



Digitally-Signed Rootkits are Back – A Look at FiveSys and Companions

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Foreword

More than a decade ago, rootkits were the apex predators of cybercrime. These clandestine computer programs were built to offer attackers an uninterrupted foothold onto victims' computers and conceal malicious activities from the operating system as well as from antimalware solutions.

These intruders living inside the operating system's kernel have been evicted by the security mitigations introduced with Windows Vista, but once in a while, they make a comeback.

For the past few months, Bitdefender researchers have seen a surge in malicious drivers with valid digital signatures issued by Microsoft through the WHQL signing process. This whitepaper documents FiveSys – a digitally signed rootkit that made its way through the driver certification process.

Digital signatures are a way of establishing trust. In our case, a valid digital signature helps the attacker navigate around the operating system's restrictions on loading third-party modules into the kernel. Once loaded, the rootkit allows its creators to gain virtually unlimited privileges.

Digital signatures also contain information about the identity of the author. Most of the rootkit cases we documented in the past rely on stolen digital certificates from legitimate companies, so up until recently malware writers used stolen digital certificates to sign their drivers. This campaign takes a fundamentally different approach.

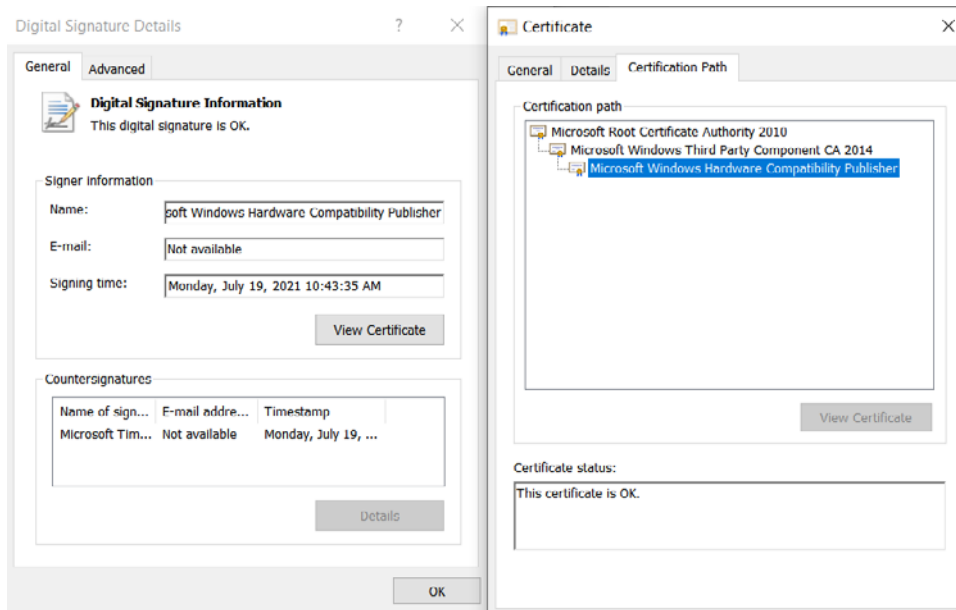
Key Findings

- » Bitdefender researchers have identified a rootkit with a Microsoft-issued digital signature;
- » The rootkit is used to proxy traffic to Internet addresses that interest the attackers.
- » We assume that the rootkit targets online games with the main goal of credential theft and in-game-purchase hijacking
- » The rootkit has been targeting computer users for more than a year now
- » Rootkit spreading is limited to China and we presume that it is operated by a threat actor with significant interest in the market.

