GobRAT malware written in Go language targeting Linux routers - JPCERT/CC Eyes

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- Tool

JPCERT/CC has confirmed attacks that infected routers in Japan with malware around February 2023. This blog article explains the details of the attack confirmed by JPCERT/CC and GobRAT malware, which was used in the attack.

Attack flow up to malware execution

Initially, the attacker targets a router whose WEBUI is open to the public, executes scripts possibly by using vulnerabilities, and finally infects the GobRAT. Figure 1 shows the flow of the attack until GobRAT infects the router.

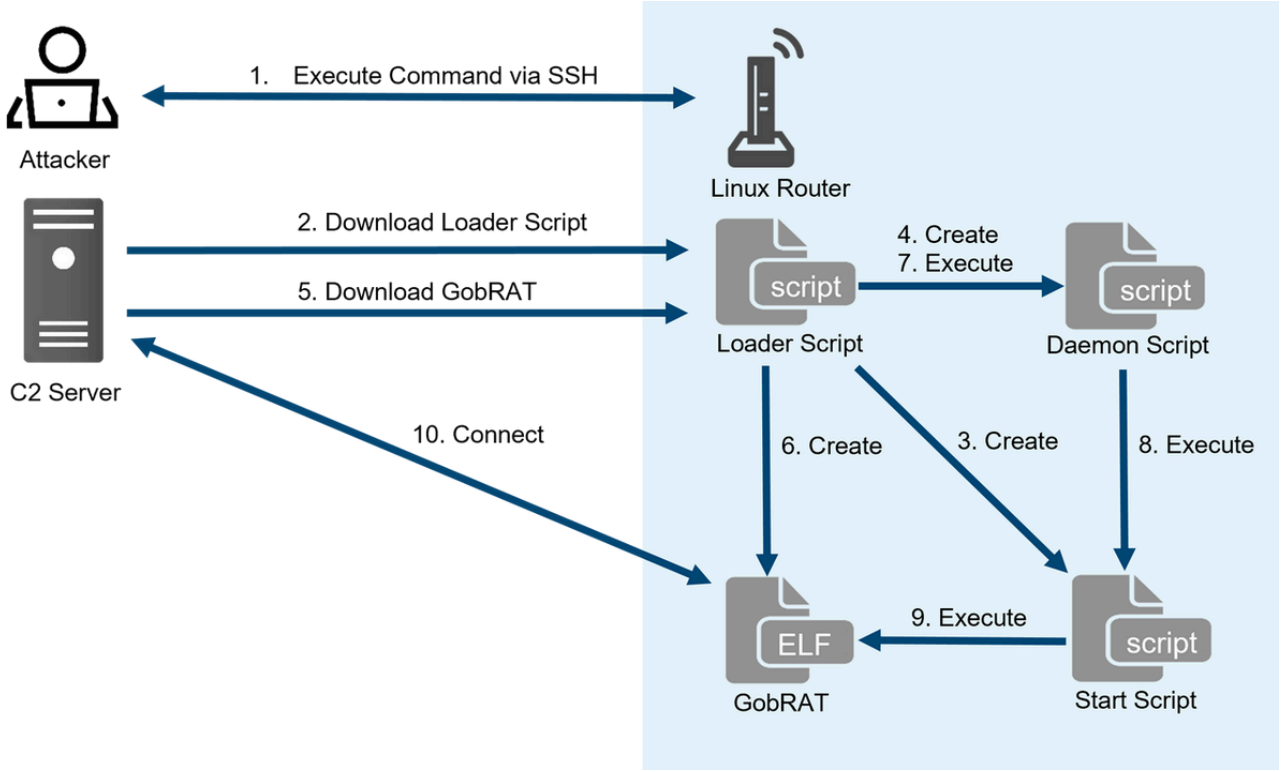

Figure 1: Attack Flow

Loader Script works as a loader, containing functions such as generating various scripts and downloading GobRAT. The SSH public key, which is assumed to be used for the backdoor, is hard-coded in the script. In

addition, since **Loader Script** uses crontab to register the file path of **Start Script** for persistence, GobRAT does not have such function. The functions of **Loader Script** are as follows:

- Disable Firewall function
- Download GobRAT for the target machine's architecture
- Create **Start Script** and make it persistent
- Create and run **Daemon Script**.
- Register a SSH public key in /root/.ssh/authorized_keys

Figure 2 is the code of **Start Script** that executes GobRAT. The script is unique in that it writes the startup time to a file named **restart.log**. In addition, this script executes GobRAT under the file name **apached** to make it look like a legitimate process.

```
#!/bin/sh
cd /tmp/env/.qnapd
file_name="/tmp/env/.qnapd/restart.log"
if (ps -ef || ps)  | grep '/tmp/env/.qnapd/apached' | grep -v grep; then
 echo
else
 if type nohup; then
  nohup /tmp/env/.qnapd/apached -d >/dev/null &
 else
  /tmp/env/.qnapd/apached -d >/dev/null &
 fi
  echo `date` >> $file_name
fi
```

Figure 2: Start Script

Figure 3 is the code of **Daemon Script**. This script checks whether **Start Script** is running or not every 20 seconds, and if not, it starts the script. This code has been possibly prepared in case **Start Script** is terminated unexpectedly.

```
#!/bin/sh
while true;do
  if ! pidof apached; then
    /tmp/env/.qnapd/sshd.sh
  fi
  sleep 20
done
```

Figure 3: Daemon Script

GobRAT Overview

GobRAT is a RAT written in Go language and communicates with C2 server via TLS and executes various commands. It is packed with UPX version 4 series, and samples for various architectures such as ARM, MIPS, x86, and x86-64 have been confirmed. GobRAT performs the following checks at startup and keeps the information within the sample itself.

- IP address and MAC address of itself
- Uptime by uptime command
- Network communication status by /proc/net/dev

The following sections describes the GobRAT's communication method, encryption method, and commands to be executed.

Communication method

GobRAT uses TLS to send and receive data with its C2 server. Figure 4 shows an example of communication with the C2 server. The first 4 bytes indicate the size of the data, and the rest is gob[1] data. gob is a data serialization protocol available only in Go language. GobRAT uses gob for receiving commands and sending the results of command execution.

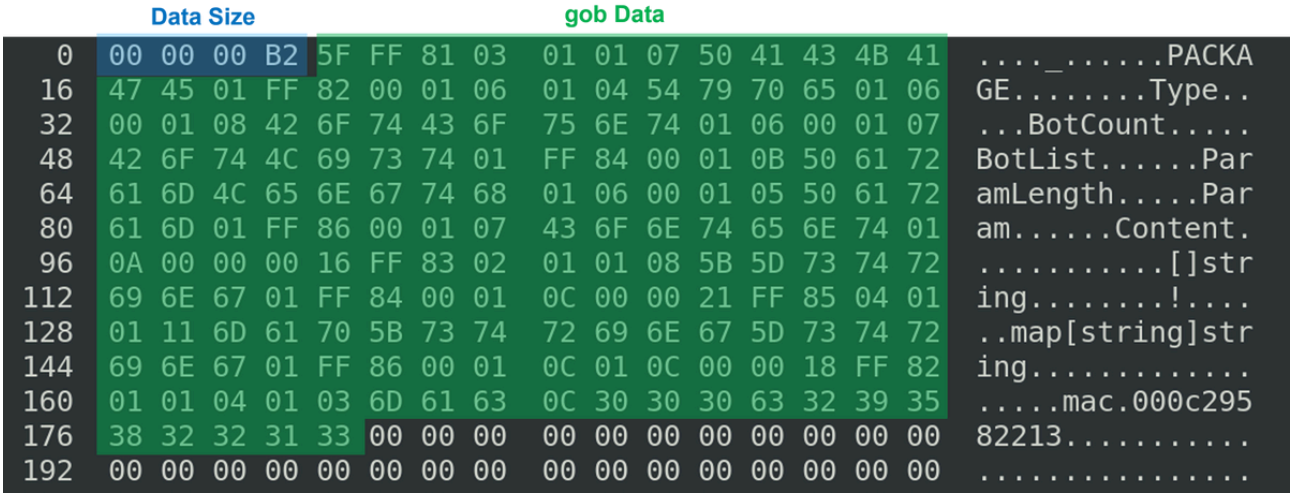

Figure 4: Example of communication content

GobRAT defines gob data as a PACKAGE structure in the sample as follows.

```
type PACKAGE struct {
    Type uint8                  // CommandID
    BotCount uint16             // Parameter
    BotList []string            // Command Parameter
    ParamLength uint16          // Length of Param
    Param map[string]string     // Command Parameter
```

```
    Content []uint8            // Command Parameter, Command Execution Result, etc
}
```

