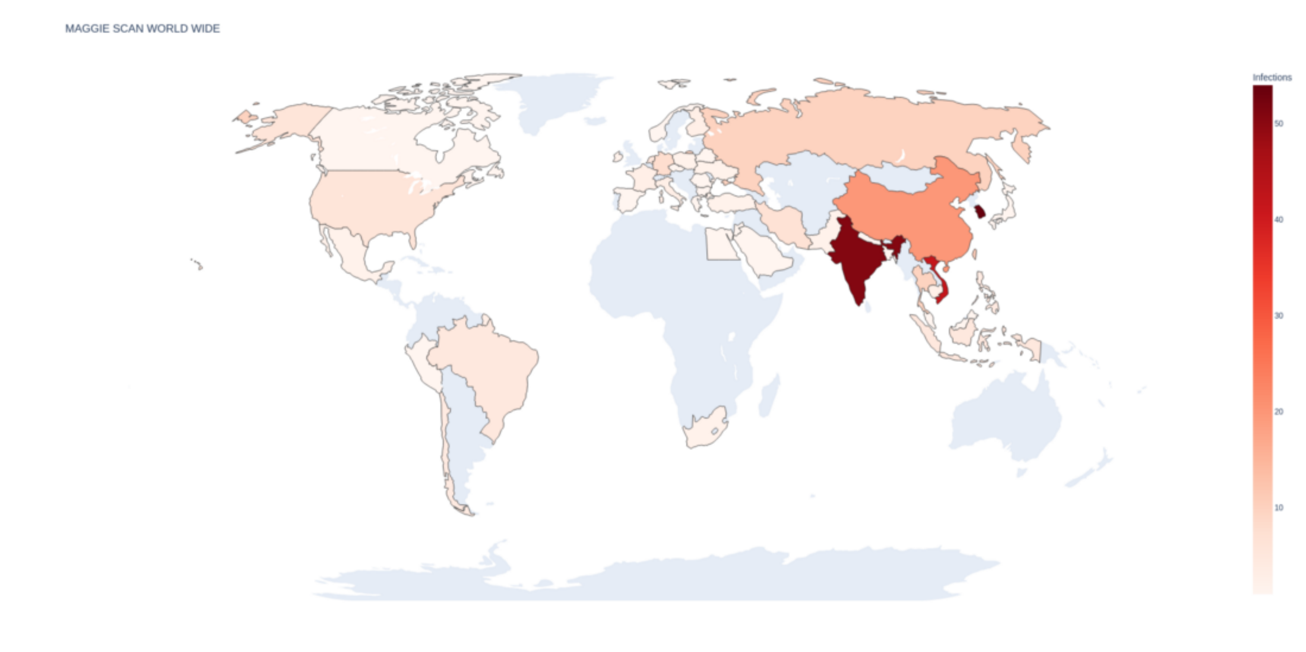
MSSQL, meet Maggie



Heatmap of Maggie backdoor user by country

Continuing our monitoring of signed binaries, *DCSO CyTec* recently found a novel backdoor malware targeting Microsoft SQL servers.

The malware comes in form of an “Extended Stored Procedure” DLL, a special type of extension used by Microsoft SQL servers. Once loaded into a server by an attacker, it is controlled solely using SQL queries and offers a variety of functionality to run commands, interact with files and function as a network bridge head into the environment of the infected server.

In addition, the backdoor has capabilities to bruteforce logins to other MSSQL servers while adding a special hardcoded backdoor user in the case of successfully bruteforcing admin logins. Based on this finding, we identified over 250 servers affected worldwide, with a clear focus on the Asia-Pacific region.

