A GATEWAY BETWEEN MHS (X.400) AND SMTP

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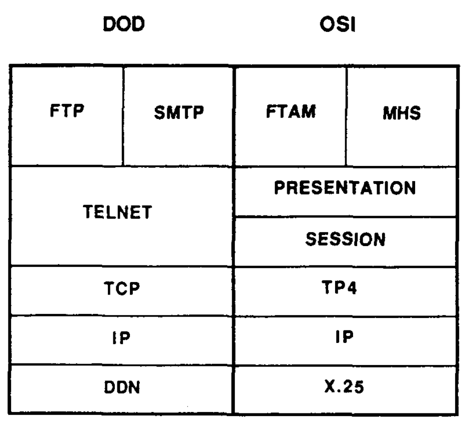
The MHS/SMTP electronic mail gateway is one of two application layer gateway projects being developed by the National Bureau of Standards (NBS) under contract to the Defense Communication Agency (DCA). This gateway will allow DoD and Open Systems Interconnection (OSI) users to interoperate during the period that DoD is migrating to the use of OSI protocols. Based on an analysis of the two protocols, a set of gateway requirements was defined, and an architecture was selected to satisfy the requirements. This paper includes: a summary of both sets of protocols, the gateway requirements, the gateway architecture, the mapping mechanisms for service elements, the Protocol Data Unit (PDU) encoding/decoding scheme, and the major constraints and problems encountered in the study. The paper begins with a general overview, and will progress towards a detailed set of instructions for designing an optimal gateway.

1. Introduction

Major developments are taking place in data communications, based on the use of the Open Systems Interconnection (OSI) protocols to provide interconnection among heterogeneous computer systems. Within a few years, use of the OSI protocols will be widespread in the world of data communications. For a number of years, the DoD has had its own suite of communications protocols. These protocols provide the same basic functionality as the OSI protocols but are not interoperable with them. In 1984, the Defense Communications Agency (DCA) explored the possibility of migrating from DoD to OSI protocols within DoD networks. This exploration resulted in jointly proposed projects between the NBS and DCA, in cooperation with industry, to facilitate migration.

The projects include building application layer gateways between the DoD and OSI protocols for electronic mail, or message handling, and file transfer. These gateways will allow users of the DoD protocols to migrate to the OSI protocols while providing interoperability during a transition period.

This paper deals with the electronic mail gateway, one of two gateway projects, that performs the mapping required to transfer information between the X.400 Message Handling System (MHS) and the DoD's Simple Mail Transfer Protocol (SMTP). The SMTP/MHS gateway (see Figure 1) is located at the Application Layer of the OSI Reference Model [1]; MHS is defined in the CCITT X.400 series of



GATEWAY PROTOCOL SUITES

FIGURE 1

Disclaimer: Certain companies and their products are mentioned in order to adequately describe the application of international standards in different environments. In no case does such identification imply recommendation or endorsement by the National Bureau of Standards.

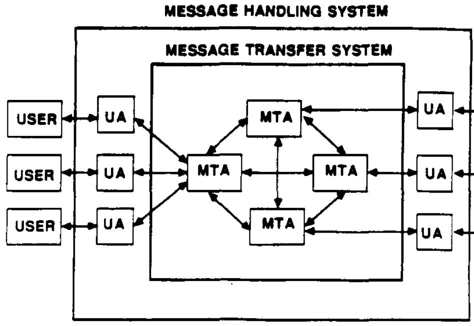
recommendations, October, 1984 [2,3,4,5,6,7,8,9]; MHS implementation agreements were developed at the NBS/OSI Implementors' Workshop [11]. SMTP is specified in MIL-STD-1781 of May, 1984 [10].