The fields used are different depending on the type of command, and string arrays, maps, and binary data are supported so that various types of parameters can be passed. In addition, while binary data can be stored in Content of the PACKAGE structure, map data with string is converted to binary data by encoding it with the json.Marshal function. The PACKAGE structure is used in various ways depending on the command, such as storing the data in Content, or converting the defined structure to binary data in the same way and storing it in Content.

Encryption Method

Strings such as C2 and Linux commands are encrypted and stored in the sample. Figure 5 shows the GobRAT's decryption function. AES128 CTR mode is used to decrypt strings, and the key and IV are hard-coded in the sample. The same key (**050CFE3706380723433807193E03FE2F**) and IV (**"12345678abcdefgh"**) are used in all the confirmed samples. In addition, as shown in Figure 6, the codes that have probably been developed by the attacker, such as this decryption function, has a unique folder structure like **aaa.com/bbb/me~**.

```
__int64 __golang aaa_com_bbb_mecrypt_AesEncrypt(
        __int64 ENCDATA,
        signed __int64 ENCDATA_SIZE,
        __int64 ENCDATA_SIZE_1,
        int AESKEY,
        __int64 KEYSIZE)
{
  __int64 v5; // r14
  __int64 KEY; // rax
  __int64 v7; // rcx
  _16_uint8 *IV; // rax
  RTYPE **AES_CTR; // [rsp+0h] [rbp-30h]
  __int64 Decrypted; // [rsp+18h] [rbp-18h]
  __int64 KEY_1; // [rsp+20h] [rbp-10h]
  void *retaddr; // [rsp+30h] [rbp+0h] BYREF

  if ( &retaddr <= *(v5 + 16) )
    JUMPOUT(0x608158LL);
  KEY = (crypto_aes_NewCipher)(AESKEY, KEYSIZE);
  if ( v7 )
    return 0LL;
  KEY_1 = KEY;
  IV = runtime_newobject(&RTYPE__16_uint8);
  qmemcpy(IV, "12345678abcdefgh", sizeof(_16_uint8));
  AES_CTR = crypto_cipher_NewCTR(KEY_1, KEYSIZE, IV, 0x10uLL);
  Decrypted = (runtime_makeslice)(&RTYPE_uint8, ENCDATA_SIZE, ENCDATA_SIZE);
  (AES_CTR[3])(KEYSIZE, Decrypted, ENCDATA_SIZE, ENCDATA_SIZE, ENCDATA);
  return Decrypted;
}
```

