Payoff

X.400 and SMTP/MIME are the subject of much canonical debate in the messaging community. Although the general consensus is that X.400 offers better functionality than SMTP/MIME as an E-mail protocol, the decision to use X.400 or SMTP/MIME must be based not only on their functionality but also other issues such as security, systems management, message management, human resources requirements, and performance.

Introduction

X.400 or SMTP/MIME? No matter what your choice in E-mail protocol, the pros and cons of each technology should be evaluated in the context of the real underlying issue—keeping the network running.

Significant improvements in network management tools, utilities, and techniques are essential before a large, integrated network can begin cost-effective operations. The lack of adequate management tools at the application layer is a major impediment to implementing economical enterprisewide messaging systems. Operating such networks requires highly skilled software engineers who understand large-scale global enterprise networks.

This article covers the issues of operating a reliable messaging environment using either X.400 or SMTP as protocols to transfer E-mail. First, however, the basic features and philosophies of X.400 and SMTP/MIME are explained, including a brief look at the state of electronic mail (E-mail) today and the development process for each protocol.

Exploring critical networking issues requires an understanding of the basic features and philosophies of X.400 and SMTP/MIME, including a brief look at electronic mail (E-mail) today and the development process for each protocol.

X.400 Background

X.400 is based on a formal messaging model created in standardization groups in the International Telecommunications Union-Telecommunications Standards Sector (ITU-TSS). It is the international standard for message handling. It is a full-feature, store-and-forward message-handling system designed to process multimedia and complex business documents.

In particular, X.400's specification of robust message delivery and non-delivery notification schemes makes it well suited to support electronic commerce transactions. X.400 is a commercially viable and secure message-handling technology supported by a worldwide infrastructure and officially sanctioned by various governments, telecommunication vendors, and public service providers. In addition, X.400 is designed to address not only messaging, but also directory, security, and network management.

SMTP Background

Transmission Control Protocol/Internet Protocol (TCP/IP) is the de facto standard network protocol offering a connectionless-mode network service in the Internet suite of protocols. Simple mail transfer protocol (SMTP) is the application-level protocol offering message-handling service. However, because SMTP has its roots in the primarily academic and
research and development background of the Internet Engineering Task Force (IETF), its use has been in a relatively benign and open environment without the need for rigidly enforced network performance, security, and message-delivery criteria.

SMTP/MIME
Messaging by SMTP has been greatly enhanced with the development of Multipurpose Internet Mail Extensions (MIME). This is the official proposed standard format for multimedia Internet mail encapsulated inside standard Internet Request for Comment (RFC) 822 messages.

In simpler terms, MIME provides a way to exchange multimedia E-mail among many different computer systems. It is a collection of specifications that describe how mail user agents (MUAs) can identify arbitrary document types and message body types so the interface can decide how best to display the incoming data to the user. All the information about the attachment is embedded in the message itself. The MUA redefines the structure and contents of RFC 822 message bodies. Users can send word processor documents, spreadsheets, audio files, images, and textual data to someone else regardless of the platform, mail transport agent (MTA), or network operational system that is used by the sender or receiver.

Electronic Mail

Electronic mail is by far the most popular application carried over the Internet. Internet mail is based on various RFCs, including RFC 822 for SMTP.

E-mail with SMTP has become very popular in research, development, and engineering environments because of their use of UNIX. UNIX and engineering environments usually have TCP/IP and SMTP interconnection protocols bundled in with their operating systems. The Internet has proved to be eminently successful in providing information services to a widely diverse worldwide community with more than 9.4 million host computers on the Internet. One hundred and twenty nine countries now have direct connectivity to the Internet and 39 million users are reachable by E-mail. (A full report is available at http://www.nw.com/zone/WWW/report.html.)

The X.400 and SMTP/MIME Development Process

X.400 was designed as a total international messaging environment from the beginning, whereas SMTP developed as an outgrowth of earlier experimental work on the Defense Advanced Researched Projects Agency (DARPA) Network. X.400 provides a complete set of internationally agreed-to standards; approved SMTP/MIME RFCs do not have the same level of official international agreement and approval. The unified design of X.400 as a total messaging environment is also reflected in its clean design interfaces with other international standards required to provide a messaging service—namely, directory (X.500), management (X.700), and security (X.900) services.