The gateway allows electronic mail to be sent from a user of one protocol to a user of the other and vice versa. The gateway was implemented on a processor containing implementations of both the DoD and OSI protocol suites (see Figure 1). Digital Equipment Corporation lent NBS a MicroVAX II and provided the OSI protocol suite; Network Research Corporation provided the DoD protocol suite. NBS is developing the software required to bridge the two protocol suites at the Application Layer. This paper includes the project background and a summary of both sets of protocols. The gateway requirements are enumerated and an optimal gateway architecture is described. The paper also includes the mapping mechanisms for service elements, the Protocol Data Unit (PDU) encoding/decoding method, the major constraints and problems, addressing considerations, and a conclusion.

2. Summary of MHS and SMTP Protocols

This section provides a brief summary of the two sets of protocols. For detailed MHS information, consult the MHS specifications in the CCITT X.400 series of recommendations [2]. The SMTP (MIL-STD-1781) is specified by Requests for Comments (RFC) 821 [12] and RFC 822 [13].

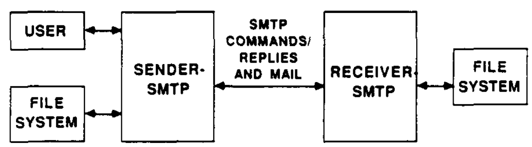
The MHS model, shown in Figure 2, consists of several different components that operate together to provide a general, application-independent, store-and-forward message transfer capability. A MHS consists of a Message Transfer System (MTS) and a set of User Agents (UAs) that submit and deliver messages. The MTS consists of a set of interconnected Message Transfer Agents (MTAs) that accept a message submitted by an Originating UA, relay the message to each of the destination MTAs, and finally deliver the message to one or more recipient UAs. The user can be either a person or a computer process that sends messages to and receives messages from a MHS through UAs.



MESSAGE HANDLING SYSTEM MODEL

FIGURE 2

The SMTP model, shown in Figure 3, is the military standard developed for mail handling in the DoD environment. SMTP, also known as RFC 821, is used in conjunction with RFC 822 to transfer mail. RFC 822 (The Standard for the Format of ARPA Internet Text Messages) specifies a syntax for RFC 821 messages which uses an augmented Backus-Naur Form (BNF) notation. The model contains two major components, a sender-SMTP and receiver-SMTP. A user initiates a sender-SMTP process. The sender-SMTP will establish a single full-duplex transmission channel to a remote receiver-SMTP. The sender-SMTP then may issue commands to a receiver-SMTP. The receiver-SMTP processes these commands, and generates a reply to be sent back to the sender-SMTP.



SMTP MODEL

FIGURE 3

SMTP and MHS have similar functionality. Both systems store and forward messages, and the primary purpose of both systems is to handle the submission, relaying, and delivering of these messages. Each system has its own addressing scheme which consists of a set of uniquely named domains, and a set of users within each domain, with each user having a unique name within the domain. There are, however, several differences in the services offered by MHS and SMTP.

A MHS includes several services that are not included in SMTP, such as: (1) a probe service to determine whether a message can or cannot be delivered to a recipient, (2) a notification of delivery, (3) the setting of the priority of a message, (4) the specifying of a deferred delivery date and time, (5) the specifying of an alternate recipient, (6) the choice to disclose or not to disclose the other recipients, (7) the ability to convert the encoded information among the various message types, (8) multiple body parts in message content, and (9) the inclusion of recursive messages in a delivered message. Also, there are several SMTP services that are not included in MHS, such as: (1) verifying user names, (2) expanding mailing lists, (3) allowing the posting of a message to a terminal and/or a mailbox, and (4) return of contents with a non-delivery notification.

3. Requirements for the Gateway Design

Before an architecture for the gateway can be considered, certain gateway requirements must be defined. The requirements can be classified from three points of view: (1) from the perspective of functional characteristics, (2) from the perspective of user knowledge, and (3) from the perspective of the complexity of software development.

