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THESIS

X.400-BASED ENTERPRISE MESSAGING SYSTEM: INDUSTRY AND DEPARTMENT OF DEFENSE IMPLEMENTATION ISSUES

by

Christina Cornell Rhodes

March 1994

Principal Advisor: Myung Suh

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X.400-Based Enterprise Messaging System: Industry and Department of Defense Implementation Issues

by

Christina Cornell Rhodes

Lieutenant. United States Navy

BA, Miami University of Oxford, Ohio, 1986

Submitted in partial fulfillment

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Author: Christina Cornell Rhodes

Christina Cornell Rhodes

Approved by: MSuh

Myung Suh, Principal Advisor

William B. Short

William B. Short, Associate Advisor

Reuben T Harris for

David R. Whipple, Chairman

Department of Systems Management

ABSTRACT

In an unprecedented globally competitive market, industry demands an electronic mail or messaging system that will transport all forms of data. The Consultative Committee for International Telegraphy and Telephony (CCITT) X.400 family of standards is a *messaging transport standard* that facilitates *international* message exchange. Combined with an appropriate network architecture, the series provides a complete package for transport of electronic objects such as digitized voice, documents, forms, graphics, images, spread sheets and text. The purpose of this thesis is to provide DoD technicians and managers, who will be utilizing X.400-based E-Mail within the Defense Message System (DMS), with a thorough discussion of the X.400 standards. Highlighted by industry examples, possible, conceptual solutions for incorporating the standards into existing electronic messaging environments are provided.

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TABLE OF CONTENTS

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I. INTRODUCTION

A. BACKGROUND

Although the Department of Defense (DoD) has had an electronic messaging infrastructure since the late 1960s, with the inception of the Automatic Digital Network (AUTODIN), there is a new architecture under procurement called the Defense Message System (DMS).

This DMS infrastructure will support both organizational and individual messaging. The current infrastructure, or DMS baseline, consists of distinctly separate, "individual" and "organizational" messaging components. Organizational service is provided by the AUTODIN, and individual service is provided by electronic mail applications on the DoD Internet.

The DMS Program is the result of a 1988 Assistant Secretary of Defense (ASD/C3I) effort to determine the future of DoD electronic messaging systems. The areas that mandated change were: (1) problems and costs associated with managing the baseline system, (2) lack of an overall DoD messaging architecture, and (3) emergence of new international standards and technology-mandated change. (DoD 1993, p.7)

The need to interconnect and interoperate has driven DoD, as well as civilian corporations, to develop international, standard-compliant systems. Organizations need to exchange messages with its components, clients, and competitors across the boundaries of the proprietary electronic mail packages they may use. X.400/X.500 protocols are one means to make this interconnection happen.

B. PURPOSE AND SCOPE

The purpose of this thesis is to provide DoD technicians and managers alike who are associated with an E-Mail system, a basic, thorough discussion of the Consultative Committee for International Telegraphy and Telephony (CCITT) X.400 family of Message Handling Standards. Additionally, a brief definition of the associated CCITT X.500 Directory standard is provided. Since many corporations have already invested significantly in various E-Mail packages, specific platforms and operating systems, a global messaging standard that transparently unites all disparate E-Mail systems would be ideal. X.400 and it's directory counterpart, X.500 are CCITT recommendations for this evolutionary messaging demand. This thesis topic has direct application to DoD since it specifically discusses X.400 implementation issues for the E-Mail portion of the Defense Message System (DMS). In the conclusive chapter, after identifying industry lessons learned on an X.400 installation, possible solutions are given for DoD components on how to incorporate X.400 into their electronic messaging environment. These conceptual solutions may assist Information Technology managers in planning their messaging systems so that they may have the message handling functionality of the standards in the interim period of the X.400-based DMS implementation.

The scope of this thesis includes: discussion of the evolution of the CCITT X.400 standard series; a description of how it works; issues from a product review and Corporate Computing's ZD Labs' report; a look at how the DMS Program plans to implement X.400; and a snapshot of how Wal-Mart Stores Inc. is currently implementing a company-wide, X.400 messaging system.

C. EVOLUTION OF X.400/X.500 PROTOCOLS

> "Electronic messaging can perhaps be said to have started around the time when, in 1851, the New York and Mississippi Valley Printing Telegraph Company (later renamed as the Western Union Telegraph Company) was founded." (Betanov 1993, p.2)

Led by this giant, common-carrier, Western Union Telegraph Company, message switching functionality was provided in a <u>torn tape</u> manner over telegraph lines that were usually dedicated. It wasn't until a hundred years later, in the 1960s and 1970s, that this message switching functionality was provided via <u>computers</u>. This enabled private organizations to assemble their own messaging networks by leasing dedicated circuits from carriers and interconnecting them using computers acting as switches. These switches were often connected to the telex network which had been in operation since the 1930s. The telex market was dominated by organizations like large banks and trading companies with international operations as well as industry groups with international scope.

Another related development in the 1960s and 1970s was that of general-purpose, packet switching networks. These networks primarily facilitated the task of communicating data to and from computers. The first significant packet switching network was the ARPANET, sponsored by the Advanced Research Projects Agency. Between 1969 and 1977, ARPANET grew from 4 nodes to 111 hosts. Within packet switched networks, the transmission protocols had to be separated from the messaging and other application protocols since messages were decomposed into packets and sent packet by packet instead of as one whole entity. This division in functionality created independent development of both application and transmission protocols. Thus, software development for these protocols and integration of packet switching technology into applications were simplified. The person programming the application did not have to know details of packet switching mechanisms. The developer just had to know how to use the Application Program Interface (API). The Consultative Committee of International Telegraphy and Telephoney's (CCITT) eventually provided formal recommendations, called X.25 and X.75 that represented packet switching. The major result of these protocols was to allow easy interconnection of dissimilar systems regardless of hardware platform. (Betanov, 1993, pp.3-4)

From the perspective of electronic mail applications and services, the customized development of X.25 applications resulted in two basic problems: (1) hardware manufactures developed electronic mail applications that operated only on platforms that they manufactured such that they were not compatible with those developed by another manufacturer; and, (2) electronic mail service providers allowed users access to their systems for sending and receiving messages. For example, Western Union provided Easylink service, MCI provided MCIMail and Sprint provided Telemail. However, these carriers offered no connectivity among themselves except through telex; therefore, the services were strictly proprietary. The following situations highlight these developmental problems: (Betanov, 1993, pp. 4-5)

- An organization using equipment from different hardware manufacturers could not easily connect E-mail systems running on the various platforms.
- An organization could not readily connect its proprietary E-mail system to a public E-mail system provided by a common carrier or service provider.
- Users of various public E-mail systems by different service providers were basically isolated from one another since these disparate systems had no interface with one another.

Customized interface solutions to the above problems evolved for interconnecting different hardware and software. Without a standardized solution, the interface-building wheel was reinvented over and over again, users were very frustrated and businesses spent a lot of money.

Industry began to demand a messaging environment that would provide common functionality across hardware platforms and service providers. If the definition of such an interface could be achieved, not only would it become as easy to interconnect electronic mail systems as it is easy to interconnect dissimilar systems using X.25, but it would also be possible to develop standardized applications that could be invoked using APIs. Theoretically, an API would remove the requirement that a programmer know all the details of message handling in order to incorporate messaging into an application. A program could be written to "pass" the message contents and selected service elements (ie., recipients address) to the API and the E-Mail system *behind* the API would then handle the specific details of ensuring the message was received at the destination.

Development of a generalized messaging system was initiated in 1975 when the United Nations Educational Scientific and Cultural Organization (UNESCO) organized "Working Group 6.5" through it's subcomponent, the International Federation of Information Processing (IFIP). The overall mission was to develop the *requirements* for a *computer-based messaging system*. In 1981, another organization within the UN, CCITT, which was mentioned earlier, followed on IFIP's work. In 1984, the CCITT X.400 series of recommendations governing message handling systems were ratified. (Betanov, 1993, pp. 5-6)

By December of 1988 service providers did not appear too anxious to change their proprietary status quo. Providers of public E-mail services developed X.400 messaging capability but were not aggressive to interconnect their respective systems. In response, an industry group called the Aerospace Industry Association (AIA), which happened to be a very large customer of the E-mail industry, invited all major E-mail providers in the U.S. to participate in a pilot project. Essentially, all providers were to connect their respective E-mail systems via X.400 to demonstrate the feasibility of X.400 connectivity. This AIA pilot project was extremely successful in that all providers were able to establish connectivity to at least one other service provider despite their extremely different implementations and hardware platforms. (Betanov, 1993, pp. 6-7)

In response to industry demands as well as the CCITT normal four-year review cycle for standards, X.400 was reviewed, improved (ie., more readable and secure, better interfaces, and a new message store functionality) and completely re-written for ratification in 1988.

1988 also documented the adoption of a series of CCITT recommendations for a *directory system*, called X.500. Many of the CCITT committee members who developed the 1988 X.400 protocols helped develop this new set of protocols (Radicati, 1994). Used in conjunction with X.400-compliant messaging, the X.500 recommendations proposed simplification of the address determination and related issues in X.400 environments.

During 1990, the U.S.-based service providers became fully interconnected so that a user of any public E-mail service could communicate with a user of any other public E-mail service. In fact, by June of 1992, many of the service providers had links to providers located in 20 to 40 other countries. In the 1990-1993 time frame, the following additional but related developments occurred: (Bet. ov, 1993, pp. 8-9)

- The number of systems providing X.400 interfaces increased sharply. For example, most E-mail packages running on local area networks (LANs) provide X.400 gateways which interconnect individual LANs and other messaging systems. This creates either a corporate electronic messaging backbone using X.400, or X.400 LANs connected to a service provider's public E-mail system.

- February 1990 - the North American Directory Forum was created to accelerate the development of a global X.500-compliant directory system.

- June 1991 - CCITT promulgated the X.435 standard , which allows for the exchange of *electronic data interchange* (EDI) documents over X.400 networks.

- February 1992 - a U.S.-based vender of X.400 products announced a suite of products that allow X.400 connections over telephone lines, as opposed to packet network connections. This development reduces the cost of maintaining X.400 connections allowing smaller user communities to become integrated into the global X.400 network, thus increasing the user base reachable via X.400.

- October 1992 - X.400 Application Program Interface Association (XAPIA) is a well-established, standardssetting organization composed of the major E-mail vendors who have created a set of APIs to the X.400 messaging-service standards. The association is also working on a set of cross-platform messaging APIs that will further enhance the functionality of X.400 (Duffy, 1992, p.S/25).

- June 1993 - Many major vendors are providing native, or 2nd generation X.400 implementations which are real, E-mail, backbone environments that comply with the 1988 X.400 standard as opposed to 1st generation 1984 X.400 "mapping" products like proprietary X.400 gateways (Radicati, 1994).

- September 1993 - Department of the Air Force publishes its Request for Proposal for the DMS-GOSIP Program specifying X.400/X.500 as mandatory requirements for the Messaging system (DoAF, 1993).

D. ORGANIZATION

Chapter II characterizes the basic requirements for any X.400/X.500 enterprise system. Chapter III will provide X.400 implementation methods and issues with an overview of an industry lab report from ZD Labs of Corporate Computing. Chapter III also identifies the top three industry E-Mail packages as well as those used in DoD. Chapters' IV and V will illustrate the DMS and Wal-Mart Stores, Inc. as the DoD and industry examples, respectively, of X.400/X.500 enterprise systems. Finally, Chapter VI will, after recapitulating industry lessons-learned on X.400 installations, provide possible solutions for DoD components who want to incorporate X.400 into their electronic messaging environment so that they may have the functionality of the standards in the interim period of the DMS X.400 implementation.

II. X.400/X.500 ENTERPRISE SYSTEM REQUIREMENTS

A. DEFINITION OF X.400/X.500

In October 1984, the Plenary Assembly of the CCITT accepted a standard to facilitate international message exchange between subscribers to computer based store-and-forward message services. This *messaging transport standard* is known as the CCITT X.400 series recommendations and happens to be the first CCITT recommendation for a network *application* (Houttuin. 1993, p.5). In October 1988, CCITT published a totally rewritten set of standards which increased the functionality of the 1984 standards. There were five significant improvements to the message handling architecture that included the Message Store (MS), distribution lists, X.500 directory services, support for postal delivery systems, and security. In addition, X.400 protocol layering architecture changed substantially to incorporate recent changes to the Open Systems Interconnection (OSI) upper layers and to provide a design that is more consistent with other OSI applications. (Burns, Radicati, 1992, p. 179)

X.400 has been defined as follows:

> The primary role for X.400 has been to define a format for the electronic envelope, so that an X.400 backbone can transmit messages regardless of contents (Brennan, 1992, p.S22).

If the "electronic envelope" depicts the X.400 role, then the functional aspect of the CCITT X.400 family of standards can be described as a model for a **Message Handling System (MHS)** and associated services and protocols. In the context of the MHS, "users" may be either humans or application processes. The **User Agent (UA)** is a process that makes the services of the MHS available to the user. The services are grouped into *message transfer services* and *interpersonal messaging services*. These services are further divided into three categories: *basic*, *essential optional*, and *additional optional*. To illustrate these categories, Table 2-1 lists the services provided by the **Message Transfer Agent (MTA)** (Stallings 1991, p.745)

The CCITT X.400 family of standards for Message Handling Systems is identified below:

- **X.400** This number represents the *Systems and Service Overview* and defines the message handling system model. It consists of Uas and MTAs, discusses naming and addressing, defines interpersonal messaging and message transfer services as well as protocols for implementation.

- **X.402** This number represents the *Overall Architecture* and serves as a technical introduction to it.

- **X.403** This number represents *Conformance Testing* specifying the criteria for acceptance of an implementation as conforming to the X.400 family of recommendations.

- **X.407** This number represents *Abstract Service Definition Conventions* and defines techniques for formally specifying the distribution information processing tasks that arise in message handling.

TABLE 2-1: BASIC AND OPTIONAL SERVICES PROVIDED BY THE MTA

Message Transfer Agent

Basic Services

Access Management	Enables UA to submit and have msgs delivered to it
Content type indication	Specified by originating UA
Converted indication	Specifies any conversion being performed on msgs being delivered.
Submit/Deliver Time Stamp	Both times are supplied with each msg.
Message Identification	Unique identifier for each msg.
Nondelivery notification	Msgs cannot be delivered.
Registered encoded info types	Allows UA to specify types that can be delivered to it.
Original encoded info types	Specified by submitting UA and supplied to receiving UA.

Essential Optional Services

Alternate recipient allowed	Deliver to alternate if designated recipient not found.
Deferred delivery	Deliver no sooner than specified date and time.
Deferred delivery cancellation	Abort delivery of deferred msg.
Delivery notification	Notify originator of successful delivery.
Disclosure of other recipients	Disclosure list of other recipients to recipient
Grade of delivery selection	Request urgent, normal or non urgent
Multi-destination delivery	Specify more than one recipient
Conversion prohibition	Prevents MTS from conversion
Probe	Determines if msg could be deliverable

Additional Optional Services

Prevent non-delivery notice	Suppress potential non-delivery notification
Return of contents	Return msg contents if non delivery
Explicit conversion	Specifies specific conversion
Implicit conversion	Perform all necessary conversions on all msgs without explicit instruction
Alternate recipient assignment	Request designation of requesting UA as alternate recipient
Hold for delivery	Requests that msgs intended for specific UA be held in the MTS until suc specific time

- **X.408** This number represents *Encoded Information Type Conversion Rules* to allow dissimilar devices to exchange messages. The encoded information types that are handled include Telex, Teletex, ASCII terminals, facsimile, and videotex.

- **X.411** This number represents the *Message Transfer Layer* conceptually defining the message transfer layer service and the message transfer protocol.

- **X.413** This number represents the *Message Store* defining its services.

- **X.419** This number represents *Protocol Specifications* defining the protocols for accessing the MTS, the MS and those that are used between MTAs to provide for the distributed operation of the MTS.

- **X.420** This standard defines the services provided by interpersonal messaging and procedures for providing those services. (Stallings, 1992, p.738)

Ratified in 1988, X.500 is the CCITT standard that will provide the Global Directory Services for X.400. X.500 provides for naming facilities over networks, and it enhances the X.400 addressing mechanism by improving mail addressing within large, distributed message systems. Linked but dissimilar E-mail systems can now have common directories, a feature that hides complex addressing schemes from users. These directories are maintained on X.400 file servers. Directories can be accessed independently by any number of components, including Uas, MTAs, Access Units (AUs) and Message Store (MS) facilities, and even directly by end users. (Burns, Radicati 1992, pp.180-182). These components are fully defined in the next section.