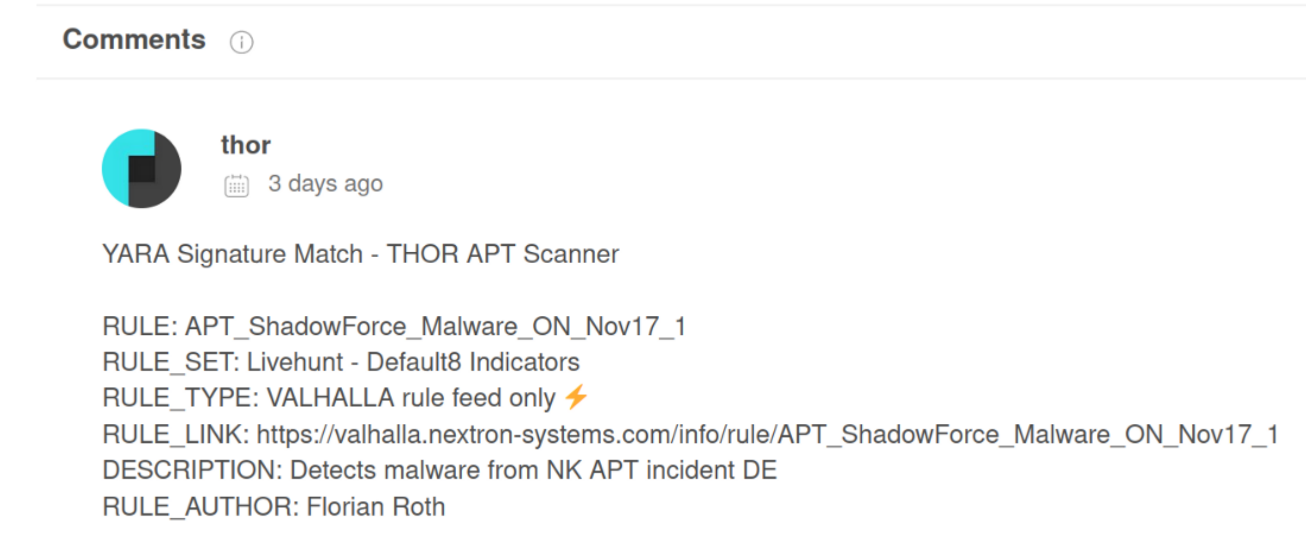
Based on artifacts found in the malware, *DCSO CyTec* calls this novel threat “Maggie”.

In our follow-up post “Tracking down Maggie” we also provide practical tips on how to detect Maggie in your environment.

Blog authored by Johann Aydinbas and Axel Wauer

Discovery

While looking for new threats, a file caught our attention. Detected as `APT_ShadowForce_Malware_ON_Nov17_1` by THOR and with a matching AV detection by AhnLab-V3 as `Trojan/Win.ShadowForce.R472810` we decided to take a closer look.



Comments

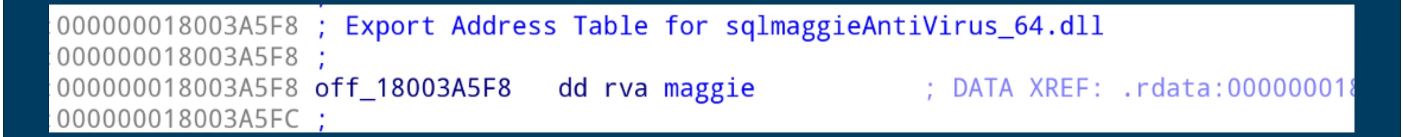
thor
3 days ago

YARA Signature Match - THOR APT Scanner

RULE: APT_ShadowForce_Malware_ON_Nov17_1
RULE_SET: Livehunt - Default8 Indicators
RULE_TYPE: VALHALLA rule feed only ⚡
RULE_LINK: https://valhalla.nextron-systems.com/info/rule/APT_ShadowForce_Malware_ON_Nov17_1
DESCRIPTION: Detects malware from NK APT incident DE
RULE_AUTHOR: Florian Roth

THOR detection on VirusTotal

The DLL file is signed by `DEEPSoft Co., Ltd.` on 2022–04–12. According to its export directory, the file calls itself `sqlmaggieAntiVirus_64.dll` and only offers a single export called `maggie` .



```
000000018003A5F8 ; Export Address Table for sqlmaggieAntiVirus_64.dll
000000018003A5F8 ;
000000018003A5F8 off_18003A5F8   dd rva maggie          ; DATA XREF: .rdata:000000018
000000018003A5FC ;
```

DLL export in IDA

Extended Stored Procedures

Closer inspection revealed this DLL to be an `Extended Stored Procedure`.

Extended Stored Procedures are a way to offer extended functionality to SQL queries for use in an MSSQL server, similar to the infamous xp_cmdshell stored procedure, which allows SQL queries to run shell commands.

ESPs are common DLL files using a simplistic API. When executed, ESPs are passed a handle to the client connection which allows them to fetch user-supplied arguments (via srv_paramdata) and return unstructured data to the caller (via srv_sendmsg).

