FORTIGUARD LABS THREAT RESEARCH

Enter Th… Mining a…cy

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Summary of the Malware Campaign

Recently, enSilo researcher Adi Zeligson - now part of the FortiGuard Labs research team - discovered a never-before-detected, highly sophisticated malware campaign named DarkGate. Targeting Windows workstations and supported by a reactive Command and Control system, DarkGate malware is spread through torrent files. When executed by the user, DarkGate malware is capable of avoiding detection by several AV products, and of executing multiple payloads including cryptocurrency mining, crypto stealing, ransomware, and the ability to remotely take control of the endpoint.

The critical elements of the DarkGate malware are that it:

- Leverages a C&C infrastructure cloaked in legitimate DNS records from legitimate services, including Akamai CDN and AWS, which helps it avoid reputation-based detection techniques
- Uses multiple methods for avoiding detection by traditional AV using vendor-specific checks and actions, including the use of the process hollowing technique
- Has the ability to evade the elimination of critical files by several known recovery tools
- Uses two distinct User Account Control (UAC) bypass techniques to escalate privileges
- Is capable of detonating multiple payloads with capabilities that include cryptocurrency mining, crypto stealing (theft of credentials associated with crypto wallets), ransomware, and remote control

The technical analysis of the DarkGate malware that follows demonstrates how advanced malware can avoid detection by traditional AV products and highlights the importance of the post-infection protection capabilities of the enSilo Endpoint Security Platform.

Technical Analysis

Named DarkGate by the author, the malware seeks to infect targets across Europe, particularly in Spain and France. DarkGate has several capabilities, including crypto mining, stealing credentials from crypto wallets (crypto stealing), ransomware, and remote access and control.

enSilo observed that the author behind this malware established a reactive Command and Control infrastructure that is staffed by human operators who act upon receiving notifications of new infections with crypto wallets. When the operator detects any

interesting activity by one of the malware, they then proceed to install a custom remote access tool on the machine for manual operations.

As part of our normal research activities, we occasionally perform a controlled infection of what seems to be a legitimate user endpoint. The controlled infection is performed in order to investigate several aspects of the malware, as well as the reactivity of the malware operator. For example, in one of these encounters our research team was able to determine that the operator detected our activity and immediately responded to our activity by infecting the test machine with a customized piece of ransomware.

It appears that the author behind this malware invested significant time and effort into remaining undetected by leveraging multiple evasion techniques. One of the techniques used is a user-mode hooks bypass that enabled the malware to evade identification by various AV solutions for an extended period of time.

The enSilo research tea to detect it. It was this discovery that led bed in the Technical Analysis section. It is cl new variant.

Further investigation is rrency mining, crypto stealing, and ransomwa her motive.

Family Ties

Within DarkGate, we were able to identify ties to a previously detected password stealer malware called Golroted. The Golroted malware is notable because of its use of the Nt* API calls for performing process hollowing. Additionally, Golroted used a second technique, UAC bypass, based on a schedule task called SilentCleanup. DarkGate utilizes both of these techniques.

After performing a binary diff between Golroted and DarkGate, we discovered a significant amount of overlapping code. As shown in Figure 1, both malware variants perform the process hollowing method on the process vbc.exe. However, DarkGate contains a slightly modified version of the process hollowing function.

FIGURE 1: BINARY DIFF BETWEEN GOLRATED AND DARKGATE

Infection Tactics and Methods

We identified two distinct infection methods employed by the author of DarkGate, as well as the author of Golroted. Both infection methods are spread through Torrent files posing as a popular movie and a television series that then execute VBscript on the victim.

The second file, the-walking-dead-9-5-hdtv-720p.torrent.vbe, uses a more trivial approach to infecting victims. It distributes emails containing malicious attachments from a spoofed address. An example of this is shown in Figure 3.

FIGURE 2: SCREEN CAPTURE OF TORRENT FILES

FIGURE 3: EXAMPLE OF EMAIL DISTRIBUTED BY THE-WALKING-DEAD-9-5-HDTV-720P.TORRENT.VBE

Four Stages of Unpacking DarkGate Malware

One of the unique techniques used by the DarkGate malware lies within its multi-stage unpacking method. The first file executed is an obfuscated VBScript file, which functions as a dropper and performs several actions. In the first stage, several files are dropped into a hidden folder *“C:|{computername}”*. The files are autoit3.exe, which in some versions is disguised with a random name: test.au3, pe.bin and shell.txt. Next, test.au3 AutoIt script is executed using the dropped instance of autoit3.exe.

