Final Investigation

IA 455 – Incident Response: Final Exam

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Contents

Executive Summary

Due to a weakness in a remote access technology in use on the network, an attacker was able to enter the network and both alter and steal files from at least two machines on the network. Additionally, one of these machines is responsible for many core functions of the network, and due to the type of access gained by the attacker, all functionality of that machine is now suspect and will likely require some highly impactful downtime to regain a sense of trust in the machine in questions. Furthermore, because of how thoroughly this machine was compromised, any user accounts on the network will need to be audited and, at a minimum, reset with new passwords.

Tools and Resources

- Security Onion 4.3.8
  "A free and open source Linux distribution for threat hunting, enterprise security monitoring, and log management."
  https://securityonionsolutions.com/software/
- Windows 10 1903 (OS Build 18362.356)
  "A series of operating systems developed by Microsoft and released as part of its Windows NT family of operating systems."
  https://www.microsoft.com/en-us/software-download/windows10
- Volatility 2.6.1 (Phocean)
  "An open-source memory forensics framework for incident response and malware analysis."
  https://www.volatilityfoundation.org/releases
- Wireshark 2.6.10
  "A free and open-source packet analyzer. It is used for network troubleshooting, analysis, software and communications protocol development, and education."
  https://www.wireshark.org/
- NetworkMiner 2.4
  "An open source Network Forensic Analysis Tool (NFAT) for…Linux/ FreeBSD)."
  https://www.netresec.com/?page=NetworkMiner
- Autopsy 4.12
  "Computer software that makes it simpler to deploy many of the open source programs and plugins used in The Sleuth Kit."
  https://www.autopsy.com/
- Zimmerman Tools' Timeline Explorer 1.3.0.0
  "View CSV and Excel files, filter, group, sort, etc. with ease"
  https://ericzimmerman.github.io/
- XDot 1.1.2
  "An interactive viewer for graphs written in Graphviz's dot language."
  https://github.com/jrfonseca/xdot.py
- Sleuthkit 4.6.7
  "A collection of UNIX-based command line file and volume system forensic analysis tools."
  https://sleuthkit.org/sleuthkit/download.php
- MD5Sum 8.30
  "Calculates and verifies MD-5 hashes. It is commonly used to verify the integrity of files. It (or a

variant) is installed by default in most Linux distributions."
https://man7.org/linux/man-pages/man1/sha1sum.1.html

- MiTec's Windows Registry Recovery x64 (3.1.0.0)
  "a freeware utility designed to allow for the extraction and reading of Windows registry hive files"
  https://mitec.cz/wrr.html
- Sha256Sum 8.30
  "calculates and verifies SHA-256 hashes. It is commonly used to verify the integrity of files. It (or a variant) is installed by default in most Linux distributions."
  https://man7.org/linux/man-pages/man1/sha1sum.1.html
- PowerShell 5.1.18362.145
  "A task automation and configuration management framework from Microsoft, consisting of a command-line shell and the associated scripting language."
  https://docs.microsoft.com/en-us/powershell/
- VirusTotal:
  "Analyze suspicious files and URLs to detect types of malware, automatically share them with the security community."
  https://www.virustotal.com/gui/home
- Abuse IP DB:
  "Our mission is to help make Web safer by providing a central blacklist for webmasters, system administrators, and other interested parties to report and find IP addresses that have been associated with malicious activity online."
  https://www.abuseipdb.com/
- Hybrid Analysis:
  "This is a free malware analysis service for the community that detects and analyzes unknown threats using a unique Hybrid Analysis technology."
  https://www.hybrid-analysis.com/

Evidence List

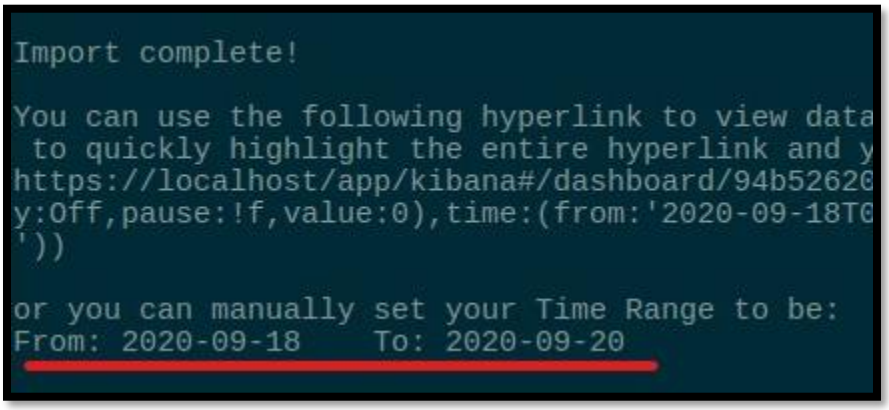
MD5 Hash	File Name
422046B753CF8A4DF49D2C4CE892DB16	case001-pcap.zip
964F2D710687D170C77C94947DA29E66	DC01-autorunsc.zip
E57FC636E833C5F1AB58DFACE873BBDE	DC01-E01.zip
64A4E2CB47138084A5C2878066B2D7B1	DC01-memory.zip
964EEAF0009D08CC101DE4A83A4E5D23	DC01-pagefile.zip
AD29830A583EFE49C8C1C35FAFFD264F	DC01-ProtectedFiles.zip
71C5C3509331F472ABCDF81EB6EFFF07	DESKTOP-E01.zip
3627DCAFA54E1365489A4EC0CC3D6A1C	DESKTOP-SDN1RPT-autrunsc.zip
CF31E2635C77811AAA1BB04A92A721E2	DESKTOP-SDN1RPT-memory.zip
45C096F2688A0B5DE0346FB72391B245	Desktop-SDN1RPT-pagefile.zip
3E1A358D50003A9351AC2160AE6F0495	DESKTOP-SDN1RPT-Protected Files.zip

Network Evidence

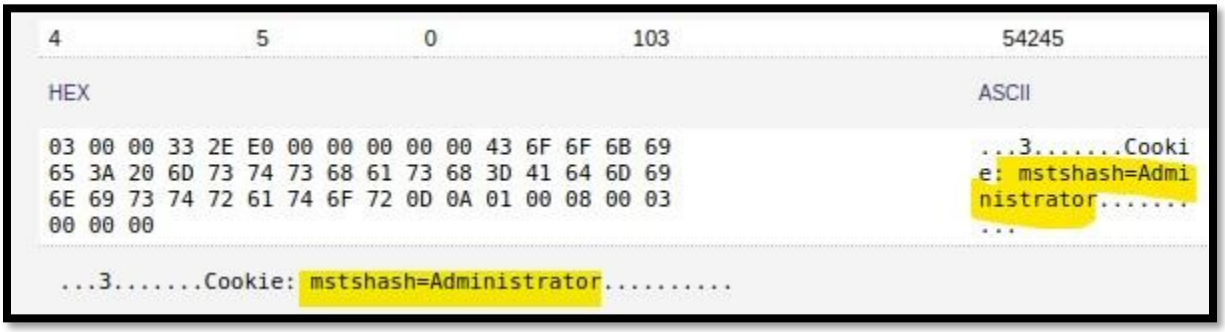
IP Address Involved	DNS Name (If available)

10.42.85.10	citadel-dc01.c137.local
10.42.82.115	desktop-sdn1rpt.local
194.61.24.102	
203.78.103.109	

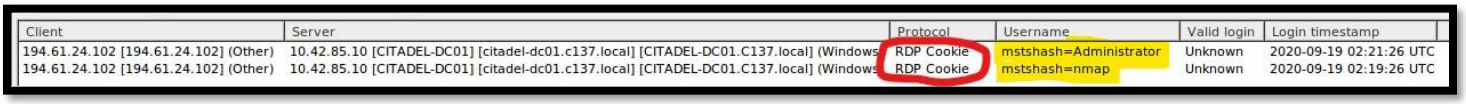
To being with, I set up a Security Onion machine, transferred case001-pcap (MD5: f81a3ab2cb74dc3c1d91d1bab1b5fc9d) to this machine, and verified that the pcap transferred properly by comparing the hash before and after. Next, I loaded the pcap into the system by using the *sudo so-import-pcap case001.pcap* command. From this point I started up the built-in Squert installation and narrowed the time display to 2020-09-18 through 2020-09-20 as dictated by the pcap:



Immediately, several problems are evident:

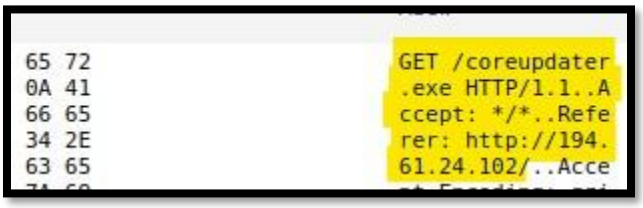


More than six hundred RDP attempts with connection confirmation, and from a remote IP address as well:



This begins to paint a picture of a remote attacker attempting to brute force their way into Remote Desktop Protocol credentials. Shortly after this burst, there is evidence of success and further compromise:

ST	TIMESTAMP	EVENT ID	SOURCE	PORT	DESTINATION	PORT	SIGNATURE
RT	2020-09-19 02:24:06	5.2719	10.42.85.10	62410	194.61.24.102	80	ET INFO Executable Download from dotted-quad Host



This clearly shows an HTTP GET request for 194.61.24.102/coreupdater.exe, which is the same IP as the brute force attacker. Opening the pcap in Wireshark, I was quickly able to isolate the traffic sessions from 194.61.24.102 to citadel-dc01.c137.local (10.42.85.10):

232420	194.61.24.102 [194.61.24.102] (Other)	40226	10.42.85.10 [CITADEL-DC01] [citadel-dc01.c137.local] [CITADEL-DC01.C137.local] (Windows)	3389
232508	194.61.24.102 [194.61.24.102] (Other)	40234	10.42.85.10 [CITADEL-DC01] [citadel-dc01.c137.local] [CITADEL-DC01.C137.local] (Windows)	3389
232563	194.61.24.102 [194.61.24.102] (Other)	40236	10.42.85.10 [CITADEL-DC01] [citadel-dc01.c137.local] [CITADEL-DC01.C137.local] (Windows)	3389
232935	194.61.24.102 [194.61.24.102] (Other)	40238	10.42.85.10 [CITADEL-DC01] [citadel-dc01.c137.local] [CITADEL-DC01.C137.local] (Windows)	3389
236782	10.42.85.10 [CITADEL-DC01] [citadel-dc01.c137.local] [CITADEL-DC01.C137.local] (Windows)	62407	194.61.24.102 [194.61.24.102] (Other)	80
236781	10.42.85.10 [CITADEL-DC01] [citadel-dc01.c137.local] [CITADEL-DC01.C137.local] (Windows)	62408	194.61.24.102 [194.61.24.102] (Other)	80
238560	10.42.85.10 [CITADEL-DC01] [citadel-dc01.c137.local] [CITADEL-DC01.C137.local] (Windows)	62409	194.61.24.102 [194.61.24.102] (Other)	80
238559	10.42.85.10 [CITADEL-DC01] [citadel-dc01.c137.local] [CITADEL-DC01.C137.local] (Windows)	62410	194.61.24.102 [194.61.24.102] (Other)	80
238560	10.42.85.10 [CITADEL-DC01] [citadel-dc01.c137.local] [CITADEL-DC01.C137.local] (Windows)	62409	194.61.24.102 [194.61.24.102] (Other)	80

and desktop-sdn1rpt.local (10.42.85.115):

327358	10.42.85.115 [DESKTOP-SDN1RPT.local] [desktop-sdn1rpt] [DESKTOP-SDN1RPT] (Windows)	50841	194.61.24.102 [194.61.24.102] (Other)	80
327357	10.42.85.115 [DESKTOP-SDN1RPT.local] [desktop-sdn1rpt] [DESKTOP-SDN1RPT] (Windows)	50840	194.61.24.102 [194.61.24.102] (Other)	80
327358	10.42.85.115 [DESKTOP-SDN1RPT.local] [desktop-sdn1rpt] [DESKTOP-SDN1RPT] (Windows)	50841	194.61.24.102 [194.61.24.102] (Other)	80
339448	10.42.85.115 [DESKTOP-SDN1RPT.local] [desktop-sdn1rpt] [DESKTOP-SDN1RPT] (Windows)	50864	194.61.24.102 [194.61.24.102] (Other)	80
339449	10.42.85.115 [DESKTOP-SDN1RPT.local] [desktop-sdn1rpt] [DESKTOP-SDN1RPT] (Windows)	50865	194.61.24.102 [194.61.24.102] (Other)	80
339449	10.42.85.115 [DESKTOP-SDN1RPT.local] [desktop-sdn1rpt] [DESKTOP-SDN1RPT] (Windows)	50865	194.61.24.102 [194.61.24.102] (Other)	80
387213	194.61.24.102 [194.61.24.102] (Other)	40240	10.42.85.10 [CITADEL-DC01] [citadel-dc01.c137.local] [CITADEL-DC01.C137.local] (Windows)	3389

