the future.]

- How many users will be on the LAN and how many sites will there be and at what distances?

- [The typical squadron would have five sites at the departments discussed earlier. Therefore, five users on the network would be the maximum load. The average squadron is in a single building with departments located anywhere from a few feet to several hundred feet dependant on the building. The squadrons on deployment are either on a ship or on a base in a foreign country. Analysis on whether to move the LAN or do without should be reviewed.]

- What data security issues need approval?

- [For the squadron LAN, privacy act information will be the only security issue unless classified information would be used in the future. Currently the LAN should only be used in an administrative support level. The Federal Acquisition Regulations Part 24 prescribes policies and procedures for complying with the Privacy Act of 1974.]

- Is the future expansion an important consideration?

- [When developing any system such as this, future expansion should always be a consideration. The squadron LAN's could eventually be connected to a WAN. Therefore, TCP/IP and OSI protocols and standards should be met for future integration.]

- Who will install, support, maintain and provide training for the network hardware?

- [The contractors or Navy departments that install the LAN should provide the training, support and documentation for the LAN. This will be determined in the final contract.]

- What are the priority, precedence, reliability, availability, etc., requirements or constraints of the LAN and applications?

- [The squadron LAN is a management tool. It provides support to the departments on an equal basis. The size of the LAN does not require any priorities to be assigned. Reliability, although not critical, should be strong enough that the LAN does not create more work than present manual administrative functions. The biggest constraint of the LAN is that most squadrons deploy for six months.]

These questions are among many that should be answered during interviews with the user. The answers, together with equirements of local connectivity between departments and outside connectivity to other networks will determine the LAN technology decision. Local and distant connectivity specifies interface requirements (gateways, bridges, protocol and outside hosts, etc.) and will translate into LAN specifications.

Application specifications have a less concrete life cycle than that of LAN's. Designing computer program specifications, "packages the input, output, file, database, terminal dialogue, and methods and procedures specifications into computer program specifications that will guide the computer programmer's activities during the construction phase of the system development life cycle."

[Ref. 31, p. 380] These specifications will lead to the system st? cture on the LAN.

After the overall program structure has been determined, the strategy for top down modular decomposition should be addressed. This strategy may best suit the development for standard applications for all squadrons because of the ability for acceptance testing as well as quicker prototyping and also a breakdown of cost. The purpose of modular design is to factor the program specifications into independent programming assignments. After completion of each module, the entire system can be tested for any integration problems. The strategy for developing the systems will be determined by the contractor who will actually be building the applications.

B. DOD SPECIFICATIONS AND REQUIREMENT ANALYSIS

1. Software Specifications

Specifications for software requirements analysis that contractors must follow in providing DOD units proposals for applications is spelled out in DOD Military Standard for Defense System Software Development (DOD-STD-2167). This instruction details each step within the system life cycle. (Figure 13) Again, the first step again is the Software Specification Review which demonstrates the adequacy of all appropriate specifications to the contracting agency.

2. Local Area Network Specifications

Local Area Networks are not new to the Department of Defense. The U.S. Air Force has been studying LAN's