SMTP is an outgrowth of the Internet and the Internet Engineering Task Force (IETF). As a quasi-official body with no set membership, the IETF and is not necessarily representative of all potential customers' needs. It has primary responsibility for the development and review of potential Internet standards from all sources. The IETF's working groups pursue specific technical issues, frequently resulting in the development of one or more specifications that are proposed for adoption as Internet standards. Most IETF members agree that the greatest benefit for all Internet community members results from the cooperative development of technically superior protocols and services.
SMTP/MIME, although capable of interfacing with these other international standards, does not work with the same level of designed interoperability as does X.400. This lack of designed interoperability will directly (and negatively) impact system operational maintenance and management costs.

The SMTP Versus X.400 Debate

There is no right or wrong answer when it comes to making a choice between X.400 and SMTP. The choice of technology depends on each organization's particular needs and which strength or weakness of different technologies is most important to them. An organization that wants to share similar technology with as many people as possible can effectively use SMTP/MIME. If security, increased functionality, and operational features such as guaranteed message traceability are most important, then X.400 is the answer.

SMTP/MIME Characteristics

SMTP/MIME supports the transmission of sophisticated information, including images and video, yet it is simple in its design and extensible in nature because of its unique content-type/subtype body part identification mechanism. In short, SMTP/MIME provides a low-cost solution for messaging backbones.

Each part of a multimedia message identifies what type of information is carried in the message part. An entire MIME message, as opposed to an individual part of a multimedia message, can also have a type. For example, a message might have the type “text/plain” and consist of entirely plain text. A MIME message containing parts of different types has the umbrella type “multipart/mixed.” Many types and subtypes have been defined to include audio, image, external data source reference, and partial messages.

The simplicity and flexibility of SMTP/MIME are its main strengths because it can easily be implemented on all systems. Its weaknesses include no support for non-ASCII character sets, limited header structure, and an unstructured message body.

The following table summarizes the strengths and weaknesses of SMTP/MIME:

<table>
<thead>
<tr>
<th>Strengths</th>
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<td>Lacks functionality</td>
</tr>
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<td>Low cost</td>
<td>Sendmail is free</td>
</tr>
<tr>
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<td>Implementations differ</td>
</tr>
<tr>
<td>Text body parts keep everything simple</td>
<td>Too simple for some uses</td>
</tr>
<tr>
<td>Runs over IP, which comes with UNIX</td>
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</tr>
<tr>
<td>Simple addressing</td>
<td>Questionable for financial transactions</td>
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<tr>
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**X.400 Characteristics**

The ITU-TSS has developed an ambitious set of standards for electronic messaging called the X.400 message-handling system (MHS) and the X.500 directory services standards. X.400 has a very complete set of functional characteristics and can accommodate any type of messaging from simple interpersonal text to attached graphics, voice, and video clips. X.435 is defined for electronic commerce, using basic MHS components. X.400 is based on a functional model consisting of a few main components:

- **User agents (UAs)** Used on the desktop for message creation/reading.

- **Message store (MS)** Stores messages until recipient chooses to read them.

- **Message transfer agents (MTAs)** Stores and forwards messages within and between networks.

- **Access units (AUs)** Interfaces to other messaging entities (i.e., voice, facsimile, telex, physical delivery).

  An X.500 directory is a collection of entries that contain information about things such as countries, organizations, people, computers, security, and application programs. The directory is a collection of one or more directory system agent (DSA) computers, each of which holds information for some portion of the directory.

  Users access the X.500 directory via a computer process referred to as a directory user agent (DUA). Specific protocols have been developed to control directory access and the exchange of information with distributed directories.
X.500 is absolutely essential for implementing the address translation, document conversion, and sophisticated message routing needed for large-scale E-mail integration efforts. Directory synchronization is the basis for implementing transparent user addresses between systems.