From the perspective of functional characteristics the gateway design must consider the following aspects of both protocols: Protocol Data Unit (PDU) definitions, PDU encoding mechanisms, and the need for converting the services and data elements of one protocol into the services and data elements of the other protocol. The operations relating to the exchange of these protocol elements, and the rules for using each protocol's provided services are also included. The recognition in the gateway design of these protocol aspects is essential to correctly map the protocol elements across the SMTP/MHS boundary, and to maximize the number of services mapped. For consistency and compatibility the gateway will retain and provide default information on each mail transaction during the mapping process; the gateway will not alter the existing protocol recovery mechanism in any fashion. From the view of system performance, the gateway requires the ability to handle numerous messages simultaneously, to provide for temporary storage to allow for the effective transfer of mail, to retain system status, and to handle various errors occurring during the transaction process.

From a user's perspective, the gateway design should minimize the procedural changes required by the user to submit or receive a message. However, since all messages must be delivered to the gateway user agent, a method must be devised for the user to specify the address of the gateway and the address of the message recipient. Where possible, the gateway should not entail loss of services provided by the user's current mail system.

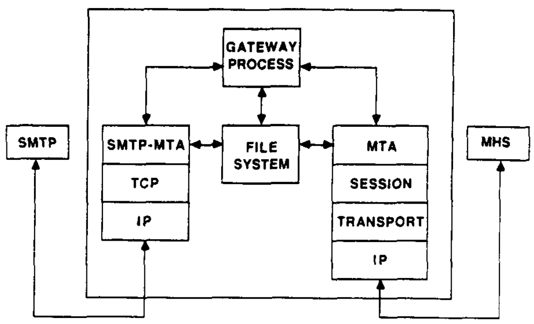
To aid software development, the gateway implementation should be developed as a single logical process residing over both the ISO and DoD protocol suites. The gateway design should be modular, so that it can be detached and modified independently of other system components. The gateway assumes that the underlying services are reliable.

4. Gateway Architecture

The developers of the X.400 Recommendations for Message Handling Systems envisioned many types of User Agents being served by the Message Transfer System. The Interpersonal User Agent, which provides for communication between people, was of particular interest to CCITT and so it was included in the X.400 Recommendations. Other User Agents can have their own protocol to communicate with each other and still use the services of the Message Transfer System, as long as they follow CCITT procedures for submitting and delivering messages. Many X.400 implementations are being designed to include a service boundary allowing other types of User Agents to be written to use the services of the MHS. The terms "UA" and "MTA" are not stated explicitly in the SMTP standard, but there is software which performs MTA and UA functions and this software can easily be identified and separated. Thus, the gateway process can be written as a special purpose user agent which uses the services of the Message Transfer System.

Early in the gateway project, several architectures were considered, evaluated, and described in a design specification (A Gateway Architecture Between SMTP and MHS) [14]. The approach chosen is called the Staged Completion at UA architecture.

The Staged Completion at UA Model, shown in Figure 4, consists of four components: the MHS protocol suite, the SMTP protocol suite, a file system, and a gateway process. The gateway process is a User Agent that accepts delivery of a message from either the MHS or SMTP MTA, performs all the required service and protocol mappings and submits the message to the other MTA for delivery to the message recipient. The file system is provided by the local host operating system. All messages from either side must be saved in the file system before further processing is possible. The gateway also logs information in the file system for each message that passes through it. The gateway process is a custom-designed process which uses a set of interface routines to connect to both existing protocols, while not altering the existing protocols. The gateway process is the core of the gateway, and performs mapping, transformation, and error handling for the two protocols. The gateway assumes that the layers below each UA provide reliable service.



STAGED COMPLETION AT UA LEVEL

FIGURE 4

The Staged Completion at UA Model takes advantage of the separate existence of both sets of protocols. The mappings are performed at the UA level; this is accomplished by using a set of callable interface functions to communicate with both protocol suites, so that the MTA functionality for both protocols is left untouched. Thus the implementors can use the existing MHS-MTA or SMTP-MTA software without modification, and can freely expand gateway functionality. This is an efficient approach to take in designing the gateway architecture since there is a logical interface between the user-oriented and message transfer functionality. The gateway developer can modify code pertaining to user activities without violating UA protocols.

