

Network Working Group
Request for Comments: 1725
Obsoletes: 1460
Category: Standards Track

J. Myers
Carnegie Mellon
M. Rose
Dover Beach Consulting, Inc.
November 1994

Post Office Protocol - Version 3

Status of this Memo

This document specifies an Internet standards track protocol for the Internet community, and requests discussion and suggestions for improvements. Please refer to the current edition of the "Internet Official Protocol Standards" (STD 1) for the standardization state and status of this protocol. Distribution of this memo is unlimited.

Overview

This memo is a revision to RFC 1460, a Draft Standard. It makes the following changes from that document:

- removed text regarding "split-UA model", which didn't add anything to the understanding of POP
- clarified syntax of commands, keywords, and arguments
- clarified behavior on broken connection
- explicitly permitted an inactivity autologout timer
- clarified the requirements of the "exclusive-access lock"
- removed implementation-specific wording regarding the parsing of the maildrop
- allowed servers to close the connection after a failed authentication command
- removed the LAST command
- fixed typo in example of TOP command
- clarified that the second argument to the TOP command is non-negative
- added the optional UIDL command

- added warning regarding length of shared secrets with APOP
- added additional warnings to the security considerations section

1. Introduction

On certain types of smaller nodes in the Internet it is often impractical to maintain a message transport system (MTS). For example, a workstation may not have sufficient resources (cycles, disk space) in order to permit a SMTP server [RFC821] and associated local mail delivery system to be kept resident and continuously running. Similarly, it may be expensive (or impossible) to keep a personal computer interconnected to an IP-style network for long amounts of time (the node is lacking the resource known as "connectivity").

Despite this, it is often very useful to be able to manage mail on these smaller nodes, and they often support a user agent (UA) to aid the tasks of mail handling. To solve this problem, a node which can support an MTS entity offers a maildrop service to these less endowed nodes. The Post Office Protocol - Version 3 (POP3) is intended to permit a workstation to dynamically access a maildrop on a server host in a useful fashion. Usually, this means that the POP3 is used to allow a workstation to retrieve mail that the server is holding for it.

For the remainder of this memo, the term "client host" refers to a host making use of the POP3 service, while the term "server host" refers to a host which offers the POP3 service.

2. A Short Digression

This memo does not specify how a client host enters mail into the transport system, although a method consistent with the philosophy of this memo is presented here:

When the user agent on a client host wishes to enter a message into the transport system, it establishes an SMTP connection to its relay host (this relay host could be, but need not be, the POP3 server host for the client host).

3. Basic Operation

Initially, the server host starts the POP3 service by listening on TCP port 110. When a client host wishes to make use of the service, it establishes a TCP connection with the server host. When the connection is established, the POP3 server sends a greeting. The client and POP3 server then exchange commands and responses

(respectively) until the connection is closed or aborted.

Commands in the POP3 consist of a keyword, possibly followed by one or more arguments. All commands are terminated by a CRLF pair. Keywords and arguments consist of printable ASCII characters. Keywords and arguments are each separated by a single SPACE character. Keywords are three or four characters long. Each argument may be up to 40 characters long.

Responses in the POP3 consist of a status indicator and a keyword possibly followed by additional information. All responses are terminated by a CRLF pair. There are currently two status indicators: positive ("OK") and negative ("-ERR").

Responses to certain commands are multi-line. In these cases, which are clearly indicated below, after sending the first line of the response and a CRLF, any additional lines are sent, each terminated by a CRLF pair. When all lines of the response have been sent, a final line is sent, consisting of a termination octet (decimal code 046, ".") and a CRLF pair. If any line of the multi-line response begins with the termination octet, the line is "byte-stuffed" by pre-pending the termination octet to that line of the response. Hence a multi-line response is terminated with the five octets "CRLF.CRLF". When examining a multi-line response, the client checks to see if the line begins with the termination octet. If so and if octets other than CRLF follow, the the first octet of the line (the termination octet) is stripped away. If so and if CRLF immediately follows the termination character, then the response from the POP server is ended and the line containing ".CRLF" is not considered part of the multi-line response.