B. HOW AN X.400/X.500 MESSAGE HANDLING SYSTEM WORKS

In an X.400 system, users are provided with the capability of sending and receiving messages. The interface to the actual user (whether human or process) is accomplished through the ***User Agents (Uas)***. For example, a UA may be implemented in the MHS as a computer program that provides utilities to create, send, receive and archive messages. Each UA is provided a "name" so that the ***Message Transfer System (MTS)*** can transfer messages from an identified *originating* UA to a specific *receiving* UA. Basically, Uas pass messages to ***Message Transfer Agents (MTAs)*** until the messages reach their destinations. As shown in Figure 2-1, which illustrates the components of a distributed messaging system, the actual work of <u>message transfer</u> is done in the MTS by the MTAs. Prior to forwarding the message to another MTA or a UA, the MTA validates the submission envelope and performs housekeeping functions such as recording submission time and generating a message identifier. Although not pictured in Figure 2-1, it is important to note that the MTA may store the message in a "mailbox" facility called a ***Message Store (MS)*** to be picked up later by a UA. Sometimes the MTA that accepts submission of a message delivers it directly to a UA or MS. Given the functionality of the MS, it could conceptually be located throughout the MHS and/or on the logical boundary between the MHS and the MTS. Other scenarios require MTAs to relay the message to one another until it reaches its destination.

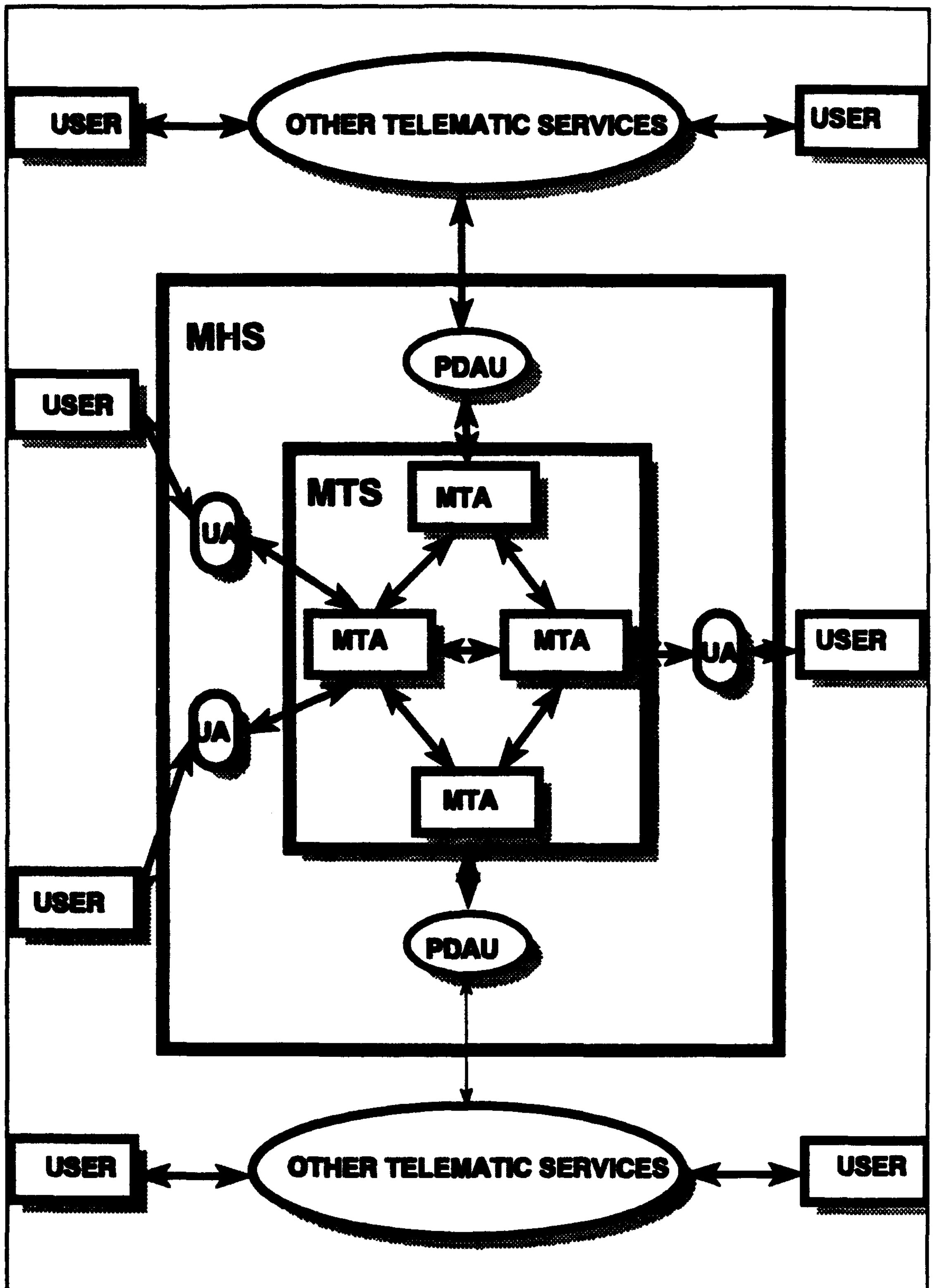

Figure 2-1: Components of a Distributed Messaging System

Using such a relay eliminates the need to have all UAs and MTAs available on a 24-hour basis; and, combined with the MS component, allows the office to "shut down" at night. The specific functionality of the MS can be defined as follows:

- One MS acts on behalf of one user (ie., one originator/ response address).
- When a UA subscribes to a MS, all messages destined for the UA are delivered to the MS. When a message is delivered to a MS, the role of the MTS in the transfer process is complete.
- The MS stores only delivered messages, not those being submitted.
- An "alert" may be requested when a certain message arrives.
- Message submission from the UA to its MTA, via the MS, is transparent.
- Users are provided with basic message management facilities such as selective message retrieval, delete and list.

In effect, the MS specification is simply a standardized definition of how otherwise local UA functions have been taken over by a separate system and accessed via a protocol. However, prior to the 1988 specification, messages sent from the UA to the MTA could be lost if the MTA was not ready to accept them. The lights had to be on. So, the MS was critical to expanding the functionality of X.400. (Stallings 1991, p.738-740)

Finally, X.400 also facilitates communication between different E-mail systems by acting as a translator. An ***Access Unit (AU)*** provides a gateway between the MHS and the external communication service such as TELEX. The rules for conversion of coded information are defined, making standardization of the conversion of message contents for transfer between dissimilar systems possible. Figure 2-2 depicts the process of message construction and transmission. Outside the scope of X.400, the user prepares the body of a message using, for instance, a word processor. The user presents the message body together with a description such as the subject, recipient and priority to the UA. The UA appends a header containing this qualifying information to the message. The MTA appends an envelope to the message containing the source and destination addresses and other control information needed for relaying the message throughout the network. (Stallings, 1991, p.741)

An example of the format for a standard X.400 message address for an E-mail network is

c={ }/admd={ }/prmd={ }/o={ }/s={ }/g={ }

where c=country; admd=administrative management domain; prmd= private management domain; o=organization; s=surname; and g=given name (Burns, Radicati 1992, p.175). Using the above format, a typical address might be:

c=US/admd=telmail/prmd=NPS/o=ms/s=msdos1

As mentioned in the previous section, X.419 is the part of the X.400 standard providing protocol specifications. How do these protocols work? Basically, they are located in the application layer (layers 6 or 7 of the model depending on the

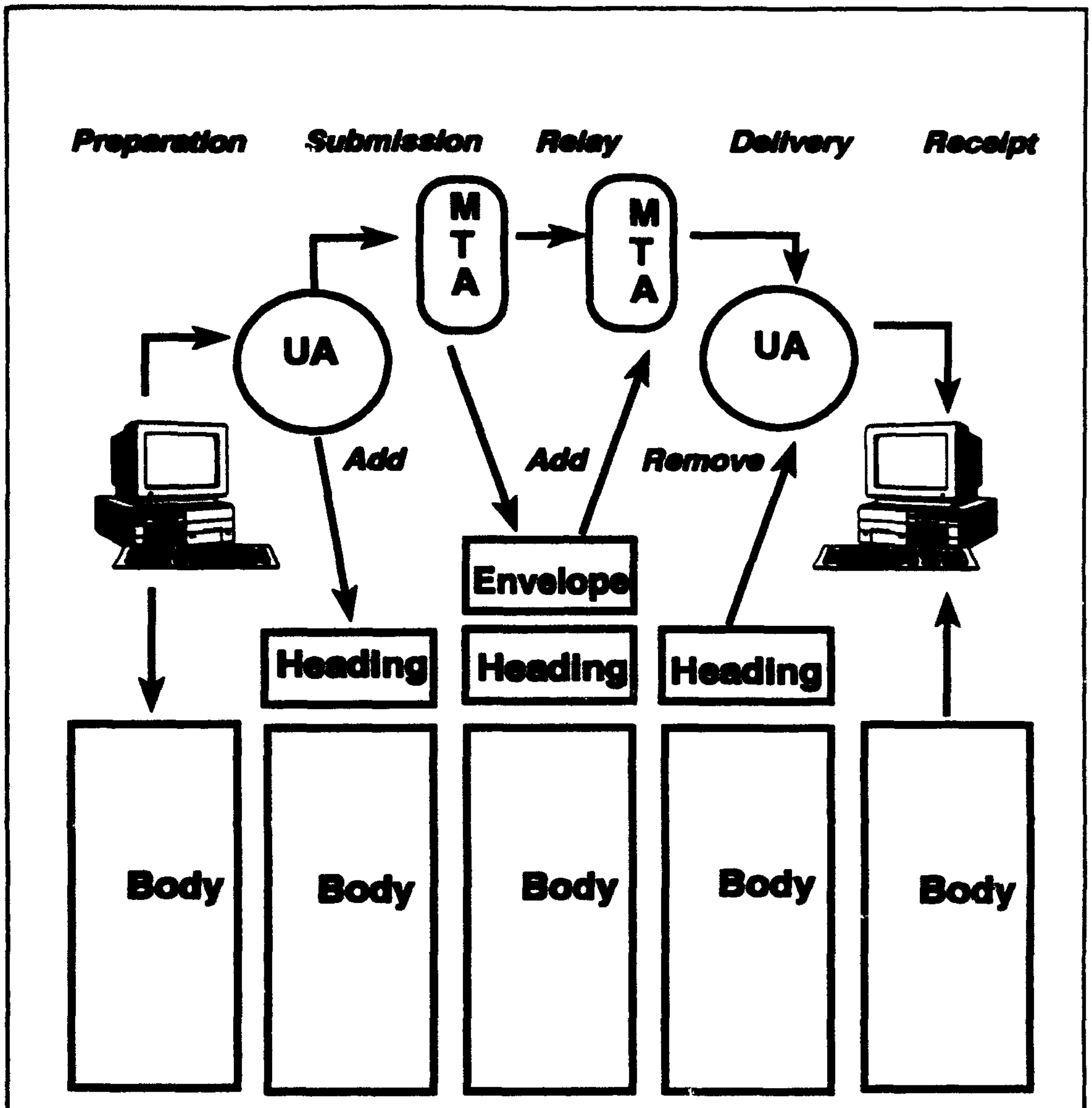

Figure 2-2: Message Construction and Transmission Process in a Messaging System

representation of the model) of the OSI model. It is assumed that the lower layer protocols used in the OSI network model are compatible between disparate systems.

The X.419 protocols consist of (1) the **Message Transfer Protocol (P1)** which acts as the "backbone switching" protocol that relays messages and other interactions among various

MTAs; (2) the **Remote UA Access Protocol (P3)** which acts as a remote procedure call by enabling a UA that is remote from its MTA to obtain access to the MTS; and (3) the **MS Access Protocol (P7)** which provides a mailbox facility. The following is an example of the use of these protocols:

> User A sends a message to User B *and* User C. The message is handed over to User A's UA, which *submits* the message after putting it in an envelope. The envelope is, in effect, the header of a **P3** protocol data unit. The MTAs take over the *transfer* of the message until it reaches an MTA which can make a *delivery* of the message. The routing of the message among the MTAs is accomplished with the **P1** protocol. The recipient, User B, gets delivery to B's UA, via protocol **P3**, where it can be directly read. For recipient, User C, a copy of the message is delivered into C's MS from where it can later be retrieved via protocol **P7**. (Stallings 1992, pp.743-744)

C. ISSUES FOR AN X.400/X.500 ENTERPRISE-WIDE SYSTEM

Since X.400 works independently with respect to any one operating system, it is ideal for global communications. However, there are a number of issues that need to be taken into account prior to implementing an X.400/X.500 enterprise-wide system. Most of these issues will be highlighted in the next chapter which provides methods for obtaining X.400 functionality as well as some product information.

First, there are few X.400 (1988) products because the majority of the vendors who invested research and development in X.400 did so with the 1984 standard. This leads to a related issue; since the 1984 specifications were not completely thought out, vendors have basically had to rewrite their 1984 products. Many vendors still feel this is risky as well as costly, and have therefore been slow to do so. (Korzeniowski, 1993, p.NP4)

Secondly, there is a lack of domestic interest and support in the OSI Model, on which X.400 is based. The TCP/IP Internet has made a "de facto" standard network model. The E-Mail on the TCP/IP Internet is supported by the Simple Mail Transport Protocol (SMTP). SMTP gained widespread acceptance in three years compared to nearly a decade for its OSI counterpart, X.400. Nevertheless, industry, in general, has accepted X.400 as the standard of the future since it has the potential to provide much more functionality than SMTP. Yet, many industry experts believe E-mail customers want to keep the TCP/IP infrastructure for their messaging transport mechanism. Figure 2-3 illustrates this dilemma with the ISO Development Environment (ISODE) link between X.400/X.500 and TCP/IP as a possible interim solution until the ideal network messaging model is achieved.

As Chapter III will illustrate, corporations who have invested in X.400/X.500 have discovered it requires a fair amount of customization before deployment. So, the third issue is that if a company or agency desires to implement an X.400/X.500 messaging environment, it will most likely experience transition problems. Time and expert personnel must be scheduled to iron out implementation bugs. This phenomenon is primarily due to vendors interpreting and

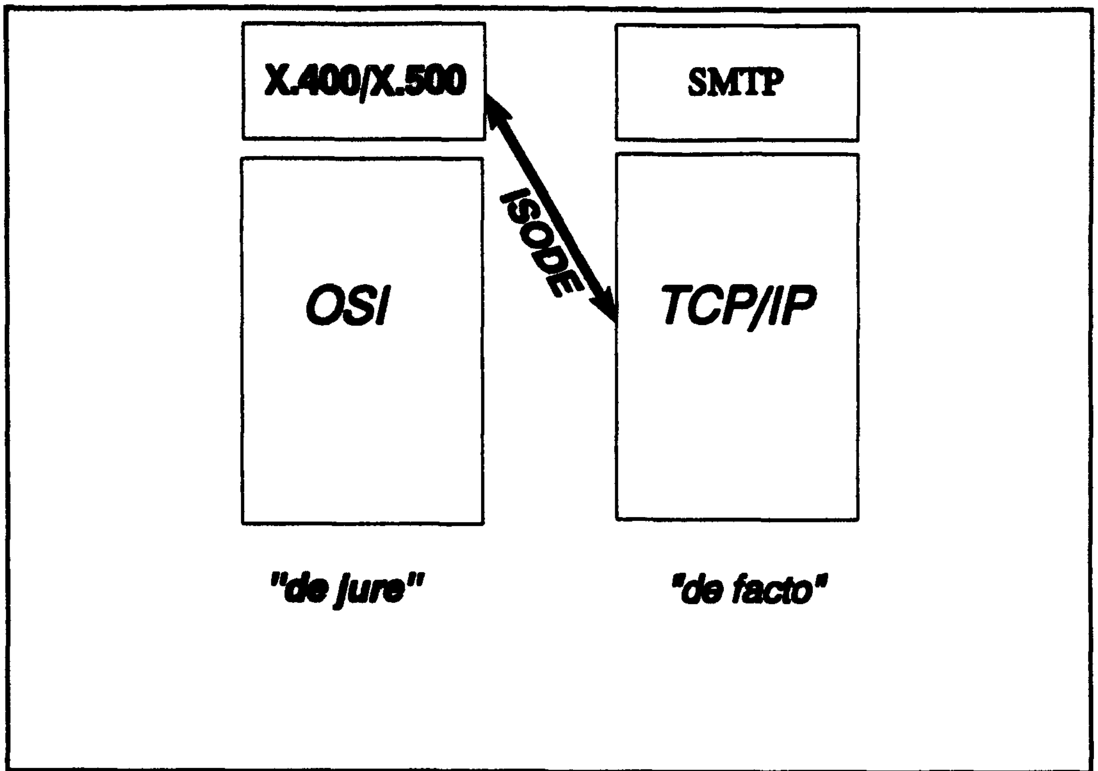

Figure 2-3: ISODE and Integration Issues With X.400 and TCP/IP

implementing the X.400 series recommendations differently in their products. Consequently, X.400 can be viewed as a standard that provides a common set of messaging features and not a full-blown integration tool. (Korzeniowski, 1993, p.NP6)

Finally, with respect to directory services, E-mail vendors using the X.500 (1988) specification often add proprietary extensions to handle directory updates since the spec does not have this aspect automated. Thus, it still calls for manual updates. The 1992 X.500 specification improves directory synchronization, but products and services based on this specification may not be available for four or five more years. (Burns, Radicati, 1992, p.182)

These issues provide serious challenges for Information Systems managers as they administer or create architecturally efficient and effective messaging infrastructures.

