Technical Analysis of Lockbit4.0 Evasion Tales - 0x0d4y Malware Research

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The *Ransomware-as-a-Service* (*RaaS*) group Lockbit is the main pillar of this Ransomware business model, largely due to its strong commitment to the development of its product, producing Ransomware with implementations that are up to date on the date of each release. The **Lockbit4.0** (or ***Lockbit Green***) version is no different, as it is a major update, especially in the *Evasion* and *Obfuscation* layer. In this research, I will analyze the main **Obfuscation** and **Evasion** capabilities implemented in Lockbit4.0, and some Intelligence insights will be provided after the analysis.

Below is the SHA256 hash of the Lockbit4.0 sample that I will analyze in this research.

```
"sha256":"21E51EE7BA87CD60F692628292E221C17286DF1C39E36410E7A0AE77DF0F6B4B"
```

Reverse Engineering of the Unpacking Process

The *Lockbit4.0* unpacking process is quite complex, and I will try to describe my analysis based on its pseudocode. Below, we can see the beginning of the unpacking algorithm.

```
140125011    void* const __return_addr_1 = __return_addr
140125011
14012501d    while (true)
14012501d        char rdx = *arg2
140125020        int32_t temp0_1 = arg5.d
140125020        int32_t temp1_1 = arg5.d
140125020        arg5 = zx.q(arg5.d * 2)
140125020        bool c_1 = temp0_1 + temp1_1 u< temp0_1
140125020
```

The code starts by reading a byte from the compressed stream, storing it in **rdx**. It then loads the value of **arg5** and multiplies it by **2** (**arg5 << 1**). This forces a carry when the most significant bit (**MSB**) is cleared. The carry is saved in the **c_1** flag and will be used later to determine whether the byte can be copied directly or needs to be processed.

```
140125022        if (temp0_1 == neg.d(temp1_1))
140125024            int32_t rbx = *arg2
140125026            char* temp2_1 = arg2
140125026            arg2 -= -4
140125026            bool c_2 = temp2_1 u< -4
14012502a            arg5 = zx.q(adc.d(rbx, rbx, c_2))
14012502a            c_1 = adc.d(rbx, rbx, c_2) u< rbx || (c_2 && adc.d(rbx, rbx, c_2) == rbx)
14012502c            rdx = *arg2
```

The code checks whether **arg5** (in *temp0_1*) is equal to its complement (**-arg5** or *temp1_1*). This is because certain values in the compressed byte stream represent special markers that need to be processed differently. If the equality is true:

1. A new byte is loaded into **rbx**.
2. The **arg2** pointer is adjusted to advance *4 bytes*.
3. An **ADC** (Add with Carry) operation is performed on **rbx**, modifying **arg5**.
4. A new byte is loaded into **rdx**, continuing the data extraction.

```
14012502e       if (c_1)
140125015           arg2 = &arg2[1]
140125018           *arg1 = rdx
14012501a           arg1 = &arg1[1]
14012502e       else
140125046           int32_t rax_3
140125046           int32_t rdx_1
140125046
140125046           do
140125033               int32_t rax_2
140125033               int32_t rcx
140125033               int32_t* rsi
140125033               rax_2, rcx, rdx_1, rsi, __return_addr_1 = __return_addr_1()
140125036               rax_3 = adc.d(rax_2, rax_2, c_1)
140125038               int32_t temp5_1 = arg5.d
140125038               int32_t temp6_1 = arg5.d
140125038               arg5 = zx.q(arg5.d * 2)
140125038               c_1 = temp5_1 + temp6_1 u< temp5_1
140125038
14012503a               if (temp5_1 == neg.d(temp6_1))
14012503c                   int32_t rbx_1 = *rsi
14012503e                   bool c_3 = rsi u< -4
140125042                   arg5 = zx.q(adc.d(rbx_1, rbx_1, c_3))
140125042                   c_1 = adc.d(rbx_1, rbx_1, c_3) u< rbx_1
140125042                       || (c_3 && adc.d(rbx_1, rbx_1, c_3) == rbx_1)
140125044                   rdx_1.b = *(rsi + 4)
140125046           while (not(c_1))
```

If carry **c_1** was previously activated, this means that the read byte (**rdx**) does not need any special transformation and can be copied directly to the output buffer.

1. The pointer **arg2** (read from the compressed stream) and **arg1** (write position in the output buffer) are incremented.
2. The stream continues with the next byte.

If **c_1** is *false*, it means that the byte cannot be copied directly and must be processed in a secondary loop. In this secondary loop, the code will execute:

1. An internal function (**__return_addr_1**) is called and returns temporary values.
2. The **arg5** register is ***ADCed*** and shifted to extract more information from the compressed bytes.
3. The marker special condition is tested again to see if a new decode is needed.
4. If the carry extraction indicates an invalid value, a new byte is loaded and tested again.

```
140125046
140125048           bool c_4 = rax_3 u< 3
140125048
14012504b           if (not(c_4))
140125053               int32_t rax_6 = (rax_3 - 3) << 8 | rdx_1
140125055               c_4 = false
140125055
140125058               if (rax_6 == 0xffffffff)
```

After decoding, the code combines the extracted values to determine whether a patch in memory is necessary.

1. If the result of the combination is **0xffffffff**, the algorithm interprets this as a signal to start the patching routine.