FIGURE 4: THE DE-OBFUSCATED VBS

In the second phase, the AutoIt code creates a shortcut of itself with the name “bill.ink” under the startup folder. Once completed, it triggers a third stage in which the binary code stored in the file “C:\{computername}\shell.txt” is decrypted and then executed. The AutoIt script uses a rather unusual technique for executing the binary code. The steps involved in the technique are:

- Loads the binary code from shell.txt into the process memory
- Copies the data into an executable memory space (DLLStructCreate and DllStructSetData)
- Invokes CallWindowProc with reference to our binary code as the lpPrevWndFunc parameter

FIGURE 5: THE DE-OBFUSCATED AUTOIT SCRIPT

Finally, in the fourth and final stage of the unpacking technique, the binary code originally loaded from shell.txt performs the followings actions:

- Searches for the executable file, which is also the name of an executable found in Kaspersky AV.
- Reads the dropped file “pe.bin” and decrypts it.
- Uses process hollowing to inject the decrypted code from pe.bin into the process “vbc.exe”.

We discovered that if DarkGate detects the presence of Kaspersky AV, it loads the malware as part of the shellcode rather than using the process hollowing method. The decrypted pe.bin file is the core of DarkGate. The core is responsible for its communication with the C&C (Command and Control) server and for executing commands received from it.

Let’s summarize this four-stage unpacking technique

1. The initial dropper code is delivered using VBScript, which drops all the relevant files:

- autoit3.exe
- test.au3
- pe.bin
- shell.txt
- autoit3.exe
- test.au3
- pe.bin
- shell.txt
- autoit3.exe
- autoit3.exe

- autoit3.exe
- test.au3
- pe.bin
- shell.txt
- autoit3.exe
- test.au3
- pe.bin
- shell.txt

Once, delivered it then runs the AutoIt script.

2. The AutoIt script runs using the AutoIt interpreter, which decrypts the binary code and loads it into memory.

3. The binary code ther

4. The final binary is de

FIGURE 6: THE FOUR STAGES OF THE UNPACKING TECHNIQUE

The final binary copies all files from “C:\{computer_name} “ to a new folder under “C:\Program data” with the name derived from the first eight digits of the user generated id (ID2 - explained later on).

The final binary installs a key in the registry designed to help it maintain persistency under the key: “\SOFTWARE\Microsoft\Windows\CurrentVersion\Run”.

The key name is the first eight digits of the user-generated id, and the value is the AutoIt script that was copied from C:\{computer_name} to the “program data” folder, as shown below in Figure 7:

FIGURE 7: EXAMPLE OF REGISTRY KEY USED TO ESTABLISH PERSISTENCY

Cryptocurrency Mining

The first connection the malware makes to the C&C server is to get the file it needs to start the cryptocurrency mining process.

FIGURE 8: RETRIEVING THE FILE

As shown in Figure 9, the command “startminer” is sent as part of the response in order to tell the malware to start mining and to separate the different parts of the message. The first part is encrypted into config.bin - that is the miner command line. The second part is written in cpu.bin, and when decrypted is the miner executable. The mining itself is done through the process “systeminfo.exe” by using process hollowing.

FIGURE 9: RETRIEVING THE CRYPTO MINER PAYLOAD

Stealing Crypto Wallet Credentials

Another capability of the malware is that it can search for, and steal, credentials for crypto wallets. The malware looks for specific strings in the names of windows in the foreground that are related to different kinds of crypto wallets, and if a matching string is found, sends the server an appropriate message.

