

SMTP
Internet-Draft
Expires: August 15, 2005

D. Crocker
Brandenburg InternetWorking
February 14, 2005

Internet Mail Architecture
draft-crocker-email-arch-03

Status of this Memo

This document is an Internet-Draft and is subject to all provisions of [section 3 of RFC 3667](#). By submitting this Internet-Draft, each author represents that any applicable patent or other IPR claims of which he or she is aware have been or will be disclosed, and any of which he or she become aware will be disclosed, in accordance with [RFC 3668](#).

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF), its areas, and its working groups. Note that other groups may also distribute working documents as Internet-Drafts.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

The list of current Internet-Drafts can be accessed at <http://www.ietf.org/ietf/lid-abstracts.txt>.

The list of Internet-Draft Shadow Directories can be accessed at <http://www.ietf.org/shadow.html>.

This Internet-Draft will expire on August 15, 2005.

Copyright Notice

Copyright (C) The Internet Society (2005).

Abstract

Over its thirty-four year history, Internet mail has undergone significant changes in scale and complexity. The first standardized architecture for email specified a simple split between the user world, in the form of Mail User Agents (MUA), and the transmission world, in the form of the Mail Handling Service (MHS) composed of Mail Transfer Agents (MTA). Core aspects of the service, such as address and message style, have remained remarkably constant. However public discussion of the architecture has not kept pace with

Internet-Draft

EMail Architecture

February 2005

the real-world refinements. This document offers an enhanced Internet Mail architecture to reflect the current service.

Table of Contents

1.	Introduction	3
1.1	Service Overview	4
1.2	Discussion venue	5
1.3	Changes	5
2.	Email Actor Roles	5
2.1	User Actors	6
2.2	MHS Actors	8
2.3	Administrative Actors	11
3.	Identities	13
3.1	Mailbox Addresses	13
3.2	Domain Names	14
3.3	Message Identifiers	14
3.4	Identity Referencing Convention	15
4.	Services	15
4.1	Message	17
4.2	Mail User Agent (MUA)	19
4.3	Mail Submission Agent (MSA)	21
4.4	Mail Transfer Agent (MTA)	22
4.5	Mail Delivery Agent (MDA)	24
4.6	Message Store (MS)	25
5.	Mediators	25
5.1	Aliasing	27
5.2	ReSending	28
5.3	Mailing Lists	30
5.4	Gateways	33
5.5	Security Filter	34
6.	Security Considerations	34
7.	References	34
7.1	References - Normative	34
7.2	Reference - Descriptive	36
	Author's Address	37
A.	Acknowledgements	37
	Intellectual Property and Copyright Statements	38

Over time the operational service has sub-divided each of these "layers" into more specialized modules. Core aspects of the service, such as address and message style, have remained remarkably constant.

However public discussion of the architecture has not kept pace with the real-world refinements. This document offers an enhanced Internet Mail architecture to reflect the current service. The original distinction between user-level concerns and transfer-level concerns is retained, and the elaboration to each "level" of the architecture is discussed separately.

For Internet mail, the term "end-to-end" usually refers to a single posting and the set of deliveries directly resulting from its single transiting of the MHS. However, note that some uses of email consider the entire email service -- including Originator and Recipient -- as a subordinate component. For these services, "end-to-end" refers to points outside of the email service. Examples

are voicemail over email [[RFC2423](#)], EDI over email [[RFC1767](#)], and facsimile over email. [[ID-ffpim](#)]

The current draft seeks to:

- o Document refinements to the email model
- o Clarify functional roles for the architectural components
- o Clarify identity-related issues, across the email service
- o Provide a document that serves as a common venue for further defining and citing modern Internet mail architecture

[1.1](#) Service Overview

End-to-end Internet mail exchange is accomplished by using a standardized infrastructure comprising:

- o An email object
- o Global addressing
- o A connected sequence of point-to-point transfer mechanisms
- o No prior arrangement between Originator and Recipient

- o No prior arrangement between point-to-point transfer services, over the open Internet

The end-to-end portion of the service is the message. Broadly the message, itself, is divided between handling control information and user message content.

A precept to the design of Internet mail is permitting user-to-user and MTA-to-MTA interoperability with no prior, direct administrative arrangement. That is, all participants rely on having the core services be universally supported, either directly or through Gateways that translate between Internet mail standards and other email conventions.

For localized environments (Edge networks) prior, administrative arrangement can include access control, routing constraints and lookup service configuration. In recent years one change to local environments is an increased requirement for authentication or, at least, accountability. In these cases, the server performs explicit validation of the client's identity.

Crocker

Expires August 15, 2005

[Page 4]

Internet-Draft

EMail Architecture

February 2005

[1.2](#) Discussion venue

Discussion about this document should be directed to the IETF-SMTP mailing list <<http://www.imc.org/ietf-smtp>>. It is the most active, long-standing venue for discussing email architecture. Although it is primarily for discussing only the SMTP protocol, it is recommended that discussion of this draft take place on that mailing list because it attends to end-to-end infrastructure and architecture issues more than other email-related mailing lists.

[1.3](#) Changes

This is intended to be the last major revision, prior to seeking publication.

Significant changes to this version:

Administrative Domain: Extensive discussion of this operational construct, including distinguishing User, Edge and Transit ADs. This elaborates the reference to "providers" in earlier drafts.

Mediator: Extensive revision both to the description of Mediator and use of the construct throughout the document.

Gateway: The construct of a gateway is elaborated.

Set by: Tables that had an entry for "Actor:" have been changed to "Set by:" in order to clarify the nature of the Actor reference being made. It is intended to indicate who is responsible for setting the identity, rather than indicate what identity is referred to. The specific references were carefully reviewed and modified, to reflect this focus. The list of "set by" entries was extensively reviewed, with substantial modifications made.

Editorial proofing: A complete word-smithing pass over the document.

[2.](#) Email Actor Roles

Internet Mail is a highly distributed service, with a variety of actors serving different roles. These divide into:

- o User
- o Mail Handling Service (MHS)
- o Administrative Domain

Crocker

Expires August 15, 2005

[Page 5]

Internet-Draft

EMail Architecture

February 2005

Although related to a technical architecture, the focus on Actors concerns participant responsibilities, rather than on functional modules. Hence the labels used are different than for classic email architecture diagrams. Actors often will be associated with different organizations. This operational independence provides the motivation for distinguishing Administrative Domains.

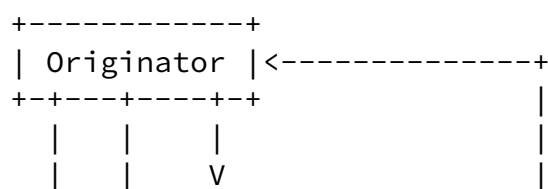
[2.1](#) User Actors

Users are the sources and sinks of messages. They may have an exchange that iterates and they may expand or contract the set of Users participating in a set of exchanges. In Internet Mail there are three types of user-level Actors:

- o Originators
- o Recipients
- o Mediators

From the User-level perspective all mail transfer activities are performed by a monolithic, shared MHS. Users are customers of this service.

The following depicts the relationships among them.