2. Otherwise, the extracted values are written directly to the output buffer.

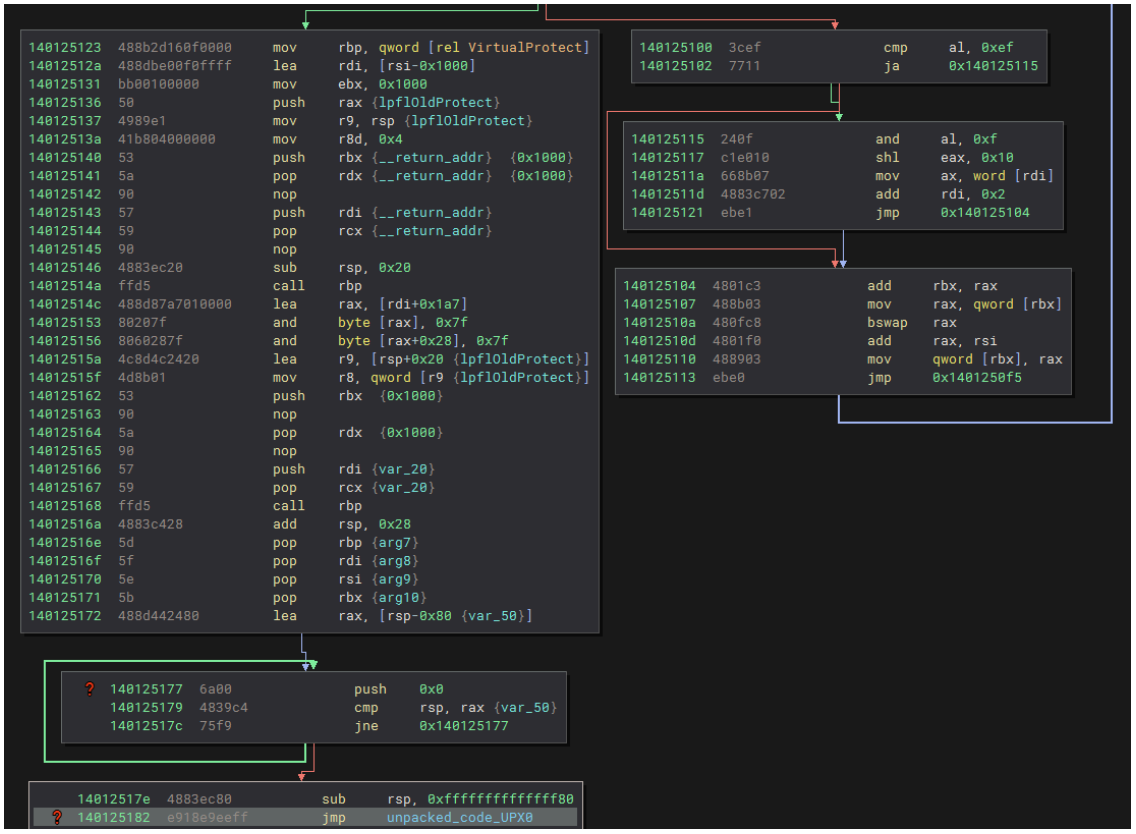
```
140125058        if (rax_6 == 0xffffffff)
140125094            void* rsi_1 = lpflOldProtect
140125095            lpflOldProtect = rsi_1
140125098            lpflOldProtect = rsi_1
1401250ac            void* const i = rsi_1
1401250ad            int32_t var_8_1 = i.d
1401250ad
1401250e3            while (i u< rsi_1 + 0x19dfd)
1401250e5                int32_t rax_7
1401250e5                rax_7.b = *i
1401250e5                void* rsi_3 = i + 1
1401250c7                label_1401250c7:
1401250c7                rax_7.b -= 0xe8
1401250cb                void* var_8_2
1401250cb
1401250cb                if (rax_7.b u> 1)
1401250b4                    if (rsi_3 u>= rsi_1 + 0x19dfd)
1401250b4                        break
1401250b4
1401250b6                    var_8_2 = rsi_3
1401250b6                    goto label_1401250b8
1401250b6
1401250d0                while (true)
1401250d0                    if (rsi_3 u>= rsi_1 + 0x19dfd)
1401250d0                        goto label_1401250e9
1401250d0
1401250d2                    var_8_2 = rsi_3
1401250d3                    rax_7 = *rsi_3
1401250d3                    i = rsi_3 + 4
1401250d4                    char temp20_1 = rax_7.b
1401250d4                    rax_7.b -= 7
1401250d4
1401250d6                    if (temp20_1 == 7)
1401250df                        *var_8_2 = _bswap(rax_7) - var_8_2.d + var_8_1
1401250df                        break
1401250df
1401250b8                    label_1401250b8:
1401250b8                    rax_7.b = *var_8_2
1401250b8                    rsi_3 = var_8_2 + 1
1401250b8
1401250bb                    if (rax_7.b u< 0x80)
1401250bb                        goto label_1401250c7
1401250bb
1401250bf                    if (rax_7.b u> 0x8f)
1401250bf                        goto label_1401250c7
```

```
1401250bf                       if (rax_7.b u> 0x8f)
1401250bf                           goto label_1401250c7
1401250bf
1401250c5                       if (*(rsi_3 - 2) != 0xf)
1401250c5                           goto label_1401250c7
1401250c5
1401250e9                   label_1401250e9:
1401250e9                   void* lpflOldProtect_2 = lpflOldProtect
1401250ea                   void* rdi_4 = lpflOldProtect_2 + 0x122000
1401250f1                   uint64_t* rbx_4 = lpflOldProtect_2 - 4
1401250f7                   uint64_t lpflOldProtect_1
1401250f7
1401250f7                   while (true)
1401250f7                       int32_t lpflOldProtect_3
1401250f7                       lpflOldProtect_3.b = *rdi_4
1401250f9                       rdi_4 += 1
1401250fc                       lpflOldProtect_1 = zx.q(lpflOldProtect_3)
1401250fc
1401250fe                       if (lpflOldProtect_1.d == 0)
1401250fe                           break
1401250fe
140125102                       if (lpflOldProtect_1.b u> 0xef)
140125115                           lpflOldProtect_1.b &= 0xf
14012511a                           lpflOldProtect_1.w = *rdi_4
14012511d                           rdi_4 += 2
14012511d
140125104                       rbx_4 += lpflOldProtect_1
140125110                       *rbx_4 = _bswap(*rbx_4) + lpflOldProtect_2
140125110
140125136                   lpflOldProtect = lpflOldProtect_1
14012514a                   void* lpAddress = VirtualProtect(
14012514a                       lpAddress: lpflOldProtect_2 - 0x1000, dwSize: 0x1000,
14012514a                       flNewProtect: PAGE_READWRITE, &lpflOldProtect)
140125153                   *(lpAddress + 0x1a7) &= 0x7f
140125156                   *(lpAddress + 0x1cf) &= 0x7f
140125168                   VirtualProtect(lpAddress, dwSize: 0x1000,
140125168                       flNewProtect: lpflOldProtect.d, &lpflOldProtect)
140125171                   void* i_1 = &arg_30
14012517c                   void var_50
14012517c
14012517c                   do
? 140125177                       *(i_1 - 8) = 0
140125177                       i_1 -= 8
14012517c                   while (i_1 != &var_50)
14012517c
? 140125182                 jump(&unpacked_code_UPX0)
140125182
```