III. X.400/X.500 IMPLEMENTATION ISSUES

While both the Department of Defense services and agencies as well as companies flatten their organizational structures and pull together merged commands or business units, Information Systems (IS) managers are seriously challenged as they try to physically and logically connect all the different E-mail systems. As defined in the previous chapter, incorporating the CCITT X.400 series recommendations into the messaging infrastructure is one way to accomplish this. This chapter will introduce three methods of obtaining X.400 services and discuss the integration of them with excerpts from a ZD Labs report. (Burns, Radicati, 1992, p.168) The report illustrates how well X.400 technology and products performed during a test of X.400 connectivity in a "typical" corporate computing environment.

A. ALTERNATIVE METHODS

Basically, there are three methods by which X.400 services can be obtained: (1) connect through a public E-mail service provider; (2) establish a corporate-wide X.400 mail handling system; or (3) install proprietary E-mail packages with X.400 gateways and/or servers.

1. Public X.400 E-Mail Service Providers

Public E-mail providers are the fastest and simplest way to set up X.400 links. They offer a subscription similar to telephone service in that they provide installation, configuration, maintenance and support as part of the service. The subscriber usually pays a set-up charge and a "per message" charge based on usage, typically 30 to 95 cents per message. For businesses that are *light* on mail traffic, public E-mail providers are most cost effective since installation costs are low and the providers take on the burden of integration and management issues. They also provide enhanced services like accounting and monitoring. The disadvantage of using public E-mail providers includes escalating costs as E-mail volume rises, less control over the E-mail links, and, possible privacy and security risks. (Burns, Radicati, 1992, pp.168-169)

All the big carriers, AT&T, MCI and Sprint, have X.400 gateways that they manage for their subscribers, although they typically do not use X.400 internally. Their Electronic Messaging packages are called AT&T Easylink, Sprint Mail and MCI Mail. (Lotus, 1993, p.4)

2. Corporate-Wide X.400 Mail Handling System

This option for X.400 connectivity requires purchase of the hardware and software needed to build in-house X.400 services. The advantages of this strategy include complete control over the E-mail system, its security and performance. Additionally, it offers better integration with existing corporate computing and data processing functions than public link services do. The primary disadvantage with installing a corporate-wide X.400 mail handling system is the burden it places on the MIS personnel with planning, design, configuration, product compatibility issues, and day-to-day maintenance and support.

If a corporation decides to build its own X.400 infrastructure, there are a number of minicomputer vendors such as DEC and HP that provide all the components needed for storing and routing X.400 messages. In most cases, these vendors have adopted X.400 capabilities on their own sites and are actively promoting an architecture that they use on a day-to-day basis. DEC is one of the few vendors that also offers an X.400 client or UA, which is the front end or user interface to the messaging system. Most vendors use proprietary UAs and E-mail servers that link to X.400 gateways, as will be discussed next. (Burns, Radicati, 1992, p.169)

3. Proprietary E-Mail System With X.400 Gateway

Most PC-based E-Mail vendors and minicomputer and mainframe computer messaging systems have X.400 gateways between their proprietary messaging systems and X.400 (Burns, Radicati, 1992, p.169). Vendors make their proprietary mail servers "talk" to a gateway prior to accessing X.400 MTAs. Some X.400 gateways perform a conversion between the vendor's own proprietary mail protocol and X.400 protocols. On the other hand, a number of third-party vendors such as Retix, DEC, World Talk and Soft-Switch provide X.400 gateways and/or servers for connecting dissimilar messaging services from different E-Mail vendors. These products support not only a wide selection of proprietary protocols but also provide the message handling agents (UAs and MTAs) required for sending X.400 messages. Some of these products include directory services that tie together dissimilar E-mail directory formats. At the high end of the X.400 gateway market, Soft-Switch has the most comprehensive and technically advanced product; however, it requires a mainframe and is relatively expensive, at approximately $100,000 for hardware and software versus a PC-based solution such as Retix's listed at approximately $5500. Retix has incorporated an effective strategy of developing a wide range of software options that allow most of the popular PC-LAN messaging systems, such as Microsoft Mail, cc:Mail, and Novel MHS, to access its OpenServer 400 MHS thus increasing the number of different MHSs a corporation can link with. (Burns, Radicati, 1992, p.172) Figure 3-1 illustrates a possible configuration for some of the X.400 gateways and/or servers.

The decision of whether or not to use a single, multi-protocol gateway or a multiple-gateway solution depends

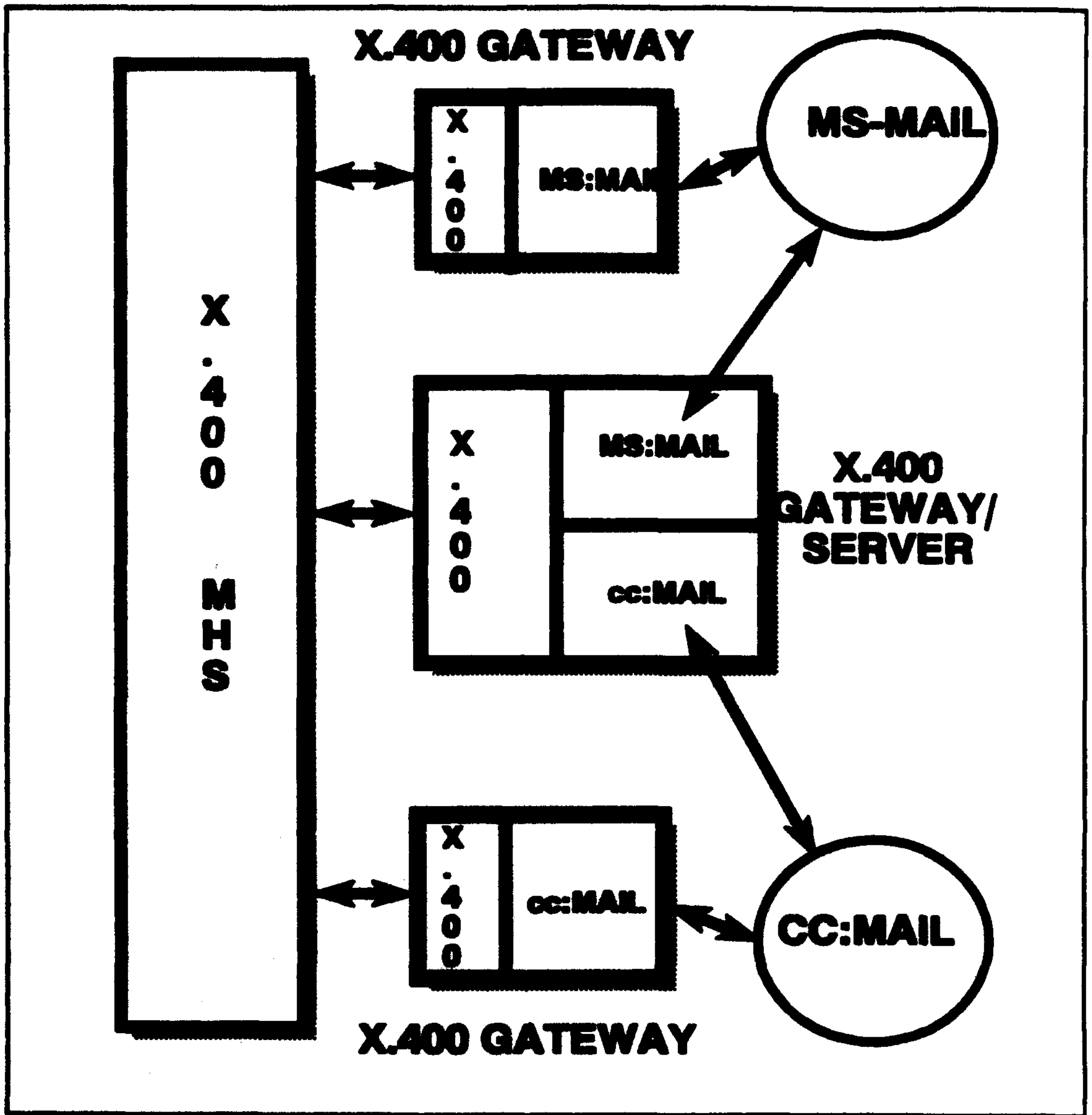

Figure 3-1: X.400 Connectivity of Proprietary E-Mail Packages

largely on the composition of the installation. In general, it is best to minimize the number of gateways because their installation, configuration, maintenance and support requirements vary. Using a third party product that provides interoperability among all the installed environments and X.400 is the preferred way of reducing the number of gateways needed for a company's messaging requirements. (Burns, Radicati, 1992, p.172)

In light of the three methods of obtaining X.400 services that were described in the preceding pages, implementation of X.400 in a particular business may require one, two or all three of those methods. A business must consider the number of users, the number of different mail systems that need to be connected, and, the level of in-house support available.

B. EVALUATION OF INTEGRATED X.400 ENVIRONMENT: ZD LAB REPORT

Corporate Computing, in its June/July 1992 issue, analyzed the conditions for implementing and managing an X.400 system in a corporate environment. Specifically, their scenario was

> a large business with different departments running isolated E-mail systems. The goal was to provide companywide communications by linking the various mail systems using X.400-compliant products. (Burns, Radicati, 1992, p.174)

1. Methodology

To evaluate X.400 technology and products, Corporate Computing and ZD Labs designed and built an integrated, multivendor, multiplatform mail system. They used an X.400 backbone and gateways from a variety of vendors linking PC-based LAN E-mail systems with Unix VAX and mainframe E-mail systems. They also connected to public E-mail providers and to third-party E-mail integration packages. They examined the pitfalls and advantages of X.400 from the perspective of the corporate E-mail decision-maker. They wanted to know how much expertise was required to successfully install X.400 products as well as compare the capabilities of X.400 messaging with those of typical E-mail systems. Finally, they looked for differences in ease of use and manageability. The E-mail integration challenge is summed up in Figure 3-2. (Burns, Radicati, 1992, p.168)

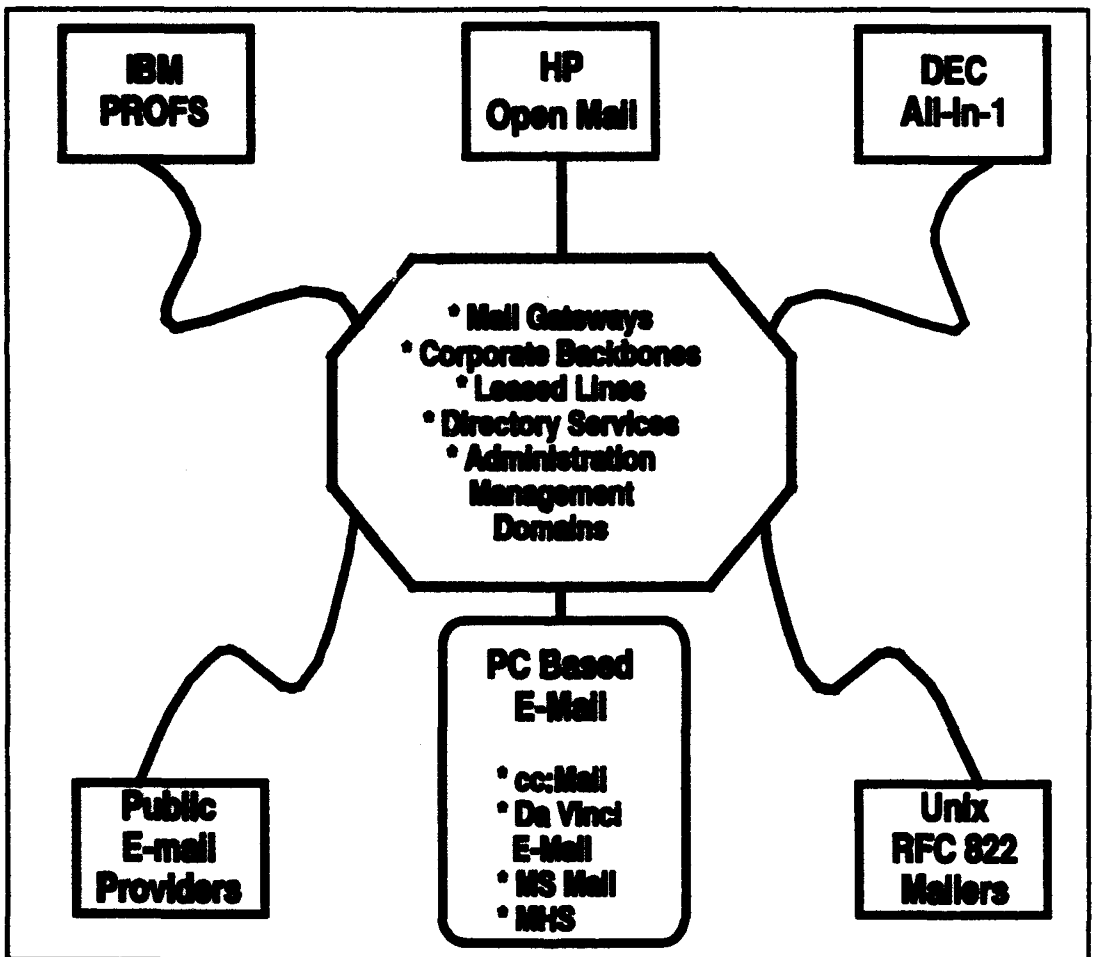

Figure 3-2: The E-mail Integration Challenge

The products tested by ZD labs were installed on the following platforms: *DOS, Windows, Macintosh, Unix, VAX, and VM (IBM Systems/370)*[1].

The E-mail packages included: *Microsoft Mail* version 2.1 (DOS, Mac, OS/2 and Windows); *Lotus' cc:Mail* version 3.1 (DOS, Mac, OS/2 and Windows); *HP OpenMail* V.A.00.02.03; and *DEC All-in-1 Mail* for VMS version 4.1; and *IBM PROFS* Release 2.21.

The Gateways were *Microsoft Mail Gateway to X.400* version 3.0, *Retix cc:Mail X.400 gateway, DEC Message Router X.400 Gateway* version 2.2, *Hewlett-Packard HP X.400/9000* c.02.00, and *Soft-Switch X.400 Gateway* version 1 level 3.[2]

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[1] The DOS, Windows, and OS/2 workstations were, specifically, Gateway 2000 80386/33c PCs with 120MB hard drives and 8MB of memory. An Ethernet Novell NE 2000T network interface card was installed in each workstation.

The Macintosh workstations were MAC llCis with 8MB of RAM, System 7.0.1, and a Technology Work Nu-Bus 10Base-T Ethernet adapter.

The DEC VAX system was a VAXserver 3100 Model 48 with 24MB RAM and over 1.5 gigabytes of hard disk storage. Unix ran on an HP9000/825 with 32MB of memory and a 400MB hard disk. Finally, PROFS was accessed through a 3270 terminal connected to an IBM System/370 located at Soft-Switch. (Burns, Radicati, 1992, p.172)

[2] The Microsoft X.400 gateway, Retix Open Server 400 and Retix X.400 cc:Mail gateways ran on the same Gateway 2000 workstations. The Microsoft Mail gateway was connected to the Retix Server through an Eicon EiconCard HSI/PC X.25 interface card and a Black Box Modem Eliminator. The Retix server also included a Retix PC320 X.25 adapter with a PC321 daughter board.