A message is transferred in successive steps, or stages, and the two protocols are kept separate, with each protocol being a complete intact unit. A message is transferred from the originator to the gateway entirely in one protocol (first stage). At the gateway, the message is stored in the file system temporarily and next mapped to the PDU format specified by the other protocol (second stage). The message is then transferred to the destination in the other protocol (third stage). This is an "automatically" staged completion; the user has no control over the gateway process. The only links between the two protocols are single thread paths connected to a file system and to each other via the gateway process. The gateway acts as an end system for each protocol; messages are delivered to the gateway and resubmitted to the recipient after being mapped into the other protocol. The chief advantage of this model is its modularity, allowing separation of the protocol mapping software from existing message transfer software.

5. Service Elements and Specific Mappings

The major gateway function is mapping of one set of protocol services and PDU elements to the corresponding services and PDU elements of the other protocol. This section describes the mapping mechanism in detail. The specific mappings of service elements are discussed, first for SMTP to MHS, and then for MHS to SMTP. Next the transfer syntax encoding mappings are discussed.

5.1 SMTP to MHS Service Analysis and Mappings

There are two parts to an SMTP transaction defined by RFC 821 [12] and RFC 822 [13], shown in Figure 5. RFC 821 defines the peer protocol for controlling the exchange and RFC 822 defines the actual representation of the text data. The originator SMTP-MTA sends a 821-MAIL command to its peer in the gateway, which extracts the originator field. Similarly, the gateway extracts from the 821-RCPT commands the set of recipients. The rest of the message is sent in the 821-DATA command. This message will contain the 822 headers and the message body. The gateway process takes the SMTP information and transforms it into a MHS-readable format. There are four possible mappings described below. The 821 originator and recipient addresses are translated to MHS addresses in the message envelope. Certain MHS Message Transfer services (e.g., message content type) are not provided by SMTP; thus, default values have to be assigned to them in the message envelope. SMTP header elements are mapped to the corresponding MHS message content header elements. Where no corresponding MHS

Message Content header element exists, the SMTP header element is preserved as text in the MHS Message Content Bodypart. Finally the SMTP body text is mapped to the MHS Message Content Bodypart.

Table 1 lists the exact mappings of the SMTP headers to the corresponding MHS headers (or Body). The SMTP headers are listed in the left column and the MHS parameters are listed in the right column. Those SMTP parameters with no equivalent parameters in the MHS are mapped to the beginning of an MHS message (bottom half of the table). For more information about the parameters refer to the gateway design specification [14].

TABLE 1

SMTP to MHS Element Mapping

SMTP Heading	MHS Parameter
	ENVELOPE
821.reverse-path	Originator O/R Name
821.forward-path	Recipient O/R Name
-	ContentType (default-P2)
	CONTENT
Sender	Originator
From	Originator if Sender null, else Authorizing.Users
Reply-To	ReplyToUsers
To	primary.Recipients
Cc	copy.Recipients
Bcc	blind.copy.Recipients
Message-Id	IPMessageId
In-Reply-To	inreplyto
References	crossreferences
Subject	Subject
Date	Submission time
Keywords	BodyPart
Comments	BodyPart
Encrypted	BodyPart
Return-path	BodyPart
Resent-*	BodyPart
Received	BodyPart
text	BodyPart

Notes:
O/R : Originator/Recipient names
P2 : Interpersonal User Agent
* : Include a set of subfields

5.2 MHS to SMTP Mappings

The structured parameters of the MHS message envelope and the message contents are mapped into an SMTP message. There are four types of mappings described below. The MHS elements map into: reverse path and forward path parameters of the MAIL and RCPT commands, SMTP header elements, extension header elements which SMTP allows a user to create, or SMTP body text. Table 2 lists these mappings.

