RotaJakiro, the Linux version of the OceanLotus

blog.netlab.360.com/rotajakiro_linux_version_of_oceanlotus/

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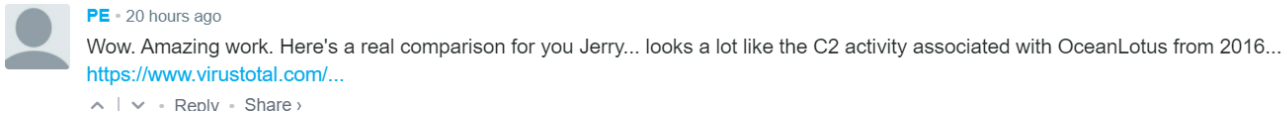
On Apr 28, we published our **RotaJakiro** backdoor blog, at that time, we didn't have the answer for a very important question, what is this backdoor exactly for? We asked the community for clues and two days ago we got a hint, `PE` (Thanks!) wrote the following comment on our blog post.



The sample mentioned in the message is a zip packing file, which has appeared in 2016. The zip contains multiple files, the Mach-O format executable file named `Noi dung chi tiet` (translated to `detailed information`) is the OceanLotus sample. When we compare the this file with the RotaJakiro sample, we noticed there are multiple similarities and it is `VERY likely` that this is **the Linux version of the OceanLotus**.

Similarity 1: Function for C2 session creation

The common domain name resolution function for Linux is `gethostbyname()`, but RotaJakiro uses the relatively niche `getaddrinfo()` function. C2 domain name resolution and session establishment are performed in one function, this is also used by the the OceanLotus sample. The comparison of the 2 functions is as follows.

RotaJakiro

```
*(_QWORD *)s = 0LL;
v16 = __readfsqword(0x28u);
memset(&req, 0, sizeof(req));
req.ai_family = 2;
v15 = 0;
req.ai_socktype = 1;
sprintf(s, "%d", v2);
if ( getaddrinfo(name, s, &req, &pai) )
  return 0LL;
v3 = pai;
if ( pai )
{
  while ( 1 )
  {
    v4 = socket(v3->ai_family, v3->ai_socktype, v3->ai_protocol);
    v1 = v4;
    if ( v4 != -1 )
    {
      if ( connect(v4, v3->ai_addr, v3->ai_addrlen) != -1 )
      {
        freeaddrinfo(pai);
        optval = 1;
        setsockopt(v1, 6, 1, &optval, 4u);
```

OceanLotus

```
*(_OWORD *)&v6.ai_addr = 0LL;
*(_OWORD *)&v6.ai_addrlen = 0LL;
v6.ai_family = 2;
v6.ai_socktype = 1;
v6.ai_flags = 0;
v6.ai_protocol = 0;
v9 = 0;
*(_QWORD *)v8 = 0LL;
sprintf(v8, "%d", *((unsigned int *)c2_info + 3));
if ( getaddrinfo(*(const char **)((char *)c2_info + 4), v8, &v6, &v5) )
  return 0LL;
for ( i = v5; i; i = i->ai_next )
{
  v2 = socket(i->ai_family, i->ai_socktype, i->ai_protocol);
  *(_DWORD *)c2_info = v2;
  if ( v2 != -1 )
  {
    v3 = 1;
    if ( connect(v2, i->ai_addr, i->ai_addrlen) != -1 )
      goto LABEL_9;
    close(*(_DWORD *)c2_info);
  }
```

It can be seen that they not only have the same function, but also use `sprintf() and getaddrinfo()` in almost exactly the same way. In addition, both RotaJakiro and

OceanLotus use separate data structures to hold C2 session information, such as `socket fd, whether active, timeout`, etc., and their data structures are also very similar.

```
*(_DWORD *)v7 = a2;
v7[4] = 1;
*((_DWORD *)v7 + 2) = 300;
```

RotaJakiro

VS

```
*(_DWORD *)(a1 + 12) = v3;
*(_DWORD *)(a1 + 16) = 300;
*(_WORD *)(a1 + 20) = 1;
```

OceanLotus

Similarity 2: registration packet construction method

The network packets of both RotaJakiro and OceanLotus are composed of `Head, Key, and Payload`, of which Head is mandatory and has a length of 82 bytes, while Key and Payload are optional.