X.400/X.500 systems are used by most of the world's telecommunication service providers. The US government is implementing a global X.400 messaging system for the military called the Defense Message System (DMS). NATO is also working toward implementing an X.400-based messaging system. This system defines a military message-handling system (MMHS) using X.400, similar to DMS. The militaries of Australia, Canada, the United Kingdom, and New Zealand are also implementing X.400-based MMHS. X.400 is the preferred technology for backbone messaging services of several large commercial companies in the US and is widely used in Europe.

The strengths and weaknesses of X.400 are summarized in the following table:

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<td>Rigorous standards process through ITU</td>
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<tr>
<td>International standard for message handling</td>
<td>Expensive</td>
</tr>
<tr>
<td>Functionality</td>
<td>Complex to understand and configure</td>
</tr>
<tr>
<td>Robust message delivery and non-delivery schemes</td>
<td>Not widely accepted by commercial marketplace</td>
</tr>
<tr>
<td>Well suited for electronic commerce</td>
<td>Lack of robust user agents from popular vendors</td>
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<tr>
<td>Strong security standards defined</td>
<td>Security implementations lagging</td>
</tr>
<tr>
<td>Works well with X.500 directory services</td>
<td>X.500 complex to implement</td>
</tr>
<tr>
<td>Predictable performance</td>
<td>Overhead is significant</td>
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Industrial-Strength Messaging Requirements

X.400 has superior functionality defined in the standards, although many of these enhanced functions, such as multimedia and security, have yet to be deployed commercially. Electronic commerce using X.435 is still waiting for large industry segments to take advantage of this defined standard. Additionally, features such as delivery notifications,
delivery to alternate recipients, and receipt notifications are critical to “industrial strength” messaging systems needed by large commercial organizations or a system such as DMS. SMTP, as defined by RFC 822, lacks the functionality required for backbone messaging systems or a highly complex network such as DMS. However, several improvements have taken place over the past few years. Functionality enhancements defined under MIME to extend SMTP and provide for messages with enclosed software objects such as images, video, audio, and binary file data have greatly enhanced Internet mail use for large organizations. Privacy Enhanced Mail (PEM) RFCs address many shortcomings with regard to security. These RFCs define data confidentiality, authenticity, integrity and nonrepudiation, message encipherment, and digital signatures.

One of the questions being asked by messaging system architects is: Can SMTP/MIME meet the messaging requirements of a large global enterprise? A “qualified” yes is the answer; assuming further extensions to MIME would be required, primarily in the areas of message management. Members of the IETF have shown great resiliency in further enhancing messaging functionality over the Internet when the need arises. IETF members could develop the missing pieces to make SMTP/MIME functionally similar to X.400.

**Critical Comparison Factors**

The most important comparisons between X.400 and SMTP/MIME concern functionality, security, systems management, message management, management manpower requirements, and performance.

**Functionality**

X.400 is more advanced in this respect, but developers are working to improve SMTP/MIME to match X.400's functionality.

**Security**

Message security capabilities provided by the X.400 standards are far superior to SMTP/MIME. However, there are very few large-scale implementations that take advantage of the numerous security-related features specified within the standards.

Internet security is a major concern for many users. Although security options (such as software for trusted and privacy enhanced mail) exist, they are not widely and uniformly deployed.

Besides lacking security, SMTP/MIME lacks reliable audit trails. Spoofing, a process by which someone masquerades as another correspondent, is easily done via Internet mail. A user is also allowed to send a message through a re-mailer service so that the original address is not attached to the message when it arrives at its final destination. It is therefore almost impossible to audit messages.

**Systems Management**

X.400 has greater potential in this respect. The entire area of management—including message management, component management, and complete MHS management—needs more attention. The experience of E-mail managers in large organizations demonstrates the need for many additional management tools for a large, complex messaging network.
Managing a Messaging System

Managing complex, enterprisewide messaging systems is difficult for several reasons:

· A lack of standards for message management.

· Interoperability—network managers have to deal with X.400, SMTP, proprietary LAN protocols, and legacy systems.

· The large number of components. An enterprisewide messaging system is composed of many different kinds of components, each with its own specific behavior characteristics (i.e., MTAs, UAs, directories, and gateways.)

