(U) Gyrfalcon v1.0 User Manual

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### Table of Changes

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<tr>
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<th>Change Description</th>
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<tbody>
<tr>
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1 Introduction

Gyrfalcon is an SSH session “sharing” tool that operates on outbound OpenSSH sessions from the target host on which it is run. It can log SSH sessions (including login credentials), as well as execute commands on behalf of the legitimate user on the remote host.

1.1 General Workflow

The tool runs in an automated fashion. It is configured in advance, executed on the remote host and left running. Some time later, the operator returns and commands gyrfalcon to flush all of its collection to disk. The operator retrieves the collection file, decrypts it, and analyzes the collected data.

1.2 Dependencies

1.2.1 Configuration Tool

The configuration tool is a zipped Python executable. It requires Python 2.5-2.7 and the openssl command line tool (included in most *nix distributions by default) for key generation.

1.2.2 Gyrfalcon Executable

The executable that runs on target comes in two flavors: 32-bit and 64-bit Linux ELF. They are dynamically linked, meaning they depend on several libraries to be present on the target system:

- libz.so.1
- libpthread.so.0
- libc.so.6

Without the required libraries, the tool will simply fail to run.

The tool must be executed on systems running Linux kernel 2.6.14 or greater, and glibc 2.5 or greater.

To get the kernel version of the target system, run the following at a command prompt:

```
$ uname -r
2.6.18-194.el5
```

To get the glibc version of the target system, run the following at a command prompt:

```
$ getconf GNU_LIBC_VERSION
glibc 2.5
```

Also, SELinux can prevent gyrfalcon from attaching to targeted processes by enabling the deny_ptrace boolean. Fortunately, this boolean is disabled by default so far, but future distros may enable it. To disable deny_ptrace do:

```
$ setsebool deny_ptrace 0
```
2 Configuration

Use the configuration tool (eyrie.pyz) to generate a configuration file and appropriate gyrfalcon executable for the target operating system. The configuration tool is invoked either as any other executable on the system, or as an argument to the python interpreter:

```bash
$ ./eyrie.pyz -c
$ python2.7 ./eyrie.pyz -c
```

Invoked with no arguments, eyrie prints a brief help message and exits. The '-c' option is used to configure an implant.

2.1 Global Configuration Options

Several implant-wide configuration options are available. Type the 'Command' letter at the cfg > prompt.

<table>
<thead>
<tr>
<th>Option Name</th>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working Directory</td>
<td>w</td>
<td>Directory on target where gyrfalcon runs and saves collect file</td>
</tr>
<tr>
<td>Collection File</td>
<td>c</td>
<td>Name of collection file gyrfalcon will write (in working directory)</td>
</tr>
<tr>
<td>Operating System</td>
<td>o</td>
<td>Target's operating system (linux is the only option)</td>
</tr>
<tr>
<td>Architecture</td>
<td>r</td>
<td>Target architecture (choice of x86, x86_64)</td>
</tr>
<tr>
<td>Max Output Size</td>
<td>m</td>
<td>Maximum size of collection file (in bytes)</td>
</tr>
<tr>
<td>Encrypted config name</td>
<td>n</td>
<td>Name of config file gyrfalcon will look for (in working directory) when it starts up. If the config file is not found, gyrfalcon will not run.</td>
</tr>
</tbody>
</table>

2.2 Per Target Configuration Options

Gyrfalcon has the ability to track multiple outbound SSH sessions. To manage this, it is configured with a list of target IP address / netmask combinations. Use the 'a' command to add a new target. You will be prompted with three questions:

1. Specify an IPv4 or IPv6 address/netmask:
2. Specify Collection Behavior

Each option is addressed in the following subsections.

Additionally, targets may be deleted or edited by target id. The target id is the # column in the targets table.

To delete a target, use the 'd' command:

```bash
cfg > d 1
```
To edit a target, use the 'e' command with the same target id. Any (or all) of the three per-target can be specified in the edit command line:

```plaintext
    cfg > e 1 IP=192.168.2.2/30 CB=ignore EXE=/path/to/dangerous_executable
```

If an element is omitted, its value will remain unchanged.