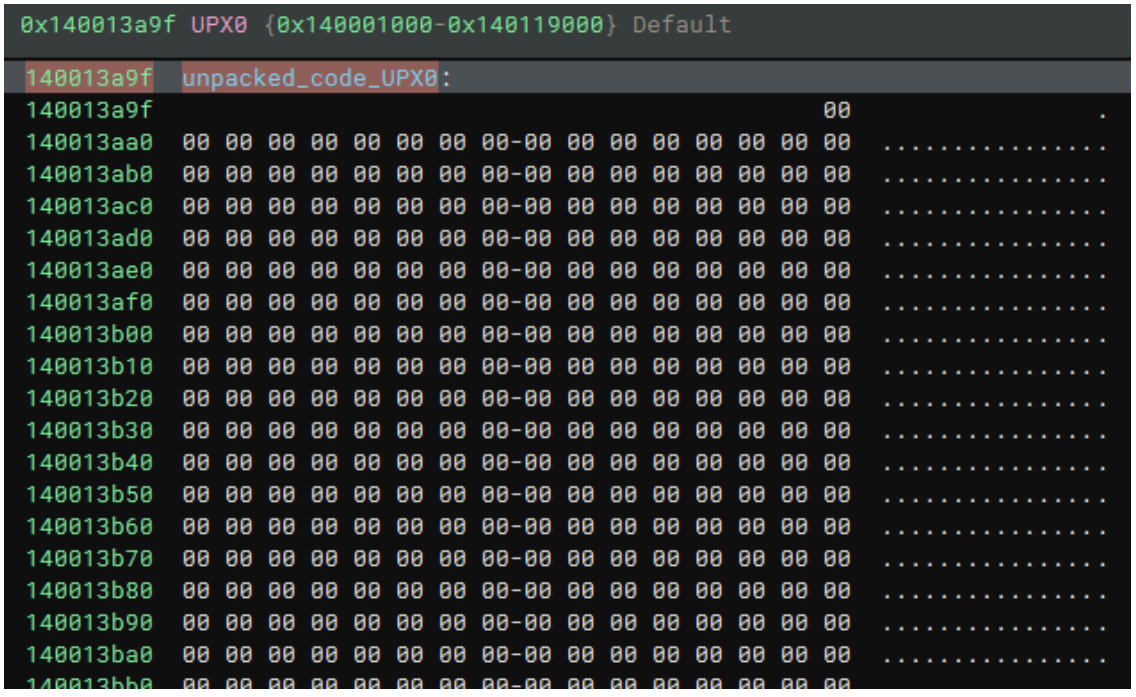
Now we come to the last data block of the unpacking code. If the code detects that patching is necessary, it performs a series of operations to directly modify specific regions of memory. So this last block of code will do:

1. A loop walks through a section of memory, identifying and correcting relative addresses.
2. Some instructions use *_bswap* to reverse the order of bytes.
3. A set of subtractions adjusts obfuscated values to restore the correct bytes of the original code.
4. Calls to **VirtualProtect** are made to change the memory permissions, ensuring that the modifications are applied.
5. The transferred code is cleared and prepared for execution in a region now filled with unpacked code, in the **UPX0** section. Specifically, the address will be offset **0x140013a9f** (**unpacked_code_UPX0**). And this offset is the entry point for the unpacked *Lockbit4.0*.