Figure 5: String decryption function

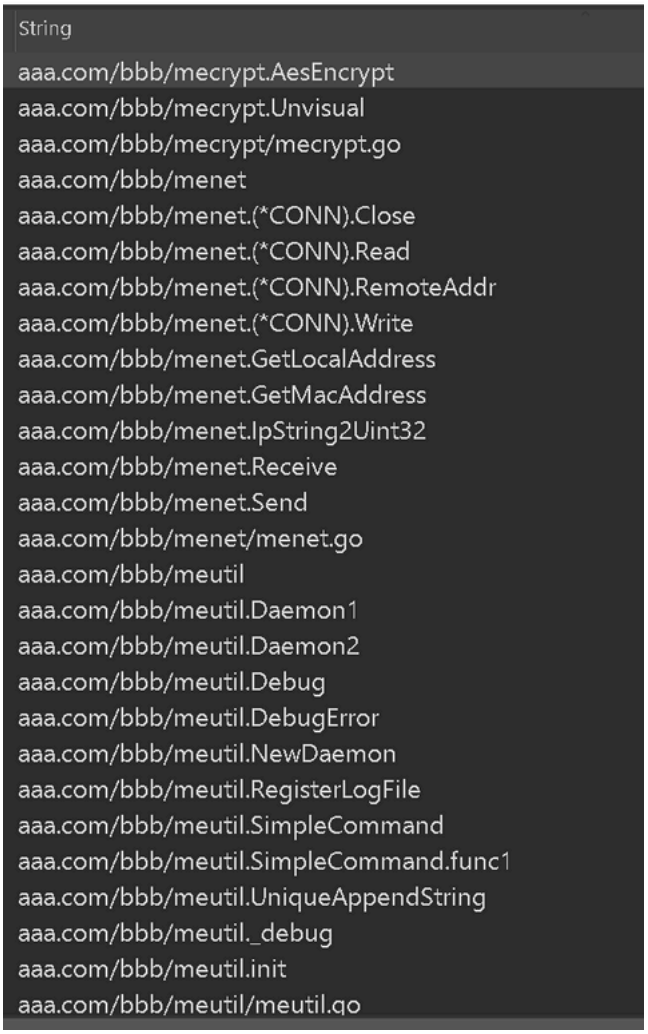

Figure 6: Characteristic folder structure

Commands executed

GobRAT has 22 commands that are executed by the commands from the C2 server, and we have identified the following commands. Since the malware targets routers, you can see that most functions are related to communication, such as frpc, socks5, and reconfiguration of C2. See Appendix A for command details.

- Obtain machine Information
- Execute reverse shell
- Read/write files
- Configure new C2 and protocol
- Start socks5
- Execute file in /zone/frpc
- Attempt to login to sshd, Telnet, Redis, MySQL, PostgreSQL services running on another machine

GobRAT Analysis Tools

Since GobRAT uses gob for communication, if you want to emulate its communication with C2 to check commands, you need to create a program using Go language. Our C2 emulation tool that supports GobRAT

analysis is available on GitHub. Please download it from the following webpage for your analysis.

JPCERTCC/aa-tools/GobRAT-Analysis - GitHub
https://github.com/JPCERTCC/aa-tools/tree/master/GobRAT-Analysis

In Closing

In recent years, different types of malware using Go language have been confirmed, and the GobRAT malware confirmed this time uses gob, which can only be handled by Go language, for communication. Please continuously beware of malware that infects routers, not limited to GobRAT, since they are difficult to detect. Please refer to Appendix B for C2 of the malware, Appendix C for the hash value of the script, and Appendix D for the hash value of the malware.

Yuma Masubuchi

Translated by Takumi Nakano

Appendix A: Commands

TableA: GobRAT commands

Value	Contents
0x0	Update json data held in malware and acquire update results
0x1	Retrieve json data held in malware
0x3	Start reverse shell
0x4	End of reverse shell connection
0x6	Confirmation of reverse shell connection
0x7	Execute shell command for daemon
0x8	Execute shell command
0xD	Read/write specified file
0x10,0x11	Read/write specified file
0x16	Obtain various machine information such as df command
0x17	Set new communication channel for TCP
0x18	Execute SOCKS5 proxy with specified port and password
0x19	Execute SOCKS5 proxy on specified port
0x1a	New communication channel setting for UDP

Value	Contents
0x1b	Execute frpc after executing SOCKS5 proxy on port 5555
0x1f	Check for the existence of the specified file
0x25	Login attempts for SSH, telenet, redis, mysql, postgres
0x27	Configuration of specified goroutine
0x2a	Scan to HTTP/HTTPS service of specified IP
0x2D	Dictionary attack to HTTP/HTTPS service of specified IP
0x30	C2 configuration related
0x31	DDoS attacks on SYN, TCP, UDP, HTTP, ICMP

Appendix B: C2

- https://su.vealcat.com
- http://su.vealcat.com:58888
- https://ktlvz.dnsfailover.net
- http://ktlvz.dnsfailover.net:58888
- su.vealcat.com
- ktlvz.dnsfailover.net
- wpksi.mefound.com