  Much work has been done on developing standards to govern the individual components associated with X.400. Although very little agreement has been reached on how to manage these various components. The network administrator must have tools and utilities available to manage day-to-day network operations. A fully deployed messaging system such as DMS with 2 million users will carry several million messages per day.

Industry Standards for E-Mail Management

Significant work has started on developing industry standards specific to E-mail management. A joint International Federation Information Processing (IFIP) group examined the overall problem of messaging management. A similar IETF task force led to the development of RFC 1566 (also known as the Mail and Directory Management MIB, or MADMAN MIB), which defines a class of managed objects that can be deployed within any vendor’s messaging architecture. The MADMAN MIB, however, is oriented to the Internet and SMTP, and therefore lacks the ability to model some of the more complex features present in X.400-based systems.

  Simple network management protocol (SNMP) and SNMP version 2, both of which are associated with the SMTP/MIME environment, are the leading protocols for managing network transport functions. However, SNMP does not work across non-TCP/IP transports. The management information base (MIB) is a definition of the managed object (i.e., what can be managed remotely). The MADMAN MIB is complete with approved standard definitions, but very limited in functionality (i.e., monitoring only). SNMP and the MIB definitions are only 5% of the puzzle, however.

  The ITU-TSS and the International Standards Organization/International Electrotechnical Commission (ISO/IEC) are currently working on the following MHS management documents:

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<th>General:</th>
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<tr>
<td>MHS Management Model and Architecture</td>
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<td>MHS Management Information</td>
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EMA Requirements for Messaging Management

The Electronic Messaging Association (EMA) is working on a framework that will allow management of multivendor messaging systems. The EMA’s work leverages the IFIP’s work and is aligned with the MADMAN MIB definitions. The effort is broad in scope because it also addresses the area of message tracing and standardizing a set of tasks for message management across a multivendor environment. The EMA’s Messaging Management Committee has characterized requirements for messaging management in the following four major categories:

- **Operational management** Deals with finding outages and fixing them as well as doing routine maintenance. Statistical analysis of traffic and components is accomplished. There is little difference between the two technologies—X.400 and SMTP/MIME—in this area.

- **Configuration management** Deals with managing the addition and deletion of components in the messaging system. It includes tasks such as dynamic updating of message routing tables, starting and stopping messaging system components, and
discovering and depicting messaging system components across the network. Both X.400 and SMTP/MIME are lacking in this respect.

- **Administration management** Provides a means of managing subscribers, distribution lists, and accounting information. It includes facilities for security administration. Control throughout some portions of the Internet is loose. No person or group has authority over some functional subnetworks, such as Usenet, as a whole. Every administrator controls their own subnetwork. This is different from the X.400 assignment and demarcation of responsibilities, which are vested in management domains, with accountability for performance and control being highly defined. X.400 is superior in this area.

- **Network management** Is the process of keeping the underlying networking layer healthy. X.400 and SMTP/MIME are equal in this category.

**Message Management**

X.400 is more sophisticated than SMTP/MIME, but still needs significant improvements. The ability to track a message through messaging systems is central to the establishment of a trusted delivery infrastructure for any complex commercial usage. Maintaining unique identification of a message as it crosses intersystem boundaries represents a significant challenge that no previous standardization activity has addressed.

**Human Resources Requirements and Support Costs**

Much work is needed in this area for both X.400 and SMTP/MIME technologies. The largest messaging networks can carry several million messages per day. Network administrators do not have time to stop and analyze trouble spots—there is too much traffic coming. They need utilities to shunt aside a problem message and let the traffic flow continue. It also takes very knowledgeable software engineers to accomplish this work, and they are expensive.

Managing these distributed messaging systems from a single, centralized, administrative control system is difficult and costly. One major Fortune 500 corporation estimates that it spends approximately $40 per user, per year to acquire messaging hardware and software versus $200-$300 per user, per year in operating costs to manage and administer the messaging network.

A study by Creative Networks, Inc. indicated messaging support costs, including end-user support, to be:

- $4,189 annual cost per desktop user.
- $5,426 annual cost per mobile user.