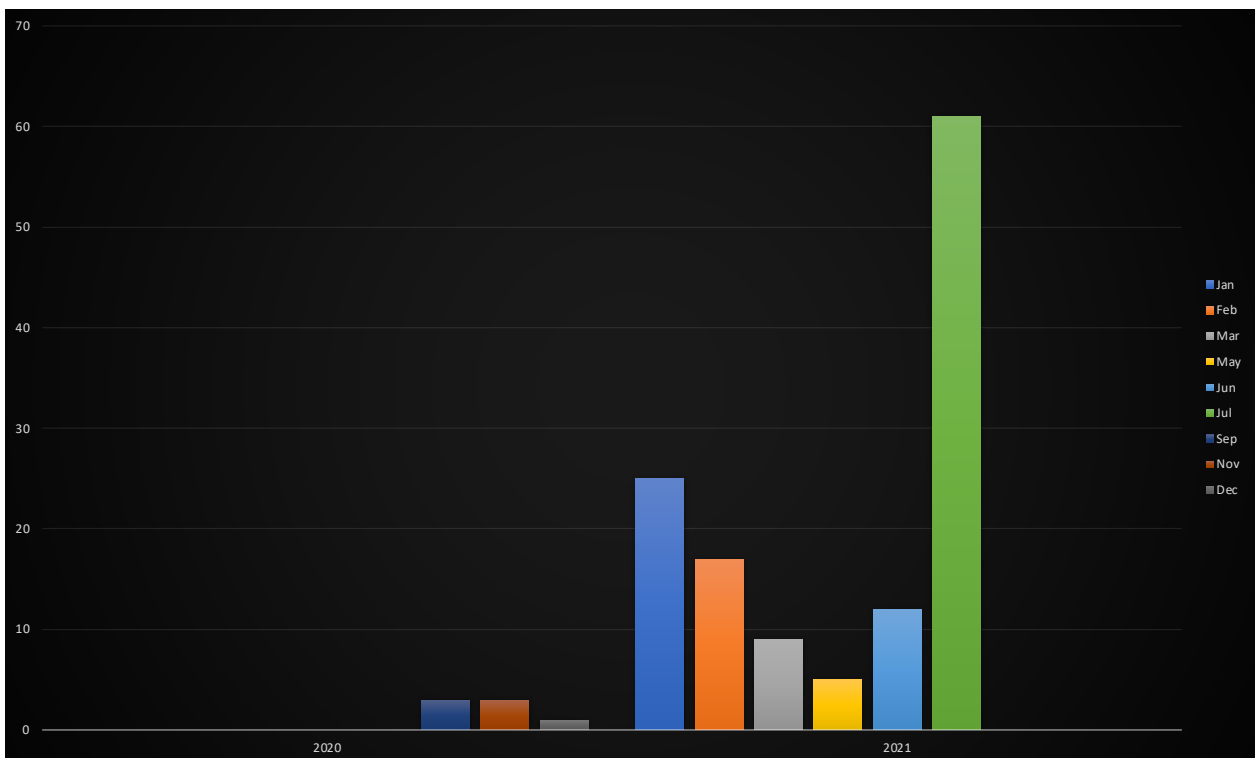
A Retrospective of Digital Trust and Rootkits

[Netfilter](#) was the first rootkit discovered to be using a WHQL digital signature issued by Microsoft directly. We have spotted a similar malicious driver, **FiveSys**, which also has a valid WHQL digital signature from Microsoft.m

We presume these two incidents might not be isolated cases, and we might increasingly see malware using digital signatures issued by Microsoft. The reason for this might be the new [Driver Signing requirements from Microsoft](#), which demand drivers to be digitally signed by Microsoft before acceptance by the operating system. This new requirement ensures that all drivers are validated and signed by the operating system vendor rather than the original developer and, as such, digital signatures offer no indication as to the identity of the real developer. It seems that malware writers managed to work around the new requirements, as Netfilter and new FiveSys demonstrated. In addition, the fact that they have digital signatures issued by Microsoft might trick unsuspecting users into believing they are legitimate drivers and accept their installation:



We started seeing its components in late 2020, as shown in our detection telemetry below:



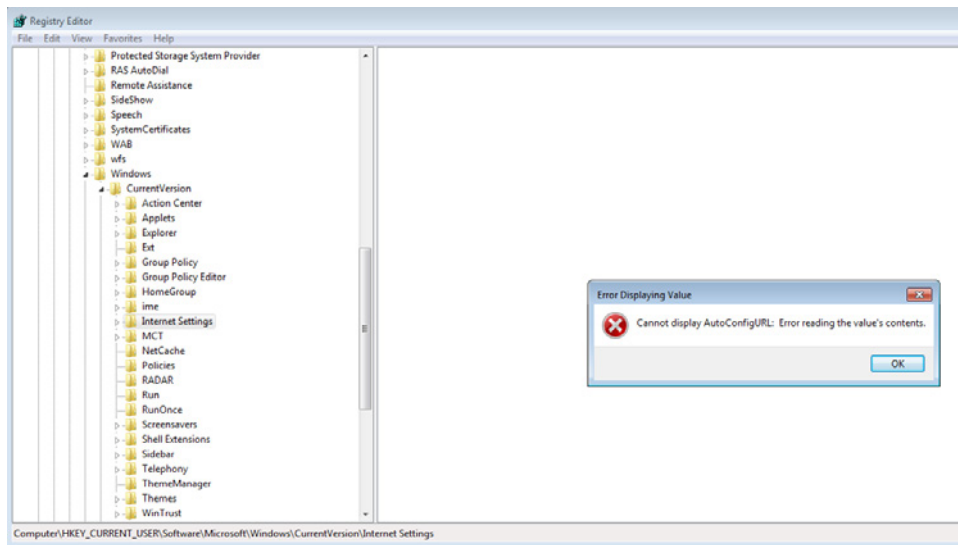
FiveSys is very similar in nature to the **Undead** malware [described in this report](#) a few years ago. The attackers seem to originate from China and target several domestic games. We can confidently attribute this campaign to several threat actors, as their tools share the same functionality but are vastly different in implementation.

Rootkit creators commonly employ the practice of blocking competing malware via a signature blacklist of stolen certificates used by other malware.

NOTE: We have reached out to Microsoft to flag this abuse of digital trust. Microsoft revoked the signature shortly after.



Modifications made in the registry are also protected by the rootkit.



Besides redirecting internet traffic, the rootkit also blocks loading of drivers from other malware writing groups, as they are probably attempting to limit competitor threat actors' access to the compromised system.

To achieve this, it uses a blacklist of digital signatures. It monitors each file access and checks the digital signature (if available). It then blocks access to the given file if its signature is in the list.

The list of digital signatures is updated periodically. Currently it has a blacklist of 68 such hashes, and each hash corresponds to a stolen/leaked signatures used by malware.

The malware authors have left debug messages revealing the list of signatures it monitors:

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00000478      186.51918030  [MY-1]MD5-0:9D9F343EAA8FB4045A4B7D05437AC02B
00000480      186.51918030  [MY-1]MD5-1:A269121725987B766740D43964E83CF3
00000482      186.51918030  [MY-1]MD5-2:698FD84F0AABAA65F8BD3E7AD417F4D4
00000484      186.51919556  [MY-1]MD5-3:CE7D7EE076A74D3C532265D8F6BBFF09
00000486      186.51919556  [MY-1]Sign-0:Zhang Zhengqi
00000488      186.51921082  [MY-1]Sign-1:Haining shengdun Network Information Technology Co., Ltd
00000490      186.51921082  [MY-1]Sign-2:SHENZHEN LIRINUOS
00000492      186.51921082  [MY-1]Sign-3:Shanghai easy kradar Information Consulting Co.Ltd

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We've searched for samples containing the blacklisted signatures, and we've found rootkits from the netfilter and fk_undead families. This reaffirms our suspicion competition is strong among the threat actors behind these campaigns, as each group tries to exclusively control the infected computers.

To make potential takedown attempts more difficult, the rootkit comes with a built-in list of 300 domains on the ".xyz" TLD. They seem to be generated randomly and stored in an encrypted form inside the binary. When contacting the C&C, it will pick a random domain from the list, each such domain having several DNS A records. This level of redundancy significantly minimizes the chance of a C&C takedown.



FiveSys has multiple components - historically we have identified several user mode binaries that would download or drop the malicious drivers. It also has an estimated four drivers, but in our research, we only managed to isolate two:

- » PacSys(PC.sys) is responsible for delivering the proxy autoconfiguration script (the *.PAC file, hence the name probably).
- » Up.sys downloads an executable and starts it using an embedded dll which it injects from kernel mode.
- » Both drivers can protect the other module too, and reinstall it if it gets deleted.