The HP X.400 gateway ran on the HP 9000/825 and the DEC Message Router X.400 was installed on the DEC VAXserver 3100/825. Soft-Switch's X.400 Gateway ran on a 25-MHz 80386 Data General with an Eicon X.25 card. (Burns, Radicati, 1992, p.172)

Connectionwise, the PCs were linked to a Cabletron 10Base-T Hub. The network file services were provided by Novell Netware 3.11 with Netware for Mac installed. The E-mail network was tied together with Retix's Open Server 400, SprintMail, and Soft-Switch X.400 Gateway. Figure 3-3 illustrates the E-mail test start-up. (Burns, Radicati, 1992, p.172)

Before starting the tests, the ZD Labs engineers and the participating vendors agreed upon the addressing and configuration parameters such as the 1984 implementation of the X.400 standard and its originator/recipient addressing model. To test the installation and configuration of the X.400 E-mail system, they accomplished the following: First, the ZD Labs engineers and the appropriate vendor technicians set up and tested each E-mail package as an isolated system until it was up and running. Second, they set up and tested the X.400 gateways until they were up and running. Third, the engineers established links by installing MTA software, reliable transport services (RTS), transport stacks (X.25 and LAN), routing tables and link information. Each system had unique X.400 setup procedures and components. Finally, they evaluated full E-mail integration by verifying that messages could be sent and received between all systems simultaneously.

Two illustrations of the required connectivity for successfully passing a message between two different E-mail systems are illustrated in Figure 3-4. (Burns, Radicati,

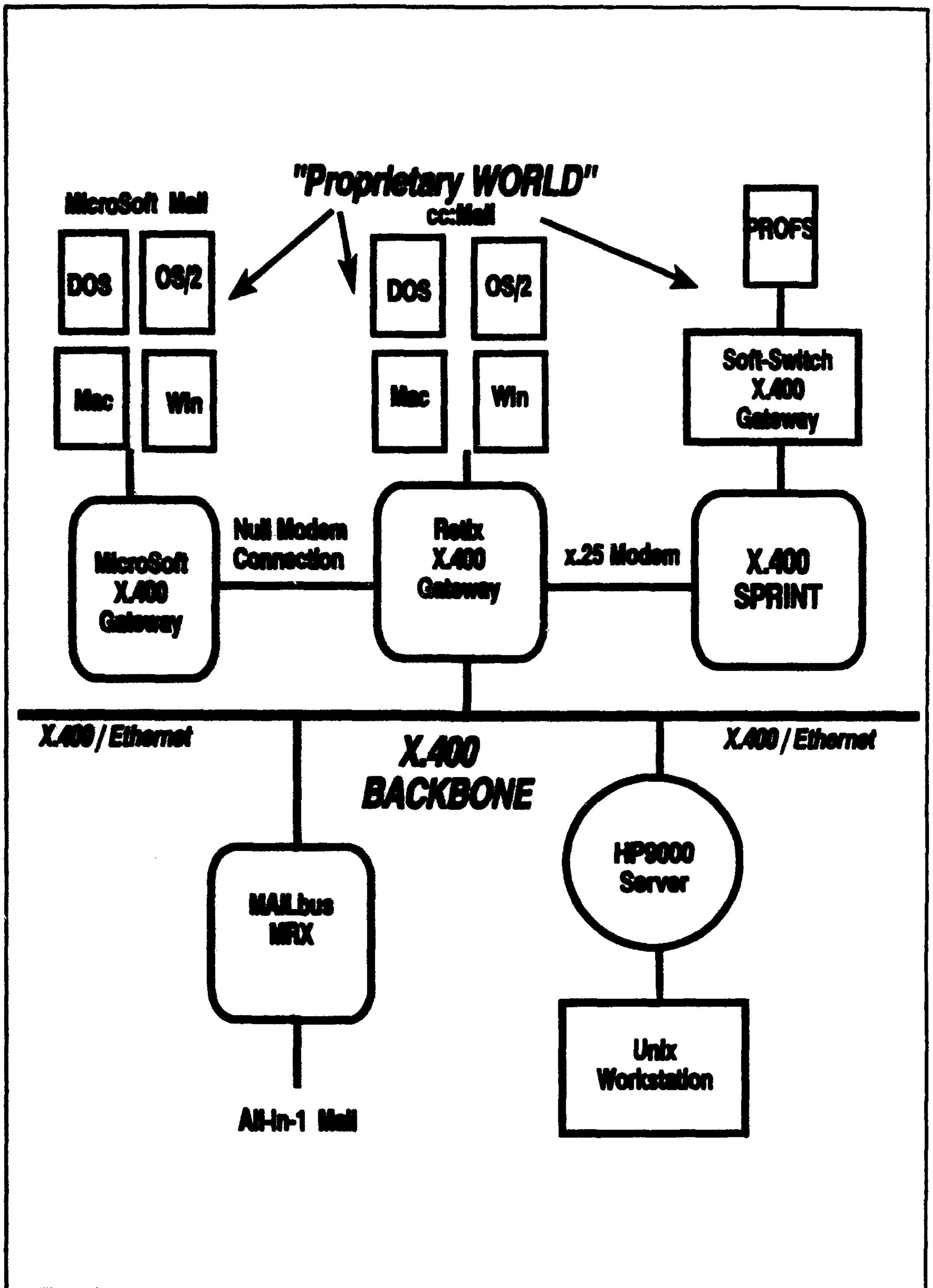

Figure 3-3: ZD Labs E-mail Test Setup

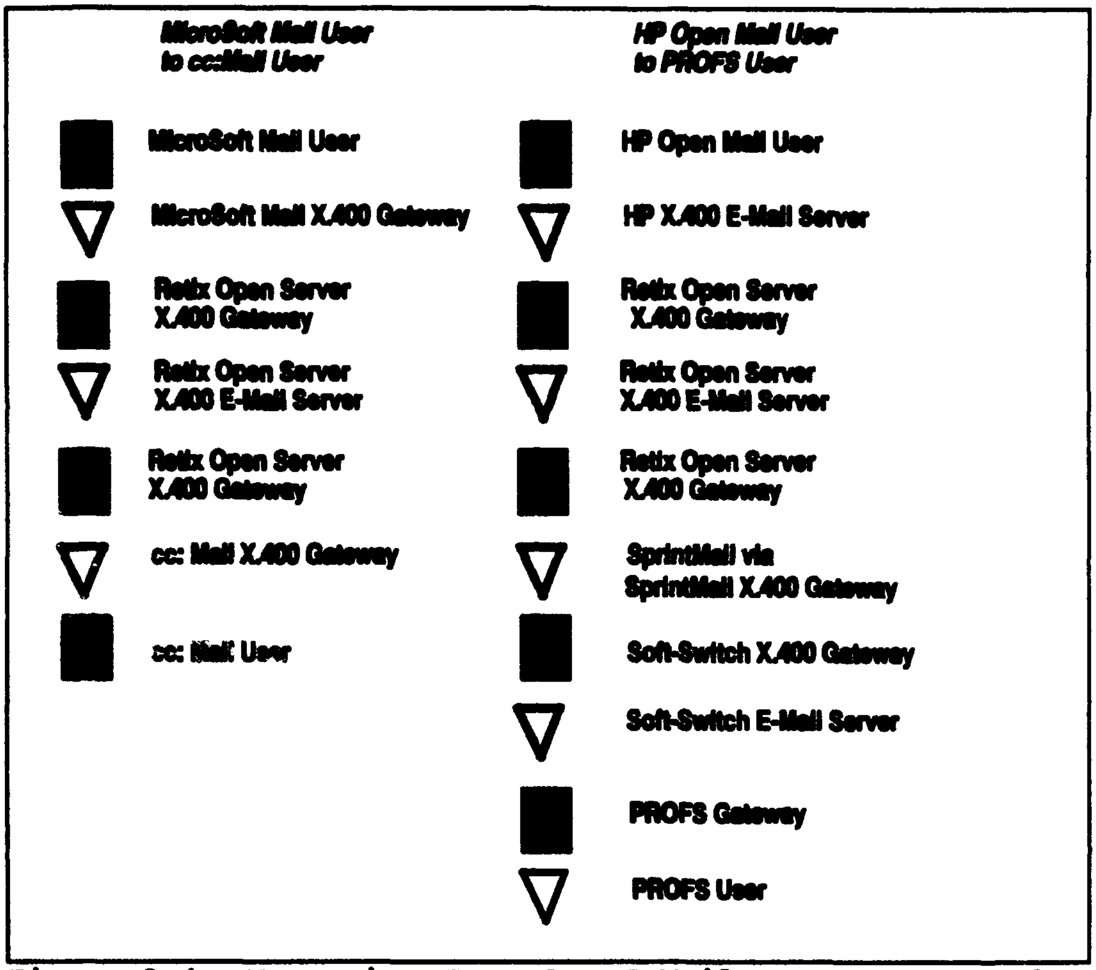

Figure 3-4: Messaging From One E-Mail System to Another Requires Several X.400 Gateways and MTAs.

1992, p.175) Messages addressed to users on the *same* E-mail system did not pass through X.400 gateways. Generally, messages addressed to users on other mail systems were routed through the Retix mail server which primarily acted as a central hub that supported the X.400 backbone.

2. Evaluation

Within two days, Microsoft Mail, Retix Open-Server, Hewlett-Packard Open Mail, Lotus cc:Mail, and SprintMail were exchanging simple messages over Ethernet and X.25 links. The only E-mail system they were unsuccessful in linking to other packages was DEC's All-In-1. Messages were passed through all X.400 gateways with the exception of DEC's VAX-based Message Router X.400.

As with all MHSs, X.400 addressing must be exact. However, X.400 addressing is more complex, with more components than the addressing protocols associated with most E-Mail systems. Usually, the system administrator handles this aspect by typing the correct name and address into the "local" address book. Problems may arise when a user attempts to address a remote recipient by himself.

In general, headers and even the text format (mostly line-spacing and tabs) changed as messages transferred from one MHS to another. Additionally, the gateways in the prototype network handled small file attachments, but were unable to handle large (two or three megabyte) files. Finally, most error messages and non-delivery notices were sporadic or not helpful in identifying the problem. (Burns, Radicati, 1992, pp.176-178)

3. X.400 Lessons Learned by Corporate Computing

Overall, interoperability among the MHSs was *good* and the X.400 implementations were *reliable*. The transport or implementation of specific features by the UAs was where most of the problems were experienced rather than problems *directly* related to the X.400 standard. Installation and debugging were challenging for both ZD Lab technicians and vendors. However, despite what they experienced, they believe that, in general, once a MHS is stable and its behavior understood, changes will be far easier to make and daily operations smoother.

Assembling this complex, wide-area network *did* require a working knowledge of network architecture, transport protocols, packet-switched networks and X.400 specifications. Although installation time was enhanced with the very best available technical resources (the X.400 vendors themselves), it took more time than anticipated to configure each MHS's options. Broad knowledge about client-server operating systems and mail applications was also essential during installation. (Burns, Radicati, 1992, p.178)

Nina Burns and Sara Radicati also give the following guidelines that may improve a business's X.400 implementation:

- Contract with vendors or reliable third party service providers to help with initial design, planning, installation and configuration, especially if you don't have specific expertise in house. This will pay for itself many times over.

- Train support people so you build expertise in-house and can maintain your systems in the long run.

- Try to minimize the number of vendors involved in the construction of your system. For example, it may be a better approach to purchase all gateways from one vendor rather than individual gateways from each vendor. Many companies are consolidating their E-Mail systems so they only need to support three or four rather than eight or ten.

- If you purchase equipment from more than one vendor, bring them all together at the same time during installation. In addition, make sure you ask about interoperability testing to ensure that the equipment you are buying interoperates. Ask specifically about version numbers and system configuration, not just the X.400 system.

- Watch out for updates and upgrades. Test everything before you install. You need to test compatibility all over again if one component changes.

- Backbone designs are usually more efficient to manage than point-to-point gateways, as they have fewer interdependent components and less equipment, reducing maintenance requirements.

- Evaluate the administrative interface and functionality of the systems. it's a woefully underappreciated fact that an easy-to-use interface can save valuable time and make troubleshooting easier by orders of magnitude.

C. E-MAIL PRODUCT REVIEW

This section provides a snapshot of today's top-three E-Mail products and the X.400 services they provide. The Local Area Network (LAN) E-Mail market is overwhelmingly dominated by Lotus Development Corp.'s cc:Mail, Microsoft Corp.'s Microsoft Mail and WordPerfect Corp.'s WordPerfect Office, in that order. In 1993, the LAN E-Mail market was estimated at $224 million in worldwide revenues according to International Data Corp., a market researcher in Framingham, Mass.. The trend is likely to continue as companies downsize to LAN-based packages from mainframe-based solutions and software suites become more entrenched.

> "The market used to be very fragmented, with the leading vendors taking 90 percent of the market," said Matt Cain, program director of the workgroup computing for Meta Group, a consultancy in Westport, Conn.. He continued,

"Lotus and Microsoft by the end of 1993 will have half of the worldwide installed base of E-Mail users, and those two companies account for 60 percent of all new sales." (Rooney, 1993, p.116)

According to Dave Whitten, program director of office information systems for Gartner Group Inc., a market researcher in Stamford, Conn., WordPerfect had only 11.6 percent of the LAN E-Mail market at the end of 1992. In September of 1993, it had 14.6 percent. (Rooney, 1993, p.116)

The main features of these packages as well as X.400 services provided are listed below:

Lotus Development Corp.'s cc:Mail

- *General Description:* cc:Mail is a "family" of more than 20 LAN-based products that provide high-end, multimedia E-Mail capabilities to users of all operating systems listed below. It provides connectivity with LAN, mini- and mainframe-based E-Mail systems and can connect to public E-Mail services and fax machines worldwide.

- *Operating Systems cc:Mail Products Support:* **DOS:** cc:Mail for MS-DOS 4.01 runs under all versions of DR, PC or MS-Dos 3.1 or later; **OS/2:** cc:Mail for OS/2 3.2 runs under OS/2 1.X and 2.0 cc:Mail for DOS and Windows can run under OS/2 2.0; **Windows:** cc:Mail for Windows 1.11 supports Windows 3.0 and 3.1; **Macintosh:** cc:Mail for Macintosh 2.0 runs on System 6.0x, System 7, and A/UX 2.0; **Unix:** cc:Mail for Unix 1.0 runs on Sun SPARC stations with the OPENLOOK user interface. (Lotus, 1993, p.5)

- *Gateway Connectivity*: Gateway products (meaning that you have to buy them in addition to cc:Mail package) from cc:Mail and leading third party vendors to allow connectivity with major E-Mail systems in the world. Cc:Mail offers gateways to Novell MHS, IBM PROFS, SMTP/UNIX/uucp, 3COM, MCI, AT&T, Sprint. In order to obtain X.400 connectivity, you must obtain other vendors' gateway support (such as Retix or Soft-Switch). (Lotus, 1994, p.7)

- *Standards Support:* cc:Mail's standards support includes the following data communications standards: Novell's MHS, X.400, SMTP and X.25 via the Lotus Communications Server and/or cc:Mail gateway products. (Lotus, 1994, p.4)

MicroSoft Corp.'s MicroSoft Mail

- *General Description:* Microsoft Corp. provides a multi-media capable (Basically, this translates to sound and graphics files being incorporated into the mail file) LAN-based E-Mail product. It provides connectivity with LAN, mini- and mainframe-based E-Mail systems and can connect to public E-Mail services and fax machines worldwide. It supports users on the following operating systems:

- *Operating Systems Microsoft Mail Products Support:* **DOS:** MicroSoft Mail for MS-DOS runs under all versions of MS-Dos 3.1 or later; **OS/2:** Microsoft Mail for OS/2 runs under OS/2 1.2 or later; **Windows:** Microsoft Mail for Windows supports Windows 3.0a or later; **Macintosh:** Microsoft Mail for Macintosh runs on System 6.0.3 or later; **Unix:** Microsoft Mail does directly support unix at this time. (Microsoft, 1994, p.4)

- *Gateway Connectivity*: Gateway products from Microsoft (meaning that you have to buy them in addition to the Microsoft Mail package) for connectivity with major E-Mail systems around the world include: Microsoft Mail Gateways to IBM, PROFS and Office Version, X.400, Fax, SMTP, MHS, MCI Mail, 3Com 3+Mail, and Microsoft Message Service for IBM SNADS. (Microsoft, 1994, p.8)

- *Standards Support:* Microsoft boasts that it's Mail and gateway package is the only single, complete solution available today for high-quality connectivity between a LAN-based mail solution and international standard X.400 systems. This is no longer true since Wordperfect Corporation launched its own X.400 gateway product in January 1994. Additional data communications standards support include: Novell's MHS, SMTP and X.25 via the Microsoft Mail Server and/or Microsoft Mail gateway products. (Microsoft, 1994, pp. 8 and 9)