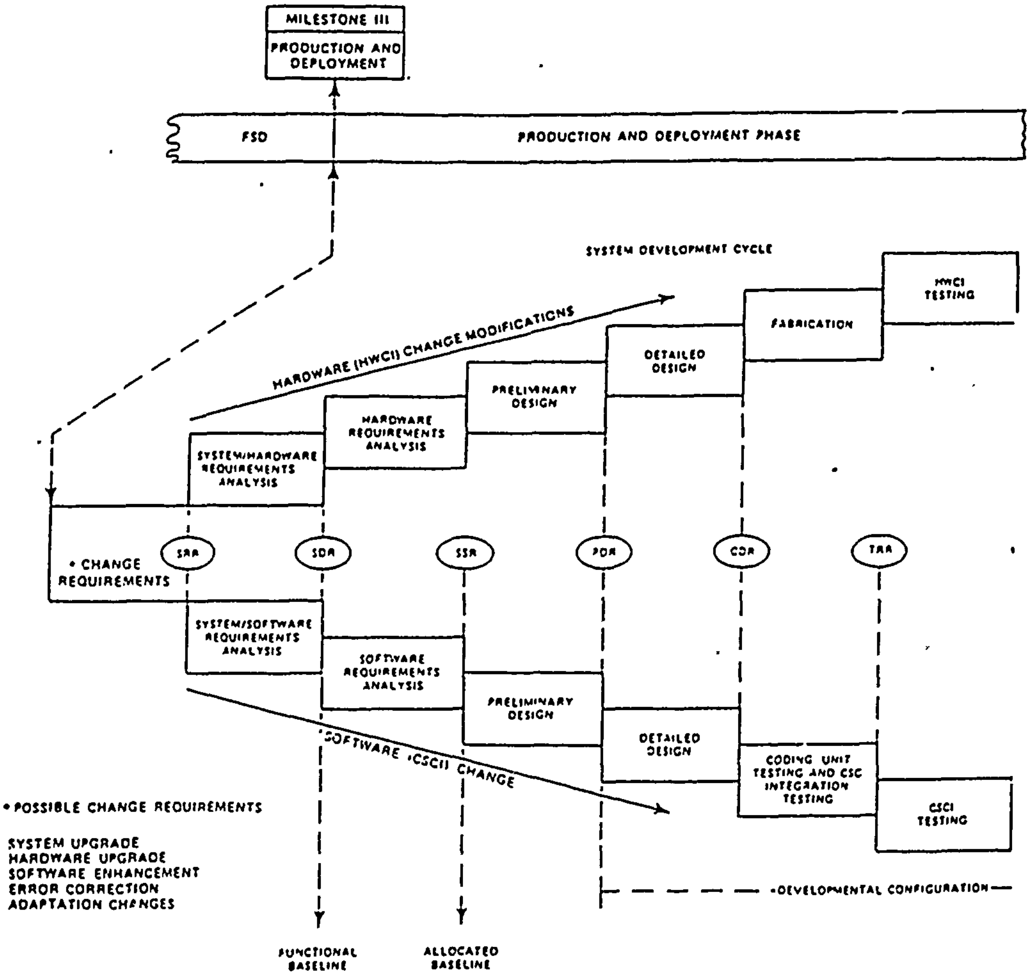

Figure 13 - System Support Cycle Within

System Life Cycle

[Ref. 32, p. 62]

since the early 1980's and has created a program called the Unified Local Area Network Architecture (ULANA), which introduces standard LAN's. Standard specifications developed by the U.S. Air Force can be used as contractual tools for procurement and implementation of Naval Aviation LAN's. Table 5 lists six tools developed by the ULANA program.

TABLE 5 - SIX TOOLS OF ULANA

[Ref. 33, p. 111]

ULANA TOOLS

STANDARD SYSTEM SPECIFICATION - RULES GOVERNING THE OVERALL ARCHITECTURE AND FUNCTIONING OF THE NETWORK.

STANDARD CABLE PLANT DESIGN SPECIFICATION - PERFORMANCE, MONITORING, AND MAINTENANCE STANDARD FOR A COMMON TRANSMISSION MEDIUM

PROTOTYPE CAD/CAE STATION - A PROTOTYPE SYSTEM FOR ENGINEERING AND DESIGNING DUAL COAXIAL BROADBAND CABLE PLANTS FOR LANS USING CAD/CAE TECHNOLOGY

STANDARD NETWORK INTERFACE AND INTERCONNECT UNIT - A FAMILY OF H/W AND S/W DEVICES THAT ALLOW THE SUBSCRIBERS TO CONNECT VARIOUS INFORMATION PROCESSING DEVICES TO THE NETWORK.

STANDARD NETWORK MANAGEMENT SYSTEM - THE ULANA NETWORKS OPERATIONAL SUPERVISORY AND CONTROL OF H/W AND S/W

ULANA MANAGEMENT SYSTEM - AN A.F. CONTROLLED SYSTEM WHICH PROVIDES DATA TO A.F. REGARDING LAN USER REQUIREMENTS, OPERATIONS , AND OTHER MNGT FUNCTIONS

C. PERFORMANCE

There are a few general software and hardware characteristics that are additional specifications to those already stated. LAN throughput is directly related to the transmission medium, access method, processing capacity at each network node, and as stated before, the amount of protocol translation required for interface variations. In technical terms maximum throughput (maximum channel utilization) is the maximum average steady-state data rate for a network divided by the bit rate of the channel. [Ref. 34, p. 397] Figure 14 shows a comparison of the CSMA/CD with the token bus access method. This type of analysis is important in measuring predicted performance in the form of mathematical models but is beyond the scope of this thesis. Analysis like this can be accomplished after the prototype and applications have been developed. The graph illustrates that the delay of token passing access methods is greater under lighter loads. The particular media access technique chosen tends to dictate the eventual performance of the network. Therefore, the contractor of the LAN should present in his/her proposal some sort of comparison between different network architectures and reasons behind his/her choice.