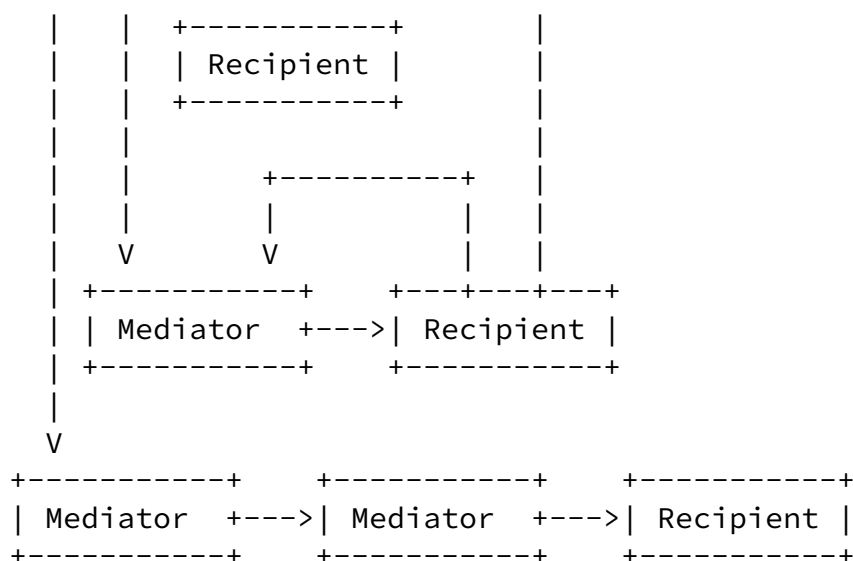


Figure 2: Relationships Among User Actors

[2.1.1](#) Originator

Also called "Author", this is the user-level participant responsible for creating original content and requesting its transmission. The MHS operates to send and deliver mail among Originators and Recipients.

[2.1.2](#) Recipient

The Recipient is a consumer of delivered content.

A Recipient may close the user-level communication loop by creating and submitting a new message that replies to an Originator. An example of an automated form of reply is the Message Disposition Notification, which informs the Originator about the Recipient's disposition of the message. See [Section 4.1](#).

[2.1.3](#) Mediator

A Mediator receives, aggregates, reformulates and redistributes messages as part of a potentially-protracted, higher-level exchange among Users. Example uses of Mediators include group dialogue and

organizational message flow, as occurs with a purchase approval process. Note that it is easy to confuse this user-level activity with the underlying MHS exchanges. However they serve very different purposes and operate in very different ways. Mediators are considered extensively in [Section 5](#).

When mail is delivered to an envelope address, a Mediator is viewed by the Mail Handling Service as a Recipient. When submitting messages, the Mediator is an Originator. What is distinctive is that a Mediator preserves the Originator information of the message it reformulates, but may make meaningful changes to the content. Hence the MHS sees a new message, but Users receive a message that is interpreted as primarily being from -- or, at least, initiated by -- the author of the original message. The role of a Mediator permits distinct, active creativity, rather than being limited to the more constrained job of merely connecting together other participants. Hence it is really the Mediator that is responsible for the new message.

A Mediator's task may be complex and contingent, such as by modifying and adding content or regulating which users may participate and when. The popular example of this role is a group mailing list. A sequence of mediators may even perform a series of formal steps, such as reviewing, modifying and approving a purchase request.

Because a Mediator originates messages, it might also receive replies. So, a Mediator really is a full-fledged User.

Gateway: A Gateway is a particularly interesting form of Mediator. It is a hybrid of User and Relay that interconnects heterogeneous mail services. Its goal of emulating a Relay, so Gateway is described in the next section.

[2.2](#) MHS Actors

The Mail Handling Service (MHS) has the task of performing a single, email-level end-to-end transfer, on behalf of the Originator and reaching the Recipient address(es) specified in the envelope. Mediated or protracted, iterative exchanges, such as those used for collaboration over time, are part of the User-level service, and are not part of this Transfer-level service.

The following depicts the relationships among transfer participants in Internet Mail. It shows the Source as distinct from the Originator, and Destination as distinct from Recipient, although it is common for each pair to be the same actor. The figure also shows multiple Relays in the sequence. It is legal to have only one, and for intra-organization mail services, this is common.

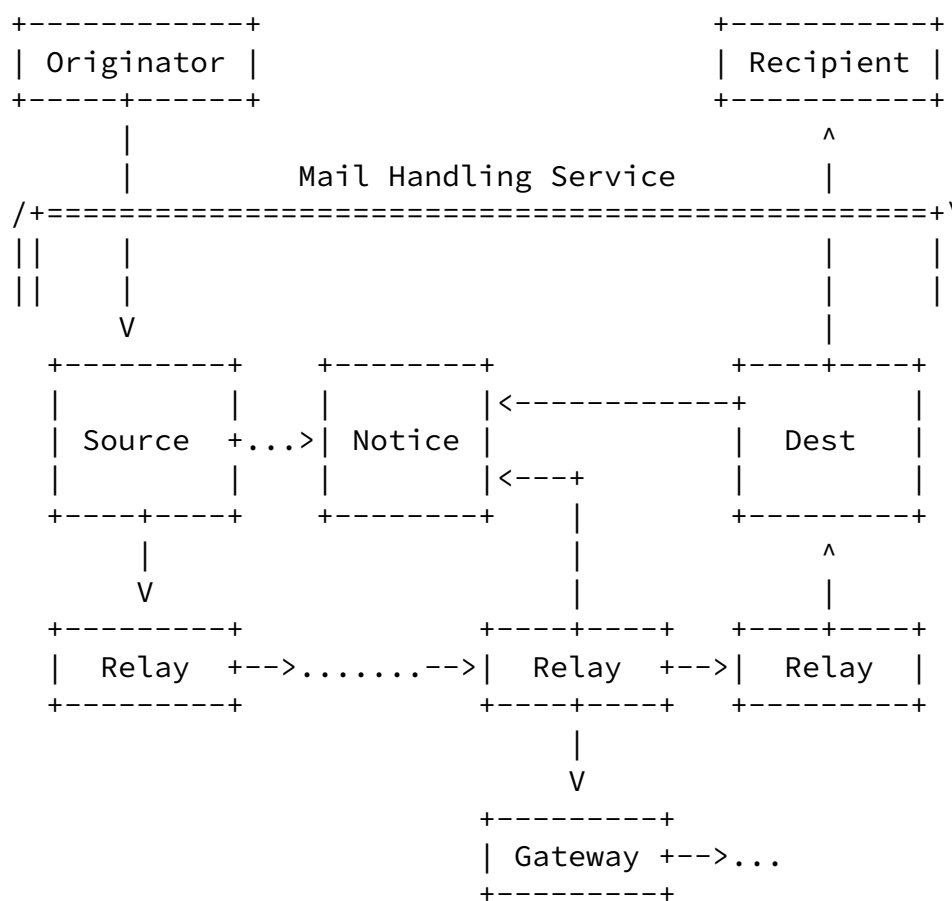


Figure 3: Relationships Among MHS Actors

[2.2.1](#) Source

The Source role is responsible for ensuring that a message is valid for posting and then submitting it to a Relay. Validity includes conformance with Internet mail standards, as well as with local operational policies. The source may simply review the message for conformance, and reject it if there are errors, or it may create some or all of the necessary information.

The Source operates with dual "allegiance". It serves the Originator and often it is the same entity. However its role in assuring validity means that it must also represent the local operator of the MHS, that is, the local Administrative Domain.

The Source also has the responsibility for any post-submission, Originator-related administrative tasks associated with message transmission and delivery. Notably this pertains to error and delivery notices. Hence, Source is best held accountable for the message content, even when they did not create any or most of it.

[2.2.2](#) Notifications Handler

The Notifications Handler processes service notifications that are generated by the MHS, as a result of its efforts to transfer or deliver the message. Notices may be about failures or completions and are sent to an address that is specified by the Source. This Notices handling address (also known as a Bounce or Return address) might have no visible characteristics in common with the address of the Originator or Source.

[2.2.3](#) Relay

A mail Relay performs email transfer-service routing and store-and-forward. It adds envelope-level handling information and then (re-)transmits the message on towards its Recipient(s). A Relay may add information to the envelope, such as with trace information. However it does not modify existing envelope information or the message content semantics. It may modify message content syntax, such as a change from text to binary transfer-encoding form, only as required to meet the capabilities of the next hop in the MHS.