### 2.2.1 Target Address Specification

The IPv4 or IPv6 address is used to identify remote hosts we wish to log the SSH session for or run an executable on. Below are some example target address specifications:

<table>
<thead>
<tr>
<th>IPv4</th>
<th>IPv6</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.168.1.1</td>
<td>2001:db8::1</td>
<td>Target applies to a single IP address. Implied netmask of 32 or 128 bits.</td>
</tr>
<tr>
<td>192.168.1.1/24</td>
<td>2001:db8::1/64</td>
<td>Target applies to an entire subnet.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The following IP's are targeted in the example:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>192.168.1.[0-255]</td>
</tr>
<tr>
<td>1.1.1.1/0</td>
<td>::1/0</td>
<td>Netmask of zero overrides the default behavior (ignore all) for any otherwise unmatched address.</td>
</tr>
<tr>
<td>host.domain.com</td>
<td></td>
<td>Targets may be specified by hostname. However this is not recommended. If a user connects using the ip address instead of the hostname, the target specification will not match. IP address specifications on the other hand, will match either way.</td>
</tr>
</tbody>
</table>

It is important to note that Gyrfalcon matches targets using the most specific rule in its configuration. So, for example a configuration that specifies two targets 192.168.1.1 and 192.168.1.0/24 would use the first target specification for remote host 192.168.1.1, and the second for all other IP addresses in the 192.168.1.0/24 subnet.

### 2.2.2 Target Collection Behavior

The collection behavior specifies the type of logging that Gyrfalcon should perform on SSH connections to the matched target. The four options are identified below.

<table>
<thead>
<tr>
<th>Collection Behavior</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ignore</td>
<td>Ignore the matched target. Do not log anything.</td>
</tr>
<tr>
<td>connections</td>
<td>Record connection events to the matched target, but nothing else.</td>
</tr>
<tr>
<td>credentials</td>
<td>Record login credentials to the matched target, but nothing else.</td>
</tr>
<tr>
<td>full</td>
<td>Record everything: connection event, login credentials, and entire session log.</td>
</tr>
</tbody>
</table>
2.2.3 Target Executable

This is where you specify the path to an executable on your configuration machine that you would like to run on the matched during the traced SSH session. It can be a bash script, or other executable file. The executable will be copied into gyrfalcon's configuration file and stored in RAM while gyrfalcon runs, so it should be kept to a small size.

**IMPORTANT:** The executable should not be a long running one. Ideally it would just daemonize itself to run in the background and exit immediately. The SSH session remains active for as long as the executable runs, so if the legitimate user tries to exit the session, he will notice that ssh doesn't quit when he tells it to.

2.3 Saving the Configuration

The eyrie tool exports a gyrfalcon executable and config file as well as some other log information to a single tar file. The 's' command is used to save the data to a user specified file. The output file is in tar.gz format, so it is recommended to use the .tgz or .tar.gz file extension.

2.3.1 Example Configuration Archive Contents

Here is the output of a tar -tvf command run on an eyrie config package.

```bash
$ tar -tvf test.tgz
```

```
drwx------ 0 user  staff       0 Dec 13 18:41 test/
drwxr-xr-x 0 user  staff       0 Dec 13 18:41 test/keys/
-rw-r--r-- 0 user  staff      16 Dec 13 18:41 test/keys/aes_iv.bin
-rw-r--r-- 0 user  staff      32 Dec 13 18:41 test/keys/aes_key.bin
-rw-r--r-- 0 user  staff     1675 Dec 13 18:41 test/keys/private.pem
-rw-r--r-- 0 user  staff     294 Dec 13 18:41 test/log/config.bin
-rw-r--r-- 0 user  staff     227 Dec 13 18:41 test/log/config.ini
drwxr-xr-x 0 user  staff       0 Dec 13 18:41 test/log/
-rw-r--r-- 0 user  staff     391 Dec 13 18:41 test/log/config.bin
-rw-r--r-- 0 user  staff     227 Dec 13 18:41 test/log/config.ini
drwxr-xr-x 0 user  staff       0 Dec 13 18:41 test/upload/
-rw-r--r-- 0 user  staff     400 Dec 13 18:41 test/upload/.gfconf
-rw-r--r-- 0 user  staff    93848 Dec 13 18:41 test/upload/gyr64-linux
```

The log directory contains a plaintext representation of the gyrfalcon config file (config.ini) which can be used as a build receipt. Incidentally, the config.ini file can be used to seed new gyrfalcon configurations.

