WEDNESDAY, JUNE 6, 2018

# VPNFilter Update - VPNFilter exploits endpoints, targets new devices


## INTRODUCTION

Cisco Talos, while working with our various intelligence partners, has discovered additional details regarding "VPNFilter." In the days since we first published our findings on the campaign, we have seen that VPNFilter is targeting more makes/models of devices than initially thought, and has additional capabilities, including the ability to deliver exploits to endpoints. Talos recently published a blog about a broad campaign that delivered VPNFilter to small home-office network devices, as well as network-attached storage devices. As we stated in that post, our research into this threat was, and is, ongoing. In the wake of that post, we have had a number of partners step forward with additional information that has assisted us in our work. This post is an update of our findings over the past week.

First, we have determined that additional devices are being

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targeted by this actor, including some from vendors that are new to the target list. These new vendors are ASUS, D-Link, Huawei, Ubiquiti, UPVEL, and ZTE. New devices were also discovered from Linksys, MikroTik, Netgear, and TP-Link. Our research currently shows that no Cisco network devices are affected. We've provided an updated device list below.

We have also discovered a new stage 3 module that injects malicious content into web traffic as it passes through a network device. At the time of our initial posting, we did not have all of the information regarding the suspected stage 3 modules. The new module allows the actor to deliver exploits to endpoints via a man-in-the-middle capability (e.g. they can intercept network traffic and inject malicious code into it without the user's knowledge). With this new finding, we can confirm that the threat goes beyond what the actor could do on the network device itself, and extends the threat into the networks that a compromised network device supports. We provide technical details on this module, named "ssler" below.

Additionally, we've discovered an additional stage 3 module that provides any stage 2 module that lacks the kill command the capability to disable the device. When executed, this module specifically removes traces of the VPNFilter malware from the device and then renders the device unusable. Analysis of this module, called "dstr," is also provided below.

Finally, we've conducted further research into the stage 3 packet sniffer, including in-depth analysis of how it looks for Modbus traffic.

## Technical details

### NEW THIRD-STAGE MODULES

'ssler' (Endpoint exploitation module — JavaScript injection)

The ssler module, which we pronounce as "Esler," provides data exfiltration and JavaScript injection capabilities by intercepting all traffic passing through the device destined for port 80. This module is expected to be executed with a parameter list, which determines the module's behavior and which websites should be targeted. The first positional parameter controls the folder on the device where stolen data should be stored. The purpose of the other named parameters are as follows:

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- dst: — Used by the iptables rules created to specify a destination IP address or CIDR range that the rule should apply to.
- src: — Used by the iptables rules created to specify a source IP address or CIDR range that the rule should apply to.
- dump: — Any domain passed in a dump parameter will have all of its HTTP headers recorded in the reps_*.bin file.
- site: — When a domain is provided in the "site" parameter, this domain will have its web pages targeted for JavaScript injection.
- hook: — This parameter determines the URL of the JavaScript file for injection.

The first action taken by the ssler module is to configure the device's iptables to redirect all traffic destined for port 80 to its local service listening on port 8888. It starts by using the insmod command to insert three iptables modules into the kernel (ip_tables.ko, iptable_filter.ko, iptable_nat.ko) and then executes the following shell commands:

- iptables -I INPUT -p tcp --dport 8888 -j ACCEPT
- iptables -t nat -I PREROUTING -p tcp --dport 80 -j REDIRECT --to-port 8888
- Example: ./ssler logs src:192.168.201.0/24 dst:10.0.0.0/16

-A PREROUTING -s 192.168.201.0/24 -d 10.0.0.0/16 -p tcp -m tcp --dport 80 -j REDIRECT --to-ports 8888

Note: To ensure that these rules do not get removed, ssler deletes them and then adds them back approximately every four minutes.