A set of Relays composes a Mail Handling Service network. This is above any underlying packet-switching network that they might be using. Hence, interesting email scenarios can involve three levels of store-and-forward:

- o User Mediators
- o MHS Relays

- o Packet Switches

Aborting a message transfer results in having the Relay become an Originator and send an error message to the Notifications (Bounce) address. (The potential for looping is avoided by having this message, itself, contain no Notifications address.)

[2.2.4](#) Gateway

A Gateway is a hybrid form of User and Relay that interconnects heterogeneous mail services. It operates as a User process, but its purpose is simply to Relay messages. The more closely a Gateway is

able to operate as a Relay, the better. Differences between mail services can be as small as minor syntax variations, but usually encompass significant, semantic distinctions. For example, the concept of an email address might be as different as a hierarchical, machine-specific address versus a flat, global name space. Or between text-only content and multi-media. Hence the Relay function in a Gateway offers the minor challenge in design. The more significant challenge is in ensuring the user-to-user functionality that matches syntax and semantics of independent email standards suites.

The basic test of a Gateway's adequacy is, of course, whether an Originator on one side of a Gateway can send a message to a Recipient on the other side, without requiring changes to any of the components in the Originator's or Recipient's mail services, other than adding the Gateway. To each of these otherwise independent services, the Gateway will appear to be a "native" participant. However the ultimate test of a Gateway's adequacy is whether the Originator and Recipient can sustain a dialogue. In particular, can a Recipient's MUA automatically formulate a valid Reply?

[2.3](#) Administrative Actors

Operation of Internet mail services is apportioned to different providers (or operators). Each can be composed of an independent Administrative Domain (AD). Examples include an end-user operating their desktop client, a department operating a local Relay, an IT department operating an enterprise Relay, and an ISP operating a public, shared email service. These can be configured into many

combinations of administrative and operational relationships, with each Administrative Domain potentially having a complex arrangement of functional components. Figure 4 depicts the relationships among ADs. Perhaps the most salient aspect of an AD is the differential trust that determines its policies for activities within the AD, versus those involving interactions with other ADs.

Basic components of AD distinction include:

Transit: These are Mail Service Providers (MSP) offering value-added capabilities for Edge ADs, such as aggregation and filtering.

Edge: Independent transfer services, in networks at the edge of the Internet mail service.

User: End-user services. This might be subsumed under the Edge service, such as is common for web-based email access.

Note that Transit services are quite different from packet-level transit operation. Whereas end-to-end packet transfers usually go through intermediate routers. Email exchange across the open Internet is often directly between the Edge ADs, at the email level.

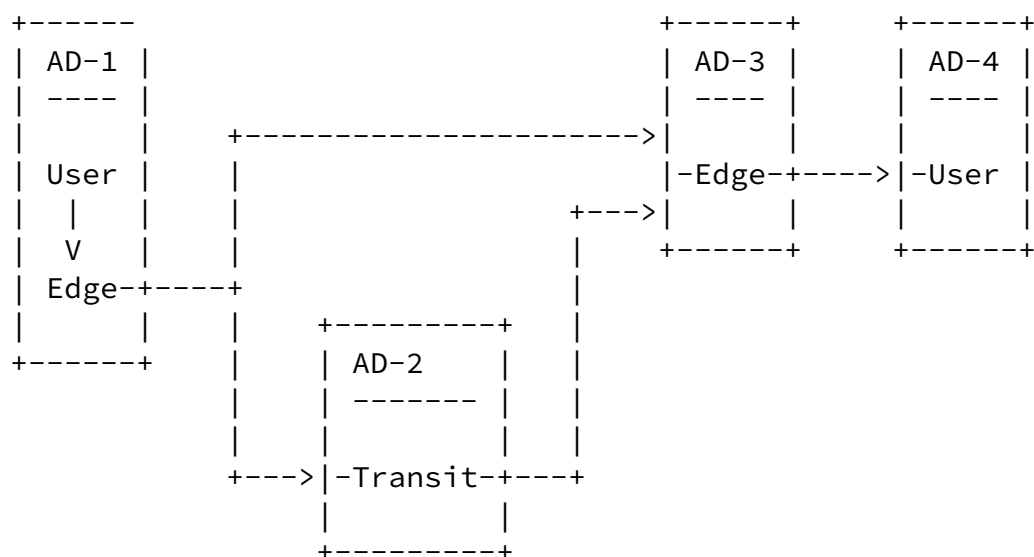


Figure 4: Administrative Domains (AD)

Edge networks may use proprietary email standards internally. However the distinction between Transit network and Edge network transfer services is primarily significant because it highlights the need for concern over interaction and protection between independent administrations. In particular, this distinction calls for additional care in assessing transitions of responsibility, as well as the accountability and authorization relationships among participants in email transfer.

The interactions between functional components within an Administrative Domain are subject to the policies of that domain. Policies can cover such things as reliability, access control, accountability and even content evaluation and modification. They may be implemented in different functional components, according to the needs of the Administrative Domain. For example, see [\[ID-spamops\]](#).

User, Edge and Transit services can be offered by providers that operate component services or sets of services. Further, it is possible for one AD to host services for other ADs. Common AD examples are:

Enterprise Service Providers:

Operating an organization's internal data and/or mail operations.

Internet Service Providers:

Operating underlying data communication services that, in turn, are used by one or more Relays and Users. It is not their job to perform email functions, but to provide an environment in which those functions can be performed.

Mail Service Providers:

Operate email services, such as for end-users, or mailing lists.

Operational pragmatics often dictate that providers be involved in detailed administration and enforcement issues, to help ensure the

health of the overall Internet Mail Service. This can include operators of lower-level packet services.

3. Identities

Internet mail uses three forms of identity. The most common is the mailbox address <addr-spec> [[RFC2822](#)]. The other two are the domain name <domain> [[RFC1034](#)] and message identifier <msg-id> [[RFC2822](#)].

3.1 Mailbox Addresses

"A mailbox sends and receives mail. It is a conceptual entity which does not necessarily pertain to file storage." [[RFC2822](#)]

A mailbox is specified as an Internet mail address <addr-spec>. It has two distinct parts, divided by an at-sign ("@"). The right-hand side contains a globally interpreted name for an administrative domain. This domain name might refer to an entire organization, or to a collection of machines integrated into a homogeneous service, or to a single machine. Domain names are defined and operated through the Domain Name Service (DNS) [[RFC1034](#)], [[RFC1035](#)], [[RFC2181](#)].

The portion to the left of the at-sign contains a string that is globally opaque and is called the <local-part>. It is to be interpreted only by the entity specified in the address's right-hand side. All other entities must treat the local-part as a uninterpreted, literal string and must preserve all of its original details. As such, its public distribution is equivalent to sending a "cookie" that is only interpreted upon being returned to its originator.

3.1.1 Global Standards for Local-Part

It is common for sites to have local structuring conventions for the left-hand side (local-part) of an addr-spec. This permits sub-addressing, such as for distinguishing different discussion groups by the same participant. However it must be stressed that these conventions are strictly private to the user's organization and must not be interpreted by any domain except the one listed in the

right-hand side of the addr-spec.

A small class of addresses has an elaboration on basic email addressing, with a standardized, global schema for the local-part. These are conventions between originating end-systems and Recipient Gateways, and they are invisible to the public email transfer infrastructure. When an Originator is explicitly sending via a Gateway out of the Internet, there are coding conventions for the local-part, so that the Originator can formulate instructions for the Gateway. Standardized examples of this are the telephone numbering formats for VPIM [[RFC2421](#)], such as "+16137637582@vpim.example.com", and iFax [[RFC2304](#)], such as "FAX=+12027653000/T33S=1387@ifax.example.com".