Maggie utilizes this message-passing interface to implement a fully functional backdoor controlled only using SQL queries.

In order to install *Maggie*, an attacker has to be able to place an ESP file in a directory accessible by the MSSQL server, and has to have valid credentials to load the *Maggie* ESP into the server. It is unclear how an actual attack with *Maggie* is performed in the real-world.

After manually loading *Maggie* with

```
sp_addextendedproc maggie, '<path to DLL>';
```

an authenticated user could start to issue commands to the backdoor via SQL queries, e.g. to call the `whoami` shell command:

```
$ exec maggie 'Exec whoami';
MSSQL Procedure 04/08/2022
Execute Command: Exec whoami
Executing whoami Successfully
nt service\mssqlserver
```

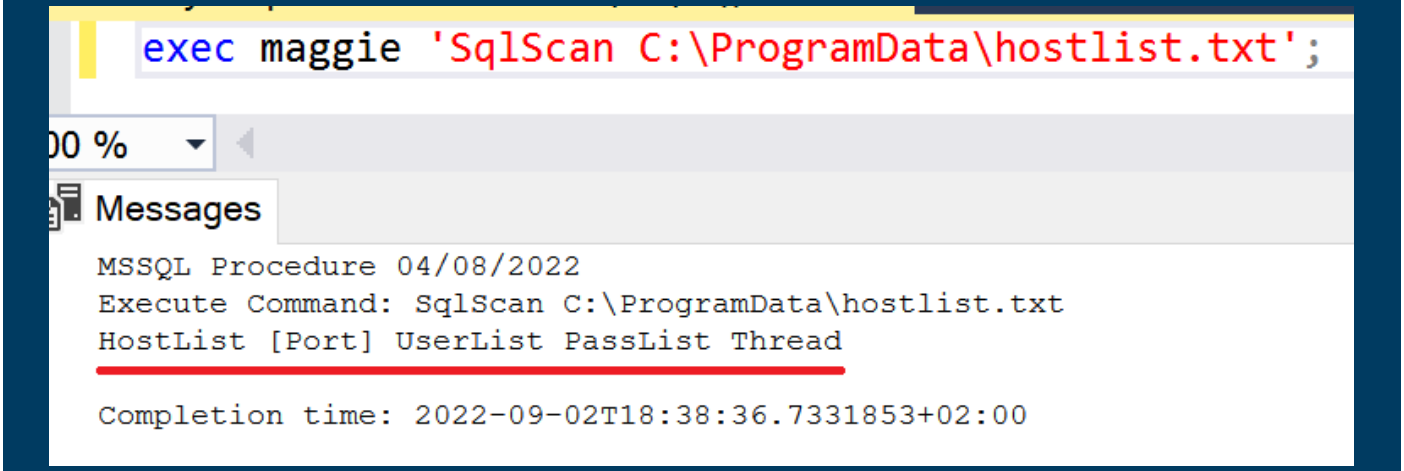
Commands

Once installed, *Maggie* offers a variety of commands to query for system information, interact with files and folders, execute programs as well as various network-related functionality like enabling TermService, running a Socks5 proxy server or setting up port forwarding to make *Maggie* act as a bridge head into the server's network environment.

The full list of commands we have identified:

List of commands available in Maggie

Commands can take multiple arguments, separated by spaces. For some commands, *Maggie* even includes usage instructions:



```
exec maggie 'SqlScan C:\ProgramData\hostlist.txt';
```

```
MSSQL Procedure 04/08/2022
Execute Command: SqlScan C:\ProgramData\hostlist.txt
HostList [Port] UserList PassList Thread

Completion time: 2022-09-02T18:38:36.7331853+02:00
```

Usage instructions for SqlScan command

Maggie as a network bridge head

Maggie contains functionality for simple TCP redirection, allowing it to function as a network bridge head from the Internet to any IP address reachable by the infected MSSQL server.

When enabled, *Maggie* redirects any incoming connection (on any port the MSSQL server is listening on) to a previously set IP and port, if the source IP address matches a user-specified IP mask. The implementation enables port reuse, making the redirection transparent to authorized users, while any other connecting IP is able to use the server without any interference or knowledge of *Maggie*.

For this to work, `StartHook` instructs *Maggie* to install network API hooks for the following functions:

- accept
- AcceptEx
- WSAAccept
- setsockopt

- CreateIoCompletionPort

allowing *Maggie* to intercept connections before reaching the underlying services.