Any outgoing web requests on port 80 are now intercepted by ssler and can be inspected and manipulated before being sent to the legitimate HTTP service. All HTTP requests are sslstripped. That is, the following changes are made to requests before being sent to the true HTTP server:

- Any instances of the string https:// are replaced with http://, converting requests for secure HTTP resources to requests for insecure ones so sensitive data such as credentials can be extracted from them.

- If the request contains the header Connection: keep-alive, it is replaced with Connection: close
- If the request contains the header Accept-Encoding with the gzip value, this is converted to Accept-Encoding: plaintext/none so no responses will be compressed with gzip (exceptions are made for certain file types, such as images).

If the host is in one of the dump: parameters, the details of the request are saved to the disk for exfiltration, including the URL, port and all of the request headers. If the host is not in a dump: parameter, it will only dump requests with an Authorization header or URLs that have credentials in them. URLs are determined to have credentials if they contain either the string assword= or ass= and one of the following strings in them:

- sername=
- ser=
- ame=
- ogin=
- ail=
- hone=
- session%5Busername
- session%5Bpassword
- session[password

Any POST requests to accounts.google.com containing the string signin will also be dumped.

After these modifications are made, a connection to the true HTTP server is made by ssler using the modified request data over port 80. Ssler receives the response from the HTTP server and makes the following changes to the response before passing it on to the victim:

- A response with an https:// in its Location header value is converted to http://
- The following headers are ignored, i.e. not sent to the client:
    - Alt-Scv
    - Vary
    - Content-MD5
    - content-security-policy

    - content-security-policy
    - X-FB-Debug
    - public-key-pins-report-only
    - Access-Control-Allow-Origin
- The entire response is sslstripped — that is, all instances of https:// with \x20http://.
- If parameter site: is provided a domain (or part of a domain, e.g. "google"), it will attempt to inject JavaScript into all Content-Type: text/html or Content-Type: text/javascript responses. The requirement is that the string <meta name= … > be present and long enough to fit the string from the hook: parameter. The <meta name= … > tag will be replaced with <script type="text/javascript" src="[hook value]">. The victim IP combined with the site is then added to an internal whitelist in ssler and will not be targeted for injection again until the whitelist is cleared (which occurs every four days).

Each domain that is sslstripped in the responses (e.g. domains found in links) is then added to a list of stripped domains. Subsequent requests that are intercepted by the ssler module to domains in this list will occur via HTTPS over port 443, instead of HTTP over port 80. By default, four domains are on this list, so ssler will always connect to these domains via HTTPS over port 443: www.google.com, twitter.com, www.facebook.com, or www.youtube.com.

'dstr' (device destruction module)

The dstr modules are used to render an infected device inoperable by deleting files necessary for normal operation. It deletes all files and folders related to its own operation first before deleting the rest of the files on the system, possibly in an attempt to hide its presence during a forensic analysis.

The x86 version of the dstr module was analyzed in-depth. This module first deleted itself from the disk and then stops the execution of the parent Stage 2 process. It will then search all running process for ones named vpnfilter, security, and tor and terminate them. Next, it explicitly deletes the following files and directories:

- /var/tmp/client_ca.crt
- /var/tmp/client.key
- /var/tmp/client.crt
- /var/run/vpnfilterm/htpx