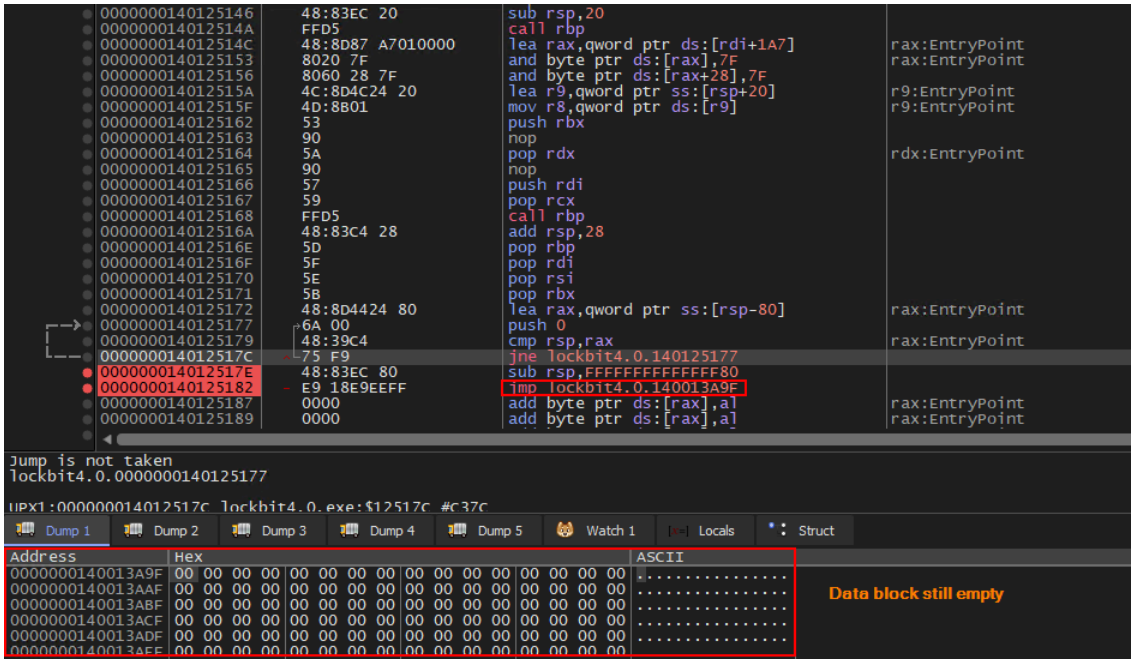
This last loop in which **VirtualProtect** is called and the program flow is unconditionally changed to the unpacked code, is clearly observed in the graphical format of the *Disassembly* below.



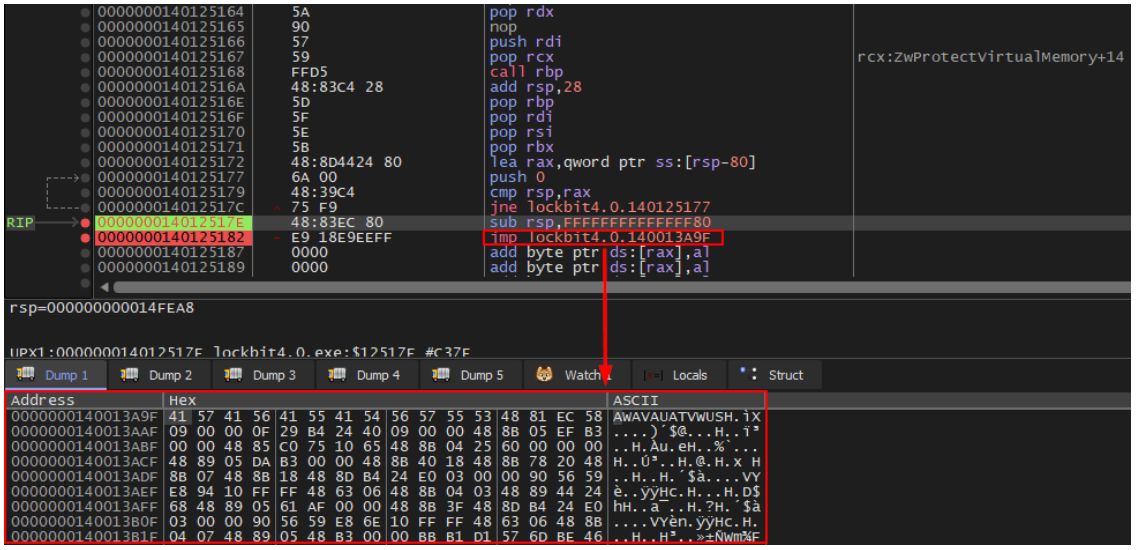
And below you can see that the region at offset **0x140013a9f** is in fact statically empty.



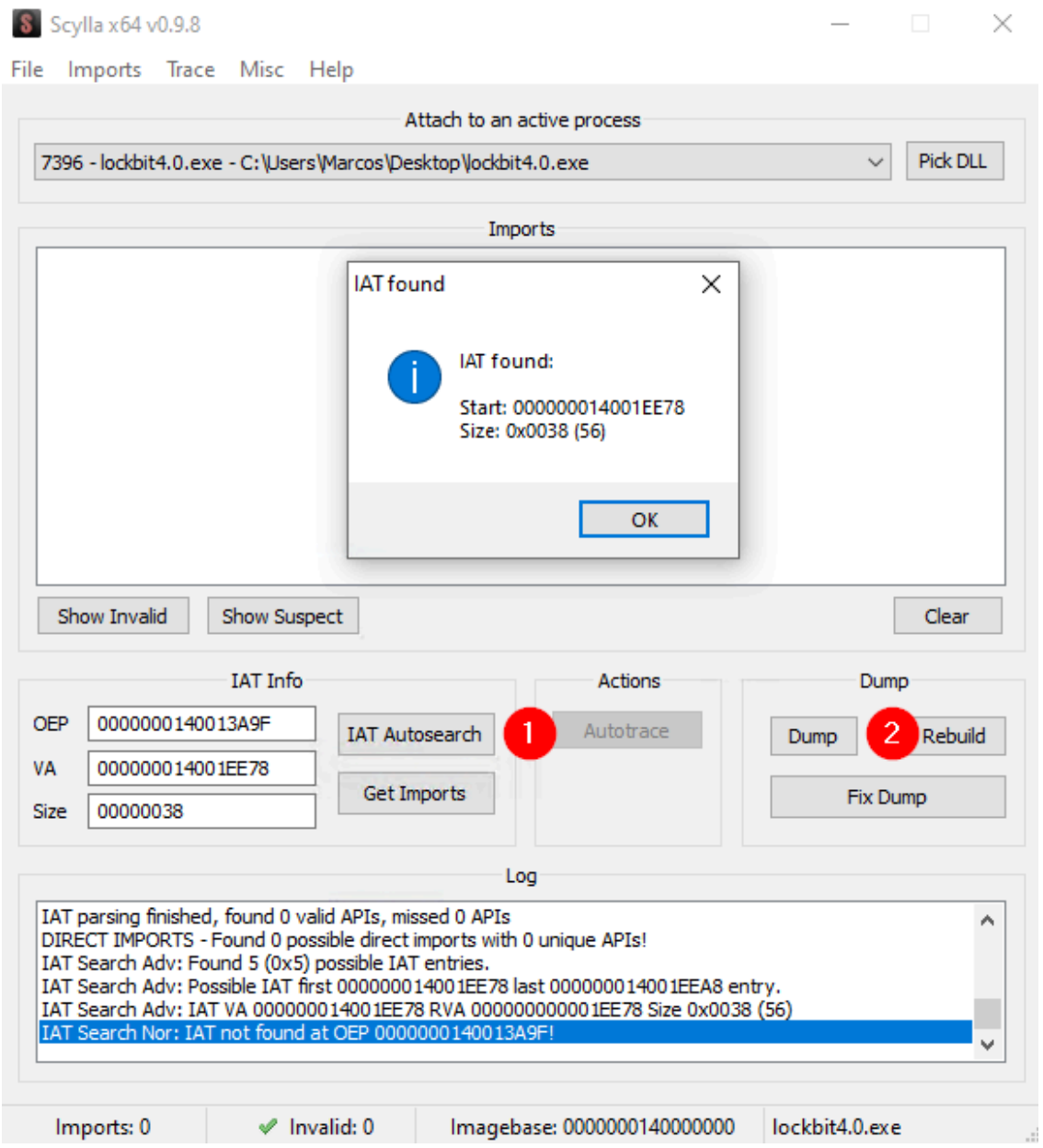
Now let’s analyze this algorithm dynamically, with the aim of extracting the unpacked code from Lockbit4.0. Below we can see the exact space still empty, before the unpacking process.