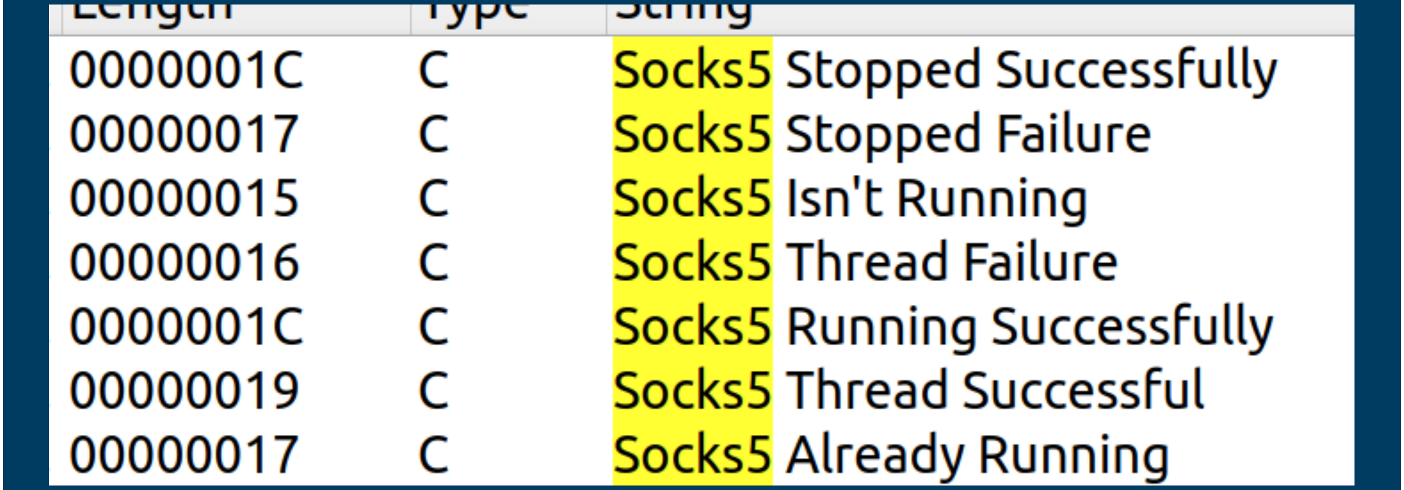
The redirection setup can be controlled using the `SetClientData` command with

```
SetClientData <allowed IP mask> <destination IP> <destination port>
```

in order to enable redirection for the given IP mask (can end with '*' wildcard) to the specified IP and port.

Once finished, an attacker can simply disable the IP redirection feature using `StopHook` again.

In addition, *Maggie* contains SOCKS5 proxy functionality for more complex network operations.



Length	Type	String
0000001C	C	Socks5 Stopped Successfully
00000017	C	Socks5 Stopped Failure
00000015	C	Socks5 Isn't Running
00000016	C	Socks5 Thread Failure
0000001C	C	Socks5 Running Successfully
00000019	C	Socks5 Thread Successful
00000017	C	Socks5 Already Running

Debug messages for SOCKS5 functionality

The unknown Exploit commands

Maggie's command list includes four commands that suggest exploit usage:

```
Exploit AddUser
Exploit Run
Exploit Clone
Exploit TS
```

It appears that the actual implementation of all four exploit commands depends on a

DLL not included with Maggie directly. Instead, the caller provides a DLL name as well as an additional parameter when calling each function. We therefore assume the caller manually uploads the exploit DLL prior to issuing any exploit commands.

Maggie would then load the user-specified DLL, look for an export named either `StartPrinter` or `ProcessCommand` (depending on the exact command used) and pass the user-supplied argument.

We were not able to dig up any potential candidate DLLs *Maggie* might be referencing during our research so it's unclear what specific exploit may be utilized here.

SQL bruteforcing and the curious Maggie backdoor user

Maggie's command set also includes two commands that allow it to bruteforce logins to other MSSQL servers:

```
SqlScan
WinSockScan
```

To start a bruteforce scan, the controller would have to specify a host, user and password list file previously uploaded to the infected server, as well as an optional thread count. *Maggie* then creates every combination of (host,user,pass) and attempts to log in via SQL using ODBC, or a reimplementation only using basic socket functions in the case of `WinSockScan`.