The following table contains the list of targeted wallet website/applications:

STING SEARCH	TARGET
sign-in / hitbtc	**https://hitbtc.com/**
binance - log in	**https://www.binance.com/login.html**
litebit.eu - login	**https://www.litebit.eu/en/login**
binance - iniciar sesi	**https://www.binance.com/login.html**

cryptopia - login	https://www.cryptopia.co.nz/Login
user login - zb spot exchange	
sign in | coinEx	https://www.coinex.com/account/signin?lang=en_US
electrum	https://electrum.org/#home
bittrex.com - input	
exchange - balances	
eth) - log in	
blockchain wallet	
bitcoin core	https://bitcoincore.org/
kucoin	https://www.kucoin.com/#/
metamask	https://metamask.io/
factores-Binance	
litecoin core	https://litecoin.org/
myether	https://www.myetherwallet.com/

TABLE 1: TARGET CRYPTO WALLETS AND STRING VALUES

Command and Control

Judging from what we’ve seen so far, it seems like the author of DarkGate leveraged sophisticated techniques to avoid detection both by endpoint and network security products.

The malware contains six hard-coded domains, shown below, which it attempts to communicate with upon infection. It looks like the domains are chosen carefully to disguise the C&C server as a known legitimate service, such as Akamai CDN or AWS, and avoids looking suspicious to anyone who may be monitoring the network traffic.

- akamai.la
- hardwarenet.cc
- ec2-14-122-45-127.compute-1.amazonaws.cdnprivate.tel
- awsamazon.cc
- battlenet.la
- a40-77-229-13.deploy.static.akamaitechnologies.pw

Additionally, it seems the author has employed another trick by using NS records that look like legitimate rDNS records from Akamai or Amazon. The idea behind using rDNS is that they’re overlooked and easily dismissed by anyone monitoring network

traffic.

Two Methods Used To Avoid Detection

It appears what the author of DarkGate fears most is detection by AV software. They have invested significant effort in anti-VM and user validation techniques, rather than anti-debugging measures.

ANTI-VM: Machine Resources Checkup

The first method used by DarkGate to avoid detection by AV software is to determine if the malware has landed inside a sandbox/virtual machin nes (VMs) are generally low on resou stence of as many VMs as possible.

In Figure 10, we can se h disk size and physical memory. If the or equal to 4GB, it will be considered as a

FIGURE 10: CHECKING THE MACHINE DISK AND RAM

ANTI-AV

DarkGate attempts to detect if any of the AV solutions listed in Table 2 are present on an infected machine. For most of the AV solutions, if the malware detects any of these AV solutions, it will just notify the server – with the exception of IOBit, TrendMicro, or Kaspersky .

PROCESS NAME	SOLUTION
astui.exe	Avast
avpui.exe	Kaspersky
avgui.exe	AVG
egui.exe	
bdagent	
avguard.exe	
nis.exe	
ns.exe	
nortonsecurity.exe	Norton
uiseagnt.exe	Trend Micro
bytefence.exe	ByteFence
psuaconsole.exe	Panda
sdscan.exe	Search & Destroy
mcshield.exe	McAfee
mcuicnt.exe	McAfee
mpcmdrun.exe	Windows Defender
superantispyware.exe	SUPER AntiSpyware
vkise.exe	Comodo
mbam.exe	MalwareBytes
cis.exe	Comodo
msascuil.exe	Windows Defender

TABLE 2: AV EXECUTABLES SEARCHED FOR BY DARKGATE MALWARE

The existence of AV solutions from IOBit, TrendMicro, or Kaspersky trigger special conditions:

- IOBit: If the path “C:\\Program Files (x86)\\IObit” exists, the malware is going to try and tackle a process named “monitor.exe” by terminating it. Additionally, it will spawn a new thread that repeatedly looks for the process “smBootTime.exe” and terminate the process if it exists.

- Trend Micro: If the Trend Micro AV process name is detected, the code will not execute the key logging thread.
- Kaspersky: The malware checks multiple times during execution, both during the unpacking process and in the malware itself, for the presence of Kaspersky AV. If detected in the final executable, and less than 5 minutes have passed since the machine's startup, then it won't initiate the key logging thread and the update thread that is responsible for:
- Copying all of the malware-related files to a folder under "C:\Program Data".
- Performing the recovery tools check described in the next section.
- And finally, if detected in the shellcode and more than 4:10 minutes have passed since system startup, it will not use the process hollowing technique to execute the final executable, and will instead load and execute it directly.

Recovery Tools

The malware also tries

PROCESS NAME	
adwcleaner.exe	
frst64.exe	
frst32.exe	
frst86.exe	**Farbar Recovery Scan Tool**

TABLE 3: RECOVERY TOOLS PROCESS NAMES AND TARGETS

If such a process is found, the malware will initiate a new thread that will reallocate the malware files every 20 seconds, making sure that if the files were deleted during the lifetime of a recovery tool they will be recreated and relocated somewhere else.