From this information it seemed likely that my original assumption was correct: the attack originated with a brute force attack on RDP (port 3389) and then moved onto establishing a beachhead with the coreupdate.exe program through an HTTP request from the victim machine (port 80). Working on this hypothesis, I then used NetworkMiner to carve out the files from the pcap, which yielded the malware from both machines:

Filter keyword: 194.61.24.102

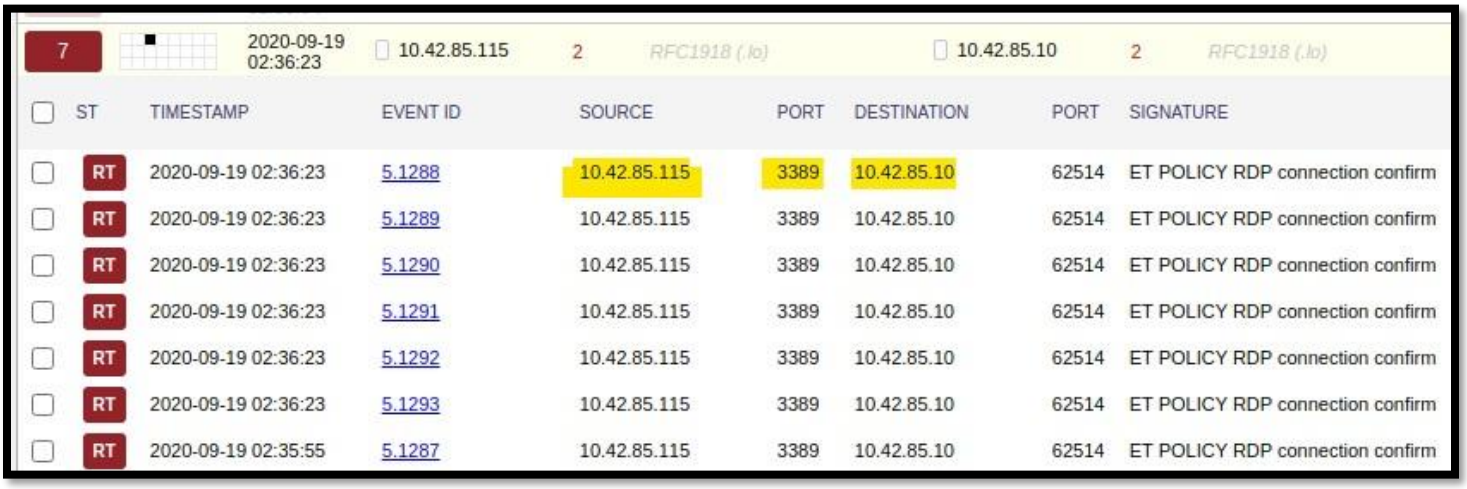
Frame nr.	Filename	Extension	Size	Source host	S. port	Destination host	D. port
236787	index.html	html	228 B	194.61.24.102 [194.61.24.102] (Other)	TCP 80	10.42.85.10 [CITADEL-DC01] [citadel-dc01.c137.local] [CITADEL-DC01.C137.local] (Windows)	TCP 62408
238565	coreupdater[1].exe	exe	7 168 B	194.61.24.102 [194.61.24.102] (Other)	TCP 80	10.42.85.10 [CITADEL-DC01] [citadel-dc01.c137.local] [CITADEL-DC01.C137.local] (Windows)	TCP 62410
327363	index[1].html	html	228 B	194.61.24.102 [194.61.24.102] (Other)	TCP 80	10.42.85.115 [DESKTOP-SDN1RPT.local] [desktop-sdn1rpt] [DESKTOP-SDN1RPT] (Windows)	TCP 50840
339455	coreupdater[2].exe	exe	7 168 B	194.61.24.102 [194.61.24.102] (Other)	TCP 80	10.42.85.115 [DESKTOP-SDN1RPT.local] [desktop-sdn1rpt] [DESKTOP-SDN1RPT] (Windows)	TCP 50864

Transferred to the infected system via HTTP GET request:

	D. port	Protocol	Timestamp	Reconstructed file path	Details
Windows)	TCP 62408	HttpGetNormal	2020-09-19 02:23:41 UTC	/opt/networkminer/AssembledFiles/194.61.24.10...	194.61.24.102/
Windows)	TCP 62410	HttpGetNormal	2020-09-19 02:24:06 UTC	/opt/networkminer/AssembledFiles/194.61.24.10...	194.61.24.102/coreupdater.exe
indows)	TCP 50840	HttpGetNormal	2020-09-19 02:39:26 UTC	/opt/networkminer/AssembledFiles/194.61.24.10...	194.61.24.102/
indows)	TCP 50864	HttpGetNormal	2020-09-19 02:39:58 UTC	/opt/networkminer/AssembledFiles/194.61.24.10...	194.61.24.102/coreupdater.exe

Content-Type	text/html	236809	194.61.24.102 [194.61.24.102] (Other)	TCP 80
GET	/coreupdater.exe	238565	10.42.85.10 [CITADEL-DC01] [citadel-d...	62410
Referer	http://194.61.24.102/	238565	10.42.85.10 [CITADEL-DC01] [citadel-d...	TCP 62410
User-Agent	Mozilla/5.0 (Windows NT 6.3; WOW64; Tr...	238565	10.42.85.10 [CITADEL-DC01] [citadel-d...	TCP 62410
Host	194.61.24.102	238565	10.42.85.10 [CITADEL-DC01] [citadel-d...	TCP 62410

Next, there are RDP connections from citadel-dc01 (10.42.85.10) to desktop-sdn1rpt (10.42.85.115):

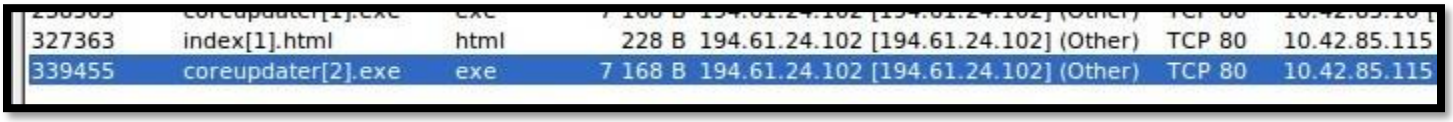


ST	TIMESTAMP	EVENT ID	SOURCE	PORT	DESTINATION	PORT	SIGNATURE
RT	2020-09-19 02:36:23	5.1288	10.42.85.115	3389	10.42.85.10	62514	ET POLICY RDP connection confirm
RT	2020-09-19 02:36:23	5.1289	10.42.85.115	3389	10.42.85.10	62514	ET POLICY RDP connection confirm
RT	2020-09-19 02:36:23	5.1290	10.42.85.115	3389	10.42.85.10	62514	ET POLICY RDP connection confirm
RT	2020-09-19 02:36:23	5.1291	10.42.85.115	3389	10.42.85.10	62514	ET POLICY RDP connection confirm
RT	2020-09-19 02:36:23	5.1292	10.42.85.115	3389	10.42.85.10	62514	ET POLICY RDP connection confirm
RT	2020-09-19 02:36:23	5.1293	10.42.85.115	3389	10.42.85.10	62514	ET POLICY RDP connection confirm
RT	2020-09-19 02:35:55	5.1287	10.42.85.115	3389	10.42.85.10	62514	ET POLICY RDP connection confirm

From shortly after this connection, there was evidence of the download of coreupdater.exe via HTTP GET request to 194.61.24.102:

T	TIMESTAMP	EVENT ID	SOURCE	PORT	DESTINATION	PORT	SIGNATURE
RT	2020-09-19 02:39:58	5.1362	10.42.85.115	50864	194.61.24.102	80	ET INFO Executable Download from dotted-quad Host

Again, I was able to carve out this file using NetworkMiner (MD5 eed41b4500e473f97c50c7385ef5e374):



327363	index[1].html	html	228 B	194.61.24.102 [194.61.24.102] (Other)	TCP 80	10.42.85.115
339455	coreupdater[2].exe	exe	7 168 B	194.61.24.102 [194.61.24.102] (Other)	TCP 80	10.42.85.115

Finally, there appears to have been contacted with IP 203.78.103.109 using Metasploit:

ST	TIMESTAMP	EVENT ID	SOURCE	PORT	DESTINATION	PORT	SIGNATURE
RT	2020-09-19 02:40:50	5.1377	203.78.103.109	443	10.42.85.115	50875	ET TROJAN Possible Metasploit Payload Common Construct Bind_API (from server)

Volatile Memory Evidence

My next step in analyzing the evidence was to look at the volatile memory stored in citadeldc01.mem (MD5: 0623f97fc80c12aa508ed9926b2ec04e) using the program Volatility. My goal was to determine which OS was in use on citadeldc01 by running the *volatility -f citadeldc01.mem imageinfo* command which revealed that the best option would be the Win2012R2x64_18340 profile. Next, I wanted to see the running processes to see if coreupdater.exe was resident in memory and to carve it out to compare to the NetworkMiner version. To do this I ran the *volatility -f citadeldc01.mem --profile=Win2012R2x64_18340 pslist | tee pslist.txt* command, which showed the running processes, their Process IDs, Parent Process IDs, Start and Exit Times, etc while also saving these results into an easy to read text file for later investigation. This showed that while coreupdater.exe was present in memory, it had no handles and had exited a few milliseconds after starting, which would make carving the file much more difficult:

```
Offset(V)          Name                    PID   PPID   Thds     Hnds
0xffffe00062fe7700 coreupdater.ex         3644   2244      0 --------
```

```
Start                           Exit
2020-09-19 03:56:37 UTC+0000   2020-09-19 03:56:52 UTC+0000
```

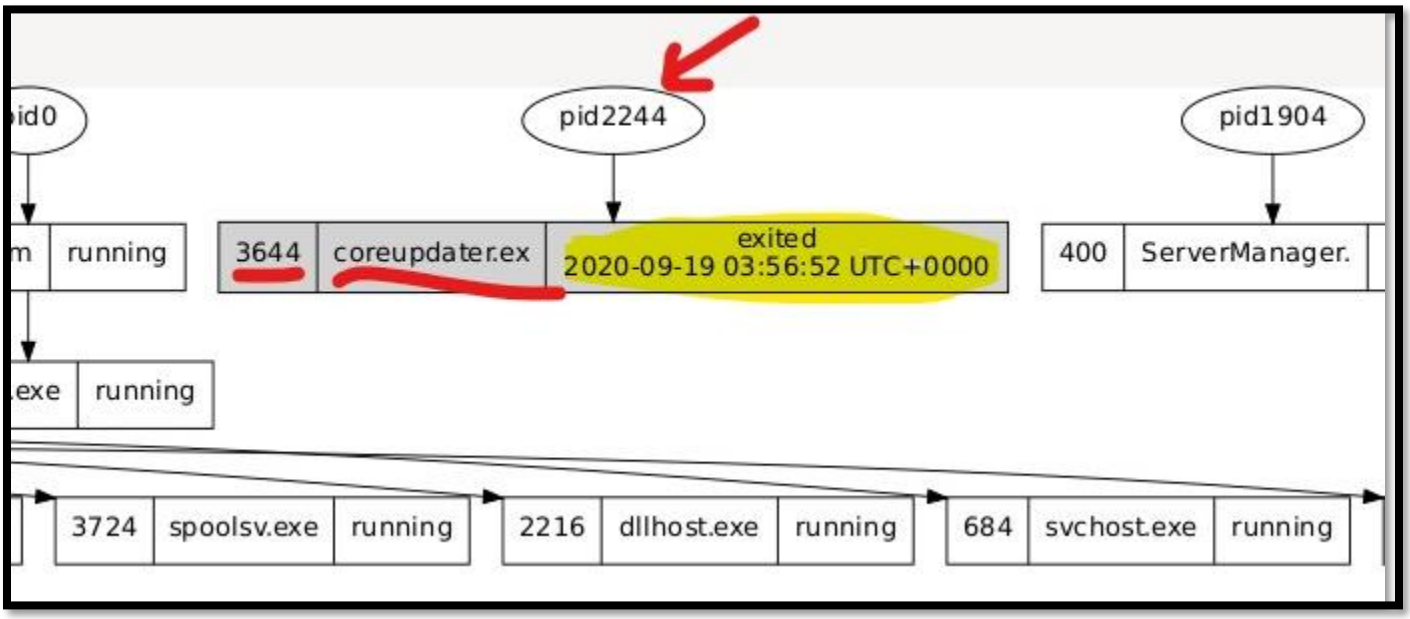
Note that the listed process name, coreupdater.ex, is just because of how Windows truncates file and process names running in memory, but a successful carving of the process should still have the same hash as the file carved by NetworkMiner. My next course of action was to attempt to carve out the file by running the *volatility -f citadeldc01.mem --profile=Win2012R2x64_18340 procdump -p 3644 -D procmemdump/* command which failed:

```
/investigation$ cat procdump.txt | grep 'Offset\|core'
coreupdater.ex      Error: PEB at 0x7ff5ffffe000 is unavailable (possibly due to paging)
```