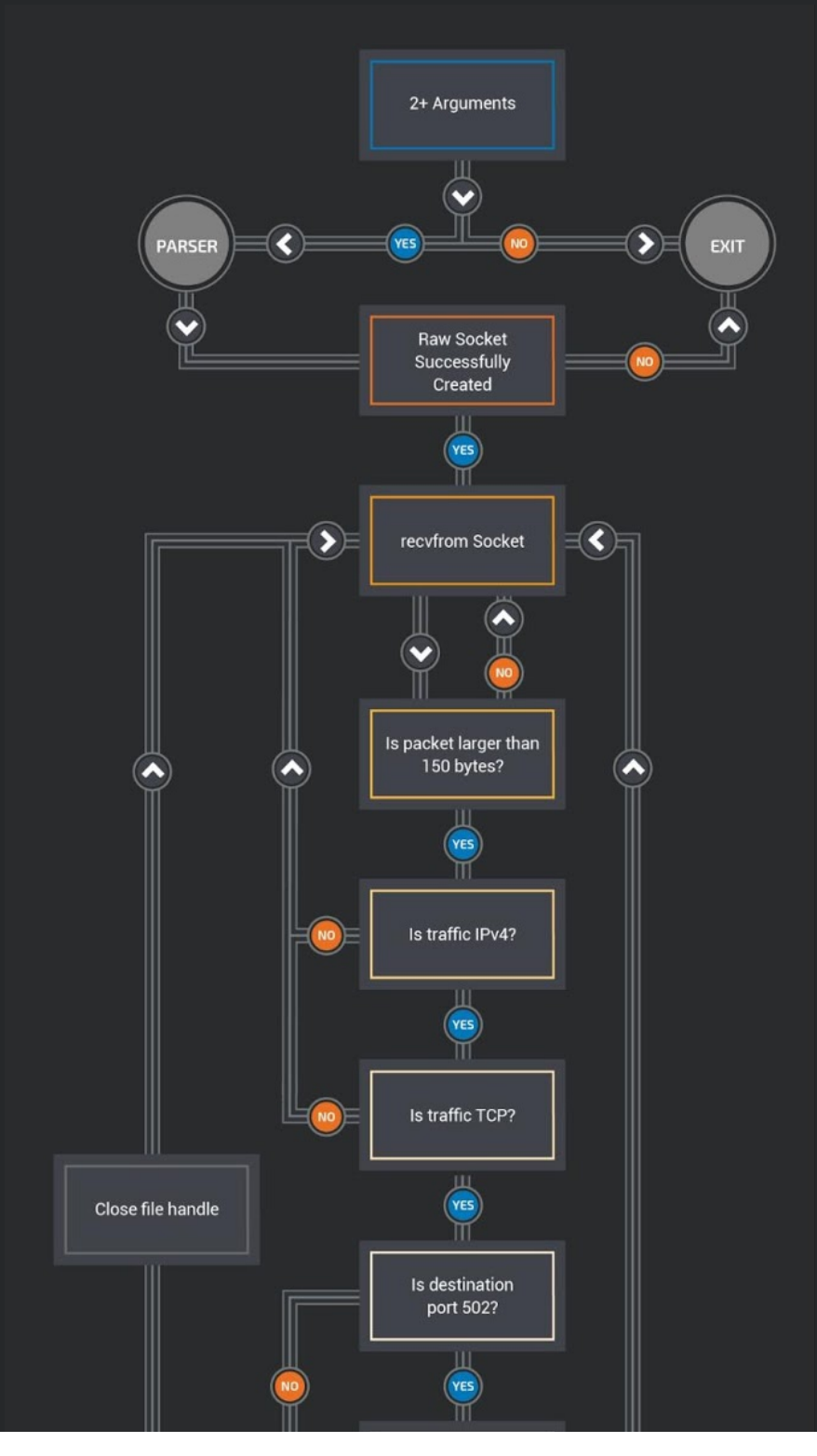
- /var/run/vpnfilterm/httpx
- /var/run/vpnfilter
- /var/run/vpn.tmp
- /var/run/vpn.pid
- /var/run/torrc
- /var/run/tord/hidden_ssh/private_key
- /var/run/tord/hidden_ssh/hostname
- /var/run/tor
- /var/run/msvf.pid
- /var/run/client_ca.crt
- /var/run/client.key
- /var/run/client.crt
- /var/pckg/mikrotik.o
- /var/pckg/.mikrotik.
- /var/msvf.pid
- /var/client_ca.crt
- /var/client.key
- /var/client.crt
- /tmp/client_ca.crt
- /tmp/client.key
- /tmp/client.crt
- /flash/nova/etc/loader/init.x3
- /flash/nova/etc/init/security
- /flash/nova/etc/devel-login
- /flash/mikrotik.o
- /flash/.mikrotik.
- /var/run/vpnfilterw/
- /var/run/vpnfilterm/
- /var/run/tord/hidden_ssh/
- /var/run/tord/
- /flash/nova/etc/loader/
- /flash/nova/etc/init/