An in-depth traffic analysis of the network usage levels by each department would be useful for the specification document. The characteristics of transmissions; message size, frequency, response times, link speeds, sequencing and accountability; can all be used to provide accurate and specific throughput speed requirements. There are several government funded network modelling and traffic handling analysis projects that can provide appropriate throughput requirements.

Flexibility in specifications is a very important issue since modern technology changes so rapidly.

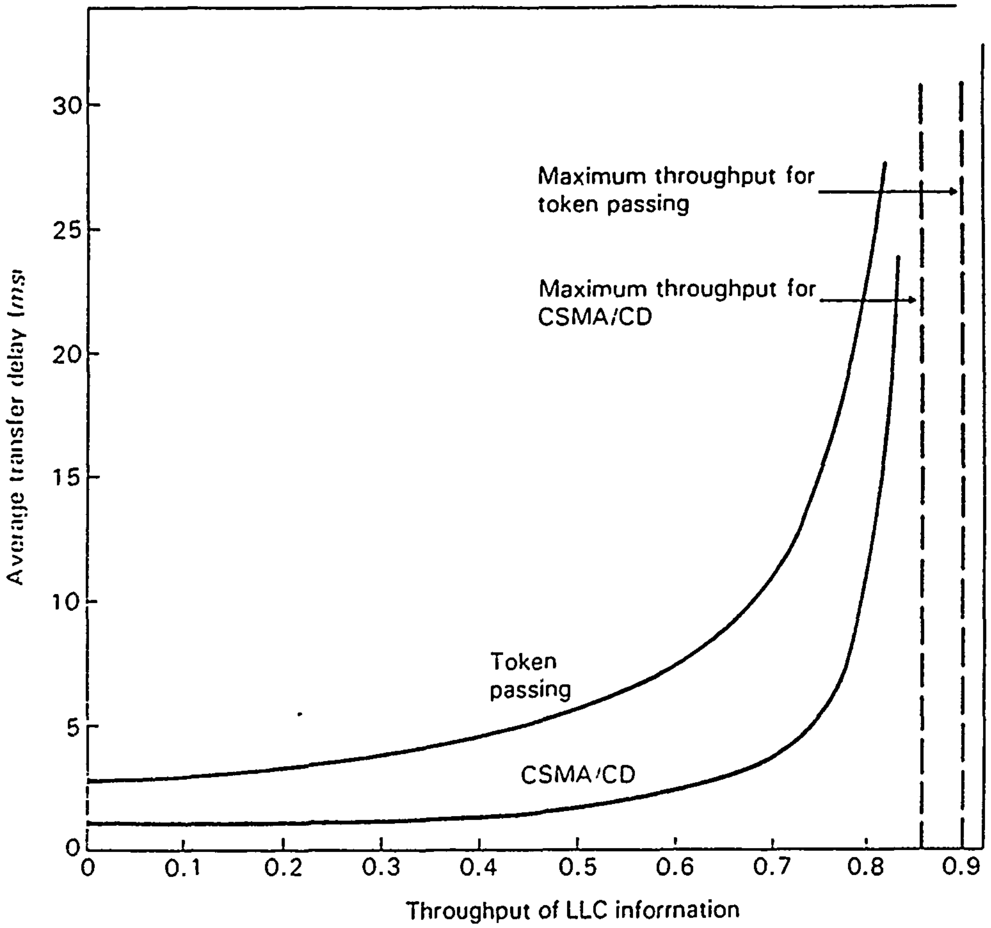

Figure 14 - Throughput Comparison Between Token Passing and CSMA/CD Access Methods [Ref. 35]

The system should be able to keep pace with these changes. Another advantage of modular design is the ease in replacing or updating components of the system when necessary. Contractual flexibility is the answer to providing more modern components during the life cycle of the contract. Future capabilities that may be built into this LAN and applications such as artificial intelligence, expert systems for flight scheduling and video teleconferencing for aircrew briefs will be dependent on the flexibility built into the system.