WordPerfect Corp.'s WordPerfect Office 4.0

- *General Description:* WordPerfect Office 4.0 is an office automation product which includes E-Mail as part of its functionality. Specifically, the product supports group calendaring and scheduling, task management (who told whom to do what), workflow management (ordered distribution), message and outbox management (status of messages sent), system administration and gateway support management. (WordPerfect, 1994, pp. 1-2)

- *Operating Systems WordPerfect Office Products Support:* WordPerfect Office 4.0 supports PC users in the DOS 3.0 or higher environment, the Windows 3.1 or DOS for Windows 3.1 or higher, and Macintosh System 7 or higher. (WordPerfect, 1994, p.3)

- *Gateway Connectivity:* The following WordPerfect gateways are available separately from the WordPerfect Office 4.0 product: PROFS and Office Vision/VM, SNADS, cc:Mail, Novell MHS, SMTP, X.400, MCI Mail and AT&T EasyLink. With respect to X.400, the WP X.400 gateway allows the X.400 system to function as a long distance message transport service to connect with other external WP Office system users. The gateway operates on an OS/2 version 2.0 or higher environment. (WordPerfect, 1994, pp. 2,7-8)

D. E-MAIL IN DOD

As part of the Administration's "reinventing government initiative" led by Vice President Al Gore, E-Mail is playing an increasingly important role in the Federal Government. In August of 1993, an interagency task force was created to design a strategy for providing interconnectivity among agencies. Its charter is to develop an infrastructure for E-Mail using X.400/X.500 standards. (Smith, 1993, p.68)

The next chapter discusses the Department of Defense's role in this requirement with the Defense Message System (DMS) Program. One of the preliminary requirements was to identify the major products and quantities[3] in use by DoD

[3]These numbers are based on a DoD-wide survey conducted in 1992 by DISA. As of March 1994, the current quantities in use of these E-Mail packages have not been identified. (Dittmer, 1994)

users that are desired for upgrade to DMS compliance. This enabled specifications to be written for X.400/X.500 compatibility and connectivity. These packages are identified in Table 3-1. Not surprisingly, the worldwide E-Mail leaders are included. (DoAF DMS RFP, 1993, p.A13-1)

TABLE 3-1: E-MAIL PACKAGES USED IN DOD AS OF JULY, 1992

E-mail Vendor	E-mail Product/# Components
Lotus Development Corp.	cc:Mail/85,730
Microsoft Corp.	Microsoft Mail/62,000
Beyond Inc.	Beyond Mail/28,000
Banyan Systems Inc.	Banyan Mail/27,750
Da Vinci Systems Corp.	Da Vinci eMail/16,000
Word Perfect Corp.	WordPerfect Office /6,000
LJL Enterprises, Inc.	PC MAX E-mail/100,000

Can these disparate E-Mail packages be incorporated in DMS? If ZD Labs test results are any indication, the answer will be "yes" with some compromises. Chapter IV has excerpts from DoD's draft Request for Proposal (RFP) for the DMS that was released to industry for comments September 1993. Overall, the chapter illustrates the basic plan for an X.400/X.500 enterprise, or DoD-wide messaging infrastructure with specific focus on the E-Mail requirements.

IV. X.400/X.500 AND THE DEFENSE MESSAGE SYSTEM

A. BACKGROUND OF DMS

In January, 1988, the Assistant Secretary of Defense (ASD)/ Command, Control, Communications and Intelligence (C3I) formed a multi-Service and agency Defense Message System Working Group (DMSWG) to assess the future of DoD's messaging system. The primary objectives were to: first, define the baseline DMS; second, reliably estimate its cost to the DoD; and third, formulate a target DMS architecture based on achievable technology. The DMSWG developed a Target Architecture and Implementation Strategy (TAIS) by using inputs from Government and industry, and by capitalizing on advances in technology and standards. The conceptual TAIS was approved by the Defense Acquisition Board in May 1988; and the Under Secretary of Defense for Acquisition issued DMS Program Guidance in August 1988. The Program Guidance provided approval of the target architecture, the phased implementation strategy, the test and evaluation and the management structure. Additionally, it tasked the Defense Communication Agency (now called the Defense Information Services Agency [DISA]) with responsibility of overall DMS coordination, and provided initial tasking to the services and agencies necessary to begin execution of the DMS implementation strategy.

In October 1988, the DMS management structure was fully activated. By February 1989, the Joint Staff implemented the validated Multi-command Required Operational Capability for the DMS (MROC-DMS). Finally, in accordance with the interim policy guidance, transition planning is now underway by all services and agencies. (TAIS, 1993, p.1-1)

As mentioned, one of the first tasks for the DMSWG was to identify a DMS "baseline" to serve as the reference against which the future cost, manpower and performance during the evolution to the target architecture would be measured. It is important to note that this baseline is "frozen" in time, and will not change over the DMS planning period.

B. DMS BASELINE COMPONENTS

The primary components of the DMS baseline are the Automatic Digital Network (AUTODIN) system which provides organizational messaging between organizational elements (usually chain of command) and electronic mail on the DoD Internet (called the Defense Data Network or DDN) providing messaging capability between individuals (staff personnel).

The components of the AUTODIN are: (TAIS, 1993, pp. 2-1,2-3)

- *AUTODIN Switching Centers (ASCs)* - The ASCs, of which there are 15 operational ones throughout the world, perform store-and-forward message switching functions, some message validation functions, format conversion and some specialized routing functions.

- *Automated Message Processing Exchanges (AMPEs)* - There are over 100 AMPEs worldwide which include the Navy's Local Digital Message Exchange (LDMX), the Army's Automated Multi-Media Exchange (AMME), the Air Force's Automated Message Processing Exchange (AFAMPE), National Security Agency's STREAMLINER and Defense Intelligence Agency's Communication Support Processor (CSP). The AMPEs provide concentrator and limited switching for attached terminals, plus other functions such as conversion of destination names (Plain Language Addresses [PLAs]) into internal AUTODIN addresses (called Routing Indicators [RIs]).

- *Telecommunication Centers (TCCs)* - TCCs are the principal entry and exit points for AUTODIN messages. TCCs contain administrative message centers with manual over-the-counter operations, a variety of terminal equipment, optical character readers and video display terminals to enter messages.

- *Data Processing Installations (DPIs)* - The message function of sending and receiving data rather than narrative messages is accomplished by the interfaces between AUTODIN and the DPIs. This interface can either be direct into an ASC or indirect via an AMPE.

- *Automated Message Handling Systems (AMHSs)* - Some users of the DMS baseline have implemented AMHSs which assist in the automated processing of messages. This may include message coordination and release, storing, sorting and retrieving messages, and electronic mailbox distribution schemes.

- *Directories (DIR)* - DIRs are paper documents such as the Message Address Directory (MAD) containing organization names and associated PLAs and the ACP 117 series of publications which include PLAs with assigned Ris for AUTODIN recognition.

The baseline architecture is represented in Figure 4-1.

(TAIS, 1993, p.2-2)

C. DMS REQUIREMENTS

The main problem with the DMS baseline is one of interoperability. While both primary components provide messaging service to DoD users, their disjointedness prevents

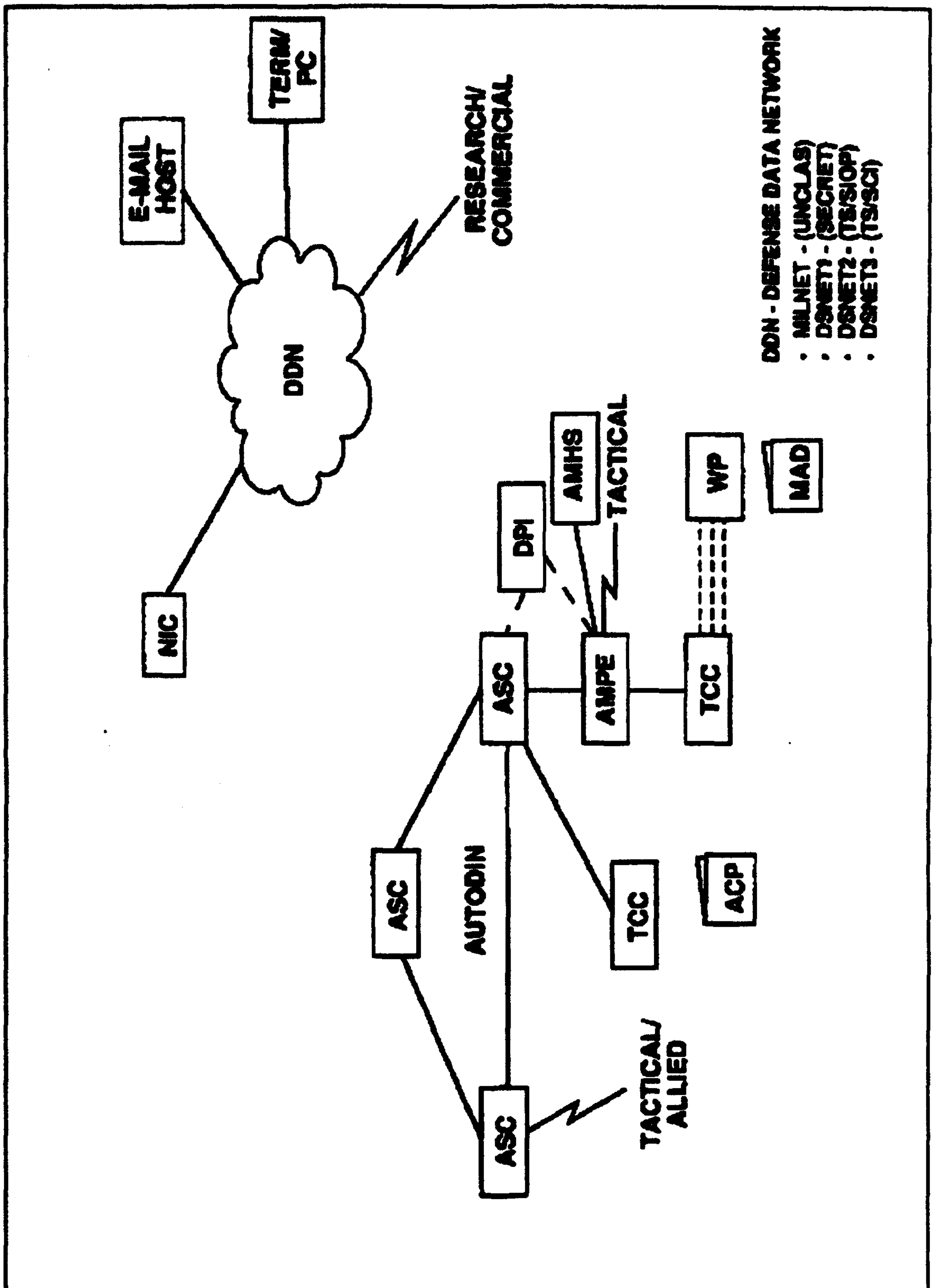

Figure 4-1: DMS Baseline Architecture

the interoperability required to allow an efficient and effective exchange of message traffic from AUTODIN to DDN. In order to solve this problem, the following brief requirements have been identified for DMS: (TAIS, 1993, pp.1-4 to 1-6)

- *Connectivity/Interoperability* - Within the community of users identified as organizations and personnel in the DoD, the DMS should allow a user to communicate with any other user whether fixed or mobile. Additionally, DMS must support interfaces to systems of other government agencies, allies, tactical and defense contractors. Connectivity must extend from writer to reader. And, it should lead DoD's migration to international standards and protocols.

- *Guaranteed Delivery and Accountability* - With a high degree of certainty, DMS must deliver a message to the intended recipient(s). Prompt notification of non-delivery to the sender must occur if the system cannot deliver a message.

- *Timely delivery* - The DMS must recognize messages that require preferential handling. It must also dynamically adjust to changing traffic loads and conditions during peacetime, conflict and war. Delivery time will be a function of message precedence and system stress level.

- *Confidentiality/Security* - The DMS must process and protect all levels and compartments of classification of message traffic. It must maintain separation of messages within user communities to ensure confidentiality or the preclusion of access to or release of information to unauthorized recipients. Security will also be based on requirement for authentication and integrity as well as confidentiality.

- *Sender Authentication* - Information marked as having originated at a given source must be unambiguously verified by the DMS. For organizational traffic, a message must be approved by competent authority before transmission.

- *Integrity* - Information content received must be the same as that sent. If authorized by the writer, DMS may make necessary format changes to account for differences between the component systems serving the writer and the reader.

- *Survivability* - The DMS must not degrade the survivability of the systems interfaced to it. Methods such as redundancy, proliferation of system assets and distributed processing may be employed to achieve survivability.

- *Availability/Reliability* - The DMS must provide message service to users on a continuous basis. Availability will be achieved through a combination of reliable and maintainable components, thoroughly tested software, and necessary operational procedures.

- *Ease of Use* - Use of the DMS should not require extensive training or the knowledge of a communications specialist.

- *Identification of Recipients* - The sender must be able to unambiguously identify to the DMS the intended recipient(s). The necessary directories and their authenticity are part of the DMS.

- *Message Preparation Support* - User-friendly preparation of messages for transmission must be provided by the DMS (i.e., U.S. Message Text Format assistance)

- *Storage and Retrieval Support* - The DMS must promote storage of messages after delivery to allow retrieval for such purposes as readdressal, retransmission and automated handling functions with the capability of incorporating segments into future messages.

- *Distribution, Determination and Delivery* - For organizational message traffic, the DMS must determine the destination(s) of each message (in addition to the addresses(s) specified by the originator) and ensure delivery in accordance with requirements of the recipient organization. For individual message traffic, delivery of each message to the individual(s) specified by the originator must be accomplished.

D. DMS TARGET ARCHITECTURE & IMPLEMENTATION STRATEGY

Summarized in Figure 4-2, the Target Architecture is shown in terms of the primary functional elements required to provide the DMS messaging services (TAIS, 1993, p.3-3). The message transfer agents **(MTAs)**, message stores **(MSs)**, user agents **(Uas)**, and organizational user agents **(OAUs)** accomplish

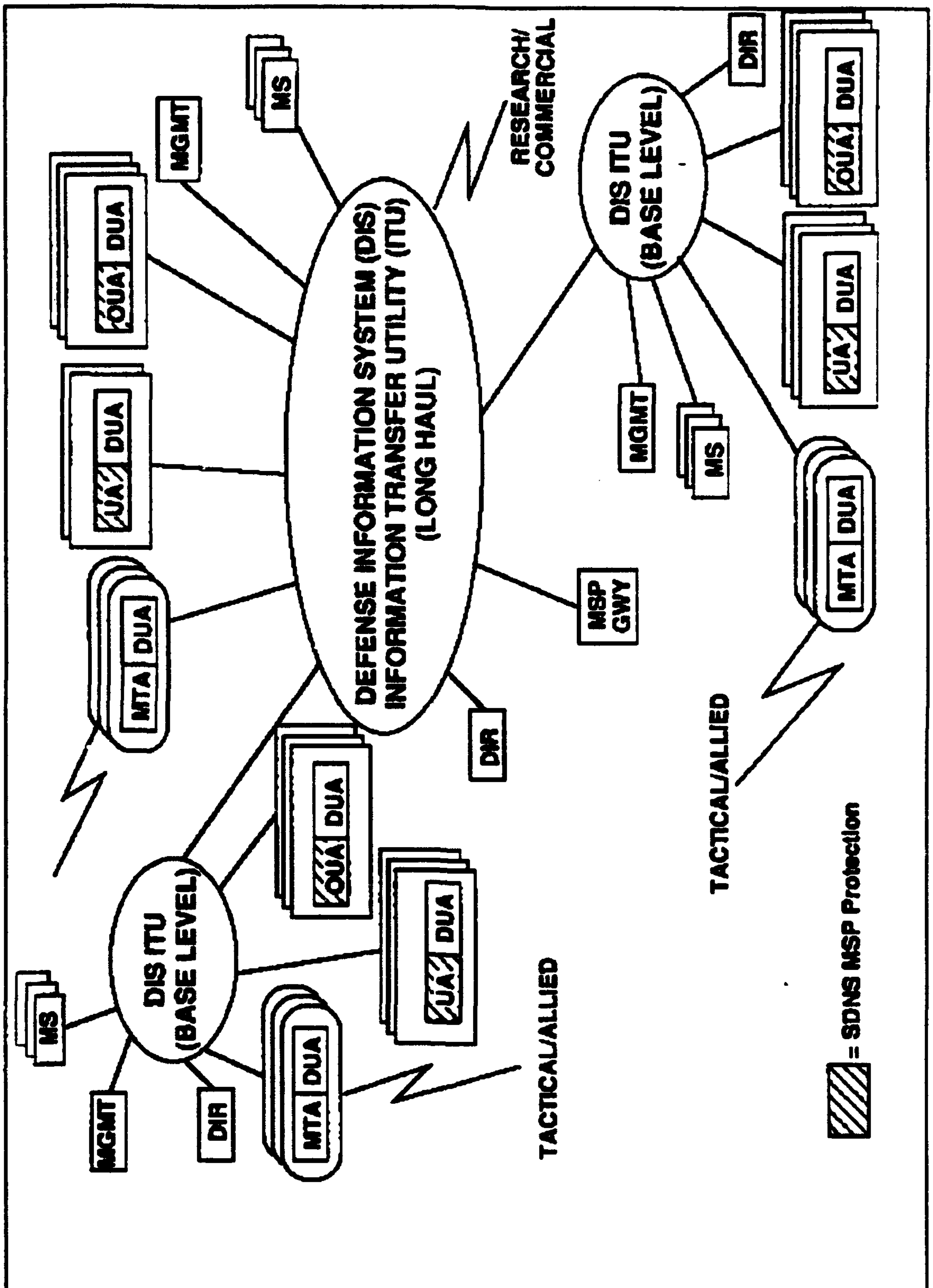

Figure 4-2: DMS Target Architecture

the X.400 message handling functions that were described in Chapter II. A hierarchical distribution directory **(DIR)** along with directory user agents **(DUAs)** provide the DMS X.500 directory services. Security services are provided using the Secure Data Network System Message Security Protocol (SDNS MSP) and other various lower layer protection mechanisms. An MSP gateway provides the necessary interfaces with non-MSP DMS users in the NATO, allied, tactical, civil, commercial and research communities. These various functions are performed within physical components which are distributed geographically and organizationally, but act in harmony to provide the DMS services. (TAIS, 1993, p.3-2)

The implementation strategy involves three phases spanning the years 1989 to 2008. Figure 4-3 illustrates this timeline and the corresponding objectives of each phase (TAIS, 1993, p.4-2).