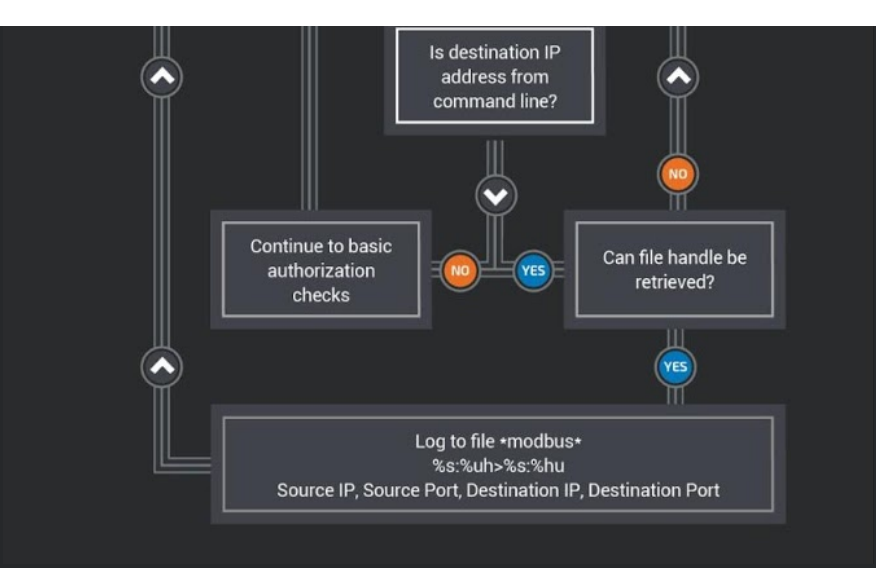
The dstr module clears flash memory by overwriting the bytes of all available /dev/mtdX devices with a 0xFF byte. Finally, the shell command rm -rf /* is executed to delete the remainder of the file system and the device is rebooted. At this point, the device will not have any of the files it needs to operate and fail to boot.

Additional research on the third stage packet sniffer

'ps' (stage 3 packet sniffer)

One of stage 3 packet sniffer module samples we have is the R600VPN MIPS-like (Lexra architecture) sample. This sample is a packet sniffer that is looking for basic authentication as well as monitoring ICS traffic, and is specific to the TP-LINK R600-VPN. The malware uses a raw socket to look for connections to a pre-specified IP address, only looking at TCP packets that are 150 bytes or larger (note: This is the full packet size, with headers. Depending on the size of the TCP header, the PDU could be approximately 56 to 96 bytes and still meet the criteria to get logged). It has the ability to view, but not modify, the network traffic. Very significant changes would be required to implement functionality that could modify traffic.






Packets that are not on port 502, are scanned for BasicAuth, and that information is logged.

- Else: (non-Modbus traffic): sniffing HTTP basic auth credentials
    - Destination IP Address == command line argument IP address
    - Source port > 1024
    - Source port != 8080
    - Source port != 8088
    - Packet Data length > 20 bytes
    - Packet does not contain
        - </ and >
        - <?xml
        - Basic Og==
        - /tmUnblock.cgi
        - Password Required
        - <div
        - <form
        - <input
        - this. and .get
        - {
        - }
        - 200 OK
        - <span
        - <SPAN
        - <DIV
    - Packet contains 'Authorization: Basic' OR one user/pass combination
        - User

        - User=
        - user=
        - Name=
        - name=
        - Usr=
        - usr=
        - Login=
        - login=
    - Pass
        - Pass=
        - pass=
        - Password=
        - password=
        - Passwd=
        - passwd=