Appendix C: Hash values of the scripts

- 060acb2a5df6560acab9989d6f019fb311d88d5511f3eda0effcbd9fc6bd12bb
- feaef47defd8b4988e09c8b11967e20211b54e16e6df488780e2490d7c7fa02a
- 3e44c807a25a56f4068b5b8186eee5002eed6f26d665a8b791c472ad154585d1
- 60bcd645450e4c846238cf0e7226dc40c84c96eba99f6b2cffcd0ab4a391c8b3

Appendix D: Hash values of the malware

- a8b914df166fd0c94106f004e8ca0ca80a36c6f2623f87a4e9afe7d86b5b2e3a
- aeed77896de38802b85a19bfcb8f2a1d567538ddc1b045bcdb29cb9e05919b60
- 6748c22d76b8803e2deb3dad1e1fa7a8d8ff1e968eb340311fd82ea5d7277019
- e133e05d6941ef1c2e3281f1abb837c3e152fdeaffefde84ffe25338fe02c56d
- 43dc911a2e396791dc5a0f8996ae77ac527add02118adf66ac5c56291269527e
- af0292e4de92032ede613dc69373de7f5a182d9cbba1ed49f589ef484ad1ee3e
- 2c1566a2e03c63b67fbdd80b4a67535e9ed969ea3e3013f0ba503cfa58e287e3
- 98c05ae70e69e3585fc026e67b356421f0b3d6ab45b45e8cc5eb35f16fef130c
- 300a92a67940cfafeed1cf1c0af25f4869598ae58e615ecc559434111ab717cd

- a363dea1efda1991d6c10cc637e3ab7d8e4af4bd2d3938036f03633a2cb20e88
- 0c280f0b7c16c0d299e306d2c97b0bff3015352d2b3299cf485de189782a4e25
- f962b594a847f47473488a2b860094da45190738f2825d82afc308b2a250b5fb
- 4ceb27da700807be6aa3221022ef59ce6e9f1cda52838ae716746c1bbdee7c3d
- 3e1a03f1dd10c3e050b5f455f37e946c214762ed9516996418d34a246daed521
- 3bee59d74c24ef33351dc31ba697b99d41c8898685d143cd48bccdff707547c0
- c71ff7514c8b7c448a8c1982308aaffed94f435a65c9fdc8f0249a13095f665e

References

[1] Gobs of data
https://go.dev/blog/gob

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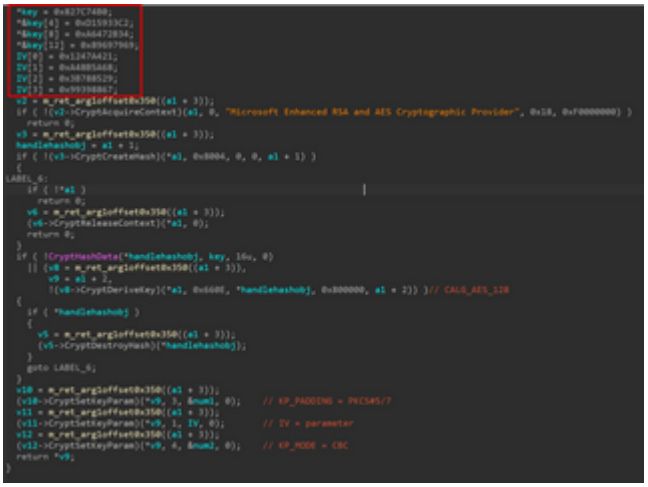
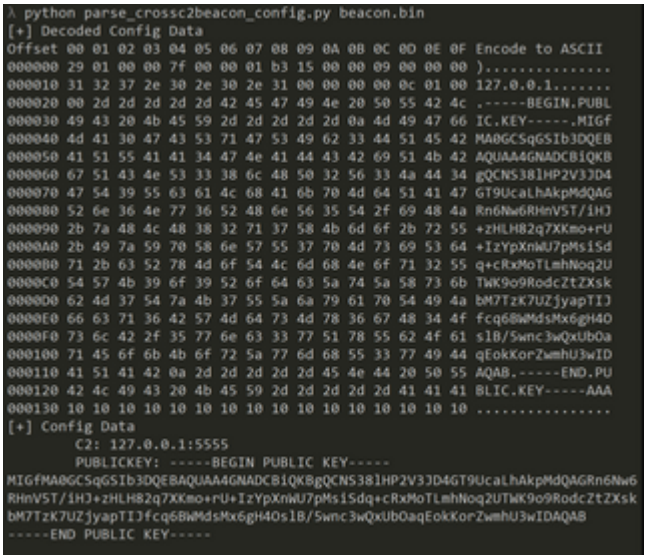
Yuma has been engaged in malware analysis in JPCERT/CC Cyber Security Coordination Group since 2020.