My next course of action was to run the *volatility -f citadeldc01.mem --profile=Win2012R2x64_18340 psscan | tee psscan.txt* command which can show unlinked (hidden) processes:

```
Offset(P)          Name                PID   PPID
0x000000002082c700 coreupdater.ex     3644   2244
0x000000005fa61700 coreupdater.ex     3644   2244
```

Another visualization from exporting the psscan data into Xdot:



This was interesting in and of itself, since there were additional offsets to try and also because the parent process id (2244) was nowhere to be found, but I also noticed that there was another unlinked process:

```
Offset(P)          Name                PID   PPID
0x0000000020fcb900 spoolsv.exe        3724    452
0x0000000060186900 spoolsv.exe        3724    452
```

I wasn't sure, but at the time my thought was that perhaps there was some process injection that would account for the

very fast run time of coreupdater.exe. Note that PID 452 is a legitimate process, services.exe, which does normally start spoolsv.exe, so if this instance of spools was malicious it was mostly because of process injection. I made a note that for later and went back to recovering coreupdater.exe. I next attempted to run the *procdump* command using the various offsets discovered earlier but had no luck. Unable to carve out the file from memory, I proceeded to try to gather more information about coreupdater.exe (PID: 3644). To try to scope out how successful the attacker had been at escalating privileges, I ran the *volatility -f citadeldc01.mem --profile=Win2012R2x64_18340 sids | tee sids.txt* command, which showed the worst-case scenario:

```
coreupdater.ex (3644): S-1-5-21-2232410529-1445159330-2725690660-500 (Administrator)
coreupdater.ex (3644): S-1-5-21-2232410529-1445159330-2725690660-513 (Domain Users)
coreupdater.ex (3644): S-1-1-0 (Everyone)
coreupdater.ex (3644): S-1-5-32-544 (Administrators)
coreupdater.ex (3644): S-1-5-32-545 (Users)
coreupdater.ex (3644): S-1-5-32-554 (BUILTIN\Pre-Windows 2000 Compatible Access)
coreupdater.ex (3644): S-1-5-14 (Remote Interactive Logon)
coreupdater.ex (3644): S-1-5-4 (Interactive)
coreupdater.ex (3644): S-1-5-11 (Authenticated Users)
coreupdater.ex (3644): S-1-5-15 (This Organization)
coreupdater.ex (3644): S-1-5-5-0-5975976 (Logon Session)
coreupdater.ex (3644): S-1-2-0 (Local (Users with the ability to log in locally))
coreupdater.ex (3644): S-1-5-21-2232410529-1445159330-2725690660-520 (Group Policy Creator Owners)
coreupdater.ex (3644): S-1-5-21-2232410529-1445159330-2725690660-512 (Domain Admins)
coreupdater.ex (3644): S-1-5-21-2232410529-1445159330-2725690660-518 (Schema Admins)
coreupdater.ex (3644): S-1-5-21-2232410529-1445159330-2725690660-519 (Enterprise Admins)
coreupdater.ex (3644): S-1-18-1 (Authentication Authority Asserted Identity)
coreupdater.ex (3644): S-1-5-21-2232410529-1445159330-2725690660-572
coreupdater.ex (3644): S-1-16-12288 (High Mandatory Level)
```

The attacker had managed to get Domain Admin privileges on what is presumably a Domain Controller is about as bad as it can get. Serious remediation efforts are needed to resolve something like this. My next step was to run the *volatility -f citadeldc01.mem --profile=Win2012R2x64_18340 netscan | tee netscan.txt* command to check on any network traffic associated with coreupdater.exe:

```
  TCPv4    10.42.85.10:62613          203.78.103.109:443   ESTABLISHED      3644     coreupdater.ex
  TCPv4    10.42.85.10:62613          203.78.103.109:443   ESTABLISHED      3644     coreupdater.ex
```

Which shows it was connected to the Metasploit-related address. I also checked for connections from spoolsv.exe:

```
  0.0.0.0:62475          0.0.0.0:0              LISTENING        3724     spoolsv.exe
  0.0.0.0:62475          0.0.0.0:0              LISTENING        3724     spoolsv.exe
  :::62475               :::0                   LISTENING        3724     spoolsv.exe
  0.0.0.0:62475          0.0.0.0:0              LISTENING        3724     spoolsv.exe
  0.0.0.0:62475          0.0.0.0:0              LISTENING        3724     spoolsv.exe
  :::62475               :::0                   LISTENING        3724     spoolsv.exe
/memory/dc01/investigations$
```

All this showed was that spoolsv.exe was listening on TCP port 62475 which isn't necessarily strange behavior. I knew that I would need to do some disk forensics, so I wanted to see if I could find where the coreupdater.exe file was located on the infected machine, so I ran the *volatility -f citadeldc01.mem --profile=Win2012R2x64_18340 filescan | tee filescan.txt* command:

```
RWD--- \Device\HarddiskVolume2\Windows\System32\coreupdater.exereupdater.exe.2424urv.partial
R--r-d \Device\HarddiskVolume2\Windows\System32\coreupdater.exereupdater.exe
```

This showed me that the file was located at \Windows\System32\coreupdater.exe which would make it much easier to

find. I wanted to look more into spoolsv.exe and the coreupdater.exe listing situation, so I ran the *volatility -f citadeldc01.mem --profile=Win2012R2x64_18340 psxview | tee psxview.txt | grep 'coreupdater\|spoolsv'* command:

```
Name                 PID pslist psscan thrdproc pspcid csrss session deskthrd ExitTime
spoolsv.exe         3724 False  True   False    False  False False   False
coreupdater.ex      3644 False  True   False    False  False False   False    2020-09-19 03:56:52 UTC+0000
```

From this, it was clear that *something* strange is going on with spoolsv.exe since it had been unlinked from most of the normal process listings, the same with coreupdate.exe. My next command to run was the *volatility -f citadeldc01.mem --profile=Win2012R2x64_18340 svcscan -v | tee svcscan-v.txt* command, which shows service information. Running that output through *| grep 'core' -C10* showed the following:

```
Offset: 0x895057cce0
Order: 410
Start: SERVICE_AUTO_START
Process ID: -
Service Name: coreupdater
Display Name: coreupdater
Service Type: SERVICE_WIN32_OWN_PROCESS
Service State: SERVICE_STOPPED
Binary Path: -
```

This suggested to me that coreupdater.exe might have gained persistence by setting itself as an automatically starting service. There was enough evidence at this point to make me suspicious of spoolsv.exe, so I tried dumping it using the same commands that I attempted to use on coreupdater.exe and received the same error:

```
justin@dfir-ubuntu:~/final/memory/dc01$ volatility -f citadeldc01.mem --profile=Win2012R2x64_18340 procdump -p 3742 --dump-dir temp/
Volatility Foundation Volatility Framework 2.6.1
ERROR   : volatility.debug    : Cannot find PID 3742. If its terminated or unlinked, use psscan and then supply --offset=OFFSET
justin@dfir-ubuntu:~/final/memory/dc01$ volatility -f citadeldc01.mem --profile=Win2012R2x64_18340 procdump --offset=0xffffe000631cb900 --dump-dir temp/
Volatility Foundation Volatility Framework 2.6.1
Process(V)         ImageBase          Name                 Result
------------------ ------------------ -------------------- ------
------------------ ------------------ -------------------- Error: Cannot acquire process AS
justin@dfir-ubuntu:~/final/memory/dc01$
```

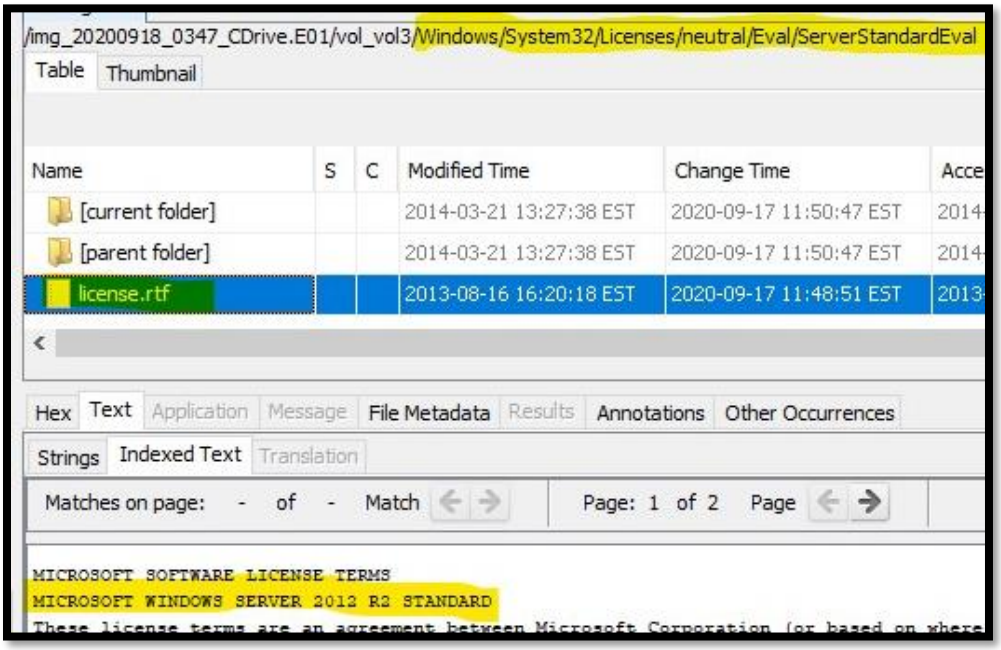
This suggested there was something strange happening, as spoolsv.exe wasn't even exited so it should have been resident enough in memory to dump; however, I was unable to dump it by process ID nor by offset. My final step for this process was to use a data visualization tool, Zimmerman Tools' Timeline Explorer, on data exported using the *volatility -f citadeldc01.mem --profile=Win2012R2x64_18340 timeliner --output-file=timeliner.body* command and then to use the *mactime -y -d -z UTC -b timeliner.body > timerliner.csv* command. From that point I simply needed to load the CSV file into Timeline Explorer:

```
[USER ASSIST] %windir%\system32\coreupdater.exe Registry: \??\C:\Users\Administrator\ntuser.dat /ID: N/A/Count: 3/FocusCount: 0/1
[THREAD] Microsoft.Acti PID: 1292/TID: 708
[THREAD] spoolsv.exe PID: 3724/TID: 2508
[DLL LOADTIME (dll)] MPR.dll Process: spoolsv.exe/PID: 3724/PPID: 452/Process POffset: 0x20fcb900/DLL Base: 0x7fffcec10000
[DLL LOADTIME (dll)] NETAPI32.dll Process: spoolsv.exe/PID: 3724/PPID: 452/Process POffset: 0x20fcb900/DLL Base: 0x7fffd8850000
[DLL LOADTIME (dll)] PSAPI.DLL Process: spoolsv.exe/PID: 3724/PPID: 452/Process POffset: 0x20fcb900/DLL Base: 0x7fffdd8d0000
[DLL LOADTIME (dll)] WINHTTP.dll Process: spoolsv.exe/PID: 3724/PPID: 452/Process POffset: 0x20fcb900/DLL Base: 0x7fffd0a70000
[DLL LOADTIME (dll)] WININET.dll Process: spoolsv.exe/PID: 3724/PPID: 452/Process POffset: 0x20fcb900/DLL Base: 0x7fffd25b0000
[DLL LOADTIME (dll)] WINMM.dll Process: spoolsv.exe/PID: 3724/PPID: 452/Process POffset: 0x20fcb900/DLL Base: 0x7fffcfb60000
[DLL LOADTIME (dll)] WINMMBASE.dll Process: spoolsv.exe/PID: 3724/PPID: 452/Process POffset: 0x20fcb900/DLL Base: 0x7fffcfa30000
[DLL LOADTIME (dll)] iertutil.dll Process: spoolsv.exe/PID: 3724/PPID: 452/Process POffset: 0x20fcb900/DLL Base: 0x7fffd27e0000
[DLL LOADTIME (dll)] ole32.dll Process: spoolsv.exe/PID: 3724/PPID: 452/Process POffset: 0x20fcb900/DLL Base: 0x7fffdc9a0000
[DLL LOADTIME (dll)] wkscli.dll Process: spoolsv.exe/PID: 3724/PPID: 452/Process POffset: 0x20fcb900/DLL Base: 0x7fffd9ec0000
[PROCESS] coreupdater.ex PID: 3644/PPID: 2244/POffset: 0x2082c700
```

Taken with the rest of the spoolsv.exe related evidence, this shows spoolsv.exe loading several dlls, including WINHTTP.dll and WININET.dll, both of which include functionality for access local and remote network resources.