- Logging: Logs on IPs and ports, but not the packet contents on port 502. It does not validate the traffic as Modbus.
    - Modbus - Logs SourceIP, SourcePort, DestinationIP, DestinationPort and labels it *modbus*
    - All Other - write full packet to log file if and only if it passes basic auth check

## Conclusion

These new discoveries have shown us that the threat from VPNFilter continues to grow. In addition to the broader threat surface found with additional targeted devices and vendors, the discovery of the malware's capability to support the exploitation of endpoint devices expands the scope of this threat beyond the devices themselves, and into the networks those devices support. If successful, the actor would be able to deploy any desired additional capability into the environment to support their goals, including rootkits, exfiltration capability and destructive malware.

Talos would like to thank all of the individual researchers, companies and intelligence partners from around the world who have stepped forward to share information and address this threat. Your actions have helped us gain a greater understanding

of this campaign, and in some cases, have directly improved the situation. We recognize this is a team sport, and truly appreciate your assistance.

We will continue to monitor VPNFilter and work with our partners to understand the threat as it continues to evolve in order to ensure that our customers remain protected and the public is informed.

## Updated List of IOCs

As stated previously, we highly suspect that there are additional IOCs and versions of this malware that we are not currently aware of. The following list of IOCs comprises what we know as of this date. News IOCs are in BOLD below.

## Known C2 Domains and IPs

### ASSOCIATED WITH THE 1ST STAGE

photobucket[.]com/user/nikkireed11/library
photobucket[.]com/user/kmila302/library
photobucket[.]com/user/lisabraun87/library
photobucket[.]com/user/eva_green1/library
photobucket[.]com/user/monicabelci4/library
photobucket[.]com/user/katyperry45/library
photobucket[.]com/user/saragray1/library
photobucket[.]com/user/millerfred/library
photobucket[.]com/user/jeniferaniston1/library
photobucket[.]com/user/amandaseyfried1/library
photobucket[.]com/user/suwe8/library
photobucket[.]com/user/bob7301/library
toknowall[.]com

### ASSOCIATED WITH THE 2ND STAGE

91.121.109[.]209
217.12.202[.]40
94.242.222[.]68
82.118.242[.]124
46.151.209[.]33
217.79.179[.]14

91.214.203[.]144
95.211.198[.]231
195.154.180[.]60
5.149.250[.]54
94.185.80[.]82
62.210.180[.]229
91.200.13[.]76
23.111.177[.]114

6b57dcnonk2edf5a[.]onion/bin32/update.php
tljmmy4vmkqbdof4[.]onion/bin32/update.php
zuh3vcyskd4gipkm[.]onion/bin32/update.php
4seiwn2ur4f65zo4.onion/bin256/update.php
zm3lznxn27wtzkwa.onion/bin16/update.php

## Known File Hashes

### 1ST STAGE MALWARE

50ac4fcd3fbc8abcaa766449841b3a0a684b3e217fc40935f1ac22c34c58a9ec
0e0094d9bd396a6594da8e21911a3982cd737b445f591581560d766755097d92
b9770ec366271dacdae8f5088218f65a6c0dd82553dd93f41ede586353986124
51e92ba8dac0f93fc755cb98979d066234260eafc7654088c5be320f431a34fa
6a76e3e98775b1d86b037b5ee291ccfcffb5a98f66319175f4b54b6c36d2f2bf
313d29f490619e796057d50ba8f1d4b0b73d4d4c6391cf35baaaace71ea9ac37

### 2ND STAGE MALWARE

9683b04123d7e9fe4c8c26c69b09c2233f7e1440f828837422ce330040782d17
d6097e942dd0fdc1fb28ec1814780e6ecc169ec6d24f9954e71954eedbc4c70e
4b03288e9e44d214426a02327223b5e516b1ea29ce72fa25a2fcef9aa65c4b0b
9eb6c779dbad1b717caa462d8e040852759436ed79cc2172692339bc62432387
37e29b0ea7a9b97597385a12f525e13c3a7d02ba4161a6946f2a7d978cc045b4