Direct Syscall Invocation

In order to hide the use of the process hollowing technique, DarkGate uses a special capability that enables it to call kernel mode functions directly. This can potentially help the malware escape any breakpoints set by a debugger, as well as evade userland hooks set by the different security products.

How Does it Work?

When using functions from ntdll.dll, a system call is made to the kernel. The way the call is done is different between 32 and 64-bit systems, but they both eventually call the function "KiFastSystemCall", which is different for each architecture. The "KiFastSystemCall" function is used to switch between ring 3 and ring 0. The Darkgate malware avoids loading the ntdll.dll functions the proper way, and instead creates its own "KiFastSystemCall" function that will make the syscall.

DarkGate is a 32-bit process that can become a challenge when running on a 64-bit system due to the differences between the systems when switching to the kernel. In order to use the right "KiFastSystemCall" function for the process, the Darkgate malware checks which architecture it's running on by searching for the path "C:\Windows\SysWOW64\ntdll.dll". If this path exists, it means the process is running on a 64-bit system.

FIGURE 11: ASSIGN THE RIGHT FUNCTION BASED ON THE ARCHITECTURE

In a 32-bit system, the “KiFastSystemCall” function will look like this:

FIGURE 12: 32-BIT SYSTEM KIFASTSYSTEMCALL FUNCTION

In a 64-bit system, the following code is used to call the “KiFastSystemCall” 64-bit function from a 32-bit process:

FIGURE 13: 64-BIT SYSTEM KIFASTSYSTEMCALL FUNCTION

The offset “fs:0C0h” is a pointer in the TEB (Thread Information Block) to “FastSysCall” in wow64. This pointer points to an address in “wow64cpu.dll” that jumps to the 64-bit “KiFastSystemCall” function. The DarkGate malware will pass to the assigned function the ntdll requested function syscall number and the needed parameters. This way, a kernel function is called without the need to call the function from within ntdll.dll. To conclude, the DarkGate malware creates its own “KiFastSystemCall” to bypass ntdll.dll.

We found a similar code that might have been the source of the DarkGate code.

UAC Bypass Capabilities

DarkGate uses two distinct UAC bypass techniques that it uses to try and elevate privileges.

Disk-Clean up Bypass

The first UAC bypass technique exploits a scheduled task called DiskCleanup. This scheduled task uses the path *%windir%|system32|cleanmgr.exe* to execute the actual binary. Therefore, the malware overrides the *%windir%* environment variable with the registry key: *“HKEY_CURRENT_USER|Enviroment|windir”* with an alternative command, which will execute the AutoIt script. This bypass process was covered by Tyranid’s Lair.

FIGURE 14: DISK-CLEANUP UAC BYPASS

EVENTVWR UAC Bypass

Another UAC bypass exploits the fact that eventvwr.exe, by default, runs in high integrity, and will execute the mmc.exe binary (Microsoft Management Console). The mmc.exe command is taken from the registry key “HKCU\Software\Classes\mscfile\shell\open\command”. This registry key is also writable from a lower integrity level, which enables it to execute an AutoIt script in a higher integrity.

FIGURE 15: EVENTVWR UAC BYPASS

Keylogging

A thread is started that is responsible for capturing all keyboard events and then logging them to a predefined log file. Other than logging the key logs, it also logs the foreground windows and the clipboard. The log is saved with the name “current date.log” in the following directory listed below:

“C:\users\ {username}\appdata\roaming\{ID1}”.

FIGURE 16: KEYLOG FILE

Information Stealing

DarkGate uses some of the NirSoft tools in order to steal credentials or information from infected machines. The toolset that is used enables it to steal user credentials, browser cookies, browser history, and Skype chats. All tools are executed using the process hollowing technique into a newly created instance of vbc.exe or regasm.exe.

DarkGate uses the following applications to steal credentials:

- Mail PassView
- WebBrowserPassView
- ChromeCookiesView
- IECookiesView
- MZCookiesView
- BrowsingHistoryView
- SkypeLogView

The resulting data collected from the tools is extracted from the hosting process memory. DarkGate malware first looks for the tool’s window by using The FindWindow API function. It then uses the SysListView32 control and the sendMessage API function in order to retrieve the information needed from the tool. The retrieval works by first allocating a memory buffer in the hollowed process, as shown in Figure 17.