A POP3 session progresses through a number of states during its lifetime. Once the TCP connection has been opened and the POP3 server has sent the greeting, the session enters the AUTHORIZATION state. In this state, the client must identify itself to the POP3 server. Once the client has successfully done this, the server acquires resources associated with the client's maildrop, and the session enters the TRANSACTION state. In this state, the client requests actions on the part of the POP3 server. When the client has issued the QUIT command, the session enters the UPDATE state. In this state, the POP3 server releases any resources acquired during the TRANSACTION state and says goodbye. The TCP connection is then closed.

A POP3 server MAY have an inactivity autologout timer. Such a timer MUST be of at least 10 minutes' duration. The receipt of any command from the client during that interval should suffice to reset the autologout timer. When the timer expires, the session does NOT enter

the UPDATE state--the server should close the TCP connection without removing any messages or sending any response to the client.

4. The AUTHORIZATION State

Once the TCP connection has been opened by a POP3 client, the POP3 server issues a one line greeting. This can be any string terminated by CRLF. An example might be:

S: +OK POP3 server ready

Note that this greeting is a POP3 reply. The POP3 server should always give a positive response as the greeting.

The POP3 session is now in the AUTHORIZATION state. The client must now identify and authenticate itself to the POP3 server. Two possible mechanisms for doing this are described in this document, the USER and PASS command combination and the APOP command. The APOP command is described later in this document.

To authenticate using the USER and PASS command combination, the client must first issue the USER command. If the POP3 server responds with a positive status indicator ("OK"), then the client may issue either the PASS command to complete the authentication, or the QUIT command to terminate the POP3 session. If the POP3 server responds with a negative status indicator ("-ERR") to the USER command, then the client may either issue a new authentication command or may issue the QUIT command.

When the client issues the PASS command, the POP3 server uses the argument pair from the USER and PASS commands to determine if the client should be given access to the appropriate maildrop.

Once the POP3 server has determined through the use of any authentication command that the client should be given access to the appropriate maildrop, the POP3 server then acquires an exclusive-access lock on the maildrop, as necessary to prevent messages from being modified or removed before the session enters the UPDATE state. If the lock is successfully acquired, the POP3 server responds with a positive status indicator. The POP3 session now enters the TRANSACTION state, with no messages marked as deleted. If the the maildrop cannot be opened for some reason (for example, a lock can not be acquired, the client is denied access to the appropriate maildrop, or the maildrop cannot be parsed), the POP3 server responds with a negative status indicator. (If a lock was acquired but the POP3 server intends to respond with a negative status indicator, the POP3 server must release the lock prior to rejecting the command.) After returning a negative status indicator, the server may close the

connection. If the server does not close the connection, the client may either issue a new authentication command and start again, or the client may issue the QUIT command.

After the POP3 server has opened the maildrop, it assigns a message-number to each message, and notes the size of each message in octets. The first message in the maildrop is assigned a message-number of "1", the second is assigned "2", and so on, so that the n'th message in a maildrop is assigned a message-number of "n". In POP3 commands and responses, all message-number's and message sizes are expressed in base-10 (i.e., decimal).

Here are summaries for the three POP3 commands discussed thus far:

USER name

Arguments:

- a string identifying a mailbox (required), which is of significance ONLY to the server

Restrictions:

- may only be given in the AUTHORIZATION state after the POP3 greeting or after an unsuccessful USER or PASS command

Possible Responses:

- +OK name is a valid mailbox
- ERR never heard of mailbox name

Examples:

```
C: USER mrose
S: +OK mrose is a real hoopy frood
...
C: USER frated
S: -ERR sorry, no mailbox for frated here
```

PASS string

Arguments:

- a server/mailbox-specific password (required)

Restrictions:

- may only be given in the AUTHORIZATION state after a successful USER command

Discussion:

Since the PASS command has exactly one argument, a POP3 server may treat spaces in the argument as part of the password, instead of as argument separators.