- Offset 1, type DWORD, which holds a magic.
- Offset 9, type DWORD, holding the length of the Payload.
- Offset 13, type WORD, holding the Key length.
- Offset 15, type DWORD, holds the message code.

The RotaJakiro initializes the Head of the registration packets with a separate function.

```
{
  char *register_buf; // rbx
  unsigned int v1; // eax
  char *result; // rax

  register_buf = (char *)malloc(0x52uLL);
  v1 = time(0LL);
  srand(v1);
  *register_buf = rand();
  *(_DWORD *)(register_buf + 1) = 0x3B91011;
  *(_DWORD *)(register_buf + 5) = 0x4FB0CB1;
  *(_WORD *)(register_buf + 13) = 0;
  *(_DWORD *)(register_buf + 9) = 0;
  register_buf[19] = 0xC2u;
  *((_DWORD *)register_buf + 5) = 0x1206420;
  register_buf[24] = 0xE2u;
  *(_DWORD *)(register_buf + 25) = 0;
  register_buf[29] = 0xC2u;
  *(_DWORD *)(register_buf + 30) = 0;
  bzero(register_buf + 34, 0x20uLL);
  result = register_buf;
  register_buf[66] = -56;
  *(_WORD *)(register_buf + 75) = 255;
  register_buf[77] = 9;
  return result;
}
```

This function first calls the malloc() function to dynamically allocate memory for the registrationpacket, then calls the time()/srand()/rand() function in turn to generate a random character and then assign it to the first field of the registration packet, and the remaining large swath of code is to assign values to the remaining fields one by one with multiple constants, so the most obvious feature of this function is to `initialize the registration packet with multiple constants`.

There is also a function in the OceanLotus sample that is dedicated to initializing the Head of the registration packets.

```
{
  *(_DWORD *)(a1 + 1) = 0x3B91011;
  *(_DWORD *)(a1 + 5) = 0x54F051C;
  *(_DWORD *)(a1 + 9) = 0;
  *(_WORD *)(a1 + 13) = 0;
  *(_BYTE *)(a1 + 19) = 0x7F;
  *(_BYTE *)(a1 + 24) = 0xE2u;
  *(_BYTE *)(a1 + 29) = 0x7F;
  *(_DWORD *)(a1 + 62) = 0;
  *(_QWORD *)(a1 + 54) = 0LL;
  *(_QWORD *)(a1 + 46) = 0LL;
  *(_QWORD *)(a1 + 38) = 0LL;
  *(_QWORD *)(a1 + 30) = 0LL;
  *(_BYTE *)(a1 + 66) = 0xE9u;
  *(_WORD *)(a1 + 75) = 0xFF;
  *(_BYTE *)(a1 + 77) = 9;
  *(_QWORD *)(a1 + 122) = 0LL;
  *(_QWORD *)(a1 + 114) = 0LL;
  *(_QWORD *)(a1 + 106) = 0LL;
  *(_QWORD *)(a1 + 98) = 0LL;
  *(_QWORD *)(a1 + 90) = 0LL;
  *(_QWORD *)(a1 + 82) = 0LL;
  *(_DWORD *)(a1 + 15) = a2;
  *(_DWORD *)(a1 + 20) = a3;
  *(_DWORD *)(a1 + 25) = a4;
}
```

This function has no code for memory allocation and random character generation, and the whole function uses multiple constants to assign values to specific fields of the registration packet one by one, `exactly like the RotaJakiro`. In addition, OceanLotus shares the same field values with RotaJakiro at offsets 1, 24 and 75, especially the magic at offset 1 is `0x3B91011`, which is hard to describe as a coincidence, so it greatly increases the probability that these two pieces of code are the same origin. In addition, both the RotaJakiro and the OceanLotus have assigned message codes to the registration packets, and both are `0x2170272`:

```
if ( (unsigned int)sub_4046E0((__int64)v5, 0x2170272, 0x3B91011) )
```
RotaJakiro