[3.1.2](#) Scope of Email Address Use

Email addresses are being used far beyond their original email transfer and delivery role. In practical terms, email strings have become a common form of user identity on the Internet. What is essential, then, is to be clear about the nature and role of an identity string in a particular context and to be clear about the entity responsible for setting that string.

[3.2](#) Domain Names

A domain name is a global reference to an Internet resource, such as a host, a service or a network. A name usually maps to one or more IP Addresses. A domain name can be administered to refer to individual users, but this is not common practice. The name is structured as a hierarchical sequence of sub-names, separated by dots (".").

When not part of a mailbox address, a domain name is used in Internet mail to refer to a node that took action upon the message, such as providing the administrative scope for a message identifier, or performing transfer processing.

[3.3](#) Message Identifiers

Like mailbox addresses, message identifiers have two distinct parts,

divided by an at-sign ("@"). The right-hand side is globally

interpreted and specifies the administrative domain assigning the identifier. The left-hand side of the at-sign contains a string that is globally opaque and serves to uniquely identify the message within the domain referenced on the right-hand side. The duration of uniqueness for the message identifier is undefined.

The identifier may be assigned by the user or by any component of the system along the path, within the AD responsible for the indicated domain. Although Internet mail standards provide for a single identifier, more than one is sometimes assigned.

[3.4](#) Identity Referencing Convention

In this document, fields references to identities are labeled in a two-part, dotted notation. The first part cites the document defining the identity and the second defines the name of the identity. Hence, <[RFC2822](#).From> is the From field in an email content header, and <[RFC2821](#).MailFrom> is the address in the SMTP "Mail From" command.

[4.](#) Services

The Internet's MHS architecture distinguishes six types of functional components, arranged to support a store-and-forward service architecture:

- o Message
- o Mail User Agent (MUA)
- o Message Submission Agent (MSA)
- o Message Transfer Agent (MTA)
- o Message Delivery Agent (MDA)
- o Message Store (MS)

This section describes the specific functional components for Internet Mail, and the standard protocols associated with performing them.

This figure shows function modules and the protocols used between them.

```

+-----+
.....+ oMUA |<-----+
```

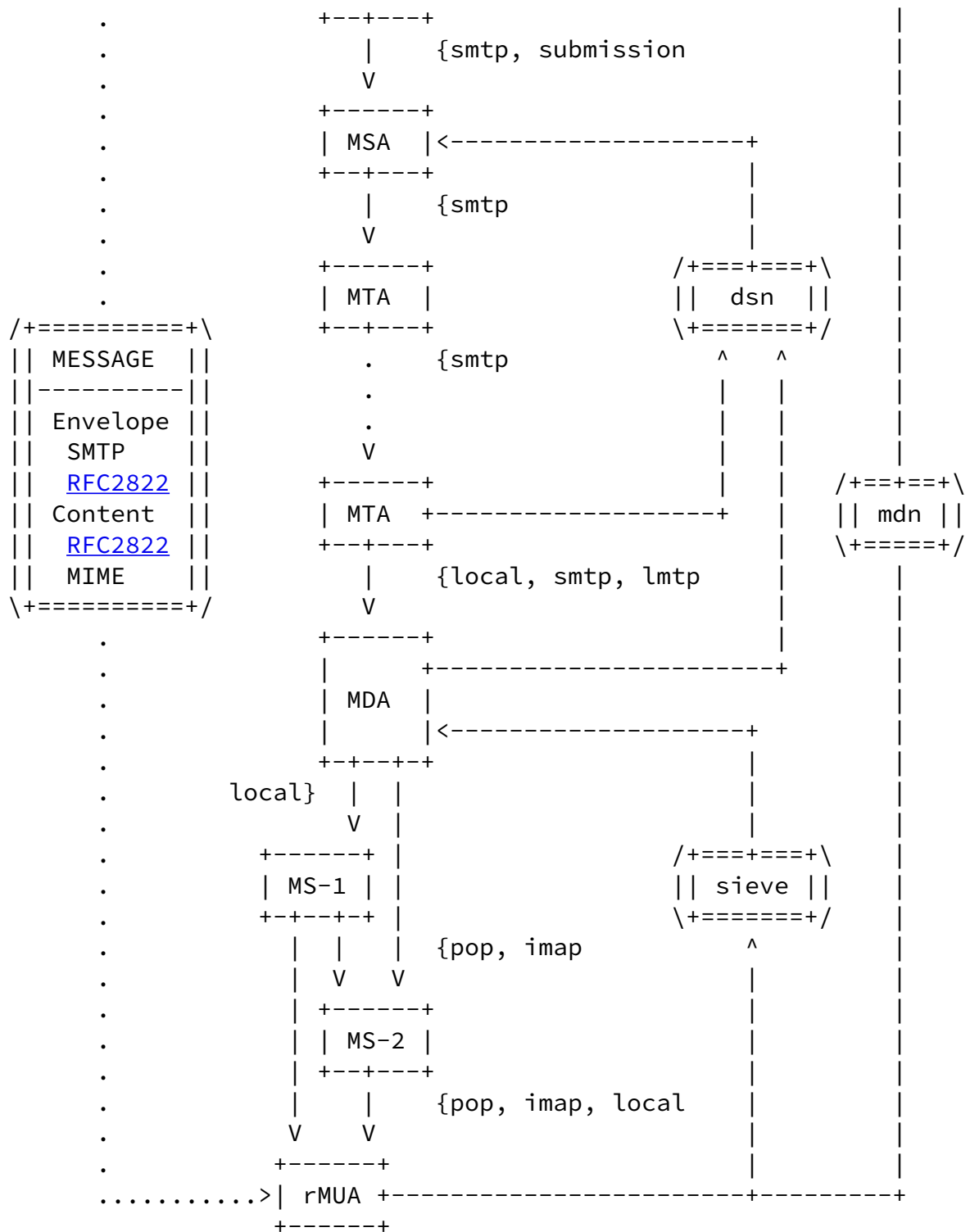


Figure 5: Protocols and Services

Software implementations of these architectural components often compress them, such as having the same software do MSA, MTA and MDA functions. However the requirements for each of these components of

the service are becoming more extensive. So, their separation is increasingly common.

NOTE:

A discussion about any interesting system architecture is often complicated by confusion between architecture versus implementation. An architecture defines the conceptual functions of a service, divided into discrete conceptual modules. An implementation of that architecture may combine or separate architectural components, as needed for a particular operational environment. It is important not to confuse the engineering decisions that are made to implement a product, with the architectural abstractions used to define conceptual functions.

[4.1](#) Message

The purpose of the Mail Handling Service is to exchange a message object among participants. Hence, all of the underlying mechanisms are merely in the service of getting that message from its Originator to its Recipients. A message may be explicitly labeled as to its nature. [[RFC3458](#)]

A message comprises a transit handling envelope and the end-user message content. The envelope contains handling information used by the Message Handling Service, or generated by it. The content is divided into a structured header and the body. The body may be unstructured, simple text, or it may be a tree of multi-media subordinate objects.

Internet mail has distinguished some special versions of messages, for exchanging control information:

Delivery Status Notification (DSN):

A Delivery Status Notification (DSN) may be generated by the Mail Handling Service (MSA, MTA or MDA) and sent to the [RFC2821](#).MailFrom address. It provides information about message transit, such as transmission errors or successful delivery. [[RFC3461](#)]

Message Disposition Notification (MDN):

A Message Disposition Notification (MDN) may be generated by an rMUA and is sent to the Disposition-Notification-To address. It provides information about Recipient-side message processing, such as indicating that the message has been read [[RFC2298](#)] or the form of content that can be supported. [[RFC3297](#)]

Crocker

Expires August 15, 2005

[Page 17]

Internet-Draft

EMail Architecture

February 2005

Message Filtering (SIEVE):

SIEVE provides a means of specifying conditions for differential handling of mail, at the time of delivery. [[RFC3028](#)]

[4.1.1](#) Envelope

Information that is directly used by, or produced by, the email transfer service is called the "envelope". It controls and records handling activities by the transfer service. Internet mail has a fragmented framework for handling this "handling" information. The envelope exists partly in the transfer protocol SMTP [[RFC2821](#)] and partly in the message object [[RFC2822](#)]. The SMTP specification uses the term to refer only to the transfer-protocol information.