D. SUPPORT AND MAINTENANCE

Squadrons are organized in a highly centralized, hierarchical structure with a formal chain of command. The architecture of a LAN will be more distributed than the squadron structure in the sharing of information. A very important issue, because of the LAN distribution, is the support for the LAN. The squadron will not be able to support or control the effective use of the LAN without well defined functional control and support procedures. These procedures will specify and evaluate potential network technical/performance, processing communications and maintenance diagnostic features as well as the hardware configurations.

The ever-decreasing availability of budget funds available for ADP investments will not allow a separate maintenance support contract for every LAN installed in squadrons. The users will eventually become familiar with the system. As more personnel become computer literate, more stringent specifications will be required to prevent tampering with data and/or the file server. This knowledge base will eventually lead to improved and more maintainable technology for data systems. At a time when most DOD units are being forced into personnel reductions, needed increases for the support of LAN's will be even more difficult to obtain. Therefore, part of the support strategy should include people to support the system. These decisions should be reflected in the individual LAN procurement specifications if support is to come from the outside contractor or the Navy department should dedicate personnel for the squadron LAN's.

E. NETWORK MANAGEMENT

When designing the system, there are specific performance status report requirements, administration and control functions that will be required by DOD LAN's. These and other administrative functions could be performed by a LAN coordination center for all the squadrons. A wing level network management facility should be addressed for this type of control center. Future connection to other networks such as the Defense Data Network (DDN), will require status and service access reports at least down to the switching node level. Since each squadron LAN could not feasibly support a dedicated network control center the next higher level such as a wing, base, or region should be included in the overall network strategy. The squadron LAN manager could still provide basic traffic and usage statistics as well as the ability to report error or fault conditions to the responsible network control.

The LAN manager should hold the responsibility to maintain records of cabling plans, access points, users from each department, authorized access levels and any other similar administrative requirements that could be handled at the squadron level. Another important aspect of LAN management is the ability to add or reconfigure users on the network without disrupting or bringing the entire network to a stop. The contractors and system designers should develop these administrative daily operational management requirements with other specifications. By doing so the responsibility for the support of the LAN's and applications will be specified.

F. DOCUMENTATION

Documentation is a critical success factor in all systems. This is one important area that the LAN and standard software will greatly improve. Where little to no documentation exists today for the locally developed software applications, standard applications should specify all the necessary types. A few examples of the documentation stated in the DOD-STD-2167 are: Computer System Operator's Manual (CSOM), Software User's Manual (SUM), Computer System Diagnostic Manual (CSDM) and the Computer Resources Integrated Support Document (CRISD). Table 6 includes the information that should be included according to Department of Defense Standard Instruction

2167. The objective of this documentation is to provide users with enough information on the LAN and software in order to effectively use the system with minimal support from the vendor.

TABLE 6 - DOD STD. -2167 S/W REQUIREMENTS

[Ref. 36, p. 29]

DOD STD.-2167
S/W REQUIREMENTS

-EQUIPMENT CONFIGURATION

-OPERATIONAL CHARACTERISTICS, CAPABILITIES, LIMITATIONS

-COMPILATION AND ASSEMBLY INFORMATION

-PROGRAMMING FEATURES

-PROGRAM INSTRUCTIONS

-I/O CONTROL FEATURES

-EXAMPLES OF PROGRAMMING TECHNIQUES

-SPECIAL FEATURES

-ERROR DETECTION AND DIAGNOSTIC FEATURES

G. SECURITY

The larger numbers of users that will have access to the LAN will increase the security requirements. For the functional requirements of the system described the privacy act information is considered a Class two by the of Commerce, Federal Information Processing Standards Pub. 41, Computer Security Guideliens for Implementing the Privacy Act of 1974. A wise choice in the early stages in the LAN and software may be to limit the information on the network to unclassified data only. Until the costs for effective security methods is reduced, benefits will be realized earlier in an unclassified LAN.

There is an abundance of research being accomplished in multilevel security. This technique allows users with different security clearances to access and use the LAN simultaneously. This is accomplished through combinations of end-to-end encryption of classified data and the joint use of tactics such as trusted software, physical protection and secure operating systems. DOD prefers end-to-end encryption for two reasons:

- 1. to keep the cost of additional systems down.
- 2. software is subject to security invasions through passive modifications and tampering.