VS

```
if ( sub_10000316A(*((_QWORD *)v1 + 2), 0x2170272LL, 0x3B91011) )
```
OceanLotus

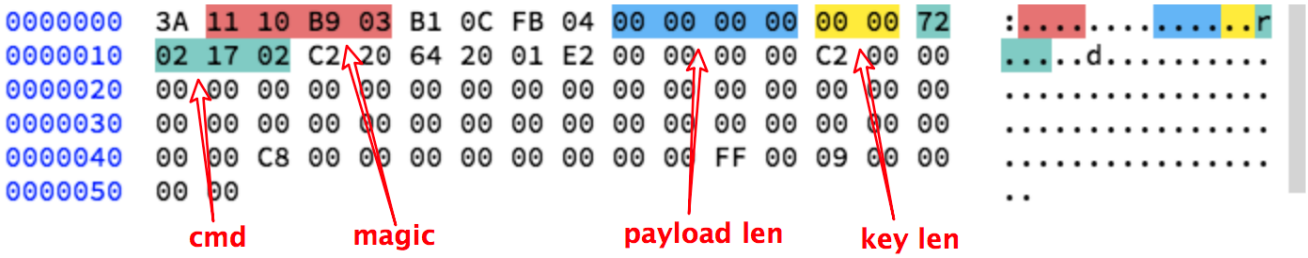
The resulting registration packets is also very similar, and the RotaJakiro registration packets is as follows.

```
00000000  24 41 61 54 03 55 e2 1c  e3 63 63 63 63 63 63 2d   $AaT.U.. .cccccc-
00000010  23 81 23 3b 67 ef 67 43  3f 63 63 63 63 3b 63 63   #.#;g.gC ?cccc;cc
00000020  63 63 63 63 63 63 63 63  63 63 63 63 63 63 63 63   cccccccc cccccccc
00000030  63 63 63 63 63 63 63 63  63 63 63 63 63 63 63 63   cccccccc cccccccc
00000040  63 63 7a 63 63 63 63 63  63 63 63 9c 63 42 63 63   cczccccc ccc.cBcc
00000050  63 63                                             cc
```

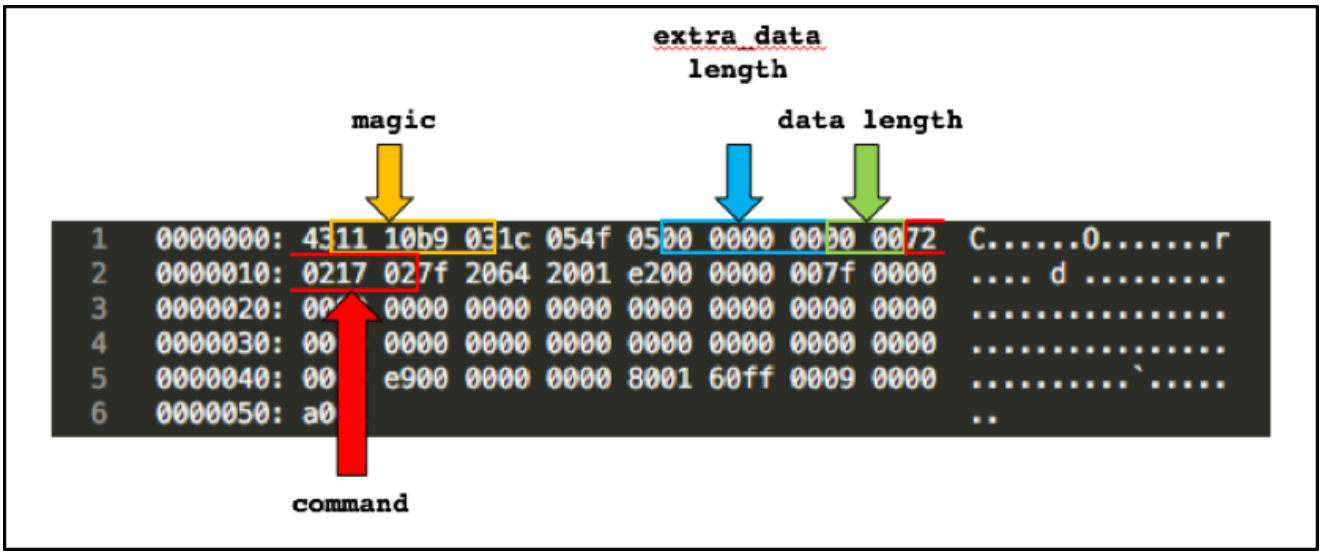
The following is the OceanLotus registration packets analyzed by PAN in 2017.

```
00000000  0b 41 61 54 03 e0 c3 8a  c3 63 63 63 63 63 63 2d   .AaT.... .cccccc-
00000010  23 81 23 8c 67 ef 67 43  3f 63 63 63 63 8c 63 63   #.#.g.gC ?cccc.cc
00000020  63 63 63 63 63 63 63 63  63 63 63 63 63 63 63 63   cccccccc cccccccc
00000030  63 63 63 63 63 63 63 63  63 63 63 63 63 63 63 63   cccccccc cccccccc
00000040  63 63 5e 63 63 63 63 63  73 43 6f 9c 63 42 63 63   cc^ccccc sCo.cBcc
00000050  77 43                                             wC
```