7d978cc045b4
776cb9a7a9f5afbaffdd4dbd052c6420030b2c7c3058c1455e0a7
9df0e6f7a1d
8a20dc9538d639623878a3d3d18d88da8b635ea52e5e2d0c2cc
e4a8c5a703db1
0649fda8888d701eb2f91e6e0a05a2e2be714f564497c44a3813
082ef8ff250b
2ffbe27983bc5c6178b2d447d8121cefaa5ffa87fe7b9e4f68272c
e54787492f
1e741ec9452aab85a2f7d8682ef4e553cd74892e629012d903b5
21b21e3a15bf
90efcaeac13ef87620bcaaf2260a12895675c74d0820000b3cd15
2057125d802
eaf879370387a99e6339377a6149e289655236acc8de88324462
dcd0f22383ff
081e72d96b750a38ef45e74d0176beb982905af4df6b8654ea81
768be2f84497
24b3931e7d0f65f60bbb49e639b2a4c77de83648ff08e097ff0fa6
a53f5c7102
4497af1407d33faa7b41de0c4d0741df439d2e44df1437d8e5837
37a07ec04a1
579b2e6290c1f7340795e42d57ba300f96aef035886e80f80cd5d
0bb4626b5fc
eeb3981771e448b7b9536ba5d7cd70330402328a884443a8996
96a661e4e64e5
952f46c5618bf53305d22e0eae4be1be79329a78ad7ec34232f2
708209b2517c
e70a8e8b0cd3c59cca8a886caa8b60efb652058f50cc9ff73a90b
c55c0dc0866
5be57b589e5601683218bb89787463ca47ce3b283d8751820d3
0eee5e231678c
fe46a19803108381d2e8b5653cc5dce1581a234f91c555bbfff63
b289b81a3dc
ae1353e8efe25b277f52decfab2d656541ffdf7fd10466d3a73465
8f1bc1187a
2ef0e5c66f6d46ddef62015ea786b2e2f5a96d94ab9350dd1073d
746b6922859
181408e6ce1a215577c1daa195e0e7dea1fe9b785f9908b4d8e9
23a2a831fce8
2aa7bc9961b0478c552daa91976227cfa60c3d4bd8f051e3ca74
15ceaeb604ca
375ededc5c20af22bdc381115d6a8ce2f80db88a5a92ebaa43c7
23a3d27fb0d6
0424167da27214cf2be0b04c8855b4cdb969f67998c6b8e719dd
45b377e70353
7e5dca90985a9fac8f115eaacd8e198d1b06367e929597a3decd
452aaa99864b