A current system called BLACKER, a multi-level technique, matches the OSI protocol model well and will probably be the accepted system for some time. [Ref. 37, p. 118] For future LAN's whose squadron's classified training, tactics and mission-essential information will be kept in a department's database, these security methods may be realized and put to use.

CHAPTER V. SUMMARY

A. CONCLUSION

The introduction of the personal computer into the Navy at the squadron level has provided a new tool to increase efficiency and capabilities in overall management. Already, more usage is seen in the daily operations at the squadrons. However, there does exist a lack of coordination and foresight into the future of the PC's at each squadron. Problems exist within the squadron such as data and program duplication, high costs of expensive peripherals, loss of expertise upon personnel transfers and maintainability of applications. Major departments in the squadron constantly spend time communicating by phone, memorandums and frequent visits. Two evolving products of information technology, Local Area Networks and standard applications, should seriously be considered to provide the interconnectivity of shared data bases and peripherals. These tools can be used to solve problems and increase the training, support and maintainability of management information systems in the aviation squadrons.

Creating LAN's and standard network applications at aviation squadrons is not a simple task. This project will require a great deal of consideration, planning and money. A project this large will require Navy-wide support at all echelons from the Chief of Naval Operations down to the Yeoman at the local squadron. Once this two part solution to the problem has gained support, user requirements and specifications need to be developed in order to understand exactly what the users want the system to be able to accomplish. "The characterization of user requirements should be done first from a functional not necessarily technical standpoint. Obviously, technical terms are often necessary to describe the application, but emphasis should be on the need first, not the solution." [Ref. 38, p. 117]

After the project has gained acceptance and the requirements have been specified, the next step is to decide whether to "make or buy" the system. That is, should the system be developed from within Navy resources or should they send out a Request for Proposal (RFP) for outside contractors. This decision will be based on budgetary restrictions from the estimated cost. In building the system, modular development can facilitate early prototyping of part of the system and test for functionality as well as feasibility.

There are other considerations that should be addressed such as standard training, support roles in and out of the squadron and control and coordination responsibilities. After system acceptance, training for the yeoman (YN), personnelman (PN) and data processing (DP) personnel who will be the primary users should be planned for either in the basic level rating school (A school) or in regularly scheduled classes prior to joining the squadron. Maintainability of the LAN's and software should also be planned for by designating certain personnel in organizations outside the squadron with that responsibility.

Unfortunately, it is not yet financially feasible to have a staff in the squadron to maintain the system. This group could also help in customizing the applications to different types of squadrons when necessary. Finally a control and coordination point for the development, implementation and operation of the system should be made for east and west coast squadrons. This point would be administratively responsible for overseeing that both east and west coast squadrons are maintaining the same degree of information technology capabilities. Emerging technologies in information systems should be another responsibility of this billet. This would continually provide the squadrons with modern technological capabilities in ADP.

B. RECOMMENDATIONS

Requirements and specifications that have been suggested throughout this thesis have provided the basic specifications that should be included for developing the LAN and the applications. Recommendations now being discussed have been developed from material that has been studied in class, discussions with local "experts" in LAN's and network software, and experience on several types of LAN's.

This research was collected during interviews with the users from two Aviation squadrons, VP-31 (a P-3 replacement air group squadron at N.A.S. Moffett Field) and VF-31 (an F-14 fighter squadron based out of N.A.S. Oceana). This thesis parallels the previously mentioned project that COMNAVAIRLANT is sponsoring with the TASC. However, these recommendations are in no way connected to that actual project.

The first recommendation concerns the project manager. This standard LAN and application concept for all squadrons requires a dedicated manager at both COMNAVAIRLANT and COMNAVAIRPAC. These two positions can coordinate the development and implementation of the LAN and applications.

The second recommendation encompasses LAN hardware. First the LAN topology and access method is a key consideration. Based on the layout of most squadrons, performance and future growth requirements, the CSMA/CD ETHERNET bus network seems best suited. Prototyping the LAN before purchase is important to ensure proper functional testing. There are numerous ETHERNET LAN's already in existence in the Navy, such as the CMAS (COMNAVBASE MEMORANDUM ACCOUNTING SYSTEM), which means it has gone through test and acceptance and is supported by NARDAC's. Secondly, an advantage of the ETHERNET is in E-mail which will be used extensively. The PC's in other departments do not need to be logged on to the network, ETHERNET LAN's can hold the mail indefinitely.