1. Phase 1

The first phase emphasizes automation of existing TCC functions and extension of messaging services to users. Basically, there will be improvements in AUTODIN's directory, an AUTODIN-to-DDN interface capability, and a migration of DDN E-mail from SMTP to X.400. services and agencies will have the opportunity to phase out their resource-intensive baselevel TCCs, migrate AUTODIN data'pattern message traffic to the DDN, begin the organizational transition and prepare their

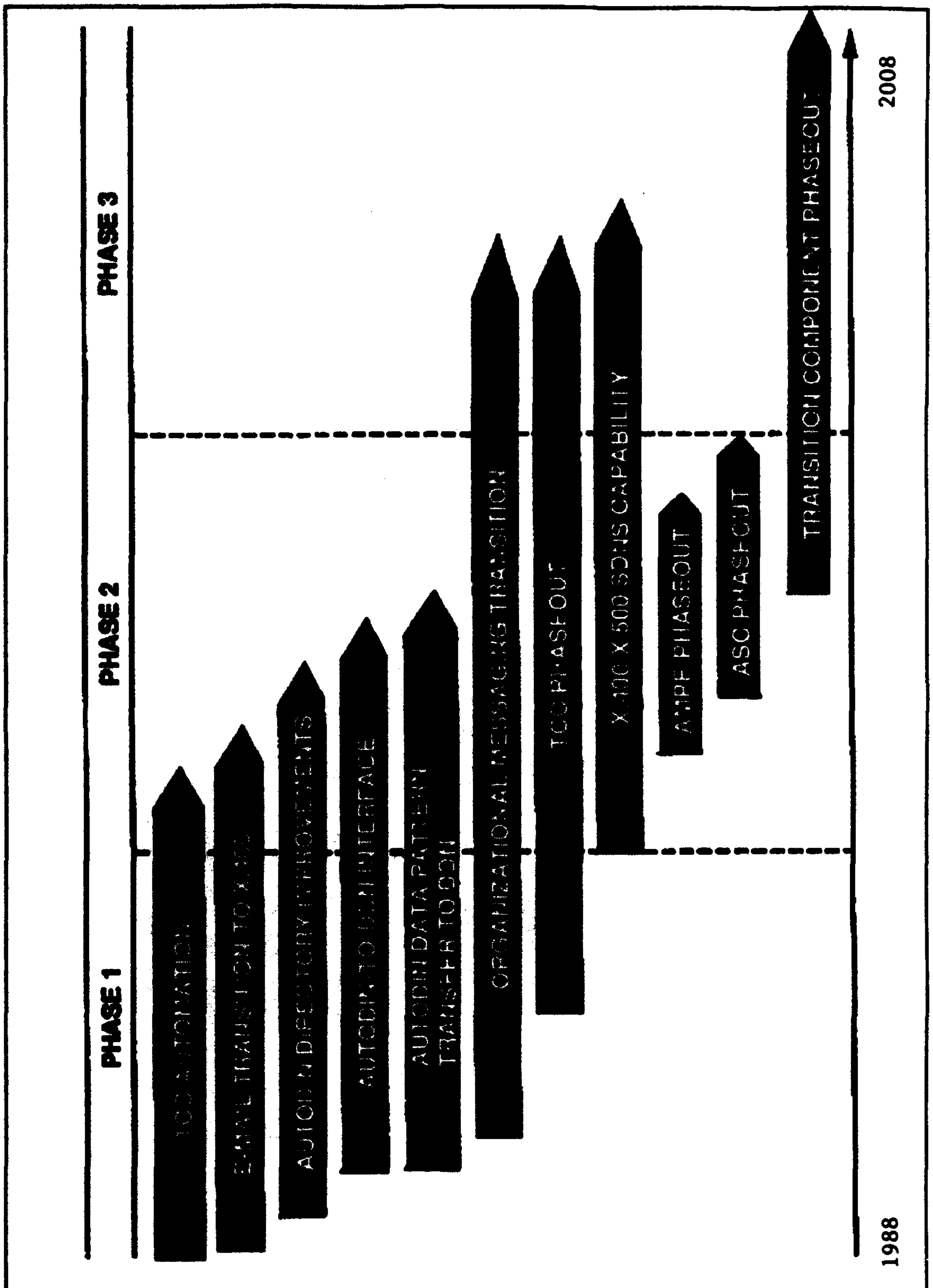

Figure 4-3: DMS Implementation Strategy

organizational and individual messaging communities for evolution to the next phase. (TAIS, 1993, p.4-1)

2. Phase 2

The second phase will produce the most obvious architectural changes and improvements. It begins with the initial operational capability for X.400/X.500 individual and organizational messaging with SDNS MSP protection. The baseline *procedures, protocols, formats, policies* and *standards* will begin the migration to the target architecture. TCC functions and responsibilities will be shifted to OAU workstation applications, thus accelerating TCC phase-outs. With the simultaneous deployment of X.400 MTAs, X.500 directory services, DMS management control capabilities and SDNS security protection, an integrated X.400/X.500 SDNS DMS organizational and individual messaging system will be rooted and maturing. AMPEs and ASCs will be phased out. (TAIS, 1993, p.4-3)

3. Phase 3

The third phase commences when the last ASC is closed. The primary emphasis during this phases is the maturation of the X.400/X.500/SDNS organizational and individual messaging system and achievement of the target architecture. The local and long haul portions of the DoD Internet will also mature and the DCS backbone will have evolved to a fully integrated Defense Information System Network (DISN). (TAIS, 1993, p.4-3)

E. X.400/X.500 AND THE DMS

1. Baseline E-mail on the DoD Internet

In 1982, the Defense Data Network (DDN) was established. It is a set of world-wide networks that are based on technology developed by the Defense Advanced Research Projects Agency (DARPA) as the ARPANET in the early 1970's. One of the primary uses of the ARPANET was to provide E-mail to the DoD research community. This capacity was extended to other operational users on the DDN. The protocols that were in use in the early eighties were expanded for connection of baseline transmission facilities to wide-area networks. Collectively, the baselevel and long-haul transmission facilities are termed the DoD Internet; and, the expanded message transfer protocols for the Internet are Transfer Control Protocol (TCP)/Internet Protocol (IP) and the Simple Mail Transfer Protocol (SMTP). The principal components of the E-mail system are host computers supporting E-mail, user terminals, on-line directories, and the DoD Internet. (TAIS, 1993, p.2-8) Specifically,

- *E-mail hosts* are computers that have (1) installed an application program which interfaces with users on terminals to compose, send and receive messages; and (2) implemented the Simple Mail Transfer Protocol (SMTP) as well as the necessary underlying protocols which allow them to send and receive mail from other E-mail hosts (which may include proprietary E-mail protocols). Additionally, storage is provided by the host computers to keep received mail until the users have read it.

- *User terminals* can be defined as any computer terminal or PC with terminal emulation software.

- *Directories* are exceptionally important since they are the phone books of E-mail. The DDN Network Information Center (NIC) computer contains a directory of over 50,000 E-mail users. It contains the user's name and mailbox address consisting of an identifier for the user and one for the E-mail host. A second directory containing host names and corresponding Internet addresses is also located at the NIC and is currently being distributed throughout the DoD Internet.

- *The DoD Internet* is included for completeness since it is the avenue for E-mail. The DoD baseline Internet has three components. The first component is the *classified DDN* which is a set of physically, procedurally, and cryptographically secured packet switched segments. These segments are referred to as DSNET1, DSNET2 and DSNET3. The second component is the *unclassified DDN* which is the packet switched segment providing the backbone for unclassified E-mail. The third component is the *Baselevel Transmission Facilities* which have traditionally supported switched voice circuits, dedicated point-to-point communications and simple star networks. MILNET is usually considered part of the DDN.

(TAIS, 1993, pp.2-8 to 2-9)

2. Transition to X.400/X.500-based DMS

For DoD services and agencies, *individual* messages are carried over the DDN using the Internet's Simple Mail Transfer Protocol (SMTP). AUTODIN is used to exchange *organizational* (both classified and unclassified) messages in DoD. As Figure 4-4 illustrates, DMS will convert the SMTP individual message transfer world into an X.400/X.500 combined (individual and organizational) message transfer world. The DMS Program is relying on another Program called the Defense Information System Network (DISN), which is being managed concurrently with DMS, to transition (1) packet switching and sub-DS1 transmission for today's DDN to broadband switching and transmission; and (2) TCP/IP (Internet) network layers into the OSI Transport network layers. (TAIS, 1993, p.A-2)

A high-level picture of what DMS is trying to accomplish with respect to X.400/X.500 and a message handling system is illustrated in Figure 4-4.

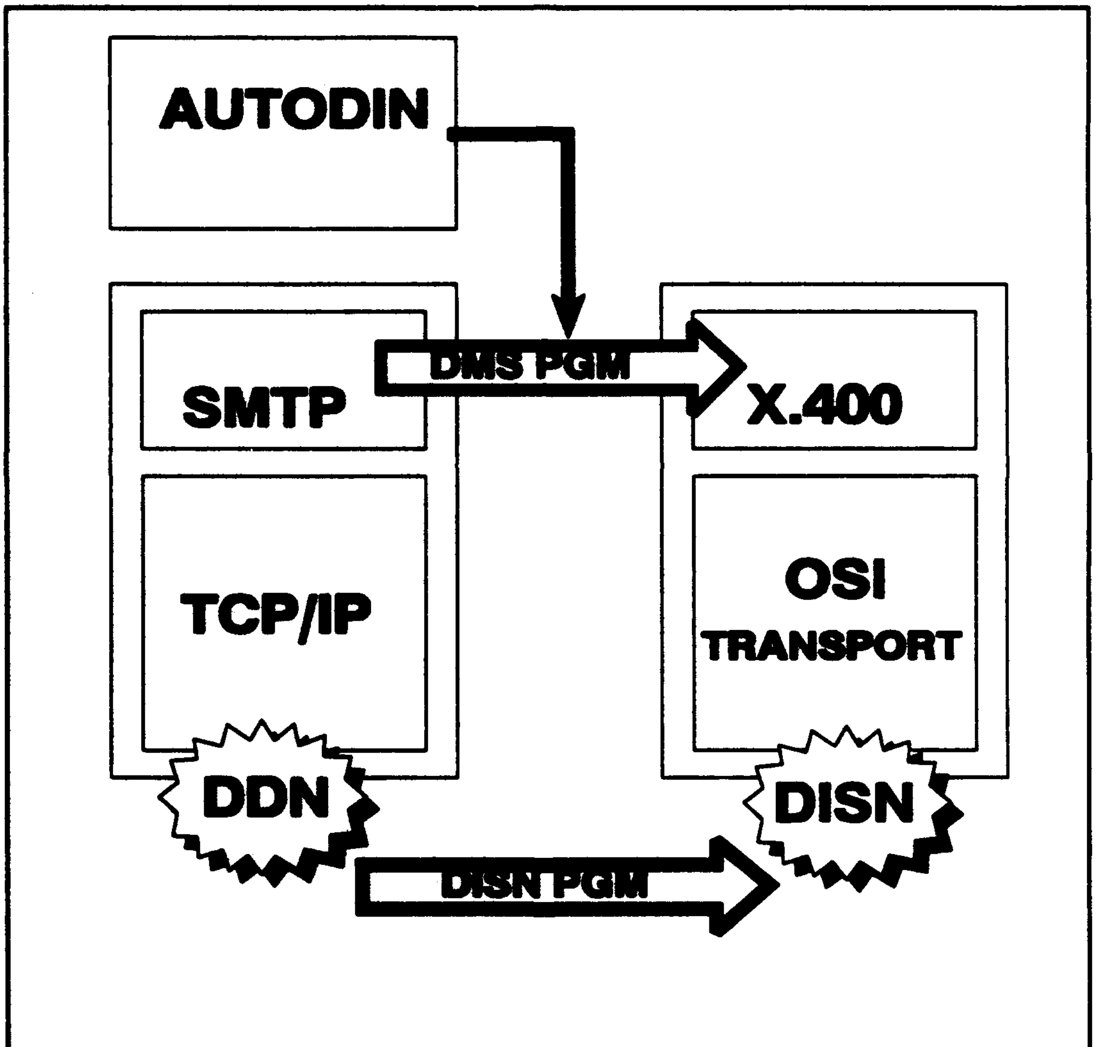

Figure 4-4: DMS is Responsible for the Transition of a "SMTP MHS" to an "X.400 MHS"

3. X.400 DMS Gateways

Figure 4-5 depicts a transitional architecture for Phase I of the DMS (TAIS, 1993, p.A-46). The primary importance of this illustration is gateway functionality. The architecture calls for gateway connections between (1) SMTP and X.400 users, (2) DISN and the global Internet and (3) AUTODIN and the MILNET segment of DISN. By Phase II, the gateways will provide the following ***AUTODIN-to-DISN Interface (ADI)*** and connectivity support: [TAIS, p. A-45]

- **AUTODIN-to-DISN Message Conversion.** This conversion occurs when narrative messages are written by AUTODIN writers and routed to DDN E-mail readers by means of AUTODIN Plain Language Addresses (PLAs). They are routed to the ADI and converted to DDN E-Mail addresses (i.e., SMTP and/or X.400)
- **DDN-to-AUTODIN Message Conversion.** Basically, an E-mail user may generate an E-mail message and transmit it via SMTP or X.400 to the ADI, with AUTODIN PLAs included as part of the address.

It is important to note that DMS specifications call for connectivity for both the Internet and OSI until DISN migration is complete. Therefore, gateways between SMTP and X.400 will be commonplace. Other gateways that will be required for E-Mail connectivity include: [TAIS A-48-56]

- **Mail Relay Gateway** between DISN and the Global Internet is required to relay SMTP and X.400 mail.
- **Multi-Function Gateway** between DISN and the Global Internet will translate between SMTP and X.400 "classified-capable" users. It must be able to translate cryptographic mechanisms for DoD and its Allies.