The upload directory contains the files to be placed on target. In this case gyr64-linux is the gyrfalcon executable, and .gfconf is the config file.

The keys directory contains crypto keys which can be used to decrypt the data that gyrfalcon collects.

2.4 Reconfiguration

Once a gyrfalcon instance has been deployed, the operator may wish to change the configuration of the running instance on target. This is also accomplished using the eyrie tool to generate a new config tarball from the previous one. Use the '-f' command line option to create an updated configuration.
$ ./eyrie.pyz -c -f test.tgz

In this case, test.tgz is the previous configuration archive. The new configuration will copy the config file encryption key from the previous one so that gyrfalcon can read the new config file. Modify the existing configuration to use the desired parameters as described in section 2.2, and then save the new configuration file as described in section 2.3.

IMPORTANT: When reconfiguring the tool, do not change the name of the config file. The executable that is already running on target expects a config file of the same name as the first one. The collection file name can change if desired.
3 Gyrfalcon Usage

3.1 Running the Tool

Once you have a configuration tarball generated by the eyrie config tool, it is time to deploy gyrfalcon to the target. This step is fairly straightforward.

1. Extract the files from the 'upload' directory in the tarball (see section 2.3.1). Both the gyr64-linux (or gyr32-linux) and the encrypted config file (in the example, .gfconf) are needed. The executable can be renamed to suit the operation.

2. Upload the files to the target using whatever means available. Place them in the 'Working Directory' (as specified in the configuration).

3. Change to the working directory and execute gyrfalcon as root:

```
$ su - (if necessary)
# cd /gyrfalcon/working/directory
# ls -a
  ..  .gfconf  gyr64-linux
# ./gyr64-linux /dev/null
```

The gyrfalcon executable takes a single command line argument. /dev/null causes it to daemonize and run in the background. (The normal usage). /dev/zero causes it to remain in the foreground, attached to the controlling terminal (not recommended).

If gyrfalcon successfully parsed the configuration file, the config file is deleted and remains in memory. It is also safe to unlink the executable from disk if desired.

3.2 Error Messages

Gyrfalcon performs a few preflight checks before it begins normal operation. If any of the checks fail, gyrfalcon will terminate and report an error message on the terminal as follows:

<table>
<thead>
<tr>
<th>Message</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td># C</td>
<td>There was an error parsing the config file. (Either the file couldn't be found or was corrupt). Remember, the config file should be placed in the gyrfalcon working directory, and the filename should not be changed when reconfiguring the tool.</td>
</tr>
<tr>
<td># M</td>
<td>Gyrfalcon is unable to monitor process launch events. This can occur because the kernel version is not supported (i.e., below 2.6.14), or if the kernel has not been compiled with the CONFIG_PROC_EVENTS and CONFIG_CONNECTOR options set to true. (Notably a Debian 6.0.6 default). Gyrfalcon will not work on this system.</td>
</tr>
<tr>
<td># R</td>
<td>Another instance of gyrfalcon is already running. Check the process list and shut that one down if you wish to run the new one.</td>
</tr>
</tbody>
</table>
3.3 Collecting Data

Gyrfalcon writes to a collection file in its working directory. The filename was specified in the config file. Gyrfalcon continues to stream data to this file during the course of its normal operation. The operator must signal gyrfalcon to flush its collection buffers before the data can be collected. This is accomplished using one of two options:

1. Shutdown gyrfalcon by sending it the SIGTERM signal (kill -SIGTERM). Gyrfalcon will finalize the collection data and exit.

2. Send gyrfalcon the SIGUSR1 signal (kill -SIGUSR1). Gyrfalcon will finalize the collected data, and continue collecting data using its current configuration.

When Gyrfalcon finalizes the data, it adds a timestamp to the collection filename to indicate that the file is ready for consumption.