FIGURE 17: MEMORY ALLOCATION IN HOLLOWED PROCESS

It will then use the “GetItem” function to make it write the item to the allocated buffer. The “GetItem” function is used by calling the API function “SendMessage” with the message “LVM_GETITEMA” and the allocated buffer as a parameter:

FIGURE 18: GETITEM MESSAGE AND THE RETRIEVAL OF THE ITEM FROM THE HOLLOWED PROCESS

After the item is written to the allocated buffer, it will then read this memory region to retreive stolen information.

Deleting Restore Points

The malware has the ability to delete all restore points, including “cmd.exe /c vssadmin delete shadows /for=c: /all /quiet”

RDP INSTALL

This command will decrypt and execute the received file, which is probably an rdp connection tool, using the process hollowing method. The hollowed process in this case is a copy of systeminfo.exe in the %temp% directory.

In addition, the following commands will be executed using cmd.exe:

- exe /c net user /add SafeMode Darkgate0!
- exe /c net localgroup administrators SafeMode /add
- exe /c net localgroup administradores SafeMode /add
- exe /c net localgroup administrateurs SafeMode /add

It is interesting to see that the newly created user is added to both the Spanish and French admin groups.

Getbotdata

The server can request the following details about the victim:

- Locale
- User name
- Computer name
- Window name
- Time, representing the period of time that passed since the last input on the host
- Processor type
- Display adapter description
- RAM amount
- OS type and version
- Is user admin
- The encrypted content of config.bin
- Epoch time
- AV type – search

In some versions it will … folder where DarkGate saves its scr… he file Install.txt under the %appdata% …

- Malware version
- The port used by …

Solutions

The **FortiEDR** platform is capable of blocking the threat.

IOCS

DOMAINS
akamai.la
hardwarenet.cc
ec2-14-122-45-127.compute-1.amazonaws.cdnprivate.tel
awsamazon.cc
battlenet.la
a40-77-229-13.deploy.static.akamaitechnologies.pw

SAMPLE HASHES
3340013b0f00fe0c9e99411f722f8f3f0baf9ae4f40ac78796a6d4d694b46d7b
0c3ef20ede53efbe5eebca50171a589731a17037147102838bdb4a41c33f94e5
3340013b0f00fe0c9e99411f722f8f3f0baf9ae4f40ac78796a6d4d694b46d7b
0c3ef20ede53efbe5eebca50171a589731a17037147102838bdb4a41c33f94e5

52c47a529e4ddd0778dde84b7f54e1aea326d9f8eeb4ba4961a87835a3d29866
b0542a719c6b2fc575915e9e4c58920cf999ba5c3f5345617818a9dc14a378b4
dadd0ec8806d506137889d7f1595b3b5447c1ea30159432b1952fa9551ecfba5
c88eab30fa03c44b567bcb4e659a60ee0fe5d98664816c70e3b6e8d79169cbea
2264c2f2c2d5a0d6d62c33cadb848305a8fff81cdd79c4d7560021cfb304a121
3c68facf01aede7bcd8c2
a146f84a0179124d96a7
abc35bb943462312437
908f2dfed6c122b46e94
3491bc6df27858257db

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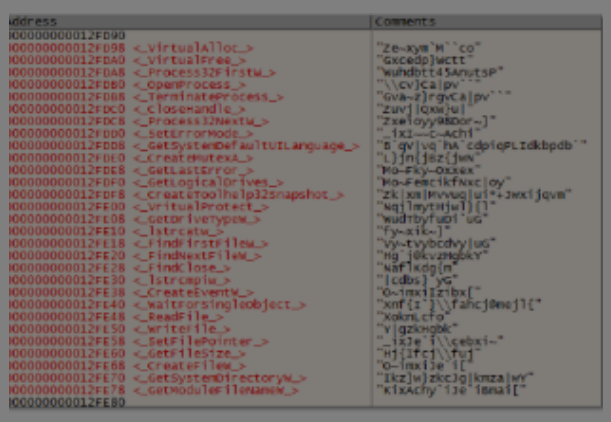

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