Disk Evidence

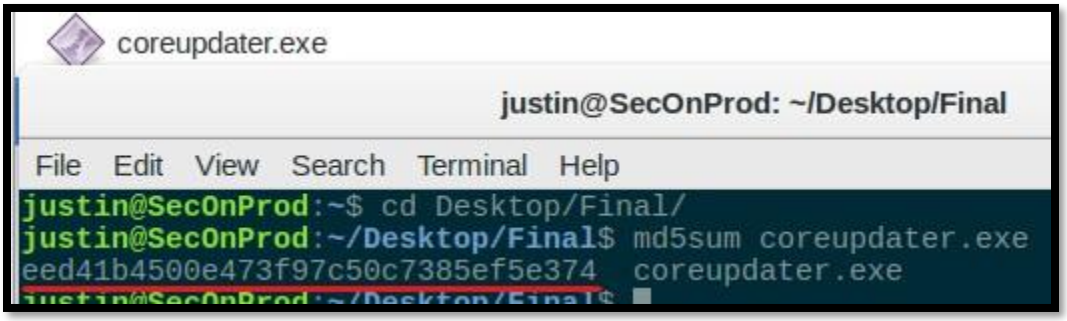
I chose to use Autopsy 4.12 on a Windows 10 (1903) VM for my disk forensics and my first step was to verify that the profile I'd been using for the memory forensics was correct:



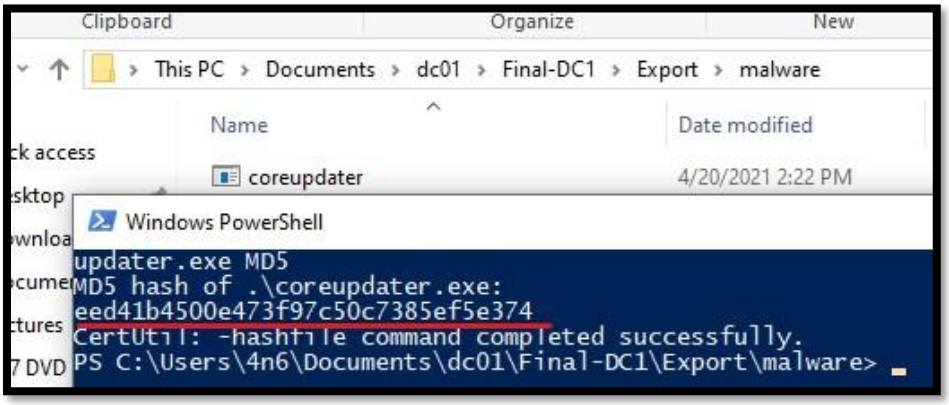
This showed that a Windows Server 2012 Standard license was present, so that confirmed that I had been using the correct license. With this complete I navigated to the location of coreupdater.exe that was established earlier during the memory forensics examination: C:\Windows\System32\coreupdater.exe and extracted it:

Immediately, I received a warning from Windows Defender:

This seems to confirm that Metasploit was being used, specifically the meterperter payload which supplies the attacker with an interactive shell on the victim machine. I then set up a working directory that is excluded from Windows Defender and extracted the file again. I then verified that MD5 from the newly extracted coreupdater.exe (MD5 eed41b4500e473f97c50c7385ef5e374) and the older one that I extracted from the pcap:



The above is from the NetworkMiner-based extraction on my Security Onion instance



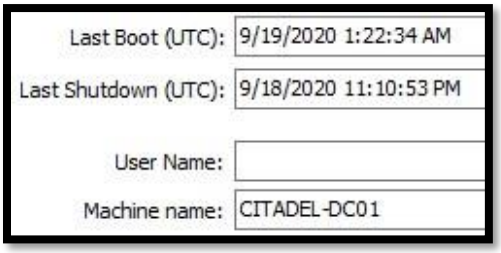
The above is from the disk forensics VM. Confirming that they matched helps to strengthen the case that this was the same malware since it was recovered from two separate captures, using two separate techniques. Next, I wanted to

gather more information from the citadel-dc01 disk image, so I ran a keyword search for coreupdater.exe and was presented with these results:

Right away it became clear that this was the same malware from the Squert alerts, as there are many references to the malicious IP address previously identified, 192.61.24.102. Next, I wanted to know how many users were on the machine to tighten my scope, so I looked in the SAM registry hive using MiTec's Windows Registry Recovery x64:

The guest user is not active, so only there appeared to be only one active account on this machine. While looking through the registry files, I also spent some time verifying various bits of system information:

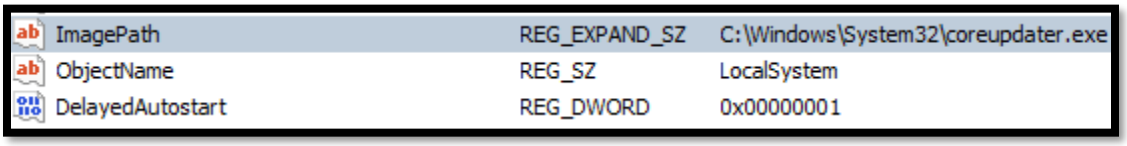
The above correlated the information I'd obtained earlier, helping to strengthen my case.



The above showed me the last boot and shutdown times of the machine, suggesting that the attacker had gained

persistence. Since I had already suspected the registry was how this was accomplished, I went back to the keyword search to see if any registry files showed up, and three did: NTUSER.dat, SYSTEM, and SOFTWARE all of which have references to the malware. NTUSER.dat had the following:

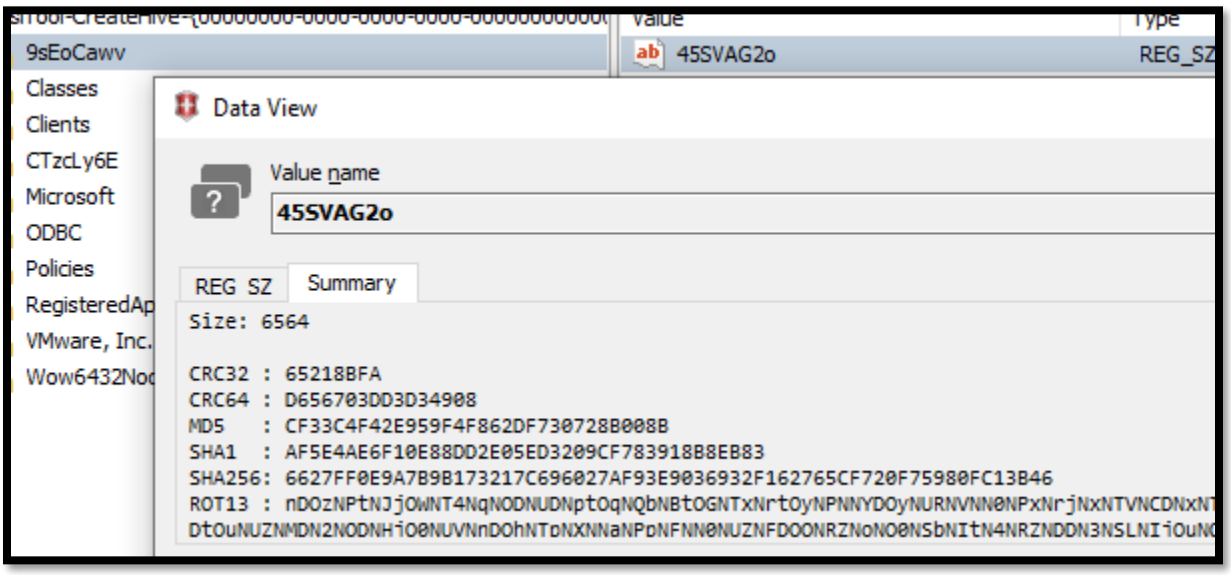
This implies that coreupdate.exe was run manually since the coreupdater.exe was in two of the Administrator user's Most Recently Used (MRU) lists. Meanwhile, the SYSTEM hive had this:



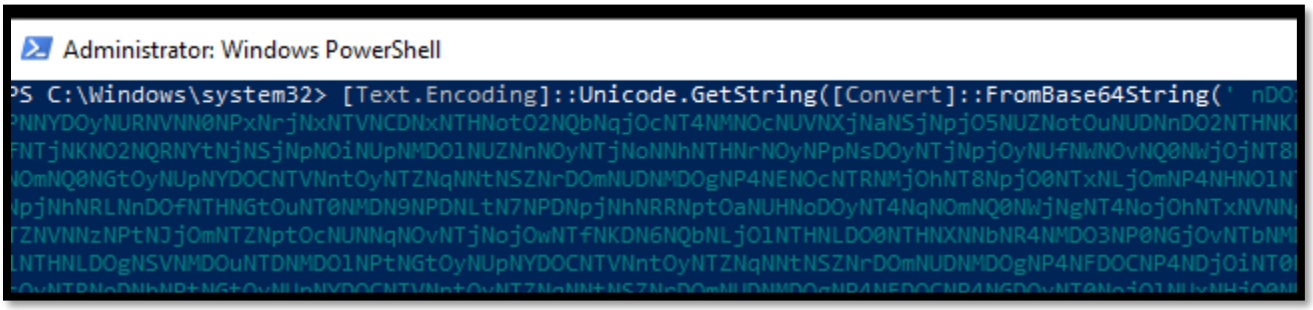
Which was located in SYSTEM\ControlSet001\Services\coreupdater. This helps to correlate the earlier hypothesis that persistence was achieved via setting itself as a service.

The SOFTWARE hive, in particular, featured this:

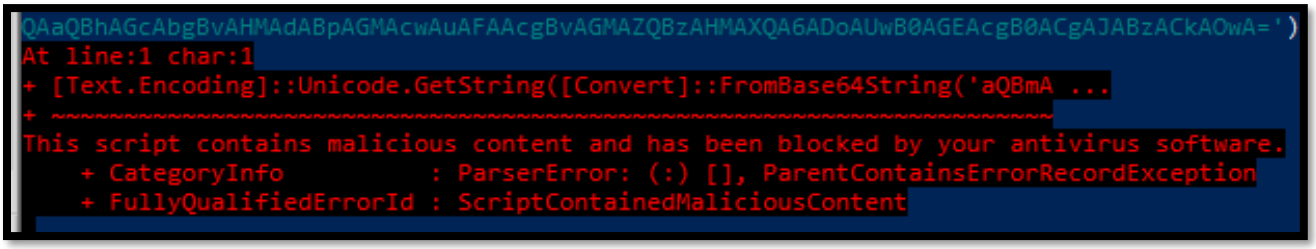
The above is all one line but was unreadably small unless broken up like this. The most important part is the end of the last line: Software\9sEoCawv\45SVAG2o:



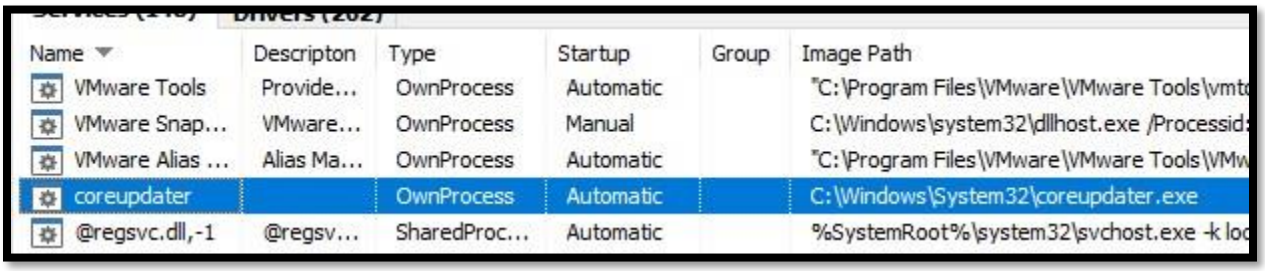
This contains a very long 'ROT13' encrypted string which is actually base64 and converts into malware:



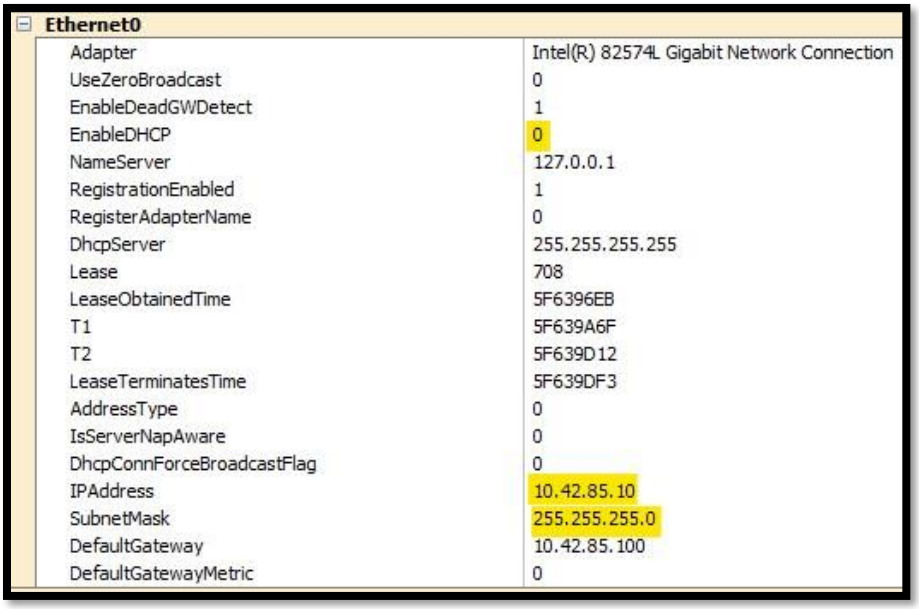
The above is before decryption and below is after:



Additionally, coreupdater.exe is listed in Services as an automatically started service:



Next, I knew that I should verify that the earlier recorded victim IP address for citadel-dc01 was correlated with 10.42.85.10. Again, I loaded up the registry hives into Windows Registry Recovery x64 and navigated to the SYSTEM\ControlSet001\Services\Tcpip\Parameters\Interfaces\{791D93FB-6EDF-4C65-B1B9-F8E46CFFEA73}, which did confirm that this machine was using 10.42.85.10 as its IP address at the time of the capture:



After confirming this, I wanted to look for evidence of data exfiltration, so my place to check was the web history:

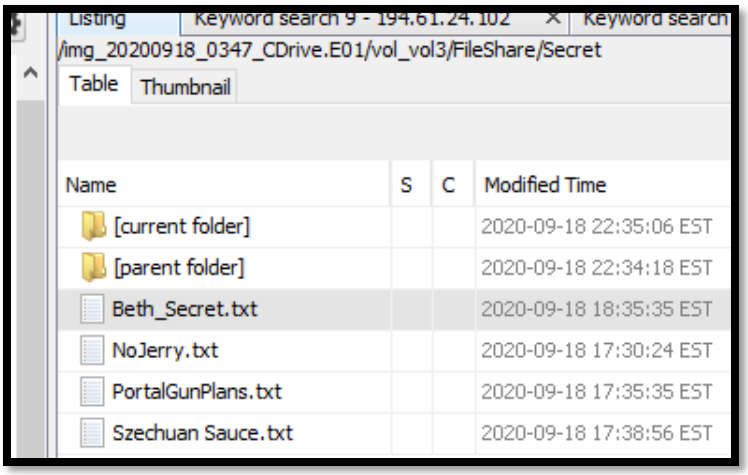
Web History

URL	Date Accessed	Referrer	Title	Program	URL Domain	Domain	Username
file:///C:/FileShare/Secret/Beth_Secret.txt	2020-09-19 05:35:07 EST			Microsoft Edge			Administrator
file:///C:/FileShare/Secret/PortalGunPlans.txt	2020-09-19 05:32:02 EST			Microsoft Edge			Administrator
file:///C:/FileShare/Secret/SECRET_beth.txt	2020-09-19 05:32:13 EST			Microsoft Edge			Administrator
file:///C:/FileShare/Secret/Szechuan%20Sauce.txt	2020-09-19 05:32:21 EST			Microsoft Edge			Administrator
http://194.61.24.102/	2020-09-19 05:23:41 EST			Microsoft Edge		194.61.24.102	Administrator
http://194.61.24.102/favicon.ico	2020-09-19 05:23:41 EST			Microsoft Edge		194.61.24.102	Administrator

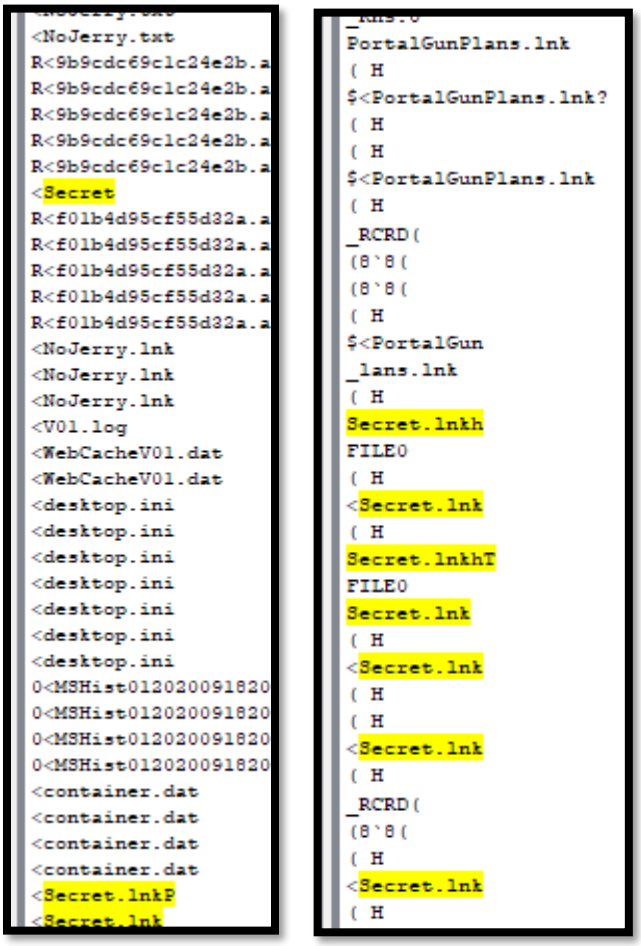
This shows four files in C:\FileShare\Secret\ were accessed via Microsoft Edge:

1. Beth_Secret.txt
2. PortalGunPlans.txt
3. SECRET_beth.txt
4. Szechuan Sauce.txt

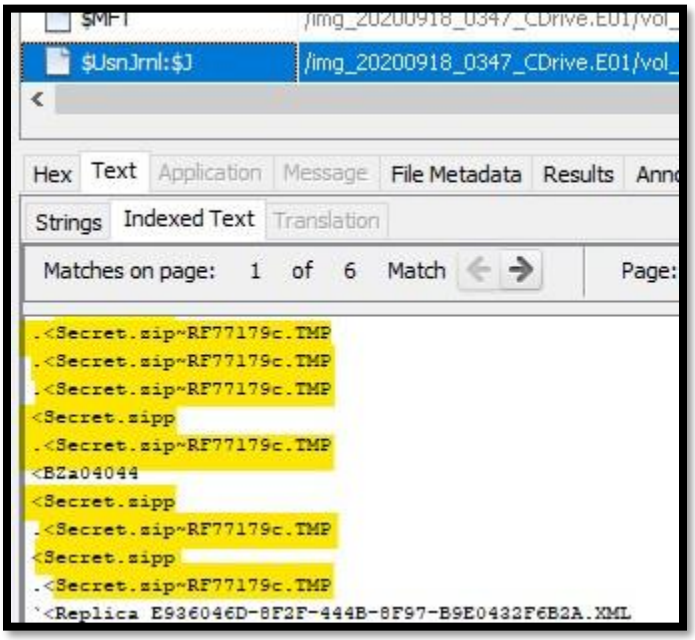
Looking at that location reveals some of those files:

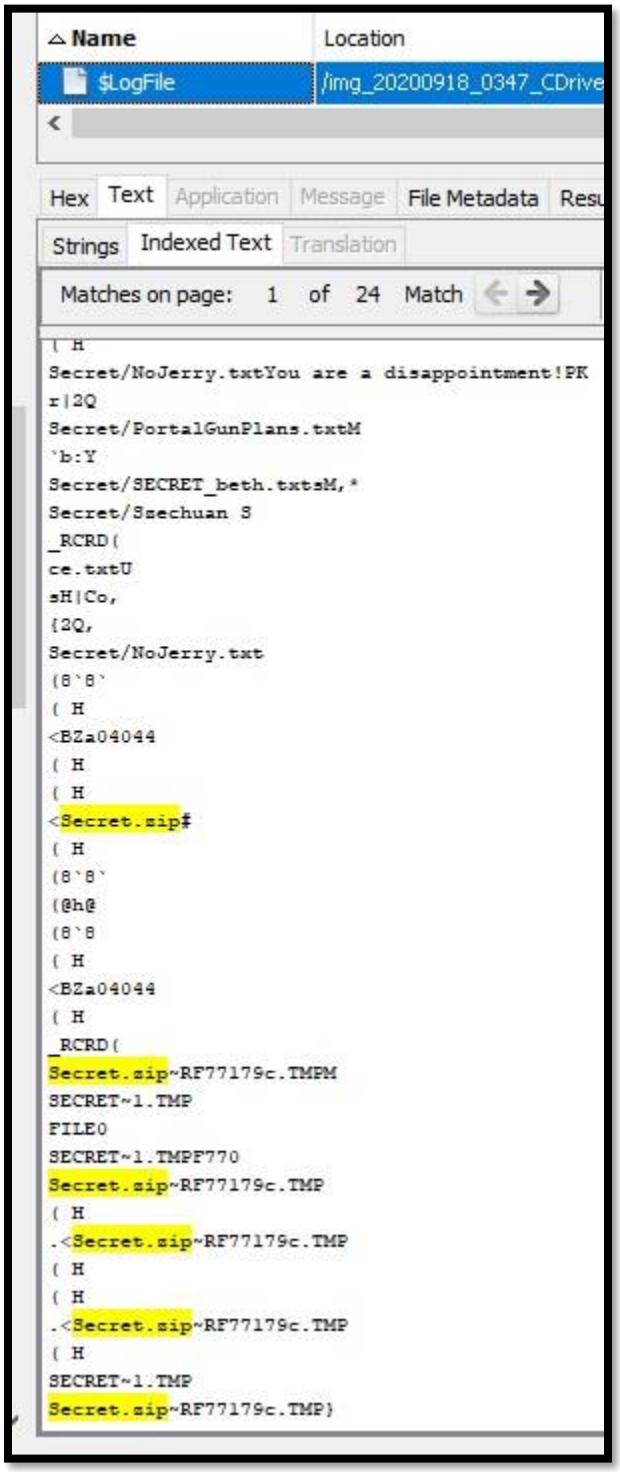


I noticed that there was no 'SECRET_beth.txt' file and that "Beth_secret.txt' has a different Modified Time than the other files, which I felt was something to look into more. When I Searched for 'secret' to find more information on the 'Beth' files, it revealed references to 'secrets.lnk' along with references to some of the other files in \FileShare\Secret:



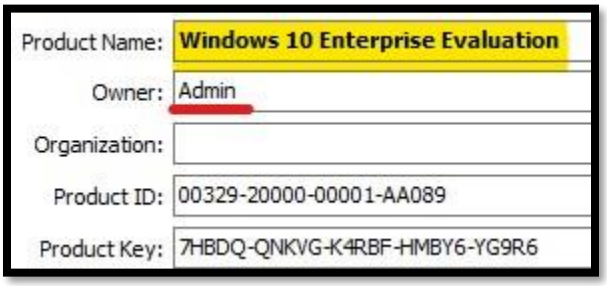
On a hunch, I thought that the attacker might have just created a zip of the Secret folder, so I searched for 'secret.zip' and found some references in $UsnJrnl:$J and $LogFile:





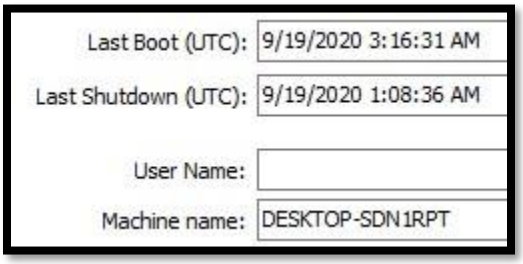
This looks to have been the data exfiltration point for the files located on citadel-dc01 in \FileShare\Secret

With this discovered, I now wanted to look at the disk image of desktop-sdn1rpt. This time my initial action was to recover and load the registry files into Windows Registry Recovery x64 to gather information about the system:



The system was revealed to be a Windows 10 **build**, created by a user called 'Admin'

The version of Windows 10 was **build** 1904



and the machine's name was indeed desktop-sdn1rpt which was both last shutdown and last booted on 09/09/2020. Both of these dates were within the timeframe of the incident and suggested to me that the same persistence method as citadel-dc01. Looking further in the registry, I again found the same persistence method:

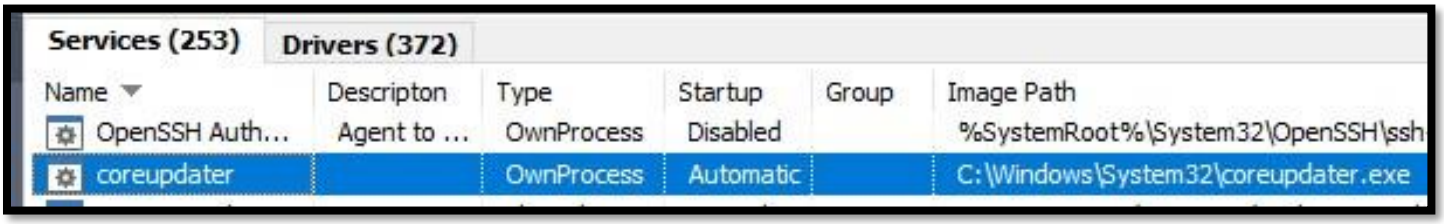
Except on the desktop, the entry was Software\q9Z1bssi\JqxNhWJA which again had a very long base64 string as its key:

that decoded into malware:

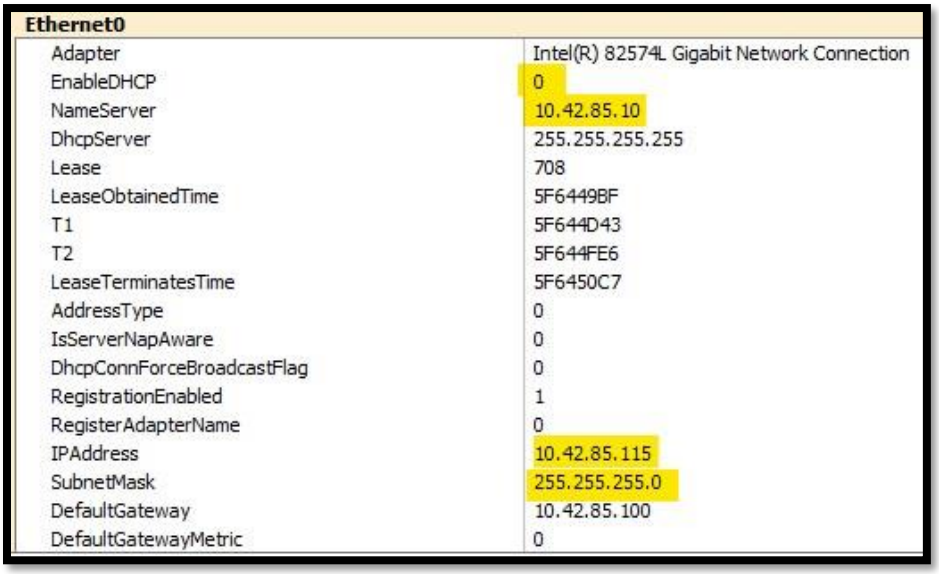
```
PS C:\Windows\system32> [Text.Encoding]::Unicode.GetString([Convert]::FromBase64String('
OgBTAGkAegB1ACAALQB1AHEAIAA0ACkAewAkAGIAPQAkAGUAbgB2ADoAdwBpAG4AZABpAHIAKwAnAFwAcwB5AHMA
```

```
cwBzAF0AOgA6AFMAdABhAHIAdAAoACQAcwApADsA'))
At line:1 char:1
+ [Text.Encoding]::Unicode.GetString([Convert]::FromBase64String('aQBmA ...
+ ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
This script contains malicious content and has been blocked by your antivirus software.
    + CategoryInfo          : ParserError: (:) [], ParentContainsErrorRecordException
    + FullyQualifiedErrorId : ScriptContainedMaliciousContent
```

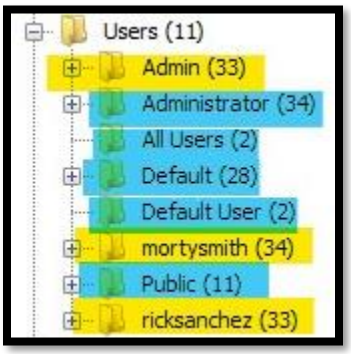
and shows up in Services :



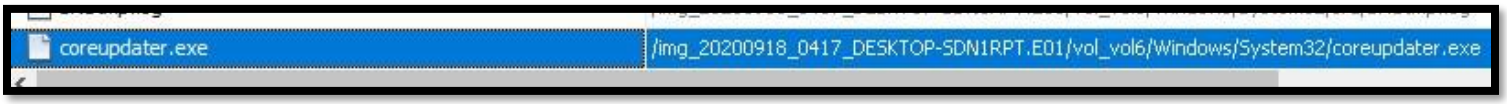
I was quickly able to confirm the IP address of the machine the same way as well:



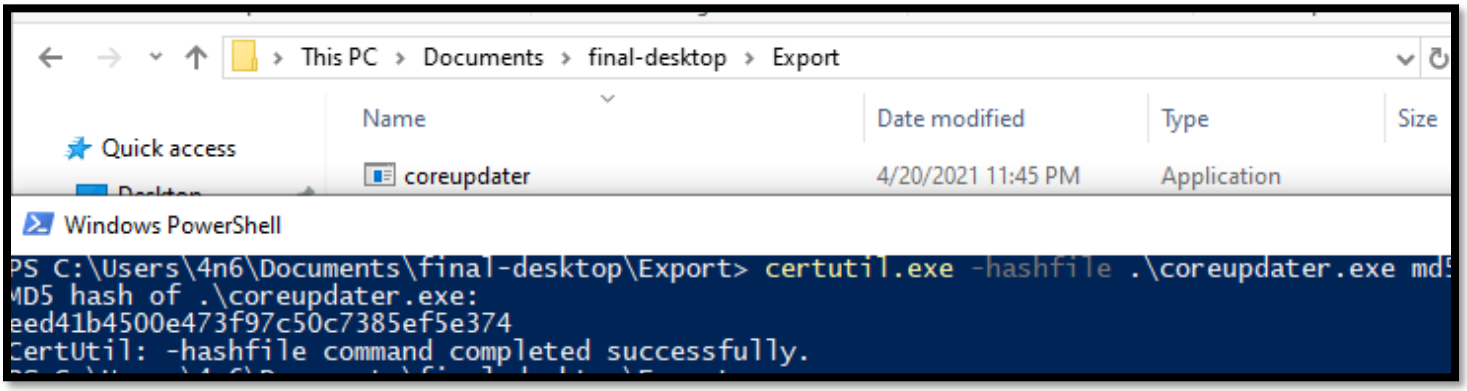
Additionally, the same method showed the user accounts on the system:



Blue accounts are the ones automatically created with the system and had no new files in them. The yellow accounts are the user accounts. Next, I looked in C:\Windows\System32\ and found the malware:



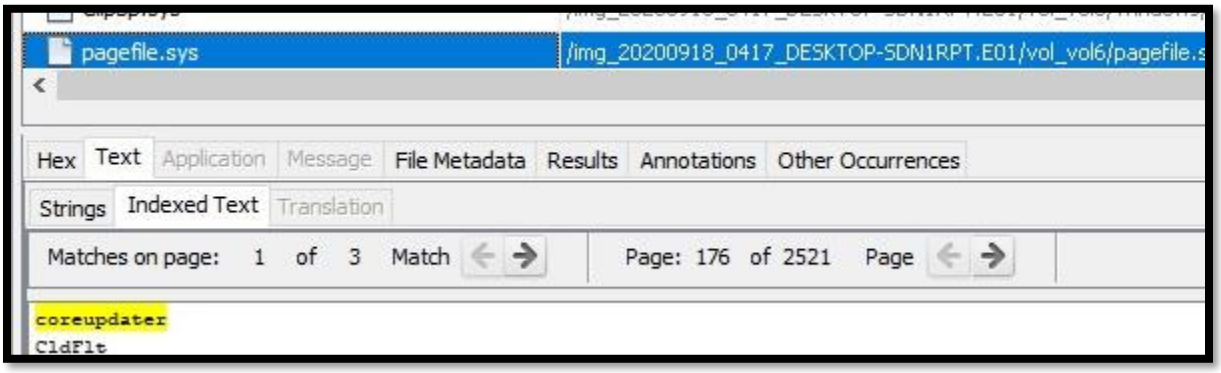
MD5: eed41b4500e473f97c50c7385ef5e374



Additionally, references to the file in the prefetch suggested that it was manually run:

References to the malware were found in webcache:

Additionally, there were references to it in the pagefile, suggesting that it was resident in memory at or around the time this disk image was taken:



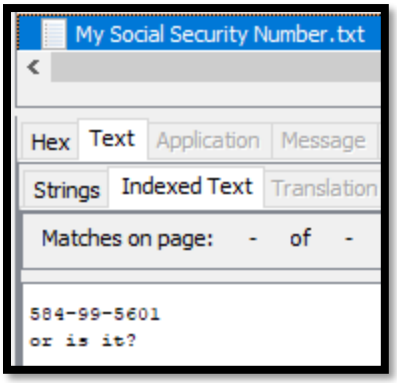
I next searched for ‘secret.zip’, ‘secret’, and ‘beth’ but found nothing; however, I did find evidence of citadel-dc01\FileShare being mapped to this machine:

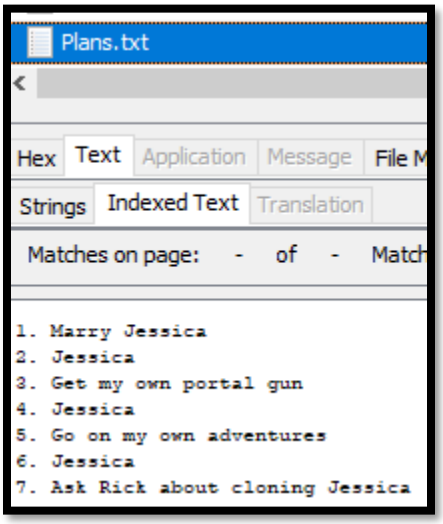
Type	Value	Source(s)
Local Path	Network\Z	Recent Activity
Remote Path	\\CITADEL-DC01\FileShare	Recent Activity
Source File Path	/img_20200918_0417_DESKTOP-SDN1RPT.E01/vol_vol6/Users/ricksanchez/NTUSER.DAT	
Artifact ID	-9223372036854775514	

Next, I looked through the Recent Documents and found mention of several user-created files:

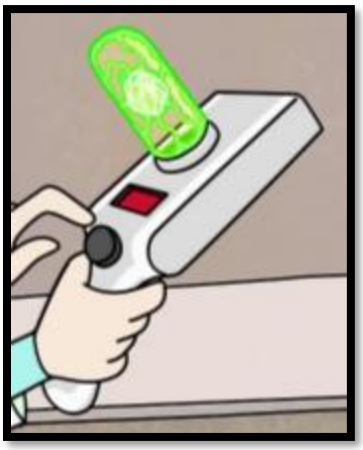
1. loot.zip
2. My Social Security Number.txt
3. Plans.txt
4. Portal_gun.png
5. Thoughts.txt
6. Jessica.jpg

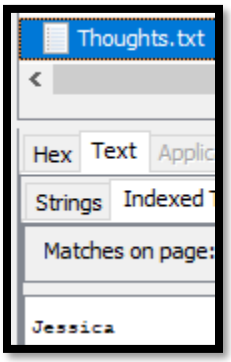
loot.lnk	C:\Users\mortysmith\Documents\loot.zip
My Social Security Number.lnk	C:\Users\mortysmith\Documents\My Social Security Number.txt
Plans.lnk	C:\Users\mortysmith\Documents\Plans.txt
Portal_gun.lnk	C:\Users\mortysmith\Documents\Portal_gun.png
Thoughts.lnk	C:\Users\mortysmith\Desktop\Thoughts.txt
Jessica.lnk	C:\Users\mortysmith\Pictures\Jessica.jpg

1. Unfound, likely file exfiltration point.
2. 

3. 