3.4 Reconfiguration

The configuration of a running gyrfalcon instance can be changed by generating a new encrypted configuration file. See section 2.4 for information on how to generate the new config archive. Once the config archive (e.g., test.tgz) has been generated, upload the encrypted config file (e.g., .gfconf) from the archive's 'upload' directory to gyrfalcon's current working directory on the target. Finally, send gyrfalcon the SIGHUP signal (kill -SIGHUP <gyrfalcon pid>). Gyrfalcon will flush its collection file to disk and add a timestamp to the output filename as discussed in section 3.2, then it parses the new configuration file, deletes the config from disk, and continues running using the new configuration.
4 Postprocessing

4.1 Introduction

After flushing the collection file to disk it is ready to be analyzed. Note that the base collection file (as specified in the config file), is not sufficient. The operator must cause gyrfalcon to finalize its collection first; either by reconfiguring it with SIGHUP, terminating it with SIGTERM, or commanding it to dump the collection file with SIGUSR1. Only finalized collection files (with a timestamp tacked on the end of the filename) can be analyzed.

4.2 Decryption

The eyrie config tool is used to decrypt and decompress a finalized gyrfalcon collection file. The original configuration archive is required to decrypt the data. Below is an example command line usage:

```
$ ./eyrie.pyz -p -f cfg.tgz -o output.txt collect.bin.20121202_135960
```

In this example, cfg.tgz is the path to the original config archive, output.txt is where the decrypted data will be stored, and collect.bin.20121202_135960 is the finalized collection file from gyrfalcon.
4.3 Analysis

The output file (in the example above, output.txt) contains the collected data organized as a python dictionary. This makes analysis of the data straightforward using the python interpreter to selectively view data of interest. Here is an example raw output file:

```python
{   '15154': {   'command_line': 'ssh test@10.5.1.10',
    'dest_addr': '10.5.1.10',
    'executed': [],
    'packets': [   {   'data': 'Password:10sne1\n
Last login:
Wed Dec 12 13:53:36 2012 from 10.5.1.11

rafes-mac-pro:~ test$
ls /
ls /
Applications/\ttc\nt/\nLibrary/\tt\nde\tn/\nSystem/\tt\nexport/\tt\npublic_key.d\nUser/\thome/\t\nbin/\t\nmach_kernel/\t\nvar/\n
bundle.h/\tnet/\nr/\nrafes-mac-pro:~ test$
logout

logout
',
    'timestamp': '2012-12-12T12:25:43'}],
    'session_id': '15154',
    'timestamp': '2012-12-12T12:25:42',
    'username': 'root'},


'15156': {   'command_line': 'ssh test@localhost',
    'dest_addr': '127.0.0.1',
    'executed': [],
    'packets': [   {   'data': 'Password:10sne1\n
Last login:
Wed Dec 12 12:25:36 2012 from 127.0.0.1

rafes-mac-pro:~ test$
ls /
ls /
bin/ dev/ home/ lib64/ media/ mnt/ opt/ root/ selinux/ sys/ usr/ boot/ etc/ lib/ lost+found/ misc/ net/ proc/ sbin/ srv/ tmp/ var/ 

logout

logout
',
    'timestamp': '2012-12-12T12:25:45'}],
    'session_id': '15156',
    'timestamp': '2012-12-12T12:25:43',
    'username': 'root'}}
```

Ugly right? The dictionary consists of a nested set of key, value pairs. At the first level, the keys are numbers (in the example 15154 and 15156). These are the process id's of the SSH instances that were traced. The value for each process id key is itself a dictionary of key, value pairs. Each value contains the following keys:
<table>
<thead>
<tr>
<th>Key</th>
<th>Value Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>command_line</td>
<td>The full SSH command line as typed by the target user.</td>
</tr>
<tr>
<td>dest_addr</td>
<td>The IP address of the destination (use this to specify targets in the config file)</td>
</tr>
<tr>
<td>executed</td>
<td>A list of dictionaries that contain output from the executed command (if any). Each entry contains two keys ('data', and 'timestamp'). The final entry in the list is also a dictionary with a 'status' key that indicates the return code of the executable.</td>
</tr>
<tr>
<td>packets</td>
<td>A list of dictionaries that contain session log data. Each dictionary in the list has two keys ('data', and 'timestamp').</td>
</tr>
<tr>
<td>session_id</td>
<td>Process id of the target (an artifact of the collection file, not particularly useful).</td>
</tr>
<tr>
<td>timestamp</td>
<td>Timestamp of the start of the session.</td>
</tr>
<tr>
<td>username</td>
<td>Name of the user that typed the ssh command (useful if the command_line did not include a username).</td>
</tr>
</tbody>
</table>
4.4 Advanced Analysis