A key cost factor is the amount of end-user support required. Companies lose approximately $684 per user annually to downtime, $764 to lost productivity, and $1,198 to lost revenues due to messaging system problems. Problems with E-mail cut productivity in environments where jobs depend on computer-based information. A typical downtime incident takes 6.3 hours of staff time to resolve.

The need for a resident administrator at each major site can significantly increase the cost of managing large-scale messaging systems. In addition to being on call to deal with system failures or changes in configuration, administrators find themselves subject to
normal corporate cost-containment efforts. They are called to manage high levels of ongoing expenses in training as well as in development of complex internal procedures for managing the messaging network across different departments and dissimilar platforms. A major business imperative is to improve the reliability of electronic messaging while reducing the costs of maintaining the messaging infrastructure.

**Performance**

There is no preferred technology from a performance standpoint. Engineering benchmarks are needed to demonstrate the performance of all components and the overall network. Performance bottlenecks must be identified and corrected by the system administrator, but additional tools are desperately needed. Further analysis and modeling of both X.400 and SMTP-based networks is needed. SMTP-based networks carry large volumes of information, but with very limited functionality. X.400-based networks also carry significant traffic loads and provide very reliable service. X.400 can be engineered to deliver reliable and predictable performance. Both technologies suffer in performance when encryption is added. However, there is overhead involved that requires additional bandwidth.

**Commercial Use**

X.400 is preferred over SMTP/MIME by large organizations needing guaranteed network services. X.400 has gained international acceptance and is used by most European Postal, Telegraph, and Telephone (PTT) services and telecommunication providers throughout the world. The International Civil Aviation Organization standardized on X.400 because of the greater flexibility and enhanced features that are available.

The most effective means of tying messaging systems together still is the old tried-and-true X.400 backbone. Numerous large commercial and government organizations need a robust and reliable messaging network. Vendors of X.400 components have not experienced significant revenues selling X.400 components because there are still too many unresolved issues; namely, lack of management tools and utilities, plus fully developed directory services. Although SMTP/MIME vendors have made significant sales, SMTP/MIME also has the same problems with lack of management tools and directory services.

In forums such as the Electronic Messaging Association, customers repeatedly state they want the benefits and capabilities offered by X.400 messaging. It is this demand that has led to changes in the current SMTP systems to attempt to offer the same functionality provided by X.400.

**Conclusion**

X.400 is a better protocol than SMTP/MIME for building a sophisticated network. The standards definitions are very complete for functionality and most networking requirements. X.400 has numerous security features and guaranteed message delivery and notification. These are extremely important for large, predictable, commercial messaging networks.

SMTP/MIME functionality is missing some important messaging requirements such as delivery notifications, delivery to alternate recipients, and receipt notifications. In fairness, these elements probably could be added, but further work is needed. SMTP grew up in the UNIX environment to provide simple text messaging. Numerous features have been added over time, but the entire process has been an ad hoc development—not the
planned architectural development process that the international standards bodies followed with X.400.

In the long run, X.400 and SMTP/MIME are expected to converge on a single set of standards, or at least sufficient development of bridging technology to enable the seamless coexistence of both technologies. The National Institute of Standards and Technology (NIST) has a special interest group working on coexistence and convergence profiles that will promote coexistence as a step toward convergence. This further effort strengthens the belief that the few functionality differences between X.400 and SMTP/MIME are not critical in choosing between the two.

From a standards perspective, the most critical missing ingredient in providing a robust, reliable network is the lack of management tools and utilities. This is where development attention needs to be focused, rather than on functional differences between the protocols. It does not matter which technology is chosen, nor how robust the individual components are, if the network cannot be managed. Users must be able to easily manage the overall network to provide the type of messaging environment that everyone is striving for.

**Author Biographies**

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Gordon L. Preston, a consulting manager for Bell Atlantic Network Integration, is responsible for the consulting practice in Electronic Messaging and Internet Services. He is an active member of the Electronic Messaging Association (EMA) and has several years’ experience providing a wide range of messaging services for commercial and government clients.