Table 2

MHS to SMTP Element Mappings

MHS parameter	SMTP Heading
ENVELOPE	
Originator O/R Name	821.reverse-path (MAIL Command)
This recipient O/R Name	821.forward-path (RCPT Command)
Other recipient O/R Name(s)	Other-Recipients (RCPT Commands)
Converted encoded information types	Converted-Encoded-Info-Types
Original encoded information types	Original-Encoded-Info-Types
Delivery time	Delivery-Time
Submission time	Date
Priority	Priority
Intended recipient	Intended-Recipient
Content (Content is a P2 PDU and maps as follows:)	
IPMessageId	X-IPMessageID
Authorizing.Users	From
Originator	if Authorizing. Users is present "Sender", else "From"
primary.Recipients	To
copy.Recipients	Cc
blind.copy.Recipients	Bcc
inreplyto	In-Reply-To
obsoletes	X-Obsoletes
crossreferences	References
Subject	Subject
expiryDate	X-Expiry-Date
replyBy	X-Reply-By
ReplyToUsers	Reply-To
importance	X-Importance
sensitivity	X-Sensitivity
autoforwarded	X-Autoforward
Bodypart	text

In the case of SMTP-originated mail, special processing is required to handle non-delivery notifications. When a non-delivery indication is received at the gateway UA, it means that an SMTP-originated message was not received by the MHS user. Non-delivery messages arrive in the form of notifications created by the X.400 Message Transfer System. These notifications contain information about the message which could not be delivered, but not the message itself. SMTP users expect that the message will be returned with a notification of non-delivery. For that reason, the gateway UA saves Message Identifier, Post Date, O/R Name, and 1024 octets of data for each message sent to MHS recipients. This is used to build a message to an SMTP user when an X.400 non-delivery notification is received.

5.3 Mapping Encoding and Mapping Mechanisms

The structure and data types of the SMTP and MHS PDUs are very dissimilar. Because of this, steps must be taken to encode and decode information going from one protocol to the other. In either direction of message flow, the incoming message is parsed and broken into a structure that can be reassembled into a format recognized by the other protocol.

The SMTP PDU is encoded in ASCII 128 which is parsed using the production rules described in Extensions to the Backus-Naur Form (EBNF) [15]. This is a set of production rules which resolves to atomic elements; this notation is used to accommodate the precise notational requirements of the SMTP PDU. The MHS PDU is encoded in notation described in X.409 [5]. Structurally, X.409 (ASN.1) notation can be viewed as hierarchical (treelike), where the nodes of the tree give partial information about the underlying subtree. A logical representation is as a sequence of type-length-value tags, where (reading from left to right) each tag gives information on the structure to the right of the tag, and each length field gives the total length of the structure to the right of that field. The intermediate value field contains tag information for the next lower level. The final value symbol at the far right is a terminal symbol and represents an atomic element. The data type such as integer or octet string is encapsulated with information to form a specific data element for a message such as recipient name.

The gateway process will take the values of one protocol's parameters and transform them into the proper encodings recognized by the other protocol. These encoding mappings may not be reversible, and since it is not the intention of the gateway to add functionality to either protocol, the integrity of reversibility is not required for successful gateway operation except for certain critical service elements (e.g., addressing). The structure and data type information will be lost when circumstances make it impossible to retain such information. In summary, although the complete structure of the MHS messages will be lost in transferring information to SMTP, the semantic meaning of the value will be preserved.

The data elements will be decoded to preserve the semantic meaning of the information whenever possible. Since SMTP supports only the ASCII character set and MHS data elements are encoded using certain data types as building blocks, the MHS data types will be mapped as in Table 3.