Possible Responses:

- +OK maildrop locked and ready
- ERR invalid password
- ERR unable to lock maildrop

Examples:

```
C: USER mrose
S: +OK mrose is a real hoopy frood
C: PASS secret
S: +OK mrose's maildrop has 2 messages (320 octets)
...
C: USER mrose
S: +OK mrose is a real hoopy frood
C: PASS secret
S: -ERR maildrop already locked
```

QUIT

Arguments: none

Restrictions: none

Possible Responses:

- +OK

Examples:

```
C: QUIT
S: +OK dewey POP3 server signing off
```

5. The TRANSACTION State

Once the client has successfully identified itself to the POP3 server and the POP3 server has locked and opened the appropriate maildrop, the POP3 session is now in the TRANSACTION state. The client may now issue any of the following POP3 commands repeatedly. After each command, the POP3 server issues a response. Eventually, the client issues the QUIT command and the POP3 session enters the UPDATE state.

Here are the POP3 commands valid in the TRANSACTION state:

STAT

Arguments: none

Restrictions:

- may only be given in the TRANSACTION state

Discussion:

The POP3 server issues a positive response with a line containing information for the maildrop. This line is called a "drop listing" for that maildrop.

In order to simplify parsing, all POP3 servers required to use a certain format for drop listings. The positive response consists of "+OK" followed by a single space, the number of messages in the maildrop, a single space, and the size of the maildrop in octets. This memo makes no requirement on what follows the maildrop size. Minimal implementations should just end that line of the response with a CRLF pair. More advanced implementations may include other information.

NOTE: This memo STRONGLY discourages implementations from supplying additional information in the drop listing. Other, optional, facilities are discussed later on which permit the client to parse the messages in the maildrop.

Note that messages marked as deleted are not counted in either total.

Possible Responses:

+OK nn mm

Examples:

C: STAT

S: +OK 2 320

LIST [msg]**Arguments:**

a message-number (optional), which, if present, may NOT refer to a message marked as deleted

Restrictions:

may only be given in the TRANSACTION state

Discussion:

If an argument was given and the POP3 server issues a positive response with a line containing information for that message. This line is called a "scan listing" for that message.

If no argument was given and the POP3 server issues a positive response, then the response given is multi-line.

After the initial +OK, for each message in the maildrop, the POP3 server responds with a line containing information for that message. This line is also called a "scan listing" for that message.

In order to simplify parsing, all POP3 servers are required to use a certain format for scan listings. A scan listing consists of the message-number of the message, followed by a single space and the exact size of the message in octets. This memo makes no requirement on what follows the message size in the scan listing. Minimal implementations should just end that line of the response with a CRLF pair. More advanced implementations may include other information, as parsed from the message.

NOTE: This memo STRONGLY discourages implementations from supplying additional information in the scan listing. Other, optional, facilities are discussed later on which permit the client to parse the messages in the maildrop.

Note that messages marked as deleted are not listed.

Possible Responses:

- +OK scan listing follows
- ERR no such message

Examples:

```
C: LIST
S: +OK 2 messages (320 octets)
S: 1 120
S: 2 200
S: .
...
C: LIST 2
S: +OK 2 200
...
C: LIST 3
S: -ERR no such message, only 2 messages in maildrop
```

RETR msg

Arguments:

- a message-number (required) which may not refer to a message marked as deleted

Restrictions:

- may only be given in the TRANSACTION state

Discussion:

If the POP3 server issues a positive response, then the response given is multi-line. After the initial +OK, the POP3 server sends the message corresponding to the given message-number, being careful to byte-stuff the termination character (as with all multi-line responses).