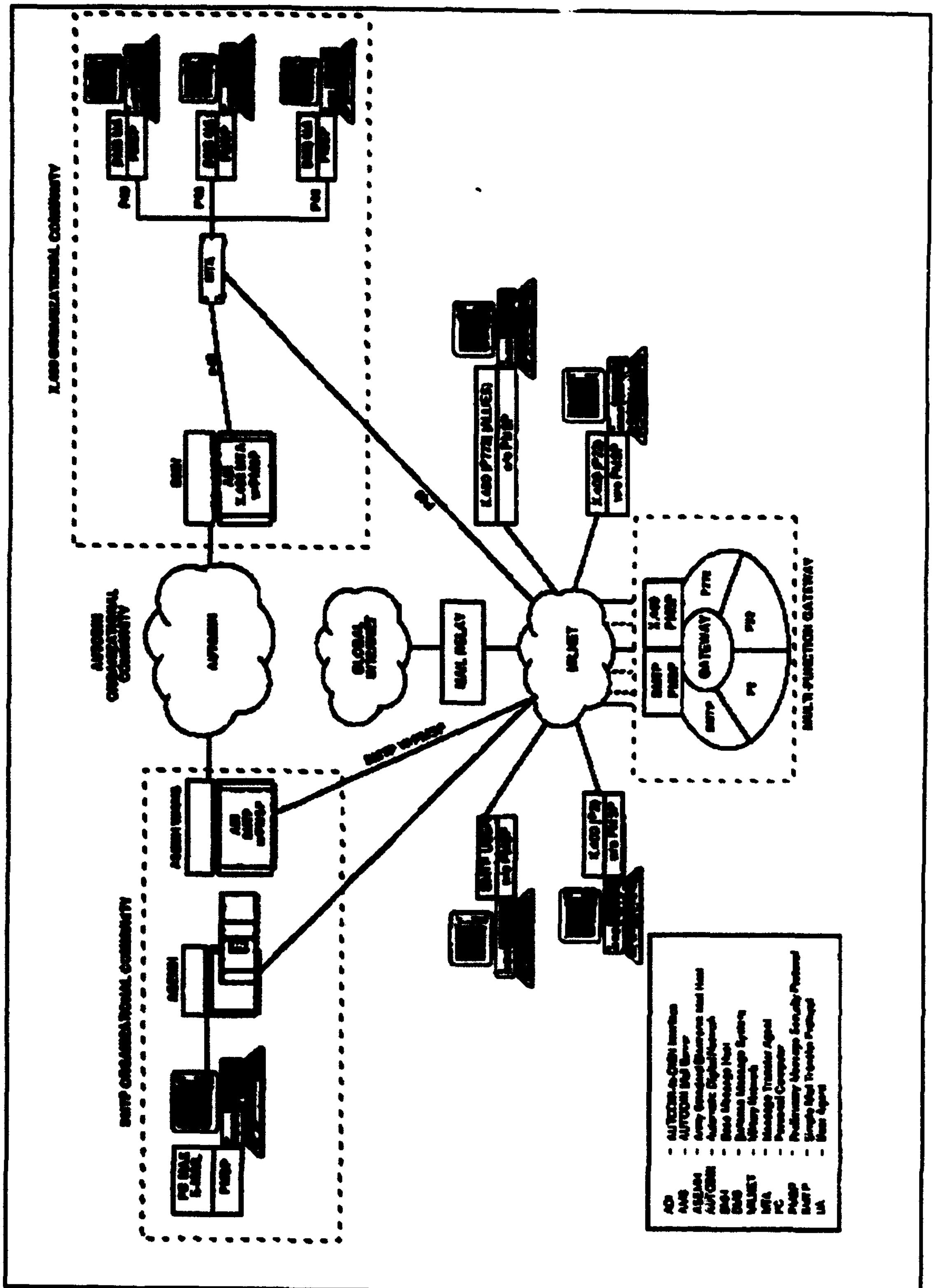

Figure 4-5: DMS Gateway Transitional Architecture

- **DMS-to-Tactical Gateways** are required to include an X.400 interface with the tactical and/or mobile users in order to bring them into the DMS E-Mail community.[4]

- **Guard Gateway** is required to ensure that classified data on DISNET is not passed inadvertently or intentionally to users on the MILNET. At the same time, it must allow unclassified-but-sensitive traffic to pass between the networks.

- **GateGuard** is a generic, Navy-developed gateway to the commercially available Automated Information Systems (AISs) or the Office Automation Systems (OASs) with proprietary and SMTP E-Mail. It is used for the electronic delivery of AUTODIN messages from the user's desktop terminal.

The above Phase 1 gateways are transitional devices needed at the application layers (layers 6&7 of the 7-layer OSI network model) to support the DMS message environment. Table 4-1 depicts the DMS transitional gateway requirements for a DMS user that is capable of sending and receiving AUTODIN, DDN E-Mail (SMTP), or X.400 messages. This user may or may not have the Preliminary Message Security Protocols (PMSPs) requirement for transmitting classified messages. It is important to note that the Message Security Protocol (MSP) conversion capability will be incorporated with the availability of MSP at the start of Phase II. Phase II and

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[4]The tactical gateways include: (1) the *Tactical Packet-Switched Network-AUTODIN Gateway* which will bridge the Army's Tactical Packet-switched Network (TPN) with AUTODIN; (2) the *Tactical Packet-switched Network-Defense Data Network Gateway* which the Army requires to bridge its TPN with the classified network portion of the DDN; (3) the *Naval Communications Processing and Routing System II Gateway* which the Navy requires for a tactical gateway link to AUTODIN allowing interoperation with the X.400 messaging environment; and, (4) the *Navy X.400 Fleet Gateway* used specifically for its interface with X.400 shipboard implementations. [TAIS, pp.A-50-51]

TABLE 4-1: DMS TRANSITIONAL GATEWAY REQUIREMENTS DURING PHASE I FOR A DMS USER

	FUNCTIONAL REQUIREMENTS \ TYPE OF GATEWAY	ADI	MAIL RELAY	MULTI - FUNCTION	DMS - TACTICAL	GUARD	GATE - GUARD
MESSAGE FORMAT CON - VERSIONS	RFC 822 <—> 822	X			X		X
	JANAP <—> ACP 123	X			X		
	RFC 822 <—>ACP 123	X		X			
	NATO MMHS <—> ACP 123			X	X		
MESSAGE PROTOCOL CON - VERSIONS	SMTP <—> AUTODIN	X			X		X
	AUTODIN <—> X.400	X			X		
	SMTP <—> X.400	X		X			
	FTAM <—> FTP			X			
SECURITY - RELATED RQMTS	AUTHORIZATION & ACCESS		X	X	X	X	X
	MSG CLASS & VERIFICATION		X	X	X	X	
	PMSP <—> MSP			X			
	PMSP <—> PLAIN TEXT			X			
BASIC OPERATION RQMTS	X.25 / LAN INTERFACE(S)	X			X	X	
	MILNET - DSNET BRIDGE					X	
	FLOW CONTROL	X	X	X	X	X	X
	ADMIN & MANAGEMENT	X	X	X	X	X	X

<—> = 2-WAY CONVERSION |———— PHASE 1 ————>

III gateway implementations and concept of operations have not been published at this time. [TAIS, pp. 86-88]

Although not as large-scale as the DoD's DMS, the next chapter discusses the r. tive X.400/X.500 implementation for 000 users at Wal-Mart Stores Inc. that is currently erway.

V. WAL-MART STORES INC. ENTERPRISE MESSAGING SYSTEM

A. BASIC HISTORY

Wal-Mart Stores, Inc. is a large retailing business currently dispersed across approximately 2,000 locations, both foreign and domestic. Each employee of Wal-Mart, whether in a store, the corporate complex, one of Sam's Clubs, or a distribution center, is referred to as an "associate" of which there are currently more than 350,000. Wal-Mart has achieved its current success because of a history of "never being satisfied with the way things are. The company is a visionary one which "learns from and cherishes its past, but does not live in it." The following momentous highlights of one of the greatest retail companies in U.S. history illustrate their success: (Wal-Mart, 1993)

- **1950** Sam Walton founded *Walton's 5&10* in Bentonville, Arkansas. Rob Walton, the current Chairman of Wal-Mart Stores Inc. reflects on his father's early business, "When my brothers and sisters were growing up, we always worked in dad's stores...sweeping floors, carrying boxes, even running the ice cream machine. I remember feeling that all the associates in the store were part of the family, always willing to help each other..."

- **1963** First Wal-Mart store in Rogers, Arkansas solidified the concept that large discount operations can succeed in small towns.

- **1970** Wal-Mart becomes a public company, entering the world of Wall Street. The 32 Wal-Mart stores had $31 million in sales.

- **1972** The Wal-Mart profit sharing plan was instituted.

- **1980** Over 300 Wal-Mart operated facilities brought in sales of $1.2 billion. Sam's Clubs and Supercenters became permanent divisions of the company.

- **1992** Mr Sam Walton received the Presidential Medal of Freedom shortly before his death.

- **1993** Wal-Mart is the largest retailer in the world, operating 1957 general merchandise discount stores, 163 Sam's wholesale clubs and 68 Supercenter stores which combine food and general merchandise under one roof. Wal-Mart's revenue reached $67.3 billion in 1993 (Merrill, 1994, p.3). The company is poised to explode into the international market and transplant the Wal-Mart way of doing business: customer service, great values and respect for each other, to other countries (Wal-Mart, 1993).

This preparation for the international market requires effective communications between the associates, the vendor partners, and the purchasing agents. The CCITT X.400/X.500 family of message transfer standards will support Wal-Mart in achieving this worldwide messaging enterprise system.

B. BACKGROUND OF WAL-MART MESSAGING SYSTEM

Wal-Mart's communications services in the past have included basic telephone services, U.S. and Wal-Mart postal services, and session-oriented computer connections. Electronic messaging systems are currently provided through the PROFS system and the Wal-Mart store message system. These systems have limited capabilities such that the company has basically outgrown them. The *desired* E-Mail system is defined as a "store-and-forward transport for electronic objects to include text, documents, forms, spread sheets, graphics, images and even digitized voice." The transport of these objects can occur across heterogenous computers, LANs, and WAN protocol environments.

C. E-MAIL REQUIREMENTS OF WAL-MART

1. Identification of Wal-Mart's MHS Platform And UAs

Wal-Mart currently has an Ethernet-based X.400 E-Mail backbone which overlays on the internal computer networks with gateways to the public data networks. There are approximately 1,000 users with X.400 E-Mail capabilities and 3,000 or so users of IBM's mainframe host environment, PROFS, which has provided most of the electronic messaging functionality for the company. Wal-Mart has identified the following UAs:

- *Direct-Connect Synchronous Terminal.* The hardware platform for this UA is a synchronous terminal directly connected via a 327x cluster-controller to the mainframe. The Mail option is selected from a menu and the interface is limited to text.

- *PC with Windows and LAN.* Primarily a user within the General Office, this hardware platform is a 386/486 PC with LAN connection and an operating stack of DOS, Windows and Attachmate for 3270 connectivity. These users are currently either using X.400 E-Mail or are still using IBM PROFS via 3270 emulation.

- *PC with DOS and LAN.* This is the same type of user as above with DOS as the only element of the operating stack. Some of the foreign offices and agents fall into this category. They communicate by asynchronous modems using a proprietary telex-type communication package (i.e, MCI Mail, AT&T EasyLink or Sprint Mail).

- *PC with Windows or DOS and Modem.* Vendors, smaller foreign offices and managers that are remote have a modem for direct connection to the Public Switched telephone Network (PSN).

- *Mac with LAN.* Several users within advertising or the general office have Mac workstations that use QuickMail and are not connected to the PROFS messaging system. they will be provided a gateway to the X.400 backbone.

- *X-Term and/or UNIX Client-Server.* These users are primarily in the development and technical support areas of the general office. Elm is an example of a current E-Mail system used on a Unix mailer which is connected to PROFS through address translation programs on the host and Fibronics interface connections to the network.

- *Wal-Mart Stores.* The stores have no E-Mail system, only a message drop which literally prints out text on printers at the stores. Each store will be connected to the X.400 backbone separately by implementing local mail servers by installing software on the In-Store Processor (ISP) to provide mail storage and directory service. The basic idea for the stores is to keep E-Mail uncomplicated, so the UA will be "simplified" (SUA) with only basic on-line UA functions. Installation is not to disrupt any of the stores' business operations since they are truly the backbone of the company. Typical UAs within a store are the various types of managers (i.e., Store, Department, Customer-Service) and some of the clerks.

- *Distribution Centers.* Currently using PROFS through sessions back to the host, they will migrate to local mail servers similar to the stores.

- *Sam's Clubs.* These are wholesale distribution membership-only clubs. They have a similar computing environment to the stores and distribution centers.

- *Vendor's Enterprise Network.* The computer systems, networks and mail protocols can vary greatly; therefore, using an X.400 E-Mail backbone is extremely important since many proprietary systems provide interoperability and/or connectivity with X.400. Wal-Mart provides MTAs and UA software for the vendors so that they can access their enterprise messaging system.

- *Fax.* Although not currently connected, the basic E-Mail idea with respect to fax is to attach a scanned fax image to a message to either a recipients' mailbox or their fax machine. Similarly, fax images could be received and reviewed on graphics UAs and printed.

Figure 5-1 illustrates a conceptual version of Wal-Mart's Enterprise E-Mail System, some of which is still in conceptional phases. It shows the connections of different

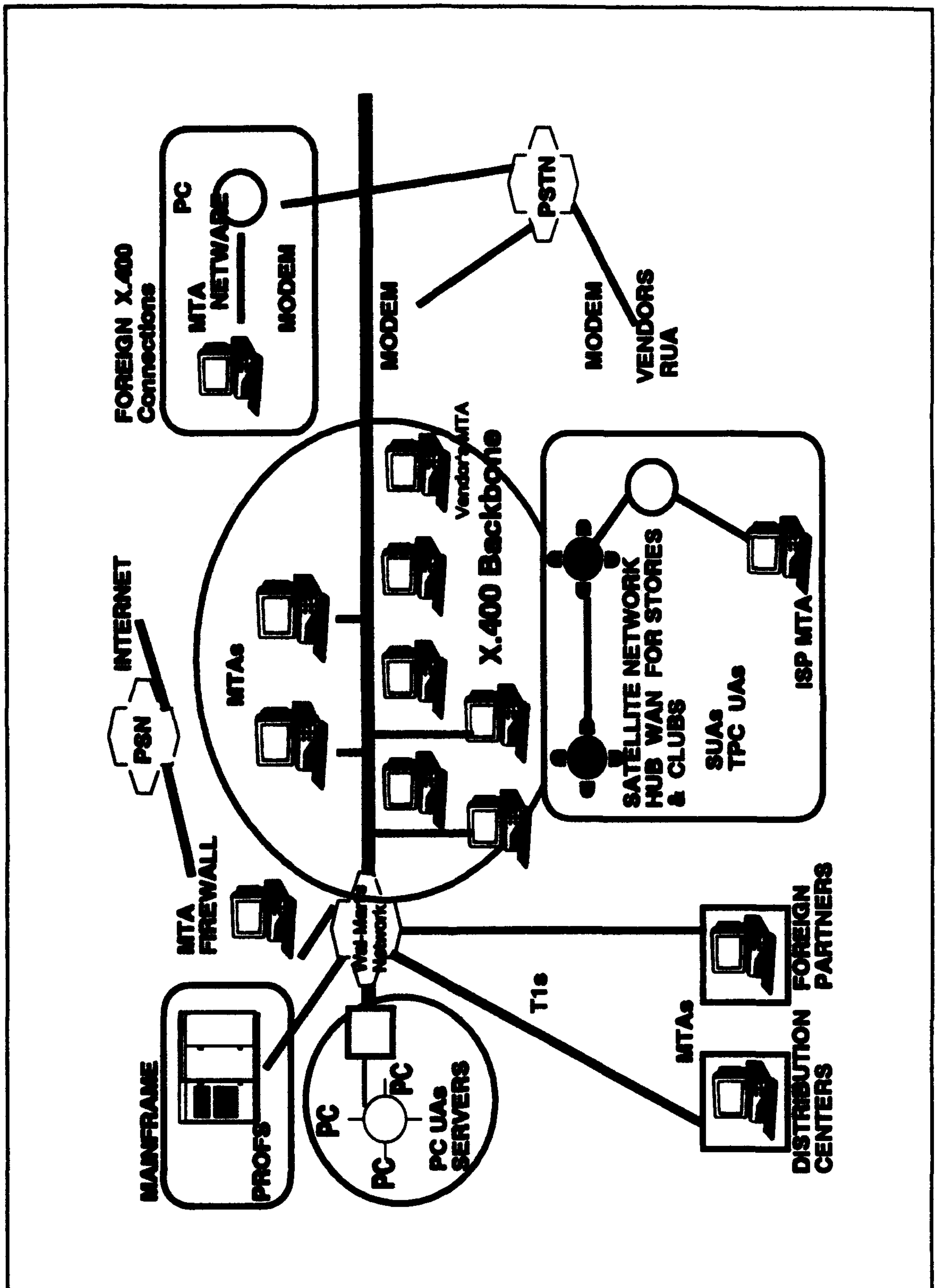

Figure 5-1: Wal-Mart Enterprise Messaging System Areas.