Table 3

Mappings for MHS Data Types

MHS Data Types	SMTP-ASCII
BOOLEAN	"true" or "false"
INTEGER	string of digits 0-9
BITSTRING	0 or 1 for each meaningful bit
OCTETSTRING	2 ASCII hex digits for each octet
NULL	"null"
NumericString	NumericString subset of ASCII
PrintableString	as defined in Implementation Agreements for OSI Protocols [17]
S.100String	S.100String subset of ASCII
S.61String	as defined in section 5 of CCITT Recommendation X.408 [4]
IA5String	IA5String subset of ASCII
UTCTime	UTCTime subset of ASCII
GeneralizedTime	GeneralizedTime subset of ASCII
ANY	any of the above Data types

6. Addressing Method

To send a message through the gateway to a recipient served by the other protocol, the originator must supply the address of the gateway in addition to providing the address of the recipient in the form mandated by the other protocol. The SMTP and MHS standards use different formats to represent the address of a message recipient. The SMTP address format is <user@host>. The X.400 user is represented by a set of attribute values sufficient to distinguish the user from all other MHS users. In order for the gateway to transfer a message between the two protocols, the gateway user must provide the information as described below.

6.1 MHS User

When specifying a SMTP address, a MHS user must provide enough information to identify the gateway and the SMTP user who is to receive the message. The gateway can be addressed by a set of attribute-value pairs, with the attributes being a subset of the Standard Attribute List portion of the O/R name found in X.411 [7]. The set of attribute-value pairs used by a MHS user to address the gateway is as follows.

C = US,
ADMD = ICST-MHS,
PRMD = OSINET
S = SMTP_user
G = SMTP_domain_name

Where :
C : COUNTRY
G : GIVENNAME
S : SURNAME
ADMD : ADMINISTRATION MANAGEMENT DOMAIN NAME
PRMD : PRIVATE MANAGEMENT DOMAIN NAME

The Surname and Givenname attributes of the Standard Attribute List are reserved for the SMTP address. They identify the SMTP user and the SMTP domain with the symbol "(a)" serving as a delimiter. Since these MHS address attributes are encoded as type PrintableString which does not contain the character "@", "@" delimiters used in SMTP addresses must be encoded as "(a)". The general format of a SMTP address is "SMTP_user(a)SMTP_domain_name".

If the length of the SMTP address exceeds the preassigned Surname limit of 40 characters, the Surname attribute is used to identify the SMTP user only. The Givenname attribute of the Standard Attribute List, which has a maximum limit of 16 characters, is used to identify the SMTP domain name. The delimiting symbol "(a)" is not included. In this case the format of a SMTP address is as follows:

S = SMTP_user
G = SMTP_domain_name

For example a MHS user wishing to send a message to SMTP user Taylor at domain name ICST-MHS would submit the following recipient address information:

S = Taylor(a)icst-mhs
C = US
ADMD = ICST-MHS
PRMD = OSINET
.
.
.

Note: Vertical ellipses indicate that additional attributes can be entered.

6.2 SMTP User

The SMTP-user portion of the address contains the entire X.400 address. This is implemented by use of the double quotes ('"') and slash ('/') as delimiters. The double quotes delimit the user part, the internal format of which is handled transparently by SMTP-MTAs; the slash is used internally to separate the X.400 address components. A full X.400 address will appear as follows:

<"/C=../ADMD=..{/PRMD=../S=../G=../I=../GEN=../OU1=../ON=..} .../"@icst-mhs>

Where:
S : Surname
G : GivenName
I : Initials
GEN : GenerationQualifier
OU1 : OrganizationalUnit 1
ON : OrganizationName

Notes:
{} : The braces are used to enclose lists from which at least one of the element must be chosen.

... : Horizontal ellipses indicate that additional data or text can be entered.

For example, to send mail to Doug Bodger of XYZ Corp, served by SOMENET in the United States, the X.400 address representation would appear as follows:

<"/C=US/ADMD=SOMENET/ON=XYZ/S=Bodger/G=Doug/"@icst-mhs>

7. Conclusion

Based on an analysis of the DoD and OSI electronic mail protocols, a set of gateway requirements was defined, and a gateway architecture was selected. This paper specifies the requirements to build a viable gateway which minimizes changes to user procedures. The user only needs to know about the naming and addressing schemes, and to recognize some minor differences about the availability of provided services.

The gateway takes full advantage of the MTA's store-and-forward feature by residing at the UA level. A set of callable interface routines allows the gateway to have a minimal effect on the existing MTAs, simplifies the gateway software development, allows easy modification of updated protocols, and provides portability.