Even though, technically speaking, the malware families are not among the sophisticated ones, the fact that they abuse digital signatures in this manner seriously undermines the credibility of this protection mechanism.

Indicators of Compromise

An up-to-date and complete list of indicators of compromise is available to [Bitdefender Advanced Threat Intelligence](#) users. The currently known indicators of compromise can be found below.

C2 IPs

103.85.85.90	125.77.158.136	180.188.19.11	103.91.209.141
110.42.9.69	211.99.103.229	36.99.113.51	103.219.31.147
60.217.248.67	45.248.11.7	103.40.13.51	180.188.17.204
103.88.32.158	43.228.66.130	221.229.210.107	162.14.178.70
103.230.236.90	103.85.85.97	103.53.124.199	211.99.99.190
110.42.5.55	45.248.11.29	110.42.11.6	113.141.163.181
27.159.65.61	125.77.168.118	115.230.124.18	
45.113.202.114	103.219.31.42	103.107.190.138	

C2 Domains

08tayh19pzog51.7hgum3mdrpl1y6h4unvp[.]xyz	1bwbosmlqqp3gf.vhld53sxiosqjm[.]xyz
0dt7fmri.n7vzlm2tfdz4[.]xyz	1cjikxci-oxeq2p.7kp8z05-ow9yctundemu[.]xyz
0erhtboedcix.sopl05iznfgywa[.]xyz	1h3d5vlcmsbuwk2ggo.tytzanm[.]xyz
0kt49g-xympazsf.ynuembkr98wvsf-x[.]xyz	1ik2-8l4.jmc9wrzgz6f[.]xyz
0mnt1bqfssen4.zwquakqgtje[.]xyz	1kt9q4wo.agfkt-zmupw[.]xyz
0o1sgni.cjbae26sz0hogx9cbz[.]com	1mhifv8tjq3a.0fhm7qi[.]xyz
0obhfsqtmcl.nyrufig[.]xyz	1ocalnawcnq.bilgmms[.]xyz
0q8w7d4so.mwzaeyj2gg[.]xyz	1tcocsr-w42.axwzdfs[.]xyz
0qhpcznfzyo.bvdwhl4tvylr[.]xyz	1y6rv4w8ovo7tsbyed.anysq-ahjlm67r0fpzwb[.]xyz
0-umr89woqaheqd.yso3fpianv8cdvrwzq[.]xyz	20mussw4c9pfhea.mpydj[.]xyz
19gq0tjscglhzduwy8h.atqvx69f1[.]xyz	2afybptuag7bi94c.fodvtlyn[.]xyz