8de0f244d507b25370394ba158bd4c03a7f24c6627e42d9418fb
992a06eb29d8
7ee215469a7886486a62fea8fa62d3907f59cf9bf5486a5fe3a0da
96dabea3f9
ff70462cb3fc6ddd061fbd775bbc824569f1c09425877174d43f0
8be360b2b58
f5d06c52fe4ddca0ebc35fddbbc1f3a406bdaa5527ca831153b74
f51c9f9d1b0
bc51836048158373e2b2f3cdb98dc3028290e8180a4e460129fe
f0d96133ea2e
d9a60a47e142ddd61f6c3324f302b35feeca684a71c09657ddb4
901a715bd4c5
95840bd9a508ce6889d29b61084ec00649c9a19d44a29aedc86
e2c34f30c8baf
3bbdf7019ed35412ce4b10b7621faf42acf604f91e5ee8a903eb5
8bde15688ff
9b455619b4cbfeb6496c1246ba9ce0e4ffa6736fd536a0f99686c
7e185eb2e22
bfd028f78b546eda12c0d5d13f70ab27dff32b04df3291fd46814f
486ba13693
a15b871fcb31c032b0e0661a2d3dd39664fa2d7982ff0dbc0796f
3e9893aed9a
d1bc07b962ccc6e3596aa238bb7eda13003ea3ca95be27e8244e
485165642548
eec5cd045f26a7b5d158e8289838b82e4af7cf4fc4b9048eaf185
b5186f760db
29ae3431908c99b0fff70300127f1db635af119ee55cd8854f6d3
270b2e3032e
ca0bb6a819506801fa4805d07ee2ebaa5c29e6f5973148fe25ed6
d75089c06a7
6d8877b17795bb0c69352da59ce8a6bfd7257da30bd0370eed8
428fad54f3128
5cf43c433fa1e253e937224254a63dc7e5ad6c4b3ab7a66ec9db
76a268b4deeb
a6e3831b07ab88f45df9ffac0c34c4452c76541c2acd215de8d01
09a32968ace
f4f0117d2784a3b8dfef4b5cb7f2583dd4100c32f9ee020f164025
08e073f0a1
7093cc81f32c8ce5e138a4af08de6515380f4f23ed470b89e6613
bee361159e1
350eaa2310e81220c409f95e6e1e53beadec3cffa3f119f60d0daa
ce35d95437
776cb9a7a9f5afbaffdd4dbd052c6420030b2c7c3058c1455e0a7
9df0e6f7a1d
d2de662480783072b82dd4d52ab6c57911a1e84806c229f614b
26306d5981d98
c8a82876beed822226192ea3fe01e3bd1bb0838ab13b24c3a692

6bce6d84411b
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e65e7ab50d92
8a20dc9538d639623878a3d3d18d88da8b635ea52e5e2d0c2cc
e4a8c5a703db1
0649fda8888d701eb2f91e6e0a05a2e2be714f564497c44a3813
082ef8ff250b
2c2412e43f3fd24d766832f0944368d4632c6aa9f5a9610ab39d2
3e79756e240
218233cc5ef659df4f5fdabe028ab43bc66451b49a6bfa85a5ed4
36cfb8dbc32
cccbf9bff47b3fd391274d322076847a3254c95f95266ef06a3ca8
be75549a4b
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6417de379c5
4896f0e4bc104f49901c07bc84791c04ad1003d5d265ab7d99fd
5f40ec0b327f
5e715754e9da9ed972050513b4566fb922cd87958ecf472d1d14
cd76923ae59a
797e31c6c34448fbecda10385e9ccfa7239bb823ac8e33a4a7fd1
671a89fe0f6
48bfcbc3162a0b00412cba5eff6c0376e1ae4cfbd6e35c9ea92d2
ab961c90342
7a66d65fa69b857beeeaaef67ec835900eee09a350b6f51f51c83
919c9223793
b0edf66d4f07e5f58b082f5b8479d48fbab3dbe70eba0d7e8254c
8d3a5e852ef
840ba484395e15782f436a7b2e1eec2d4bf5847dfd5d4787ae64f
3a5f668ed4f
80c20db74c54554d9936a627939c3c7ea44316e7670e2f7f5231
c0db23bc2114
5dabbce674b797aaa42052b501fb42b20be74d9ffcb0995d933fb
f786c438178
055bbe33c12a5cdaf50c089a29eaecba2ccf312dfe5e96183b810
eb6b95d6c5a
c084c20c94dbbffed76d911629796744eff9f96d24529b0af1e78c
da54cdbf02
5f6ee521311e166243d3e65d0253d12d1506750c80cd21f6a195
be519b5d697f
fcb6ff6a679ca17d9b36a543b08c42c6d06014d11002c09ba7c3
8b405b50debe
a168d561665221f992f51829e0b282eeb213b8aca3a9735dbbae
cc4d699f66b9
98112bd4710e6ffe389a2beb13ff1162017f62a1255c492f29238
626e99509f3
afacb38ea3a3cafe0f8dbd26dee7de3d0b24cdecae280a9b884fb