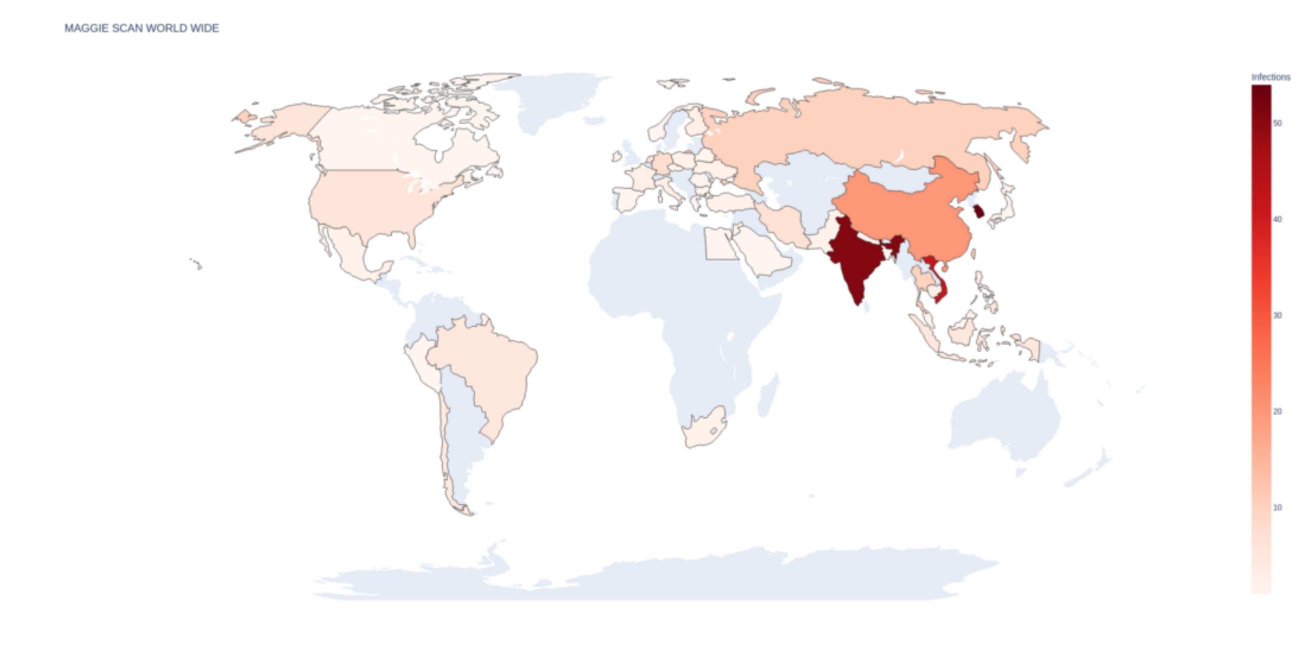
Successful logins are written to a hardcoded log file, which can be in one of two locations:

```
C:\ProgramData\success.dat
<MAGGIE_LOCATION>\success.dat
```

Maggie then tries to determine if the bruteforced login has admin rights. In case it successfully bruteforced an admin user, *Maggie* proceeds with adding a hardcoded backdoor user.