2bk1xqfde7.zeo6huvsjd0km[.]xyz
2dgbzotyw.fplmtp-kqo7bay[.]xyz
2drjju0adtla91.5aavy09eonzwm-h[.]xyz
2eiY6akscfg.j0ilh[.]xyz
2ej3dw7pr8otpyu.aumvhwio[.]xyz
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2qaporw8r9km.9nttegmhdo[.]xyz
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2vftek6px0ihdsua.hzwnmidqrc1gmbdq[.]xyz
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2wv5sjh7uqxnqze.icxcjw5[.]xyz
2xxea-vm6ezk0h.0fdq4lyv[.]xyz
30ku9efzdtj.oq873mn[.]xyz
31mewt-iugrsmty5f4hk.ftrnoxld[.]xyz
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3f1pdv6yf.xwd9hlczqcvelpl[.]xyz
3m8uiascjds51olp.tmqyriqsstn2k7f[.]xyz
3mnu5karozci94.cmfaxcf-3bz6q0tj1[.]xyz
3mvlrws41jxj.bdxe4hkfk[.]xyz
3o809gtctbio2.t89ctd[.]xyz
3oibvymhvi9wu2dt.tw7bqlq6dgn8e4btX[.]xyz
3p2ycniuqh-xjq.7pmundwx[.]xyz
3pirkuovrt9j6g.x7c8-yfufjsgpd4[.]xyz
3s9ijboln.eh1lcpm2xjwkfdg9[.]xyz
3sncz6v7jae0b.qlyvd0bmo[.]xyz
3utvpp4nxsdmhrkzxt.wqxopwt3cilfy7is[.]xyz
3wiyu5zcr92lg8xf.i6p-ybdw[.]xyz
3ydabhom8lda6t5nu.icxcjw5[.]xyz
403czrsfpkldsqolk6ag.mibkc7fvuefw3[.]xyz
4cjhmtfi.gg-mmfpz79[.]xyz
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4dpyp1ftay8g90qb7l.kkvgstcw4hsn3g0nc5r[.]xyz
4dyivtanev8.cmfaxcf-3bz6q0tj1[.]xyz
4evie8nsxp3hkuk0.rjhho15rowi7lv[.]xyz
4k5swsv8tauelrqbX9.fgak-0l8egpu7icwzryt[.]xyz
4m6bjthzS7d.0fdq4lyv[.]xyz
4mahwtvq9py.tw7bqlq6dgn8e4btX[.]xyz
4odk0n.fmogj1g1jrd[.]xyz
4qylg5ijr9ux3x.jphdsj[.]xyz
4s0b5xuq2ztvc7ejiny.vhlkte2-gmrqy1zmvki[.]xyz
4tqfvthqi-zy.i2bpla0tfg1t7y69[.]xyz
4tun0cpzbl.1keuzwjK2187[.]xyz
4vdcmeqnu9rh.gle-g5uorvb16kikjf[.]xyz
4wd2g1fsh3uc.5bxfyseilj09t[.]xyz
4xn9gjixs1fqzw-dth.sj8yninf3ga6tv9r[.]xyz
4yi2pcyhw9xm1si7w08jh.jzlo[.]xyz
4zvjrhnlzocswv1706d.wz9hrfe4fdiu[.]xyz
54hgsruf.jzdqjbf1mx9[.]xyz
5-8wh.aeowncjzrefT[.]xyz
5aki63obhpz4.hdiioe4focsn[.]xyz
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5hdabznqrjkgxw7a.fwv5vfmYrqsWt[.]xyz
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esp6hkudavi.llygr0f3qqmahxctfng[.]xyz
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evyfdhs64qbw9mrk73w.szebgl[.]xyz
evz0mrku8wbnx6x.qhijobr6n4s9ni[.]xyz
ewsi3bdyhmukfuc.7blwuafgmjcnpbdeia[.]xyz
exv3s1.ec9tn4brybhcomdzmiwi[.]xyz
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WHY BITDEFENDER?

UNDISPUTED INNOVATION LEADER.

38% of all cybersecurity vendors worldwide integrated at least one Bitdefender technology. Present in 150 countries.

WORLD'S FIRST END-TO-END BREACH AVOIDANCE

The first security solution to unify hardening, prevention, detection and response across endpoint, network and cloud.

#1 RANKED SECURITY. AWARDED ACROSS THE BOARD.



Bitdefender

UNDER THE SIGN OF THE WOLF

Founded 2001, Romania
Number of employees 1800+

Headquarters
Enterprise HQ – Santa Clara, CA, United States
Technology HQ – Bucharest, Romania

WORLDWIDE OFFICES
USA & Canada: Ft. Lauderdale, FL | Santa Clara, CA | San Antonio, TX | Toronto, CA
Europe: Copenhagen, DENMARK | Paris, FRANCE | München, GERMANY | Milan, ITALY | Bucharest, Iasi, Cluj, Timisoara, ROMANIA | Barcelona, SPAIN | Dubai, UAE | London, UK | Hague, NETHERLANDS
Australia: Sydney, Melbourne

A trade of brilliance, data security is an industry where only the clearest view, sharpest mind and deepest insight can win – a game with zero margin of error. Our job is to win every single time, one thousand times out of one thousand, and one million times out of one million.

And we do. We outsmart the industry not only by having the clearest view, the sharpest mind and the deepest insight, but by staying one step ahead of everybody else, be they black hats or fellow security experts. The brilliance of our collective mind is like a **luminous Dragon-Wolf** on your side, powered by engineered intuition, created to guard against all dangers hidden in the arcane intricacies of the digital realm.

This brilliance is our superpower and we put it at the core of all our game-changing products and solutions.