NOTE:

Due to the frequent use of the term "envelope" to refer only to SMTP constructs, there has been some call for using a different term, to label the larger set of information defined here. So far, no alternative term has developed any community support.

Direct envelope addressing information, as well as optional transfer directives, are carried within the SMTP control channel. Other envelope information, such as trace records, is carried within the content header fields. Upon delivery, SMTP-level envelope information is typically encoded within additional content header fields, such as Return-Path.

[4.1.2](#) Message Header Fields

Header fields are attribute/value pairs covering an extensible range of email service, user content and user transaction meta-information. The core set of header fields is defined in [\[RFC2822\]](#), [\[RFC0822\]](#). It is common to extend this set, for different applications. A complete set of registered header fields is being developed through [\[ID-hdr-reg\]](#).

One danger with placing additional information in header fields is that Gateways often alter or delete them.

[4.1.3](#) Body

The body of a message might simply be lines of ASCII text or it might be structured into a composition of multi-media, body-part attachments, using MIME [\[RFC2045\]](#), [\[RFC2046\]](#), [\[RFC2047\]](#), [\[RFC2048\]](#), and [\[RFC2049\]](#). It should be noted that MIME structures each

body-part into a recursive set of MIME header field meta-data and MIME Content sections.

[4.1.4](#) Identity References in a Message

For a message in transit, the core uses of identity references combine into:

Layer	Field	Set By
Message Body	MIME Header	Originator
Message header fields	From	Originator
	Sender	Source
	Reply-To	Originator
	To, CC, BCC	Originator
	Message-ID	Source
	Received	Source, Relay, Dest
	Return-Path	MDA, from MailFrom
	Resent-*	Mediator
SMTP	HELO	Latest Relay Client
	MailFrom	Source
	RcptTo	Originator
IP	IP Address	Latest Relay Client

[4.2](#) Mail User Agent (MUA)

A Mail User Agent (MUA) works on behalf of end-users and end-user applications. It is their "representative" within the email service.

At the origination side of the service, the oMUA is used to create a message and perform initial "submission" into the transfer infrastructure, via a Mail Submission Agent (MSA). It may also perform any creation- and posting-time archival. An MUA outbox is part of the origination-side MUA.

The Recipient-side rMUA works on behalf of the end-user Recipient to process received mail. This includes generating user-level return control messages, display and disposition of the received message, and closing or expanding the user communication loop, by initiating replies and forwarding new messages.

An MUA may, itself, have a distributed architecture, such as implementing a "thin" user interface module on a limited end-user device, with the bulk of the MUA functionality operated remotely on a more capable server. An example of such an architecture might use

IMAP [[RFC3501](#)] for most of the interactions between an MUA client and an MUA server.

A Mediator is special class of MUA performs message re-posting, as discussed in [Section 2.1](#).

Identity fields relevant to the MUA include:

[RFC2822](#).From

Set by: Originator

Names and addresses for author(s) of the message content are listed in the From field

[RFC2822](#).Reply-To

Set by: Originator

If a message Recipient sends a reply message that would otherwise use the [RFC2822.From](#) field address(es) contained in the original message, then they are instead to use the address(es) in the [RFC2822.Reply-To](#) field. In other words, this field is a direct override of the From field, for responses from Recipients.

[RFC2822.Sender](#)

Set by: Source

This specifies the address responsible for submitting the message into the transfer service. For efficiency, this field should be omitted if it contains the same address as [RFC2822.From](#). However this does not mean there is no Sender specified. Rather, it means that that header field is virtual and that the address in the From field must be used. Specification of the error return addresses -- the "Notifications" (or "bounces") address, contained in [RFC2821.MailFrom](#) -- is made by the [RFC2822.Sender](#). Typically the Notifications address is the same as the Sender address. However some usage scenarios require it to be different.

[RFC2822.To](#), [RFC2822.CC](#)

Set by: Originator

These specify MUA Recipient addresses. The addresses in the fields might not be present in the [RFC2821.RcptTo](#) command. The distinction between To and CC is subjective. Generally, a To addressee is considered primary and is expected to take action on

the message. A CC addressee typically receives a copy only for their information.

[RFC2822.BCC](#)

Set by: Originator

A message might be copied to an addressee whose participation is not to be disclosed to the [RFC2822.To](#) or [RFC2822.CC](#) Recipients and, usually, not to the other BCC Recipients. The BCC header field indicates a message copy to such a Recipient. Typically,

the field lists no addresses or only lists the address of the Recipient receiving this copy. An MUA will typically make separate postings for TO and CC Recipients, versus BCC Recipients. The former will see no indication that any BCCs were sent, whereas the latter have a BCC field present. It might be empty, contain a comment, or contain one or more BCC addresses, depending upon the preferences or the Originator.

[4.3](#) Mail Submission Agent (MSA)

A Mail Submission Agent (MSA) accepts the message submission from the oMUA and enforces the policies of the hosting AD and the requirements of Internet standards. Enforcement might be passive, involving review and approval or rejection, or it might be active, involving direct modification of the message. An MSA implements a server function to MUAs and a client function to MTAs (or MDAs).

Examples of MSA-styled functions, in the world of paper mail, might range across the very different capabilities of administrative assistants, postal drop boxes, and post office front-counter employees.

The MUA/MSA interface can be implemented within a single host and use private conventions for its interactions. Historically, standards-based MUA/MSA interactions have used SMTP [[RFC2821](#)]. However a recent alternative is SUBMISSION [[RFC2476](#)]. Although SUBMISSION derives from SMTP, it operates on a separate TCP port, and will typically impose distinct requirements, such as access authorization.

Identities relevant to the MSA include:

[RFC2821](#).HELO or [RFC2821](#).EHLO

Set by: Source

The MSA may specify its hosting domain identity for the SMTP HELO or EHLO command operation.

[RFC2821](#).MailFrom

Set by: Source

This is an end-to-end string that specifies an email address for receiving return control information, such as "bounces". The name of this field is misleading, because it is not required to specify either the author or the agent responsible for submitting the message. Rather, the agent responsible for submission specifies the [RFC2821](#).MailFrom address. Ultimately the simple basis for deciding what address needs to be in the [RFC2821](#).MailFrom is to determine what address needs to be informed about transmission-level problems (and, possibly, successes.)

[RFC2821](#).RcptTo

Set by: Originator

This specifies the MUA mailbox address of a recipient. The string might not be visible in the message content header. For example, the message destination address header fields, such as [RFC2822](#).To, might specify a mailing list address, while the [RFC2821](#).RcptTo address specifies a member of that list.

[RFC2821](#).Received

Set by: Source

An MSA may record a Received header field, to indicate initial submission trace information, including originating host and MSA host domain names and/or IP Addresses.

[4.4](#) Mail Transfer Agent (MTA)

A Mail Transfer Agent (MTA) relays mail. It is like a packet-switch or IP router in that its job is to make routing assessments and to move the message closer to the Recipient(s). Relaying is performed by a sequence of MTAs, until the message reaches its destination MDA. Hence an MTA implements both client and server MTA functionality. It does not make changes to addresses in the envelope or reformulate the content, except as transfer-encoding requirements dictate. Also it may add trace information.