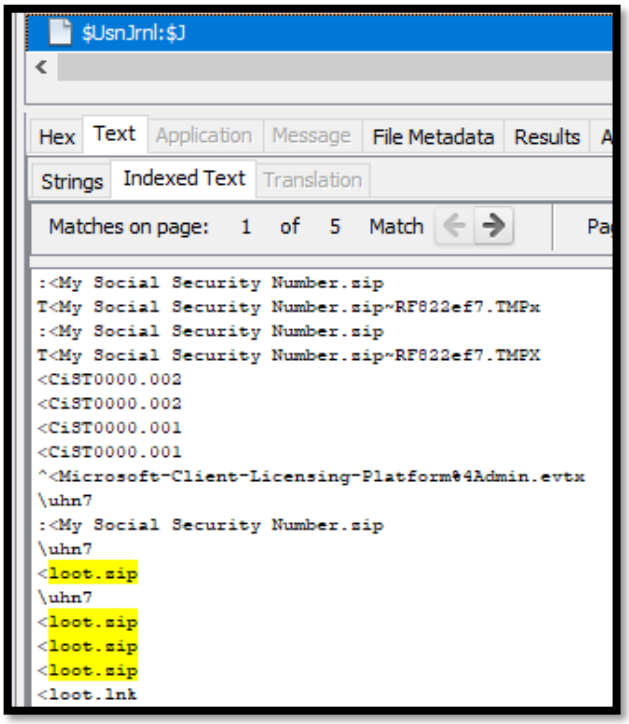
4. Portal_gun.png:



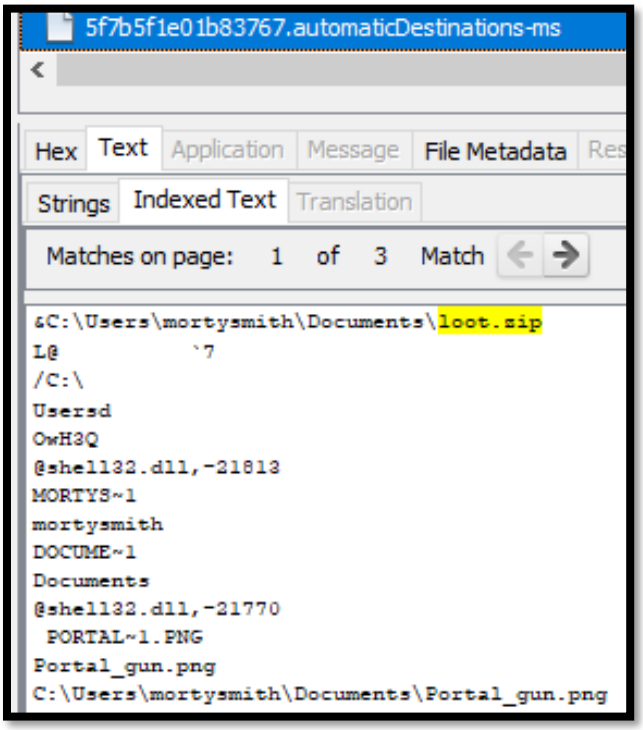
5. 

6. Jessica.jpg:

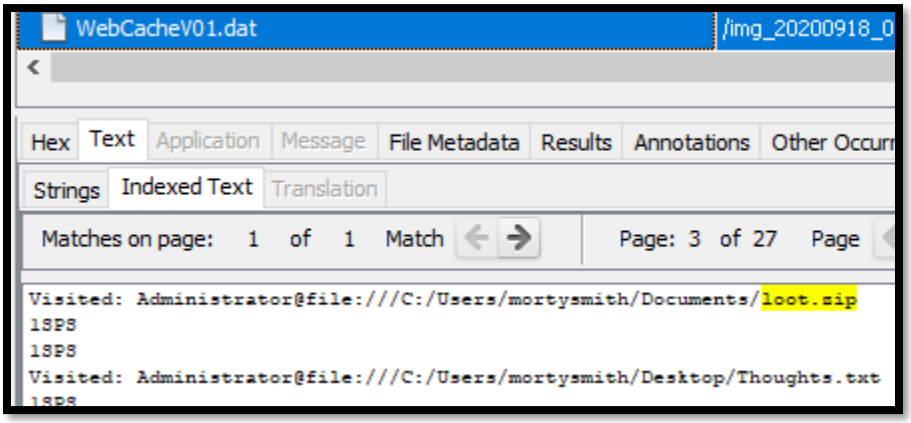
Next, I searched for 'loot.zip' since I couldn't find it at the link location and came with references to it as well as the many of the above files in '$UsnJrnl:$J', '5f7b5f1e01b83767.automaticDestinations-ms', and 'WebCacheV01.dat':



Interestingly, there's what looked the process of compressing 'My Social Security Number.txt' into 'My Social Security Number.zip'



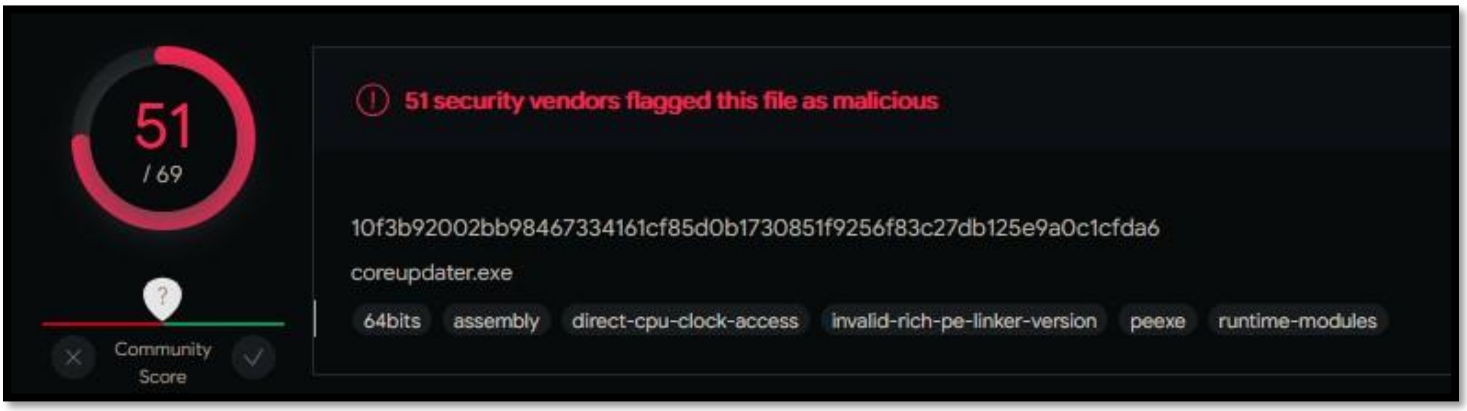
Above shows loot.zip being referenced at the same time and Portal_gun.png, including its complete path.



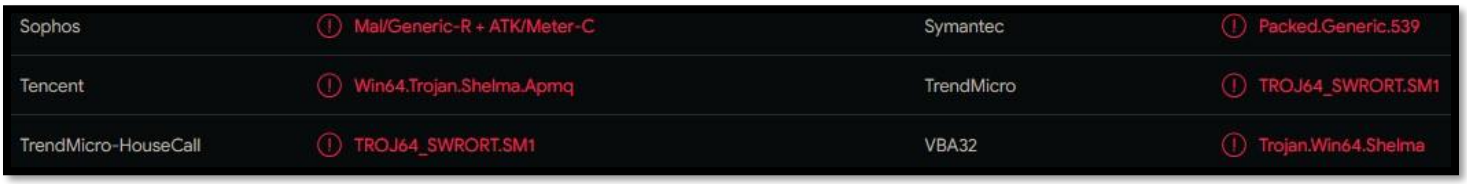
Finally, I was able to find the above reference to the Administrator account accessing Thoughts.txt and loot.zip, suggesting that file exfiltration took place on the desktop as well.

Malware Analysis

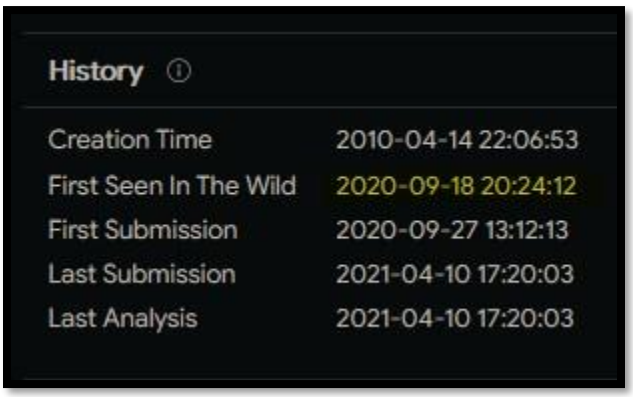
With the malware found, I wanted to see what other information was available, so I first checked it on Virustotal.com:



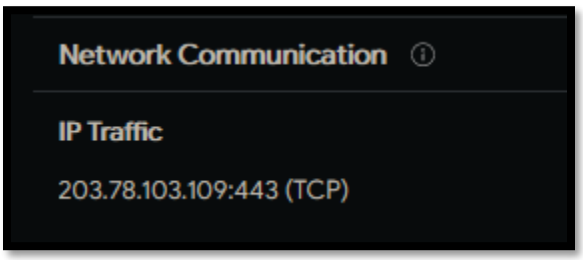
Fifty-one separate anti-virus engines flag this application as malware.



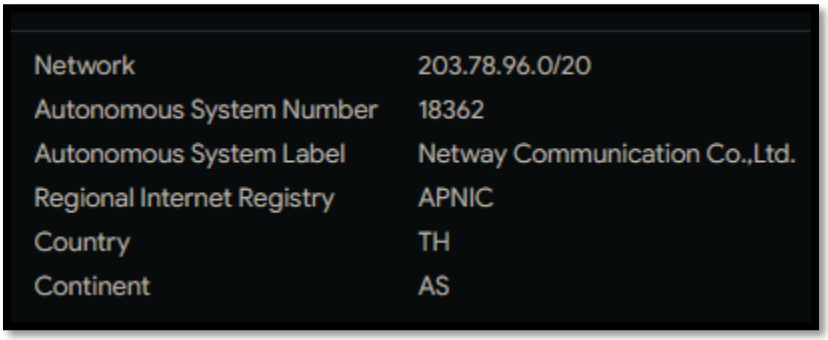
Some of the ways that it is classified: a trojan.



Interestingly, this was first seen during the time period of the intrusion. Next, I found reference to the second malicious address, 203.78.103.109:

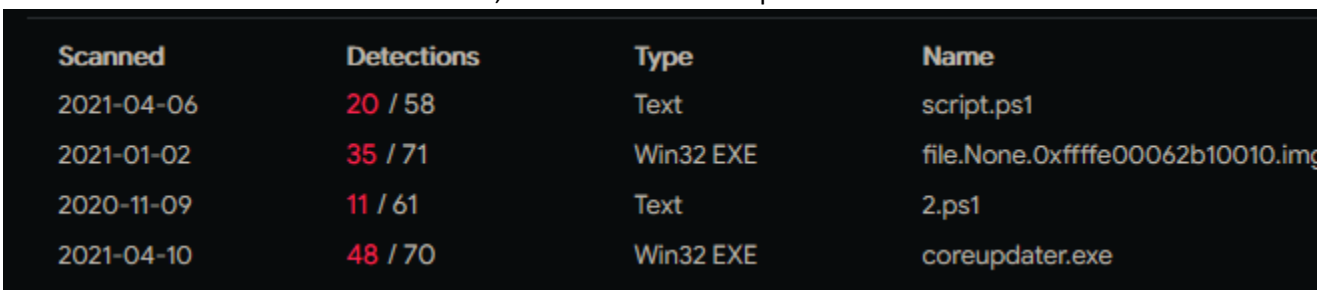


The address itself appeared to be associated with Netway Communication Co. out of Thailand:



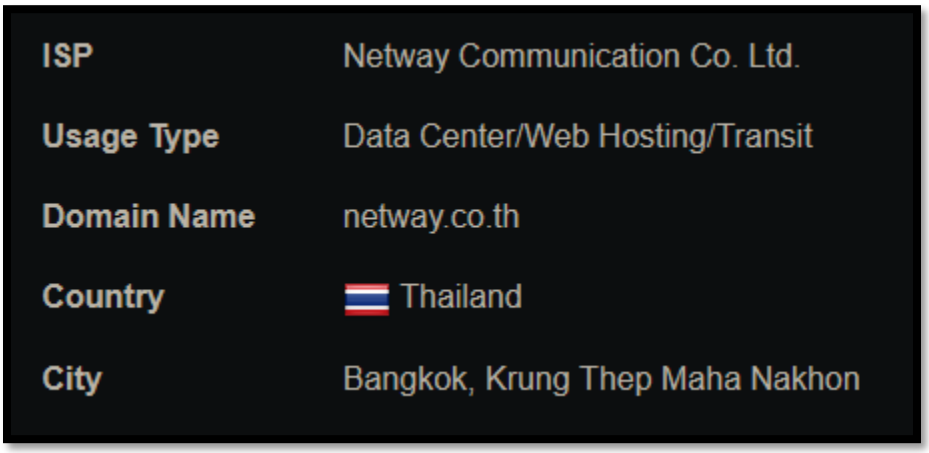
Network	203.78.96.0/20
Autonomous System Number	18362
Autonomous System Label	Netway Communication Co.,Ltd.
Regional Internet Registry	APNIC
Country	TH
Continent	AS

Some files associated with this IP address, which includes coreupdater.exe:



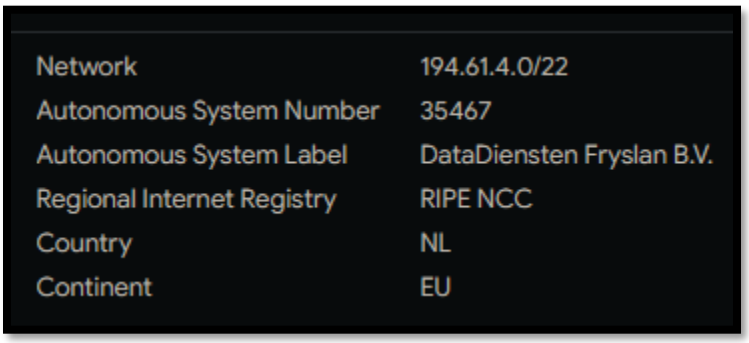
Scanned	Detections	Type	Name
2021-04-06	20 / 58	Text	script.ps1
2021-01-02	35 / 71	Win32 EXE	file.None.0xffffe00062b10010.img
2020-11-09	11 / 61	Text	2.ps1
2021-04-10	48 / 70	Win32 EXE	coreupdater.exe

The address up on abuseipdb.com:



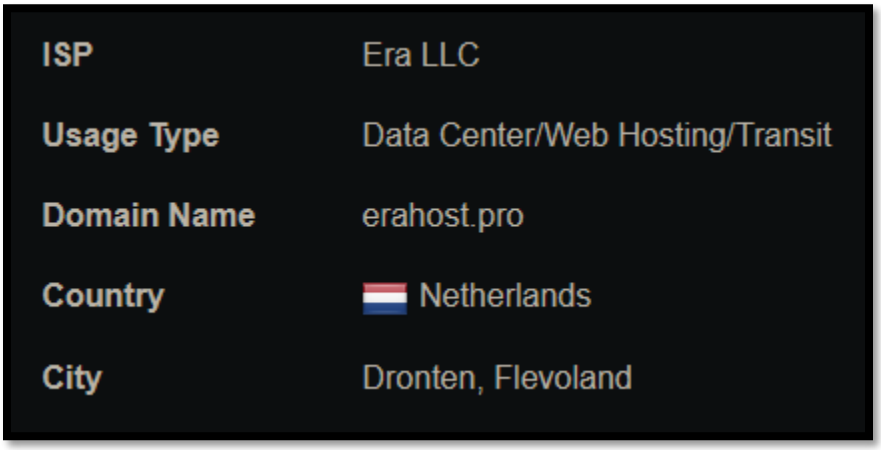
ISP	Netway Communication Co. Ltd.
Usage Type	Data Center/Web Hosting/Transit
Domain Name	netway.co.th
Country	Thailand
City	Bangkok, Krung Thep Maha Nakhon

I next looked up the other malicious address, 194.61.4.102, on virustotal.com:

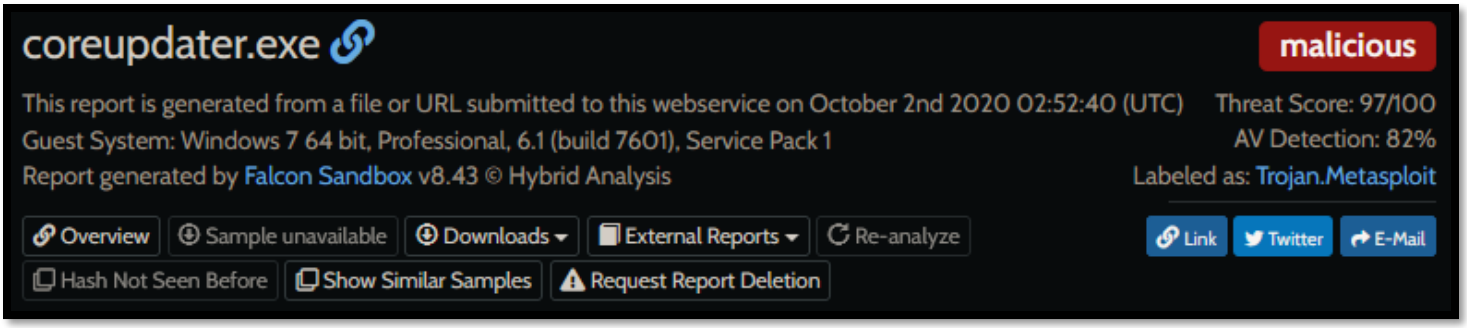


Network	194.61.4.0/22
Autonomous System Number	35467
Autonomous System Label	DataDiensten Fryslan B.V.
Regional Internet Registry	RIPE NCC
Country	NL
Continent	EU

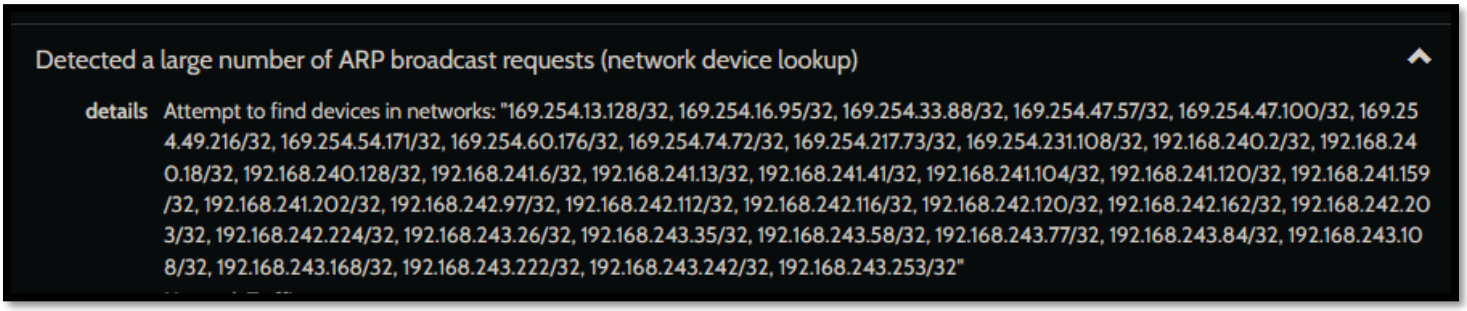
Which appeared to be out of the Netherlands, so I verified this on abuseipdb.com:



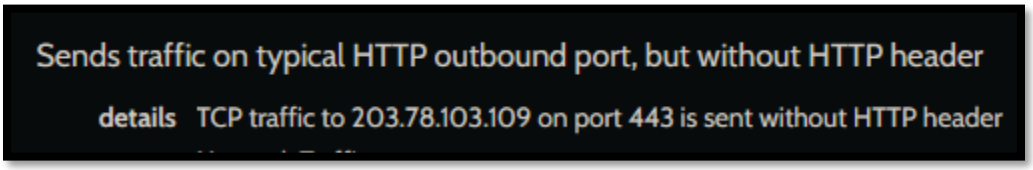
My next step was to run coreupdater.exe on hybrid-analysis.com, which uses sandboxing techniques to run submitted malware to understand its functions:



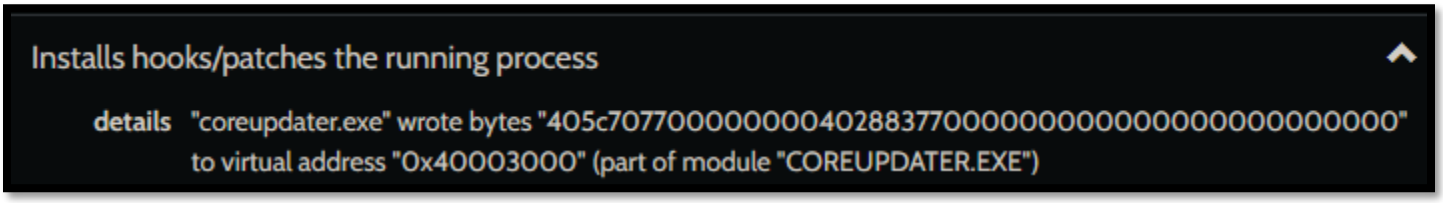
In addition to what had already been discovered, it looked like the malware was using ARP traffic to attempt to identify local networks:



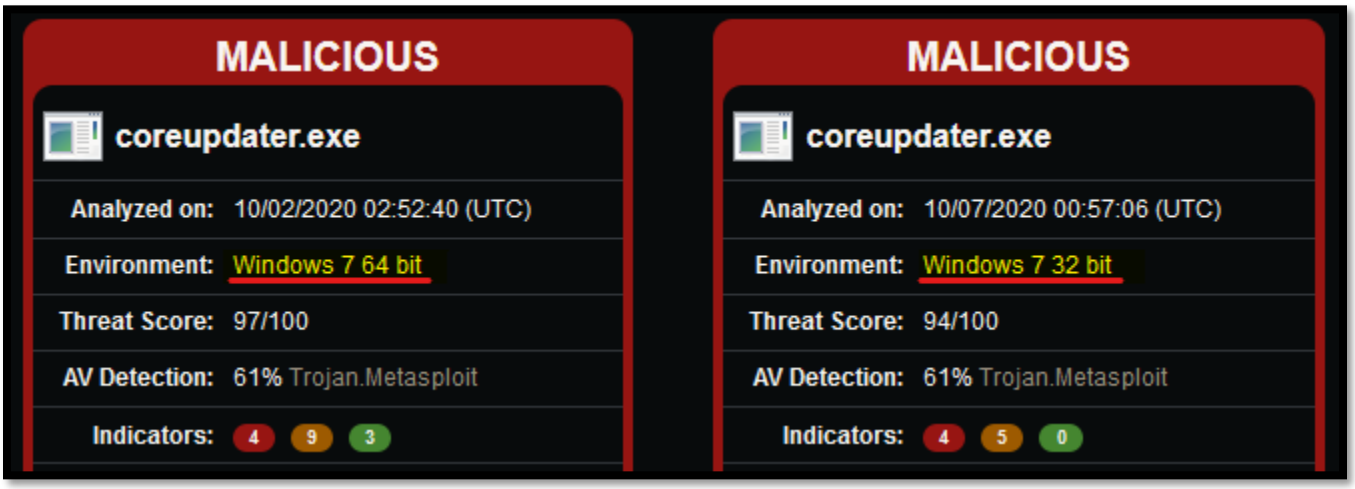
Traffic sent to 203.78.103.109:443 is sent without an HTTP header:



It also seemed to hook into another virtual address, which could be the point it attempts to hijack spoolsv.exe:



The final assessment from hybrid-analysis.com was that this was 'Trojan.metasploit" which backed up what I had determined earlier:



Remediation Recommendations

The most important recommendations I would make are to immediately stop allowing all RDP traffic from outside the organization's local intranet. RDP is extremely vulnerable and so should never be exposed to the internet. Ideally, RDP would be phased out altogether for something like VNC. Additionally, remote access to the organization's internet should be blocked by a dedicated firewall solution, such that only VPN traffic will allow remote access to internal machines from outside the network. A secondary set of suggestions would be to implement stronger password policies, given that the administrator account was brute forced relatively quickly. Additionally, implementing MFA on *at least* remote access to systems, and ideally for any access to sensitive systems like the domain controller. It would also be wise to restrict all access to the domain controller to a single jump box that requires MFA to access. Finally, it would be good to have a more expansive backup policy as it appears that at least one file was deleted and replaced with an 'imposter' file.