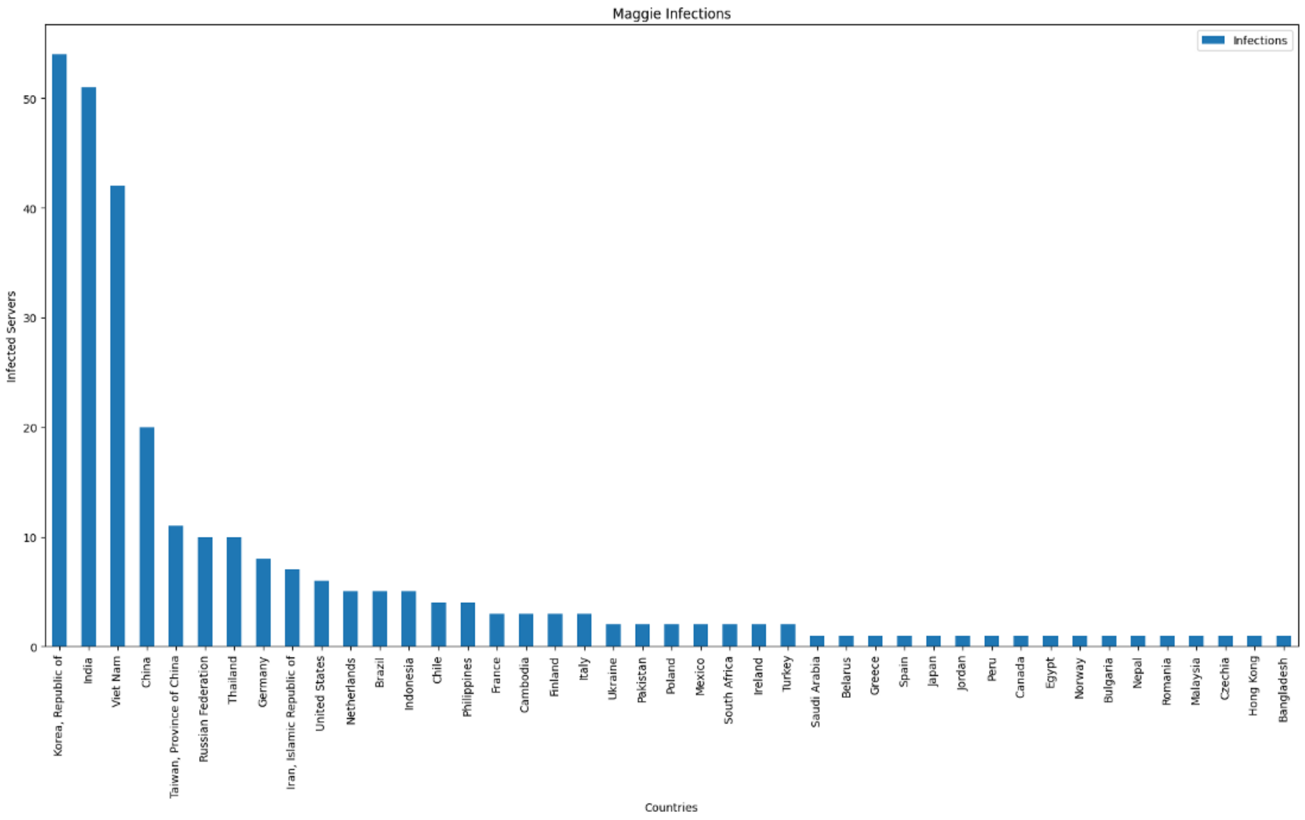
Based on this finding, *DCSO CyTec* conducted a scan on publicly reachable MSSQL servers in order to determine how prevalent the identified backdoor user is.

Out of approximately 600,000 scanned servers worldwide, we identified 285 servers infected with Maggie's backdoor user, spread over 42 countries.



Heatmap of backdoor user by country

The distribution shows a clear focus on the Asia-Pacific region, with South Korea, India and Vietnam as top 3 followed by China and Taiwan in the fourth and fifth place. Other countries appear to be incidental.



Prevalence of backdoor user by country

A logical next step would be to see if and how the affected servers are being utilized, which however goes beyond the scope of our analysis.

IoCs

As usual, you can find below IoCs in the form of a MISP event on our GitHub.

```
Maggie ESP DLLs
f29a311d62c54bbb01f675db9864f4ab0b3483e6cfdd15a745d4943029dcdf14
a375ae44c8ecb158895356d1519fe374dc99c4c6b13f826529c71fb1d47095c3
eb7b33b436d034b2992c4f40082ba48c744d546daa3b49be8564f2c509bd80e9
854bb57bbd22b64679b3574724fafd7f9de23f5f71365b1dd8757286cec87430

RAR SFX with Maggie
4311c24670172957b4b0fb7ca9898451878faeb5dcec75f7920f1f7ad339d958
d0bc30c940b525e7307eca0df85f1d97060ccd4df5761c952811673bc21bc794

ITW URLs
http://58.180.56.28/sql64.dll
http://106.251.252.83/sql64.dll
http://183.111.148.147/sql64.dll
http://xw.xxuz.com/VV61599.exe
http://58.180.56.28/vv61599.exe

Hardcoded User-Agent
Mozilla/4.0 (compatible)

File paths
C:\ProgramData\Success.dat
Success.dat
Failure.dat
AccessControl.Dat
```

MITRE ATT&CK

```
T1110       Brute Force
T1090       Connection Proxy
```