The primary "routing" mechanism for Internet mail is the DNS MX record [[RFC1035](#)]. As with most network layer mechanisms Internet mail's SMTP supports a basic level of reliability, by virtue of providing for retransmission after a temporary transfer failure. However the degree of persistence by an MTA can be highly variable.

Of course email objects are typically much larger than the payload of a packet or datagram, and the end-to-end latencies are typically much higher. Contrary to typical packet switches (and Instant Messaging services) Internet mail MTAs typically store messages in a manner that allows recovery across service interruptions, such as host system shutdown.

Internet mail primarily uses SMTP [[RFC2821](#)], [[RFC0821](#)] to effect point-to-point transfers between peer MTAs. Other transfer mechanisms include Batch SMTP [[RFC2442](#)] and ODMR [[RFC2645](#)].

An important characteristic of MTA-MTA communications, over the open Internet, is that they do not require prior arrangement between the independent administrations operating the different MTAs. Given the importance of spontaneity and serendipity in the world of human communications, this lack of prearrangement, between the participants, is a core benefit of Internet mail and remains a core requirement for it.

Identities relevant to the MTA include:

[RFC2821](#).HELO

Set by: Relay

The MTA may specify its hosting domain identity for the SMTP HELO or EHLO command. This is the only standardized way of identifying the agent responsible for operation of the Relay, during the transfer operation.

[RFC2821](#).MailFrom

Set by: Source

This is an end-to-end string that specifies an email address for receiving return control Notifications, such as "bounces". The name of this field is misleading, because it is not required to specify either the author or the agent responsible for submitting the message. Rather, the agent responsible for submission specifies the MailFrom address. Ultimately the simple basis for deciding what address needs to be in the [RFC2821](#).MailFrom is to

determine what address needs to be informed about

transmission-level problems (and, possibly, successes.)

[RFC2821](#).RcptTo

Set by: Originator

This specifies the MUA mailbox address of a Recipient. The string might not be visible in the message content header. For example, the message destination address header fields, such as [RFC2822](#).To, might specify a mailing list address, while the [RFC2821](#).RcptTo address specifies a member of that list.

[RFC2822](#).Received

Set by: Relay

An MTA must record a Received header field, to indicate trace information, including source host and receiving host domain names and/or IP Addresses.

[4.5](#) Mail Delivery Agent (MDA)

A Mail Delivery Agent (MDA) delivers email to the Recipient's mailbox. It can provide distinctive, address-based functionality, made possible by its detailed knowledge of the properties of the destination address. This knowledge might also be present elsewhere in the Recipient's Administrative Domain, such as at an organizational border Relay. However it is required for the MDA, if only because the MDA must know where to deliver the message.

Using Internet protocols, delivery can be effected by a variety of standard protocols. When coupled with an internal, local mechanism, SMTP [[RFC2821](#)] and LMTP [[RFC2033](#)] permit "push" delivery to the Recipient system, at the initiative of the upstream email service. POP [[RFC1939](#)] and IMAP [[RFC3501](#)] are used for "pull" delivery at the initiative of the Recipient system. POP and IMAP can also be used for repeated access to messages on a remote MS.

Identities relevant to the MDA include:

[RFC2821](#).Return-Path

Set by: Source

The MDA records the [RFC2821](#).MailFrom address into the [RFC2822](#).Return-Path field.

Crocker

Expires August 15, 2005

[Page 24]

Internet-Draft

EMail Architecture

February 2005

[RFC2822](#).Received

Set by: Destination

An MDA must record a Received header field, to indicate trace information, including source host and receiving host domain names and/or IP Addresses.

[4.6](#) Message Store (MS)

An MUA can use a long-term Message Store (MS). A rich set of choices for the use of that store derives from permitting more than one to be associated with a single user, demonstrated as MS-1 and MS-2 in Figure 5. MS-1 is shown as being remote from the MUA and MS-2 as being local. Further the relationship between two message store may vary. Between the MDA and the MUA, these choices are supported by a wide variety of protocol options.

The operational relationship among two MSs can be:

Online:

Only a remote MS is used, with messages being accessible only when the MUA is attached to the MS, and the MUA repeatedly fetches all or part of a message, from one session to the next.

Offline:

The MS is local to the user, and messages are moved from any remote store, rather than (also) being retained there.

Disconnected:

A remote MS and a local MS synchronize all or parts of their contents, while connected. The user may make changes while disconnected, and the two stores are re-synchronized upon reconnection.

5. Mediators

Basic email transfer is accomplished with an asynchronous store-and-forward communication infrastructure, in a sequence of independent transmissions through some number of MTAs. A very different task is a User-level sequence of postings and deliveries, through Mediators. For such re-postings, a Mediator does share some functionality with basic MTA relaying, but it enjoys a degree of

Crocker

Expires August 15, 2005

[Page 25]

Internet-Draft

EMail Architecture

February 2005

freedom with both addressing and content that is not available to MTAs.

[RFC2821](#).HELO or [RFC2821](#).EHLO

Set by: Source or Relay

The MSA may specify its hosting domain identity for the SMTP HELO or EHLO command operation.

[RFC2821](#).MailFrom

Set by: Source

This is an end-to-end string that specifies an email address for receiving return control Notifications, such as "bounces". The name of this field is misleading, because it is not required to specify either the author or the agent responsible for submitting the message. Rather, the agent responsible for submission specifies the [RFC2821](#).MailFrom address. Ultimately the simple basis for deciding what address needs to be in the [RFC2821](#).MailFrom is to determine what address needs to be informed about transmission-level problems (and, possibly, successes.)

[RFC2821](#).RcptTo

Set by: Mediator

This specifies the MUA mailbox address of a Recipient. The string might not be visible in the message content header. For example, the message destination address header fields, such as [RFC2822](#).To, might specify a mailing list address, while the [RFC2821](#).RcptTo address specifies a member of that list.

[RFC2821](#).Received

Set by: Mediator

An MSA may record a Received header field, to indicate initial submission trace information, including originating host and MSA host domain names and/or IP Addresses.

The salient aspect of a Mediator, that distinguishes it from any other MUA creating an entirely new message, is that a Mediator preserves the integrity and tone of the original message, including the essential aspects of the original origination information. The Mediator might also add commentary.

Examples of MUA message creation that are not performed by Mediators include:

New Message Forwarding Existing Message:

Curiously, this action provides a basic template for a class of Mediators. However by itself, it's typical occurrence is not, in fact, an example of a Mediator. The new message is viewed as being from the Agent doing the forwarding, rather than being from the original Originator.

A new message encapsulates the original message and is seen as strictly "from" the Mediator. The Mediator might add commentary and certainly has the opportunity to modify the original message content. The forwarded message is therefore independent of the original message exchange and creates a new message dialogue. However the final Recipient sees the contained message as from the original Originator.

Reply:

When a Recipient formulates a response to a message, the new message is not typically viewed as being a "forwarding" of the original. It's focus is the new content; any inclusion of material from the original message is contextual and secondary.

Annotator:

The integrity of the original message is usually preserved, but one or more comments about the message are added in a manner that distinguishes commentary from original text. The tone of the new message is that it is primarily commentary from a new Originator, similar to a Reply.

The remainder of this section describes common examples of Mediators.

[5.1](#) Aliasing

A simple re-addressing facility that is available in most MDA implementations is called Aliasing. It is performed just before delivering a message to the specified Recipient's mailbox. Instead, the message is submitted back to the transfer service, for delivery to one or more alternate addresses. Although implemented as part of the message delivery service, this facility is strictly a Recipient user function. It resubmits the message, replacing the envelope address, on behalf of the mailbox address that was listed in the envelope.

What is most distinctive about this forwarding mechanism is how closely it compares to normal MTA store-and-forward Relaying. In reality its only interesting difference is that it changes the [RFC2821](#).RcptTo value.