While it is possible to sift through the text file as is, Python can be used to make the data a little clearer. Here is an example of using python to dissect the output file.

```
$ python
...
1 >>> data = open('output.txt', 'rb').read()
2 >>> pdata = eval(data)
3 >>> pdata.keys()
['15154', '15156']
4 >>> s1 = pdata['15154']
5 >>> s1.keys()
['username', 'executed', 'command_line', 'packets', 'session_id',
 'dest_addr', 'timestamp']
6 >>> len( s1['packets'] )
1
7 >>> print s1['packets'][0]['data']
Password:10sne1
```

Last login: Wed Dec 12 13:53:36 2012 from 10.5.1.11
rafes-mac-pro:~ test$ ls /
ls /
Applications cores opt
Library dev private
Network etc private_key.pem
System export public_key.der
Users home sbin
Volumes home (from old Mac) tmp
Xcode3.1.3 lost+found usr
bin mach_kernel var
bundle.h net
rafes-mac-pro:~ test$ logout

4.4.1 Explanation

In line 1, we open the decrypted collection file and read it into the variable 'data' as a string.

In line 2, we evaluate the data as python code (this turns the data into a python dictionary type).

In line 3, we list the keys in the dictionary to determine the available sessions.

In line 4, we select the session associated with process id 15154 into a variable called s1.

In line 5, we list the keys for 15154's session data to see what is available.

In line 6, we determine how many packets were logged (1).

In line 7, we print out the first packet's 'data' element in a readable form.
5 Forensic Signature

5.1 Filesystem Artifacts

Gyrfalcon saves its collected data to a file in its working directory throughout its operation. It does not make any attempt on its own to hide this file.

The Gyrfalcon executable can safely be removed from disk once it is up and running.

Gyrfalcon deletes its configuration file from disk as soon as it is parsed but re-writes it to disk upon normal shutdown (e.g., via SIGTERM).

5.2 In-memory Artifacts

The Gyrfalcon executable remains running as a standard multi-threaded daemon root process. It opens a UNIX domain socket to the Kernel to receive notifications of launched processes. And it creates a POSIX semaphore to ensure no additional gyrfalcon instances can run at the same time.

Gyrfalcon traces through launched SSH processes using the ptrace API. It is possible to detect that a process is being debugged in several ways. One way involves checking /proc/pid/status. For example:

```
$ cat /proc/14164/status
Name: gnome-terminal
State: T (tracing stop)
SleepAVG: 98%
Tgid: 14164
Pid: 14164
PPid: 1
TracerPid: 25716
Uid: 500 500 500 500
Gid: 500 500 500 500
FDSize:64
...
```

The TracerPid field indicates the process id of the tracer process (in this case, Gyrfalcon). On some systems, it may be just a 1 or 0 to indicate that the process is being traced or not. The state field may also indicate whether the process is being traced.

Finally, the execute feature causes each targeted SSH session to create a named pipe on /tmp/ssh-XXXX. That is used as a control socket that gyrfalcon writes commands to, that will be executed on the remote host. The named pipe is removed when the legitimate SSH session ends.

5.3 Network Artifacts

Gyrfalcon's session log feature does not create any network traffic. It's a passive collect.

The execute feature does not create a new SSH connection, but does increase the amount of traffic exchanged within the legitimate SSH session. That is, the executable is uploaded and the results of
execution are returned over the same network connection (all encrypted of course). It simply appears on the network as if the legitimate session contains more data than it actually does.

5.4 Logging

SSH does log information about its control socket and duplexed connection when invoked using the -v option. Hence, gyrfalcon does not attach to SSH sessions invoked in this way.

For a remote execution, nothing is logged on the remote host unless the remote SSH daemon is configured to do so. The execute command is invoked as:

```
$ ssh user@remotehost /tmp/.x
```

So the command is not logged by the remote user's shell (because it causes sshd to fork and exec /tmp/.x directly), rather than run it from a shell prompt as an interactive session would.

As noted in the dependencies section, the SELinux boolean 'deny_ptrace' can prevent Gyrfalcon from running. If the boolean is enabled gyrfalcon will fail AND the failure will be logged.