During the past five months (starting May, 1987), a custom-designed gateway process has been implemented and has successfully passed hundreds of test cases using a test system designed and developed by the NBS [16]. The gateway process transfers valid messages between DoD and OSI users effectively, while detecting and appropriately handling invalid messages. The successful operation of the MHS/SMTP gateway validates the gateway design. The next step is to evaluate the performance of the gateway under operational conditions. Interoperability testing of the gateway will take place on OSINET, a network established by NBS to test and demonstrate OSI protocols [17].

The SMTP/MHS gateway being developed by NBS will assist the DoD transition to an OSI environment. The gateway is important to the DoD transition because it allows interoperability between the DoD and OSI user communities during the transition period.

REFERENCES

[1] The International Organization for Standardization, Data Processing "Open System Interconnection--Basic Reference Model." ISO Doc. DIS7498, Feb. 1982

[2] MESSAGE HANDLING SYSTEMS: SYSTEM MODEL - SERVICE ELEMENTS." CCITT RECOMMENDATION X.400, OCTOBER 1984

[3] "MESSAGE HANDLING SYSTEMS: BASIC SERVICE ELEMENTS AND OPTIONAL USER FACILITIES." CCITT RECOMMENDATION X.401, OCTOBER 1984

[4] "MESSAGE HANDLING SYSTEMS: ENCODED INFORMATION TYPE CONVERSION RULES." CCITT RECOMMENDATION X.408, OCTOBER 1984

[5] "MESSAGE HANDLING SYSTEMS: PRESENTATION TRANSFER SYNTAX AND NOTATION." CCITT RECOMMENDATION X.409, OCTOBER 1984

[6] "MESSAGE HANDLING SYSTEMS: REMOTE OPERATIONS AND RELIABLE TRANSFER SERVER." CCITT RECOMMENDATION X.410, OCTOBER 1984

[7] "MESSAGE HANDLING SYSTEMS: MESSAGE TRANSFER LAYER." CCITT RECOMMENDATION X.411, OCTOBER 1984

[8] "MESSAGE HANDLING SYSTEMS: INTERPERSONAL MESSAGING USER AGENT LAYER." CCITT RECOMMENDATION X.420, OCTOBER 1984

[9] "MESSAGING HANDLING SYSTEMS: ACCESS PROTOCOL FOR TELETEX TERMINALS." CCITT RECOMMENDATION X.430, OCTOBER 1984

[10] "MILITARY STANDARD SIMPLE MAIL TRANSFER PROTOCOL." MIL-STD-1781 10 MAY 1984, DEPARTMENT OF DEFENSE, WASHINGTON, D.C. 20301

[11] "IMPLEMENTATION AGREEMENTS FOR OPEN SYSTEMS INTERCONNECTION PROTOCOLS." NBS WORKSHOP FOR IMPLEMENTORS OF OPEN SYSTEMS INTERCONNECTION, NBSIR 86-3385

[12] POSTEL, JONATHAN B., "SIMPLE MAIL TRANSFER PROTOCOL", RFC821, AUGUST 1982

[13] CROCKER, DAVID H., "STANDARD FOR THE FORMAT OF ARPA INTERNET TEXT MESSAGES", RFC822, AUGUST 1982

[14] TANG, D., " A GATEWAY ARCHITECTURE BETWEEN SMTP AND MHS." ICST-SNA-86-11, DRAFT, DECEMBER 1987

[15] KILLE, S. E., "MAPPING BETWEEN X.400 AND RFC822." RFC987, JUNE 1986

[16] "A TEST SYSTEM FOR IMPLEMENTATIONS OF MHS/SMTP GATEWAYS." NBS ICST-SNA-87-5, SEPTEMBER 1987

[17] "IMPLEMENTATION AGREEMENTS AMONG PARTICIPANTS OF OSINET.", NBSIR 86-3478