An MDA that is re-posting a message to an alias typically changes only envelope information:

[RFC2822](#).TO, [RFC2822](#).CC, [RFC2822](#).BCC

Set by: Originator

These retain their original addresses.

[RFC2821](#).RcptTo

Set by: Mediator

This field contains an alias address.

[RFC2821](#).MailFrom

Set by: Mediator or original Source

The agent responsible for submission to an alias address will often retain the original address to receive handling Notifications. The benefit of retaining the original MailFrom value is to ensure that the origination-side agent knows that there has been a delivery problem. On the other hand, the responsibility for the problem usually lies with the Recipient, since the Alias mechanism is strictly under the Recipient's control.

[RFC2821](#).Received

Set by: Mediator

The agent should record Received information, to indicate the delivery to the original address and submission to the alias address. The trace of Received header fields should therefore include everything from original posting through final delivery to the alias.

[5.2](#) ReSending

Also called ReDirecting, ReSending differs from Forwarding by virtue of having the Mediator "splice" a message's addressing information,

to connect the Originator of the original message and the Recipient of the new message. This permits them to have direct exchange, using their normal MUA Reply functions. Hence the new Recipient sees the message as being From the original Originator, even if the Mediator adds commentary.

Identities specified in a resent message include

[RFC2822](#).From

Set by: original Originator

Names and email addresses for the original author(s) of the message content are retained. The free-form (display-name) portion of the address might be modified to provide informal reference to the agent responsible for the redirection.

[RFC2822](#).Reply-To

Set by: original Originator

If this field is present in the original message, it is retained in the Resent message.

[RFC2822](#).Sender

Set by: original Source

This field is expected to contain the original Sender value.

[RFC2822](#).TO, [RFC2822](#).CC, [RFC2822](#).BCC

Set by: original Originator

These specify the original message Recipients.

[RFC2822](#).Resent-From

Set by: Mediator

The address of the original Recipient who is redirecting the message. Otherwise, the same rules apply for the Resent-From field as for an original [RFC2822](#).From field

[RFC2822](#).Resent-Sender

Set by: Mediator

The address of the agent responsible for re-submitting the message. For efficiency this field is often omitted if it contains the same address as [RFC2822](#).Resent-From. However this does not mean there is no Resend-Sender specified. Rather, it means that that header field is virtual and that the address in the Resent-From field must be used. Specification of the error return addresses (the Notification address, contained in [RFC2821](#).MailFrom) is made by the Resent-Sender. Typically the Notifications address is the same as the Resent-Sender address. However some usage scenarios require it to be different.

[RFC2822](#).Resent-To, [RFC2822](#).Resent-cc, [RFC2822](#).Resent-bcc:

Set by: Mediator

The addresses of the new Recipients who will now be able to reply to the original author.

[RFC2821](#).MailFrom

Set by: Mediator

The agent responsible for re-submission ([RFC2822](#).Resent-Sender) is also responsible for specifying the new MailFrom address.

[RFC2821](#).RcptTo

Set by: Mediator

This will contain the address of a new Recipient

[RFC2822](#).Received

Set by: Mediator

When resending a message, the submission agent may record a Received header field, to indicate the transition from original posting to resubmission.

[5.3](#) Mailing Lists

Mailing lists have explicit email addresses and they forward messages to a list of subscribed members. The Mailing List Actor performs a task that can be viewed as an elaboration of the ReDirector role. In addition to sending the new message to a potentially large number of

Internet-Draft

EMail Architecture

February 2005

new Recipients, the Mediator can modify content, such as deleting attachments, formatting conversion, and adding list-specific comments. In addition, archiving list messages is common. Still, the message retains characteristics of being "from" the original Originator.

Identities relevant to a mailing list processor, when submitting a message, include:

[RFC2919](#).List-id

Set by: Mediator

This provides a global mailing list naming framework that is independent of particular hosts. Although [RFC2919](#) is a standards-track specification, it has not gained significant adoption.

[RFC2369](#).List-*

Set by: Mediator

[RFC2369] defines a collection of message header fields for use by mailing lists. In effect, they supply list-specific parameters for common mailing list user operations. The identifiers for these operations are for the list, itself, and the user-as-subscriber.

[RFC2822](#).From

Set by: original Originator

Names and email addresses for the original author(s) of the message content are specified.

[RFC2822](#).Reply-To

Set by: original Originator or Mediator

Mailing lists have introduced an ambiguity for the Reply-To field. Some List operations choose to force all replies to go to all list members. They achieve this by placing the list address into the

[RFC2822](#).Reply-To field. Hence, direct, "private" replies only to the original author cannot be achieved by using the MUA's typical "reply to author" function. If the author created a Reply-To field, its information is lost.

[RFC2822](#).Sender

Set by: original Source or Mediator

This will usually specify the address of the agent responsible for mailing list operations. However, some mailing lists operate in a manner very similar to a simple MTA Relay, so that they preserve as much of the original handling information as possible, including the original [RFC2822](#).Sender field.

[RFC2822](#).TO, [RFC2822](#).CC

Set by: original Originator

These will usually contain the original list of Recipient addresses.

[RFC2821](#).MailFrom

Set by: original Source or Mediator

This may contain the original address to be notified of transmission issues, or the mailing list agent may set it to contain a new Notification address. Typically, the value is set to a new address, so that mailing list members and posters are not burdened with transmission-related Notifications.

[RFC2821](#).RcptTo

Set by: Mediator

This contains the address of a mailing list member.

[RFC2821](#).Received

Set by: Mediator

An Mailing List Agent should record a Received header field, to indicate the transition from original posting to mailing list forwarding. The Agent may choose to have the message retain the original set of Received header fields or may choose to remove them. In the latter case, it should ensure that the original Received header fields are otherwise available, to ensure later accountability and diagnostic access to it.

Crocker

Expires August 15, 2005

[Page 32]

Internet-Draft

EMail Architecture

February 2005

[5.4](#) Gateways

Gateways perform the basic routing and transfer work of message relaying, but they also make any message or address modifications that are needed to send the message into the next messaging environment. When a Gateway connects two differing messaging services, its role is easy to identify and understand. When it connects environments that have technical similarity, but may have significant administrative differences, it is easy to think that a Gateway is merely an MTA. The critical distinction between an MTA and a Gateway is that the latter transforms addresses and/or message content, in order to map between the standards of two, different messaging services. In virtually all cases, this mapping process results in some degree of semantic loss. The challenge of Gateway design is to minimize this loss.

A Gateway may set any identity field available to a regular MUA. Identities typically relevant to Gateways include:

[RFC2822](#).From

Set by: original Originator

Names and email addresses for the original author(s) of the message content are retained. As for all original addressing information in the message, the Gateway may translate addresses in whatever way will allow them continue to be useful in the target environment.

[RFC2822](#).Reply-To

Set by: original Originator

The Gateway should retain this information, if it is originally present. The ability to perform a successful reply by a Gatewayed Recipient is a typical test of Gateway functionality.

[RFC2822](#).Sender

Set by: original Source or Mediator

This may retain the original value or may be set to a new address

[RFC2822](#).TO, [RFC2822](#).CC, [RFC2822](#).BCC

Set by: original Recipient

These usually retain their original addresses.

[RFC2821](#).MailFrom

Set by: original Source or Mediator

The agent responsible for gatewaying the message may choose to specify a new address to receive handling notices.

[RFC2822](#).Received

Set by: Mediator

The Gateway may record a Received header field, to indicate the transition from original posting to the new messaging environment.

[5.5](#) Security Filter

Organizations often enforce security boundaries by having message subjected to analysis for conformance with the organization's safety

policies. Examples are detection of content classed as spam or a virus. A Security Filter might alter the content, to render it safe, such as by removing content deemed unacceptable. Typically these actions will result in the addition of content that records the actions.

6. Security Considerations

This document does not specify any new Internet mail functionality. Consequently it should introduce no new security considerations.