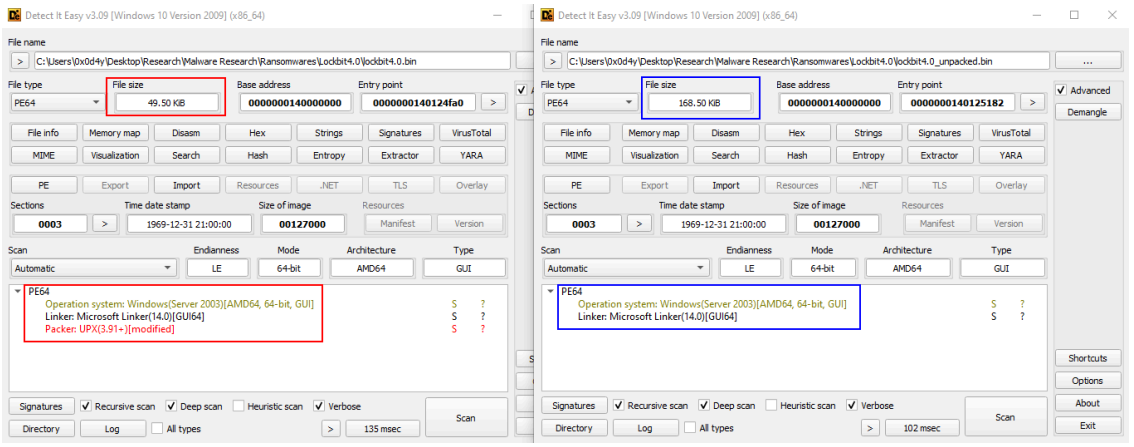
After the unpacking process is complete, the previously empty space is now filled with the unpacked code.



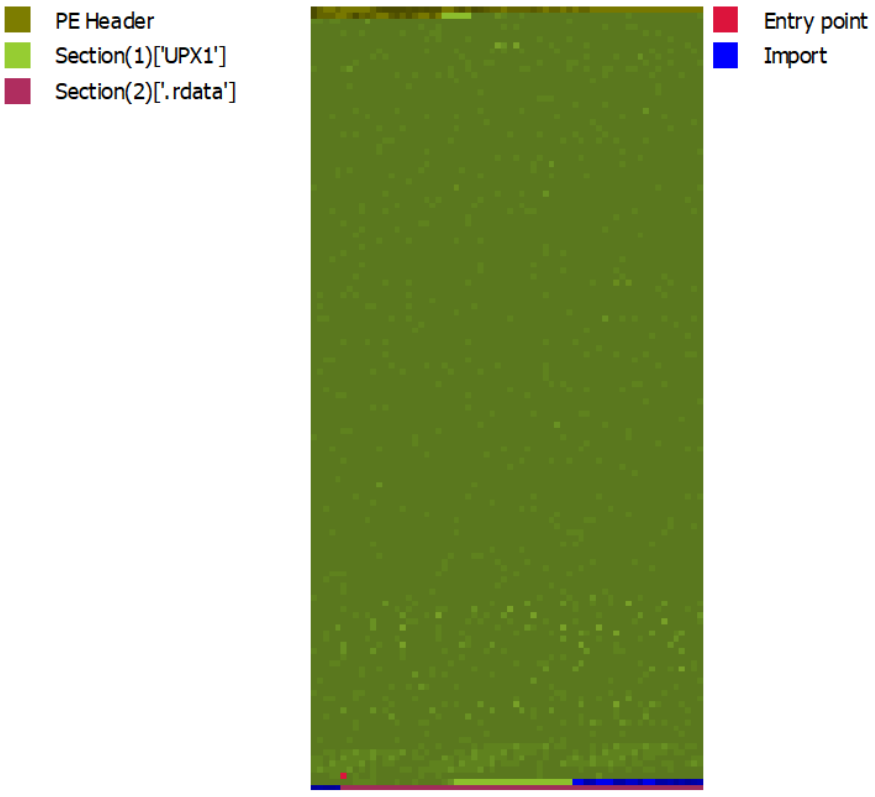
Once we reach this point, we will use the **Scylla** plugin to dump Lockbit4.0 *unpacked*.