At a recent IRM Planning Conference hosted by CNO there was a discussion of a standard PC LAN in the Navy presented by COMANVTELCOM. The proposed LAN would use an 80386 microprocessor as the file server, ARCENT NIC's and Novell's NETWARE as the NOS. Although this has not yet become the official standard LAN, consideration should be given in using this LAN as another option because of the support from the NARDAC units. As far as the PC hardware, Zenith Z-248 microcomputers are in place at the squadrons now. When the next major PC contract is awarded, those PC's that will be allocated to the squadrons can be tested on the LAN for compatibility.

Problems may exist when a network has different types of PC's and when the network boards have different interrupts from the PC. The operating system must be able to support the various types of PC's. This point is made to show the importance of prototyping the LAN before it becomes standard.

A third recommendation is to provide training for a LAN manager at each squadron. This should be manned as a collateral duty. Also an automated configuration management system that works on the LAN should be developed or acquired to help the squadron LAN manager with inventory and other management issues previously discussed. This position will be critical in the use of the LAN and working out difficulties that are sure to arise in the early stages.

The following recommendations concern the LAN software. Applications should be tested on the network for compatibility. The contractor should complete the testing of applications on the network and provide documentation. This supports the fact that LAN hardware should be chosen prior to the application development. By centralizing the software on the file server, reductions in software maintenance, configuration management, and storage requirements will be realized.

Data base management will be a key issue for overall integrity of the data. Multi-user access to the shared data base should require that the network operating system or the applications themselves use record locking. Read only files will prevent inadvertent or other reasons for degradation of the integrity of the data base information.

Finally, software security concerns are included in the recommendations for obvious reasons. Software and hardware security must be addressed because users could tamper with the server, data integrity could be compromised and theft is always a consideration. A few solutions to these problems are securing the file server by locking the keyboard, providing limited access to the database by passwords, and physical security can be accomplished by tie downs and locking the devices.

The success of this project is critically dependent on the overall coordination and planning. It is time that Naval Aviation squadron's daily administration tasks, that today are so time consuming and inefficiently accomplished, be analyzed and updated. This thesis has presented one possible answer in LAN's and standard applications. The overall system will inevitably experience many changes. Flexibility, a trait inherent in aviation, should be allowed for in the overall strategy. As more LAN's appear in DOD organizations, standardization, coordination and local and long distance LAN interconnection may eventually lead the way to a truly integrated armed forces.

APPENDIX

ACRONYMS

ADP - Automated Data Processing

ADMIN - Administration Department

CCITT - International Telegraph and Telephone Consultive Committee

CDI - Collateral Duty Inspector

CO - Commanding Officer

COMNAVAIRLANT - Commander Naval Air Force United States Atlantic Fleet

COMNAVAIRPAC - Commander Naval Air Force United States Pacific Fleet

CSMA/CD - Carrier Sense Multiple Access/Collision Detection

DAP - Data Access Protocol

DARPA - Defense Advanced Research Project Agency

DDN - Defense Data Network

DEC - Digital Equipment Corporation

DOD - Department of Defense

DP - Data Processor

IBM - International Business Machines

IEEE - Institute of Electrical and Electronic Engineers

IRM - Information Resource Management

LAN - Local Area Network

MAINT - Maintenance Department

MAINT ADMIN - Maintenance Administration Department

MAINT CONTROL - Maintenance Control Department

NARDAC - Navy Regional Data Automation Center

NAVDAC - Naval Data Automation Command

NIC - Network Interface Card

NOS - Network Operating System

ISO/OSI - International Standards Organization/Open Systems Interface

OPS - Operations Department

PC - Personal Computer

PN - Personellman

POD - Plan of the Day

QA - Quality Assurance

RFP- Request for Proposal

SNA - Systems Network Architecture

TASC - The Analytical Sciences Corporation

TI- Texas Instruments

TCP/IP - Transmission Control Protocol/Internet Protocol

UPS - Uninteruptable Power Supply

ULANA - Unified Local Area Network Architecture

VF-1, -31 - Fighter Squadrons 1 and 31

WAN - Wide Area Network

X.25 - Packet Switching Network Protocol

XO - Executive Officer

YN - Yeoman

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