Possible Responses:

+OK message follows
-ERR no such message

Examples:

```
C: RETR 1
S: +OK 120 octets
S: <the POP3 server sends the entire message here>
S: .
```

DELE msg**Arguments:**

a message-number (required) which may not refer to a message marked as deleted

Restrictions:

may only be given in the TRANSACTION state

Discussion:

The POP3 server marks the message as deleted. Any future reference to the message-number associated with the message in a POP3 command generates an error. The POP3 server does not actually delete the message until the POP3 session enters the UPDATE state.

Possible Responses:

+OK message deleted
-ERR no such message

Examples:

```
C: DELE 1
S: +OK message 1 deleted
...
C: DELE 2
S: -ERR message 2 already deleted
```

NOOP

Arguments: none

Restrictions:
may only be given in the TRANSACTION state

Discussion:
The POP3 server does nothing, it merely replies with a positive response.

Possible Responses:
+OK

Examples:
C: NOOP
S: +OK

RSET

Arguments: none

Restrictions:
may only be given in the TRANSACTION state

Discussion:
If any messages have been marked as deleted by the POP3 server, they are unmarked. The POP3 server then replies with a positive response.

Possible Responses:
+OK

Examples:
C: RSET
S: +OK maildrop has 2 messages (320 octets)

6. The UPDATE State

When the client issues the QUIT command from the TRANSACTION state, the POP3 session enters the UPDATE state. (Note that if the client issues the QUIT command from the AUTHORIZATION state, the POP3 session terminates but does NOT enter the UPDATE state.)

If a session terminates for some reason other than a client-issued QUIT command, the POP3 session does NOT enter the UPDATE state and MUST not remove any messages from the maildrop.

QUIT

Arguments: none

Restrictions: none

Discussion:

The POP3 server removes all messages marked as deleted from the maildrop. It then releases any exclusive-access lock on the maildrop and replies as to the status of these operations. The TCP connection is then closed.

Possible Responses:

+OK

Examples:

C: QUIT

S: +OK dewey POP3 server signing off (maildrop empty)

...

C: QUIT

S: +OK dewey POP3 server signing off (2 messages left)

...

7. Optional POP3 Commands

The POP3 commands discussed above must be supported by all minimal implementations of POP3 servers.

The optional POP3 commands described below permit a POP3 client greater freedom in message handling, while preserving a simple POP3 server implementation.

NOTE: This memo STRONGLY encourages implementations to support these commands in lieu of developing augmented drop and scan listings. In short, the philosophy of this memo is to put intelligence in the part of the POP3 client and not the POP3 server.

TOP msg n

Arguments:

a message-number (required) which may NOT refer to a message marked as deleted, and a non-negative number (required)

Restrictions:

may only be given in the TRANSACTION state

Discussion:

If the POP3 server issues a positive response, then the response given is multi-line. After the initial +OK, the POP3 server sends the headers of the message, the blank

line separating the headers from the body, and then the number of lines indicated message's body, being careful to byte-stuff the termination character (as with all multi-line responses).

Note that if the number of lines requested by the POP3 client is greater than the number of lines in the body, then the POP3 server sends the entire message.

Possible Responses:

- +OK top of message follows
- ERR no such message

Examples:

```
C: TOP 1 10
S: +OK
S: <the POP3 server sends the headers of the
  message, a blank line, and the first 10 lines
  of the body of the message>
S: .
...
C: TOP 100 3
S: -ERR no such message
```

UIDL [msg]

Arguments:

a message-number (optionally) If a message-number is given, it may NOT refer to a message marked as deleted.

Restrictions:

may only be given in the TRANSACTION state.

Discussion:

If an argument was given and the POP3 server issues a positive response with a line containing information for that message. This line is called a "unique-id listing" for that message.

If no argument was given and the POP3 server issues a positive response, then the response given is multi-line. After the initial +OK, for each message in the maildrop, the POP3 server responds with a line containing information for that message. This line is called a "unique-id listing" for that message.