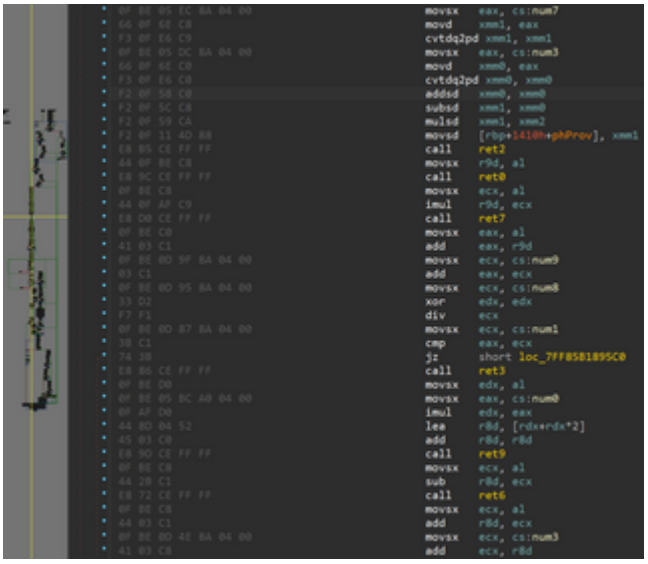
Related articles

- 

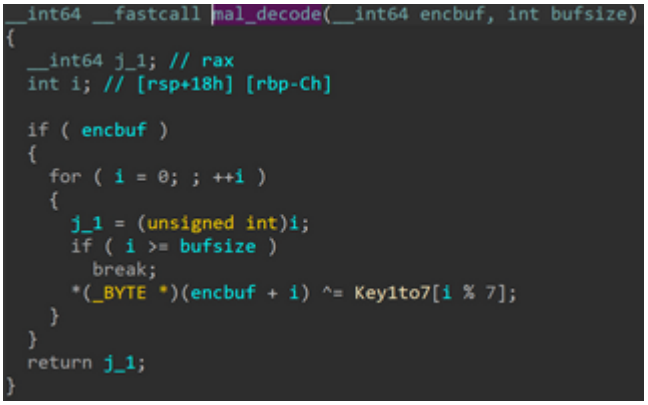
  Update on Attacks by Threat Group APT-C-60



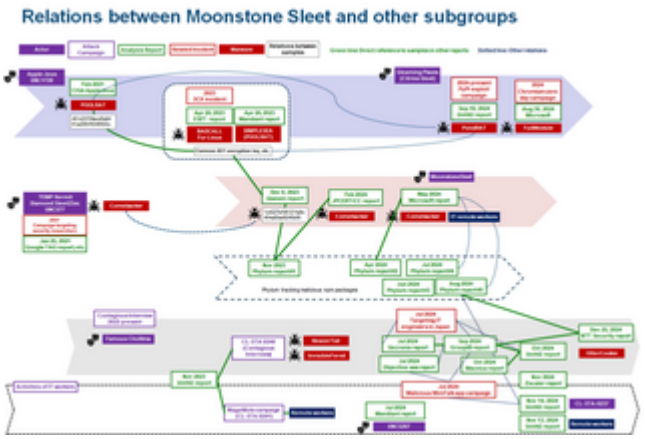
- [CrossC2 Expanding Cobalt Strike Beacon to Cross-Platform Attacks]



- [Malware Identified in Attacks Exploiting Ivanti Connect Secure Vulnerabilities]



- [DslogdRAT Malware Installed in Ivanti Connect Secure]

- 

[Tempted to Classifying APT Actors: Practical Challenges of Attribution in the Case of Lazarus's Subgroup]

Source: https://blogs.jpcert.or.jp/en/2023/05/gobrat.html