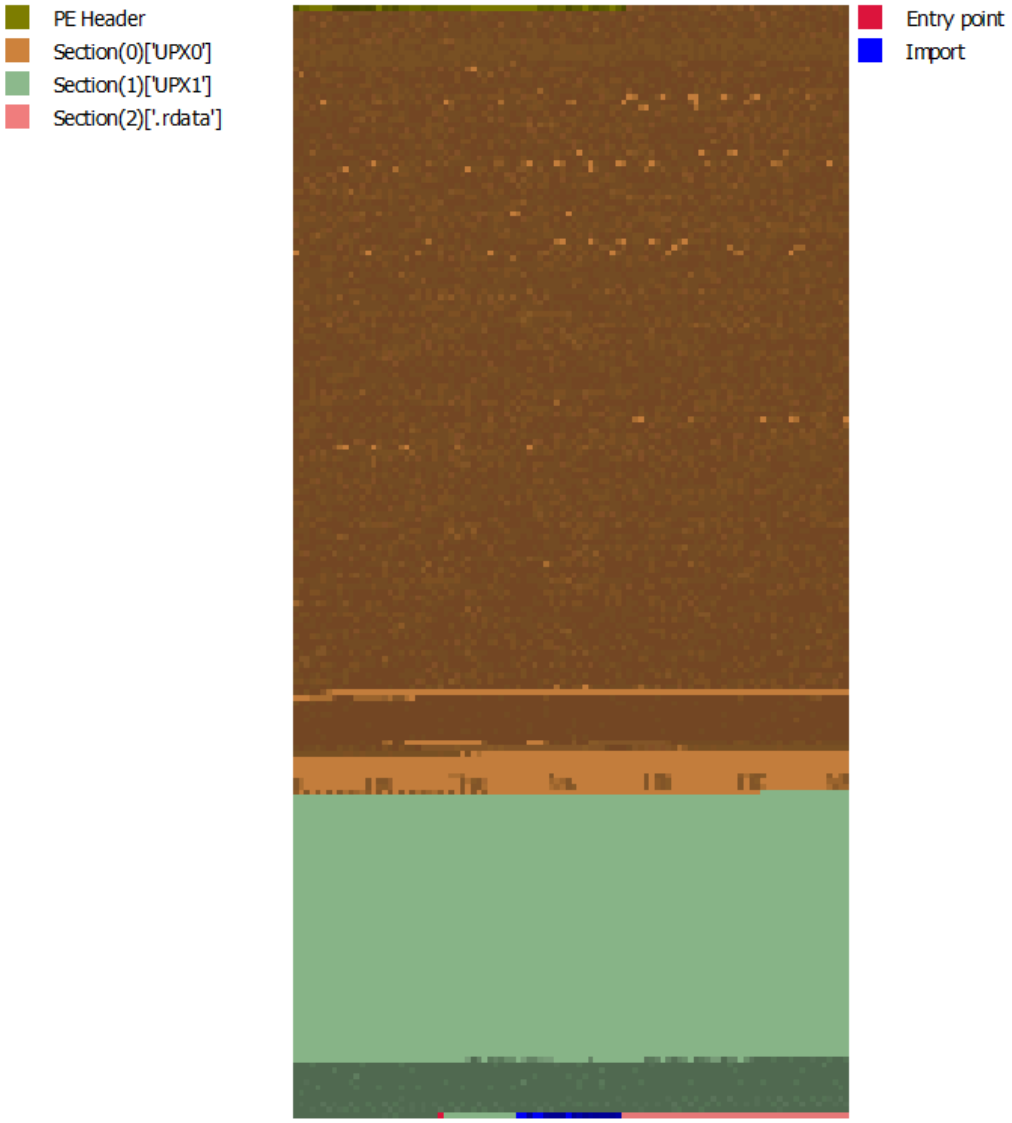
When comparing the original packed sample from Lockbit4.0 with the dynamically extracted unpacked version, we can observe a big difference in **DiE** size and detection.



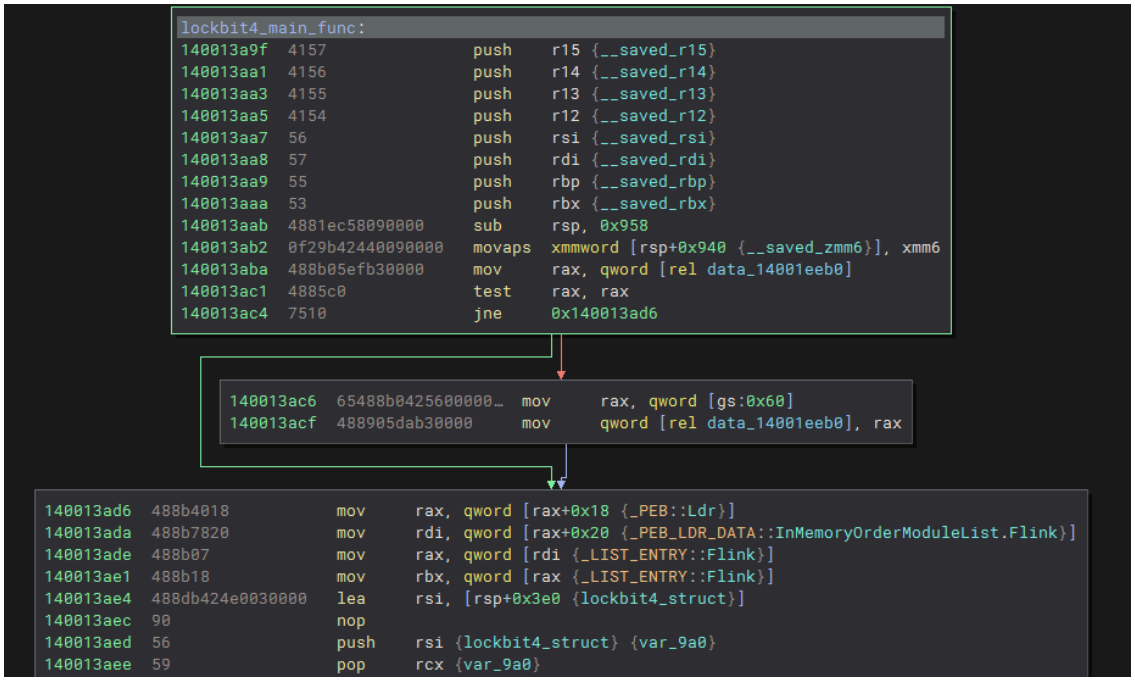
Below we can also see the difference in data organization in the packed version.