In order to simplify parsing, all POP3 servers are required to use a certain format for unique-id listings. A unique-id listing consists of the message-number of the message, followed by a single space and the unique-id of the message.

No information follows the unique-id in the unique-id listing.

The unique-id of a message is an arbitrary server-determined string, consisting of characters in the range 0x21 to 0x7E, which uniquely identifies a message within a maildrop and which persists across sessions. The server should never reuse an unique-id in a given maildrop, for as long as the entity using the unique-id exists.

Note that messages marked as deleted are not listed.

Possible Responses:

+OK unique-id listing follows
-ERR no such message

Examples:

```
C: UIDL
S: +OK
S: 1 whqtsw000WBw418f9t5JxYwZ
S: 2 QhdPYR:00WBw1Ph7x7
S: .
...
C: UIDL 2
S: +OK 2 QhdPYR:00WBw1Ph7x7
...
C: UIDL 3
S: -ERR no such message, only 2 messages in maildrop
```

APOP name digest

Arguments:

a string identifying a mailbox and a MD5 digest string
(both required)

Restrictions:

may only be given in the AUTHORIZATION state after the POP3 greeting

Discussion:

Normally, each POP3 session starts with a USER/PASS exchange. This results in a server/user-id specific password being sent in the clear on the network. For intermittent use of POP3, this may not introduce a sizable risk. However, many POP3 client implementations connect to the POP3 server on a regular basis -- to check for new mail. Further the interval of session initiation may be on the order of five minutes. Hence, the risk of password capture is greatly enhanced.

An alternate method of authentication is required which provides for both origin authentication and replay protection, but which does not involve sending a password in the clear over the network. The APOP command provides this functionality.

A POP3 server which implements the APOP command will include a timestamp in its banner greeting. The syntax of the timestamp corresponds to the 'msg-id' in [RFC822], and MUST be different each time the POP3 server issues a banner greeting. For example, on a UNIX implementation in which a separate UNIX process is used for each instance of a POP3 server, the syntax of the timestamp might be:

```
<process-ID.clock@hostname>
```

where 'process-ID' is the decimal value of the process's PID, clock is the decimal value of the system clock, and hostname is the fully-qualified domain-name corresponding to the host where the POP3 server is running.

The POP3 client makes note of this timestamp, and then issues the APOP command. The 'name' parameter has identical semantics to the 'name' parameter of the USER command. The 'digest' parameter is calculated by applying the MD5 algorithm [RFC1321] to a string consisting of the timestamp (including angle-brackets) followed by a shared secret. This shared secret is a string known only to the POP3 client and server. Great care should be taken to prevent unauthorized disclosure of the secret, as knowledge of the secret will allow any entity to successfully masquerade as the named user. The 'digest' parameter itself is a 16-octet value which is sent in hexadecimal format, using lower-case ASCII characters.

When the POP3 server receives the APOP command, it verifies the digest provided. If the digest is correct, the POP3 server issues a positive response, and the POP3 session enters the TRANSACTION state. Otherwise, a negative response is issued and the POP3 session remains in the AUTHORIZATION state.

Note that as the length of the shared secret increases, so does the difficulty of deriving it. As such, shared secrets should be long strings (considerably longer than the 8-character example shown below).

Possible Responses:

+OK maildrop locked and ready
-ERR permission denied

Examples:

S: +OK POP3 server ready <1896.697170952@dbc.mtview.ca.us>
C: APOP mrose c4c9334bac560ecc979e58001b3e22fb
S: +OK maildrop has 1 message (369 octets)

In this example, the shared secret is the string 'tanstaaf'. Hence, the MD5 algorithm is applied to the string

<1896.697170952@dbc.mtview.ca.us>tanstaaf

which produces a digest value of

c4c9334bac560ecc979e58001b3e22fb

8. POP3 Command Summary

Minimal POP3 Commands:

USER name valid in the AUTHORIZATION state
PASS string
QUIT

STAT valid in the TRANSACTION state
LIST [msg]
RETR msg
DELE msg
NOOP
RSET

QUIT valid in the UPDATE state

Optional POP3 Commands:

APOP name digest valid in the AUTHORIZATION state

TOP msg n valid in the TRANSACTION state
UIDL [msg]

POP3 Replies:

+OK
-ERR

Note that with the exception of the STAT, LIST, and UIDL commands, the reply given by the POP3 server to any command is significant only to "+OK" and "-ERR". Any text occurring after this reply may be ignored by the client.

9. Example POP3 Session

```
S: <wait for connection on TCP port 110>
C: <open connection>
S: +OK POP3 server ready <1896.697170952@dbc.mtview.ca.us>
C: APOP mrose c4c9334bac560ecc979e58001b3e22fb
S: +OK mrose's maildrop has 2 messages (320 octets)
C: STAT
S: +OK 2 320
C: LIST
S: +OK 2 messages (320 octets)
S: 1 120
S: 2 200
S: .
C: RETR 1
S: +OK 120 octets
S: <the POP3 server sends message 1>
S: .
C: DELE 1
S: +OK message 1 deleted
C: RETR 2
S: +OK 200 octets
S: <the POP3 server sends message 2>
S: .
C: DELE 2
S: +OK message 2 deleted
C: QUIT
S: +OK dewey POP3 server signing off (maildrop empty)
C: <close connection>
S: <wait for next connection>
```

10. Message Format

All messages transmitted during a POP3 session are assumed to conform to the standard for the format of Internet text messages [RFC822].

It is important to note that the octet count for a message on the server host may differ from the octet count assigned to that message due to local conventions for designating end-of-line. Usually, during the AUTHORIZATION state of the POP3 session, the POP3 server can calculate the size of each message in octets when it opens the maildrop. For example, if the POP3 server host internally represents end-of-line as a single character, then the POP3 server simply counts

each occurrence of this character in a message as two octets. Note that lines in the message which start with the termination octet need not be counted twice, since the POP3 client will remove all byte-stuffed termination characters when it receives a multi-line response.

11. References

- [RFC821] Postel, J., "Simple Mail Transfer Protocol", STD 10, RFC 821, USC/Information Sciences Institute, August 1982.
- [RFC822] Crocker, D., "Standard for the Format of ARPA-Internet Text Messages", STD 11, RFC 822, University of Delaware, August 1982.
- [RFC1321] Rivest, R. "The MD5 Message-Digest Algorithm", RFC 1321, MIT Laboratory for Computer Science, April, 1992.

12. Security Considerations

It is conjectured that use of the APOP command provides origin identification and replay protection for a POP3 session. Accordingly, a POP3 server which implements both the PASS and APOP commands must not allow both methods of access for a given user; that is, for a given "USER name" either the PASS or APOP command is allowed, but not both.

Further, note that as the length of the shared secret increases, so does the difficulty of deriving it.

Servers that answer -ERR to the USER command are giving potential attackers clues about which names are valid

Use of the PASS command sends passwords in the clear over the network.

Use of the RETR and TOP commands sends mail in the clear over the network.

Otherwise, security issues are not discussed in this memo.

13. Acknowledgements

The POP family has a long and checkered history. Although primarily a minor revision to RFC 1460, POP3 is based on the ideas presented in RFCs 918, 937, and 1081.

In addition, Alfred Grimstad, Keith McCloghrie, and Neil Ostroff provided significant comments on the APOP command.

14. Authors' Addresses

John G. Myers
Carnegie-Mellon University
5000 Forbes Ave
Pittsburgh, PA 15213

EMail: jgm+@cmu.edu

Marshall T. Rose
Dover Beach Consulting, Inc.
420 Whisman Court
Mountain View, CA 94043-2186

EMail: mrose@dbc.mtview.ca.us