ad5ed195de7
b431aebc2783e72be84af351e9536e8110000c53ebb5db25e890
21dc1a83625e
2b39634dce9e7bb36e338764ef56fd37be6cd0faa07ee3673c6e8
42115e3ceb1
11533eedc1143a33c1deae105e1b2b2f295c8445e1879567115a
debfdda569e2
36e3d47f33269bef3e6dd4d497e93ece85de77258768e2fa6111
37fa0de9a043
e6c5437e8a23d50d44ee47ad6e7ce67081e7926a034d2ac4c84
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3RD STAGE PLUGINS

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SELF-SIGNED CERTIFICATE FINGERPRINTS

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b1c40c1b412

## Known Affected Devices

The following devices are known to be affected by this threat. Based on the scale of this research, much of our observations

are remote and not on the device, so it is difficult to determine specific version numbers and models in many cases.

Given our observations with this threat, we assess that this list may still be incomplete and other devices may be affected.

ASUS DEVICES:
**RT-AC66U (new)**
**RT-N10 (new)**
**RT-N10E (new)**
**RT-N10U (new)**
**RT-N56U (new)**
**RT-N66U (new)**

D-LINK DEVICES:
**DES-1210-08P (new)**
**DIR-300 (new)**
**DIR-300A (new)**
**DSR-250N (new)**
**DSR-500N (new)**
**DSR-1000 (new)**
**DSR-1000N (new)**

HUAWEI DEVICES:
**HG8245 (new)**

LINKSYS DEVICES:
E1200
E2500
**E3000 (new)**
**E3200 (new)**
**E4200 (new)**
**RV082 (new)**
WRVS4400N

MIKROTIK DEVICES:
**CCR1009 (new)**
CCR1016
CCR1036
CCR1072
**CRS109 (new)**
**CRS112 (new)**
**CRS125 (new)**
**RB411 (new)**
**RB450 (new)**
**RB750 (new)**
**RB911 (new)**

**RB921 (new)**
**RB941 (new)**
**RB951 (new)**
**RB952 (new)**
**RB960 (new)**
**RB962 (new)**
**RB1100 (new)**
**RB1200 (new)**
**RB2011 (new)**
**RB3011 (new)**
**RB Groove (new)**
**RB Omnitik (new)**
**STX5 (new)**

NETGEAR DEVICES:
**DG834 (new)**
**DGN1000 (new)**
DGN2200
**DGN3500 (new)**
**FVS318N (new)**
**MBRN3000 (new)**
R6400
R7000
R8000
WNR1000
WNR2000
**WNR2200 (new)**
**WNR4000 (new)**
**WNDR3700 (new)**
**WNDR4000 (new)**
**WNDR4300 (new)**
**WNDR4300-TN (new)**
**UTM50 (new)**

QNAP DEVICES:
TS251
TS439 Pro
Other QNAP NAS devices running QTS software

TP-LINK DEVICES:
R600VPN
**TL-WR741ND (new)**
**TL-WR841N (new)**

UBIQUITI DEVICES:
**NSM2 (new)**
**PBE M5 (new)**

UPVEL DEVICES:
**Unknown Models* (new)**

ZTE DEVICES:
**ZXHN H108N (new)**

* Malware targeting Upvel as a vendor has been discovered, but we are unable to determine which specific device it is targeting.

POSTED BY WILLIAM LARGENT AT 9:02 AM
LABELS: AMP, CLAMAV, IOT, IOT MALWARE, NEW ROUTER MALWARE, OFFICE ROUTER ATTACK, SNORT RULES, TALOS, THREAT INTELLIGENCE, THREAT RESEARCH, VPN FILTER ATTACK, VPNFILTER, VPNFILTER MALWARE, VULNERABLE ROUTERS

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