However its discussion of the roles and responsibilities for different mail service modules, and the information they create, highlights the considerable security considerations that must be present when implementing any component of the Internet mail service.

7. References

7.1 References - Normative

[ID-hdr-reg]

"Registration of mail and MIME header fields",
[draft-klyne-hdrreg-mail-04.txt](#) (work in progress), Apr 2004.

[RFC0821] Postel, J., "Simple Mail Transfer Protocol", STD 10, [RFC 821](#), August 1982.

Crocker

Expires August 15, 2005

[Page 34]

Internet-Draft

E-Mail Architecture

February 2005

[RFC0822] Crocker, D., "Standard for the format of ARPA Internet text messages", STD 11, [RFC 822](#), August 1982.

[RFC1034] Mockapetris, P., "Domain names - concepts and facilities", STD 13, [RFC 1034](#), November 1987.

[RFC1035] Mockapetris, P., "Domain names - implementation and specification", STD 13, [RFC 1035](#), November 1987.

[RFC1939] Myers, J. and M. Rose, "Post Office Protocol - Version 3", STD 53, [RFC 1939](#), May 1996.

[RFC2033] Myers, J., "Local Mail Transfer Protocol", [RFC 2033](#), October 1996.

- [RFC2045] Freed, N. and N. Borenstein, "Multipurpose Internet Mail Extensions (MIME) Part One: Format of Internet Message Bodies", [RFC 2045](#), November 1996.
- [RFC2046] Freed, N. and N. Borenstein, "Multipurpose Internet Mail Extensions (MIME) Part Two: Media Types", [RFC 2046](#), November 1996.
- [RFC2047] Moore, K., "MIME (Multipurpose Internet Mail Extensions) Part Three: Message Header Extensions for Non-ASCII Text", [RFC 2047](#), November 1996.
- [RFC2048] Freed, N., Klensin, J. and J. Postel, "Multipurpose Internet Mail Extensions (MIME) Part Four: Registration Procedures", [BCP 13](#), [RFC 2048](#), November 1996.
- [RFC2049] Freed, N. and N. Borenstein, "Multipurpose Internet Mail Extensions (MIME) Part Five: Conformance Criteria and Examples", [RFC 2049](#), November 1996.
- [RFC2181] Elz, R. and R. Bush, "Clarifications to the DNS Specification", [RFC 2181](#), July 1997.
- [RFC2298] Fajman, R., "An Extensible Message Format for Message Disposition Notifications", [RFC 2298](#), March 1998.
- [RFC2304] Allocchio, C., "Minimal FAX address format in Internet Mail", [RFC 2304](#), March 1998.
- [RFC2369] Neufeld, G. and J. Baer, "The Use of URLs as Meta-Syntax for Core Mail List Commands and their Transport through Message Header Fields", [RFC 2369](#), July 1998.

- [RFC2421] Vaudreuil, G. and G. Parsons, "Voice Profile for Internet Mail - version 2", [RFC 2421](#), September 1998.
- [RFC2423] Vaudreuil, G. and G. Parsons, "VPIM Voice Message MIME Sub-type Registration", [RFC 2423](#), September 1998.
- [RFC2442] "The Batch SMTP Media Type", [RFC 2442](#), November 1998.

- [RFC2476] Gellens, R. and J. Klensin, "Message Submission", [RFC 2476](#), December 1998.
- [RFC2645] "On-Demand Mail Relay (ODMR) SMTP with Dynamic IP Addresses", [RFC 2465](#), August 1999.
- [RFC2821] Klensin, J., "Simple Mail Transfer Protocol", [RFC 2821](#), April 2001.
- [RFC2822] Resnick, P., "Internet Message Format", [RFC 2822](#), April 2001.
- [RFC2919] Chandhok, R. and G. Wenger, "List-Id: A Structured Field and Namespace for the Identification of Mailing Lists", [RFC 2919](#), March 2001.
- [RFC3028] Showalter, T., "Sieve: A Mail Filtering Language", [RFC 3028](#), January 2001.
- [RFC3297] Klyne, G., Iwazaki, R. and D. Crocker, "Content Negotiation for Messaging Services based on Email", [RFC 3297](#), July 2002.
- [RFC3458] Burger, E., Candell, E., Eliot, C. and G. Klyne, "Message Context for Internet Mail", [RFC 3458](#), January 2003.
- [RFC3461] Moore, K., "Simple Mail Transfer Protocol (SMTP) Service Extension for Delivery Status Notifications (DSNs)", [RFC 3461](#), January 2003.
- [RFC3501] Crispin, M., "Internet Message Access Protocol - Version 4rev1", [RFC 3501](#), March 2003.

[7.2](#) Reference - Descriptive

[ID-ffpim]

Crocker, D. and G. Klyne, "Full-mode Fax Profile for Internet Mail: FFPIM", March 2004.

[ID-spamops]

Hutzler, C., Crocker, D., Resnick, P., Sanderson, R. and E. Allman, "Email Submission Between Independent Networks", [draft-spamops-00](#) (work in progress), March 2004.

[RFC1767] Crocker, D., "MIME Encapsulation of EDI Objects", [RFC 1767](#), March 1995.

Author's Address

Dave Crocker
Brandenburg InternetWorking
675 Spruce Drive
Sunnyvale, CA 94086
USA

Phone: +1.408.246.8253
EMail: dcrocker@bbiw.net

[Appendix A](#). Acknowledgements

This work derives from a section in [draft-hutzler-spamops \[ID-spamops\]](#). Discussion of the Source actor role was greatly clarified during discussions in the IETF's Marid working group.

Graham Klyne, Pete Resnick and Steve Atkins provided thoughtful insight on the framework and details of early drafts.

Additional review and suggestions were provided by Nathaniel Borenstein, Ed Bradford, Cyrus Daboo, Frank Ellermann, Tony Finch, Ned Freed, Eric Hall, Bruce Lilly, Mark E. Mallett, Chris Newman, Daryl Odnert, Rahmat M. Samik-Ibrahim, Hector Santos, Jochen Topf, Willemien.

Internet-Draft

EMail Architecture

February 2005

Intellectual Property Statement

The IETF takes no position regarding the validity or scope of any Intellectual Property Rights or other rights that might be claimed to pertain to the implementation or use of the technology described in this document or the extent to which any license under such rights might or might not be available; nor does it represent that it has made any independent effort to identify any such rights. Information on the procedures with respect to rights in RFC documents can be found in [BCP 78](#) and [BCP 79](#).

Copies of IPR disclosures made to the IETF Secretariat and any assurances of licenses to be made available, or the result of an attempt made to obtain a general license or permission for the use of such proprietary rights by implementers or users of this specification can be obtained from the IETF on-line IPR repository at <http://www.ietf.org/ipr>.

The IETF invites any interested party to bring to its attention any copyrights, patents or patent applications, or other proprietary rights that may cover technology that may be required to implement this standard. Please address the information to the IETF at ietf-ipr@ietf.org.

Disclaimer of Validity

This document and the information contained herein are provided on an "AS IS" basis and THE CONTRIBUTOR, THE ORGANIZATION HE/SHE REPRESENTS OR IS SPONSORED BY (IF ANY), THE INTERNET SOCIETY AND THE INTERNET ENGINEERING TASK FORCE DISCLAIM ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY WARRANTY THAT THE USE OF THE INFORMATION HEREIN WILL NOT INFRINGE ANY RIGHTS OR ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

Copyright Statement

Copyright (C) The Internet Society (2005). This document is subject to the rights, licenses and restrictions contained in [BCP 78](#), and except as set forth therein, the authors retain all their rights.

Acknowledgment

Funding for the RFC Editor function is currently provided by the Internet Society.

Crocker

Expires August 15, 2005

[Page 38]