And below we can see the structural change of the unpacked version.

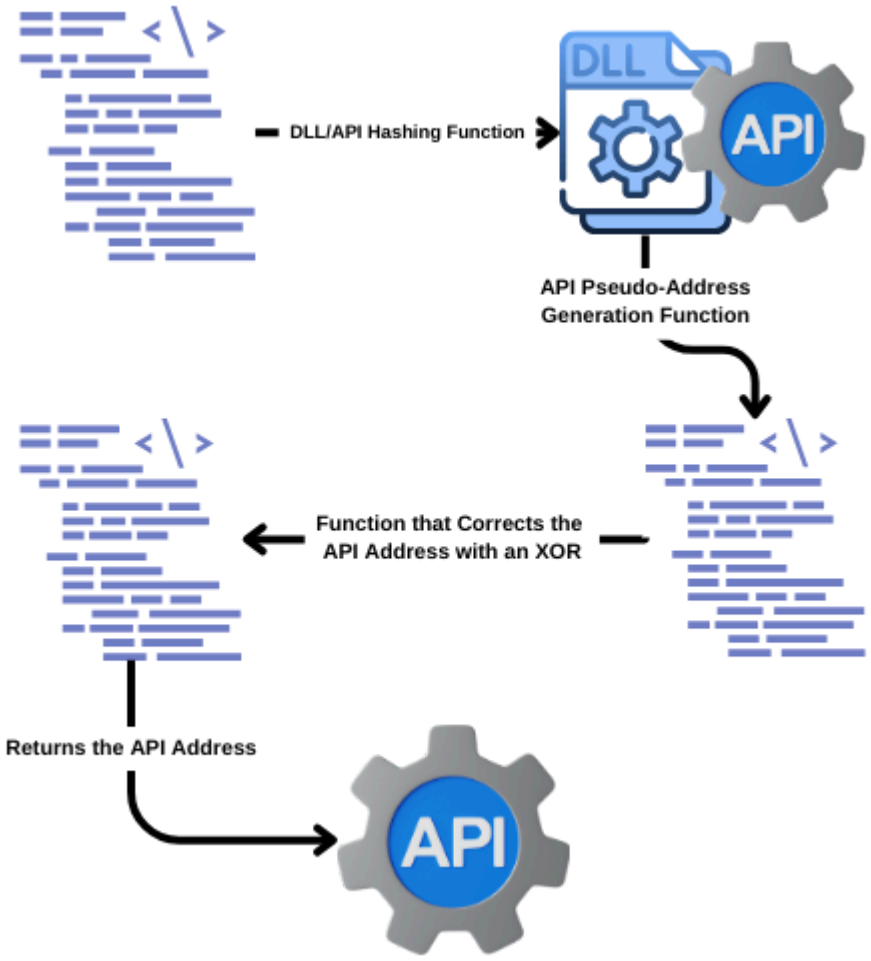


Despite the names of the sections being similar to the *IOCs* left by **UPX**, this is not a sample packed by UPX. And when we go to the offset where the unpacked code was written, we can see that it is filled with valid code, in this case the Lockbit4.0 Main function.



Analyzing Dynamic DLL and API Resolution

The great obfuscation feature implemented by Lockbit4.0 is the DLL and API resolution technique at runtime, divided into three functions. The image below illustrates the flow that is executed whenever Lockbit4.0 needs a certain API.



So, let's look first at DLL resolution via Hashing. Lockbit4.0's hashing algorithm is relatively easy, does not include any extra layers of obfuscation, and is intended to obfuscate DLLs that will be resolved at runtime. The algorithm traverses a data structure applying mathematical transformations and bitwise operations to generate an accumulative value (in the **rcx_17** variable).

```
int64_t lockbit4_hashing_resolution(int64_t arg1, int32_t arg2)

140004180        int32_t rdx_8 = 0
140004182        int32_t rcx_17 = 0x14bf
140004182
14000418a        while (true)
14000418a            int32_t r8_2 = sx.d(
14000418a                *(zx.q(*(rax_5 + (r14_2 << 2))) + hash_constant_1.q + zx.q(rdx_8)))
14000418a
140004192            if (r8_2 == 0)
140004192                break
140004192
140004198            int32_t r10_1 = r8_2 + 0x20
140004198
1400041a0            if (r8_2.b - 0x41 u>= 0x1a)
1400041a0                r10_1 = r8_2
1400041a0
1400041b4            int32_t rcx_20 = rdx_8 ^ 0x14bf
1400041b4
1400041b8            if (rdx_8 == 0)
1400041b8                rcx_20 = rdx_8
1400041b8
1400041bf            rcx_17 = rcx_20 * ((rdx_8 + 0x14bf) * r10_1 + (rcx_17 ^ r10_1)) + r10_1
1400041c2            rdx_8 += 1
1400041c2
1400041c6        r14_2 += 1
```