The decrypted registration packets for the RotaJakiro is shown below.



The following is the OceanLotus plaintext registration packets from PAN's analysis.



You can see that they have the same plaintext structure and basically the same key field values.

Similarity 3: rotate function

Both RotaJakiro and OceanLotus have a function we called `rotate()` for encryption/decryption, the rotate function of RotaJakiro is as follows.

```
  v3 = a1;
  if ( a2 > 0 )
  {
    v4 = 0;
    do
    {
      while ( !a3 )
      {
        ++v4;
        LOBYTE(v3) = __ROL1__(v3, 1);
        if ( a2 == v4 )
          return v3;
      }
      v5 = (v3 & 1) << 7;
      LOBYTE(v3) = (char)v3 >> 1;
      if ( (v3 & 0x80u) != 0 )
        v3 = v5 | (v3 - 128);
      else
        v3 |= v5;
      ++v4;
    }
    while ( a2 != v4 );
  }
  return v3;
}
```

For OceanLotus

```
if ( a2 > 0 )
{
  do
  {
    if ( a3 )
    {
      v3 = (char)a1;
      v4 = (_BYTE)a1 << 7;
      v5 = v3 >> 1;
      if ( v3 & 0x100 )
        LOBYTE(v5) = v5 + -128;
      LOBYTE(a1) = v5 | v4;
    }
    else
    {
      a1 = ((unsigned __int8)a1 >> 7) | (unsigned __int8)(2 * a1);
    }
    --a2;
  }
  while ( a2 );
}
return (unsigned int)(char)a1;
}
```

It is easy to see the commonalities between them.

1. Both accept 3 parameters.
2. The prototype is the same, where the first parameter is the actual rotate object, the second parameter is the length field, and the third parameter plays a control role.

In actual use, for example, in the process of encrypting the registration packets, you can see that the RotaJakiro and the OceanLotus `use the same parameters`.

```
*(++v8 - 1) = rotete((char)(v10 ^ 0x1B), 3, 1);          RotaJakiro
```

VS

```
result = (void *)rotate(*((char *)*a2 + v7) ^ 0x1Bu, 3, 1); OceanLotus
```

Similarity 4: Same instruction code

Both RotaJakiro and OceanLotus use DWORD type instruction codes to specify the function of the message, and share several semantically identical instruction codes, some of which are featured as shown in the following table.

Cmd	Function

Cmd	Function
0x18320e0	Upload device Info
0x2170272	Register
0x1B25503	execute function from a plugin(a aynamic library)
0x1532e65	execute function from a plugin(a aynamic library)
0x25D5082	execute function from a plugin(a aynamic library)

This similarity obviously cannot be explained by coincidence, **it is an extremely strong evidence of their code homology**.

Summary

Although the RotaJakiro and the Mac version of the OceanLotus are implemented in different languages, their similarity in function and message format design, and their similarity in specific implementation, can no longer be explained by coincidence. **It is highly likely that RotaJakiro is a Linux version of the OceanLotus.**