Wal-Mart divisions across the WAN that need to be connected to the X.400 backbone. These areas, some of which are designated UAs as identified above, include:

- Foreign Offices (including foreign purchasing agents)
- General Office
- Buyers Decision Support System,
- Retail Link and EDI (includes the vendors that use these applications)
- Stores
- Sam's Clubs
- Distribution Centers
- Subsidiaries and Business Partners
- Remote and/or mobile users

Starting in the upper left-hand corner, the IBM mainframe system with PROFS is shown which is connected by Ethernet to the backbone by an SMTP-X.400 gateway. Moving clockwise, the Enterprise Messaging System provides Internet connectivity with an X.400-SMTP gateway and modem. The gateway also ensures firewall protection to the Internet. In the upper right-hand corner, foreign agents are connected to the X.400 backbone with Netware connectivity (which *locally* connects the UA to the MTA). However, they must access the PSTN (Public-Switched Telephone Network) to reach one of the MTAs on the backbone. For the vendor partners, with fewer E-Mail users, a remote user agent (RUA) uses FTP (file transfer protocol) and a modem connection to the PSTN to the X.400 MTA backbone. Sam's Clubs and the Stores obtain X.400 backbone connectivity through their existing satellite connectivity, a satellite Network Hub WAN, and the MTAs that are installed in the In-Store and In-Club Processors (ISP and ICP, respectively). The

SUAs as well as a fully functional training UA (TUA) provide all UA activities to the associates. The distribution centers and the foreign partnership areas connect to the backbone via an MTA to the Wal-Mart Network by dedicated T1 lines. Finally, in the central backbone area, the bulk of the X.400 backbone MTAs are illustrated in at least two-level clusters. With the 1984 version of the NCR StarPRO Message Central 400 product, the maximum number of adjacent MTAs allowed is 255.

2. Wal-Mart's UA Requirements

All UAs will comply with X.400 (84). The primary commercial E-Mail package that will be utilized is Enterprise Mail from Enterprise Solutions for the following platforms:

- Icon Interface in MS Windows for 386/486 PC with LAN
- Icon Interface in MS Windows for 386/486 PC remote
- Character/Screen based for Asynchronous Terminals with serial connect
- Icon interface in X-Windows for X-Terms.

The specific X.400 specification requirements must comply with the X.411 and X.420 (Interpersonal Messaging System) portion of the standard. Refer to Chapter II for a more in-depth description of these MHS standards. These functions include: *Interpersonal Messaging Service, Support for P2, P3 protocols, and Originator/ Recipient attributes for addressing.*

3. Identification of Wal-Mart's MTAs

Wal-Mart has identified the following locations and functions for their enterprise's MTAs:

- **General Office Complex.** This MTA will function as the central mail server, the master directory server and will provide gateways externally. Also in this location, there may be additional MTAs which act as local mail servers for divisions within the complex or for high use applications.

- **Stores, Clubs and Distribution Centers.** Local MTA applications will be running on processors within these locations. It is estimated that there will be 50 users per store and 100 per distribution center.

- **Foreign Offices.** Local Unix servers will require the MTA software with modem access and a connection to the LAN or a direct serial connection (provided by the user).

- **Subsidiaries, Business Partners, and Large Vendor Enterprises.** This covers any medium-sized enterprise with whom Wal-Mart has significant E-Mail and/or EDI traffic. This system would be an MTA and provide gateways to their internal E-Mail systems (if not X.400).

4. Wal-Mart's MTA Requirements

Since Wal-Mart is creating a *native* X.400 backbone, all MTAs must meet the requirements as outlined in the CCITT X.400 standards. The reference product, NCR StarPro, is the Retix Message Server for Unix, and conforms fully to the standard. In order to be most efficient and cost effective, the MTA is required to reside on an Unix operating system which (1) takes advantage of the multi-tasking capabilities and (2) shares the hardware resources with other applications, the server file system and other mail gateways.

Similar to the UA requirements, the MTA should provide full support of the P1, P2 and P3 protocols (refer to Chapter II). It should provide reliable message store (even though Wal-Mart is implementing the 1984 version) and data transfer as well as optimized routing and track[illegible] Although MTA customization is required by Wal-Mart technicians, NCR's StarPro will provide administrative tools and servers to configure X.400 mail features and network routing, maintaining public directories and distribution lists, delivery/non-delivery reports, and system error logging. LAN interfaces are required for Novell Netware, TCP/IP, and the public data networks.

Finally, public data sharing is required between the main mail server's MTA and any other MTA within the enterprise. Administration of a public directory for an MTA will be handled locally. Eventually, directory synchronization will be required conforming to the X.500 standard.

D. WHY X.400/X.500?

Wal-Mart wants an enterprise-wide E-Mail system that will enable both users and business applications to communicate across an applicatior ver, store-and-forward transport backbone. The types o business applications the company wishes to use on the enterprise-wide E-Mail service include *office mail* for the home office complex in Arkansas, vendor mail services for *Retail Link and Electronic Data Interchange (EDI)*, and *Buyers Decision Support System (BDSS)*. The store-and-forward aspect of their E-Mail plan will better utilize the bandwidth in the company's existing LAN and satellite WAN. Additionally, X.400 is the sole representation of the open systems interconnection electronic messaging standard, yet another attractive feature.

Overall, this E-Mail system must be an enabling technology that will evolve with the industry improvements and the demands for three very big E-Mail service areas: application interfaces, administration, and directory services. Wal-Mart prefers the CCITT X.400 family of standards since it functionally meets their requirements. This X.400 enterprise system will provide store-and-forward messaging within the Wal-Mart enterprise.

E. X.400/X.500 IMPLEMENTATION STRATEGY

1. Methodology

The chronological X.400 implementation for Wal-Mart's enterprise system started with the General Office complex and the X.400 backbone. Next, vendors were connected. X.400 backbone connection for the international areas has begun. One is currently up and running; another is on the way. The stores and clubs will initially be connected one at a time. Then groups of ten stores and/or clubs will be connected. The rest will roll-out quickly in larger groups since the technicians intend to have the set-up and configuration of the MTAs totally automated. The complete installation goal is end of second quarter this year, or June 1994.

2. Current Status

The General Office complex is on-line with the X.400 backbone. Currently NCR's StarPRO is running well (It is a Retix Message Server for Unix clone). Additionally, one application is successfully running at this time on the backbone.

F. LESSONS LEARNED THUS FAR

Although the X.400 backbone installation is not complete, Wal-Mart technicians have learned the following lessons thus far. First, be cautious of gateways because they generate a lot of administrative work such as directory updates, synchronization, error-checking for E-Mail routing as well as just making sure the mail gets through. The fewer you have, the better.

Second, when investigating products, check into the administrative tools that are provided with the product. The idea is to NOT require very many people to be highly trained specialists.

Third, quality of the directory and synchronization capabilities are also key features to look for when reviewing X.400 products.

Finally, train your people internally before the actual implementation with the focus being "what the program can do for you". Ideally, the best training would be no training since that would imply a totally seamless integration.

G. FUTURE MESSAGING REQUIREMENTS

Wal-Mart intends to upgrade the X.400 backbone and messaging infrastructure with the X.400 (88) version upon completion of the current X.400 installation. The technical staff is currently looking into the message store functionality which is the primary new feature that the 1988 version offers.

Although not stated explicitly in either phone interviews or Wal-Mart correspondence, the author believes Wal-Mart intends to overlay as many application programs over this store-and-forward architecture that they can. As long as the application program interfaces (APIs) are compatable with an X.400-based architecture, they will provide the broadest, most efficient (in terms of moving information quickly to provide "better" packages for "better" business decisions) message transport system.

VI. CONCLUSIONS

A. BENEFITS OF AN X.400 ENTERPRISE ELECTRONIC MESSAGING SYSTEM

The CCITT X.400 (88) family of standards is a *messaging transport standard* that facilitates *international* message exchange between subscribers to computer-based store-and-forward message services. Combined with an appropriate network architecture, the series provides a complete package for transport of electronic objects which may include digitized voice, documents, forms, graphics, images, spread sheets and text. Its rival protocol, SMTP, as its name implies, is simply providing mostly textual messaging capability.[5] In an unprecedented globally competitive market, industry demands an electronic mail or messaging system that will transport all forms of data.

B. LESSONS LEARNED FROM INDUSTRY

Although the X.400 standard in one form or another has been around for nearly a decade, those in the corporate world that have implemented the standard have compiled a list of lessons learned. Assembling an enterprise messaging system

[5]Multiple Internet Mail Extension (MIME) has been proposed as an extension of SMTP to allow for all media types in the mail envelope.

does require a working knowledge of network architecture and transport protocols, as well as a full understanding of X.400 specifications. Although installation time may be enhanced with the very best available technical resources (the X.400 vendors themselves), it will take more time than anticipated to configure each MHS's options. Broad knowledge about client-server operating systems and mail applications is essential during installation. As mentioned previously, the following additional guidelines may improve a business's X.400 implementation:

- Contract with vendors or reliable third party service providers to help with initial design, planning, installation and configuration, especially if you don't have specific expertise in house. This will pay for itself many times over.

- Train support people so you build expertise in-house and can maintain your systems in the long run.

- Try to minimize the number of vendors involved in the construction of your system. For example, it may be a better approach to purchase all gateways from one vendor rather than individual gateways from each vendor. Many companies are consolidating their E-Mail systems so they only need to support three or four rather than eight or ten.

- If you purchase equipment from more than one vendor, bring them all together at the same time during installation. In addition, make sure you ask about interoperability testing to ensure that the equipment you are buying interoperate. Ask specifically about version numbers and system configuration, not just the X.400 system.

- Watch out for updates and upgrades. Test everything before you install. You need to test compatibility all over again if one component changes.

- Backbone designs are usually more efficient to manage than point-to-point gateways, as they have fewer interdependent components and less equipment, reducing maintenance requirements.

Finally, evaluate the administrative interface and functionality of the systems. It's a demonstrated fact that an easy-to-use interface can save valuable time and make troubleshooting easier by orders of magnitude.

C. HOW DOD AGENCIES CAN ACHIEVE X.400 FUNCTIONALITY

DMS is not scheduled for completion until the year 2007. The X.400 messaging portion may be implemented as soon as the year 2000. In the interim, with the basic premise that X.400/X.500 standards *will* be useful for *any* DoD component to incorporate into their communications architecture, components may obtain X.400/X.500 services/functionality by using any one or a combination of the methods mentioned in Chapter III. It is important to note that these methods are strictly conceptual and would rely on a case-by-case, thorough requirements analysis (including a review of any existing contracts) prior to any implementation plan. The following conceptual scenarios are provided.

For agencies that are *light* on mail traffic, public E-mail providers such as AT&T, MCI and Sprint are most cost effective since installation costs are low and the providers take on the burden of integration and management issues. Public E-mail providers are the fastest and simplest way to set up X.400 connectivity. The agency would "subscribe" to a messaging service paying a set-up charge and a "per message" charge based on usage. The public providers usually include set-up, configuration, maintenance and support as part of the service. In addition to messaging, they also provide enhanced services like accounting and monitoring.

For agencies that know they will be a *big player* in the DMS program, i.e., they have a large-volume messaging requirement or their mission is operationally critical to National Defense, the Wal-Mart implementation provides a good example of how to build an X.400 backbone on an already-existing enterprise-wide network and telecommunication infrastructure (Refer to Chapter V). Basically, the DoD component would need to purchase the hardware and software needed to build a native, in-house, X.400 enterprise system. The advantages of this strategy include complete control over the E-mail system, its security and performance. Additionally, it offers better integration with existing corporate computing and data processing functions than public link or strictly proprietary services do. As Chapter V points out, there are a number of vendors such as DEC and HP that provide all the components needed for storing and routing X.400 messages.

Finally, agencies that (1) have a number of E-Mail packages that currently can't talk to one another (or it's "addressingly" very painful for them to), and (2) are connected on a LAN or WAN, need a series of gateways. Most

PC-based E-Mail vendors and minicomputer and mainframe computer messaging systems have X.400 gateways between their proprietary messaging systems and X.400. If any of the E-Mail packages do not provide X.400 connectivity, the DoD component may have to procure another vendor's compatible X.400 gateway product. For example, a number of third-party vendors such as Retix, DEC, World Talk and Soft-Switch provide X.400 gateways and/or servers for connecting dissimilar messaging services. These products support not only a wide selection of proprietary protocols but also provide the message handling agents (UAs and MTAs) required for sending X.400 messages. Some of these products include directory services that tie together dissimilar E-mail directory formats. If the agency has strictly LAN electronic messaging requirements, they will not need a gateway for UA and MTA conversion; but, it is highly unlikely for an agency to have strictly local messaging requirements. The LAN E-Mail market is dominated by Lotus Development Corp.'s cc:Mail, Microsoft Corp.'s Microsoft Mail and WordPerfect Corp.'s WordPerfect Office, in that order. Their specific attributes are listed in Chapter III.

D. SUMMARY

Creating a global messaging standard that transparently unites all disparate E-Mail systems is both laudable and possible with X.400 and its directory counterpart, X.500. This thesis provided technicians and managers alike who are associated with an E-Mail system with a basic, thorough discussion of the CCITT X.400 family of Message Handling Standards and a brief definition of the associated CCITT X.500 Directory standard. Implementation issues were extensively discussed and illustrated using published technical reports. Showing the broad scope of these standards, examples from both DoD and industry were provided. Within DoD, native X.400 is required as part of the E-Mail portion of the global Defense Message System. Within industry, X.400 is required for international companies to maintain a competitive edge as shown through a very successful retail store's current X.400 implementation, Wal-Mart Stores Inc.

APPENDIX ACRONYMS

AAME	Automated Multi-Media Exchange
ADI	AUTODIN-to-DISN Interface
admd	administrative management domain
AFAMPE	Air Force Automated Message Processing Exchange
AIA	Aerospace Industry Association
AMHS	Automated Message Handling System
AMPE	Automated Message Processing Exchange and Telephony
API	Application Program Interface
ARPANET	Advanced Research Projects Agency Network
ASC	AUTODIN Switching Center
ASD	Assistant Secretary of Defense
AU	Access Unit
AUTODIN	Automatic Digital Network
C3I	Command, Control, Communications, and Intelligence
CCITT	Consultative Committee on International Telegraphy
CSP	Communication Support Processor
DARPA	Defense Advanced Research Agency
DDN	Defense Data Network
DEC	Digital Equipment Corporation

DIR	Directory
DISA	Defense Information Systems Agency
DISN	Defense Information System Network
DMS	Defense Message System
DMSWG	Defense Message System Working Group
DoD	Department of Defense
DPI	Data Processing Installation
DSNET	Defense Secure Network
EDI	Electronic Data Interchange
FTP	File Transfer Protocol
GOSIP	Government Open System Interconnection Profile
HP	Hewlett Packard
ICP	In-Club Processor (Wal-Mart)
IFIP	International Federation of Information Processing
IP	Internet Protocol
IS	Information Systems
ISP	In-Store Processor (Wal-Mart)
LAN	Local Area Network
LDMX	Local Digital Message Exchange
Mac	Macintosh

MHS	Message Handling System
MILNET	Military Network
MIS	Management Information Systems
MROC	Multi-command Required Operational Capability
MS	Message Store
MSP	Message Security Protocol
MTA	Message Transfer Agent
MTS	Message Transfer System
NIC	Network Information Center
OAS	Office Automation System
OSI	Open System Interconnection
OUA	Organizational User Agent
PLA	Plain Language Address
PMSP	Preliminary Message Security Protocols
prmd	private management domain
PSTN	Packet-Switched Telephone Network
RFP	Request For Proposal
RI	Routing Indicator
RTS	Reliable Transport Services
RUA	Remote User Agent (Wal-Mart)
SDNS	Secure Data Network System

SMTP	Simple Mail Transfer Protocol
SUA	Simplified User Agent (Wal-Mart)
TAIS	Target Architecture and Implementation Strategy
TCC	Telecommunication Center
TCP	Transmission Control Protocol
TELEX	Telephone Exchange
TPN	Tactical Packet-switched Network
TUA	Training User Agent (Wal-Mart)
UA	User Agent
UNESCO	United Nations Educational Scientific and Cultural
WAN	Wide Area Network
XAPIA	X.400 Application Program Interface Association

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