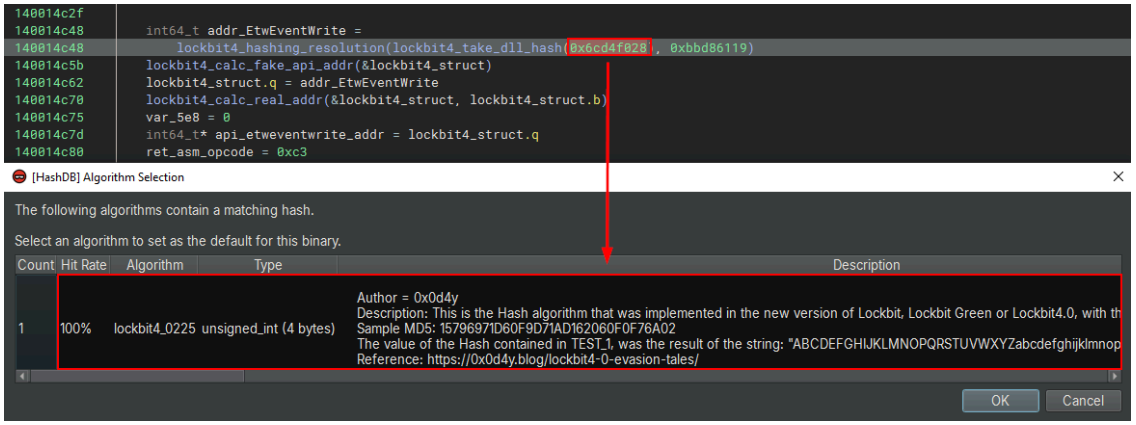
This hashing algorithm traverses a data structure applying mathematical transformations and bitwise operations to generate an accumulative value (**rcx_17**). Below is an objective summary of this algorithm:

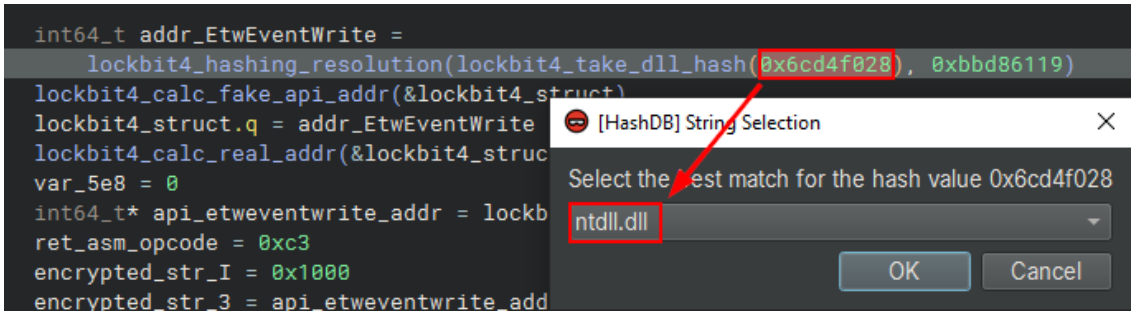
1. **Initialization**: Defines variables, specifically in **rdx_8 = 0**, **rcx_17 = 0x14bf**.
2. **The Main Loop**: Reads values from memory indexed by **r14_2** and stops when it finds a *null value*.
3. **Conditional Conversion**: If the value is an uppercase letter (**A-Z**), converts it to lowercase (**+0x20**).
4. **Hash Calculation**: The algorithm will *XORs* in **rdx_8 ^ 0x14bf**, to ensuring variation in values.
5. **Hashing or Checksum**: Multiplies and combines values with *XOR* to create a cumulative identifier.
6. **Iteration**: It will increment **rdx_8** and **r14_2**, advancing to the next data block.

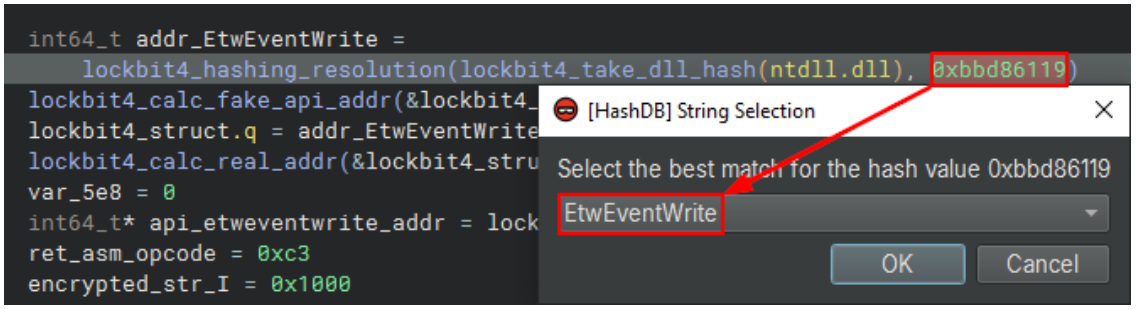
Below we can see the *Python* algorithm that I developed, which is already available in **HashDB** for automatic resolution, through the plugin available for **Ghidra**, **IDA** and **Binary Ninja**.

```
def lockbit4_hashing(hashing):

   MASK_32BIT = 0xffffffff
   hash_value = 0x14bf
   char_index = 0

   for char in hashing:
       char_code = ord(char)

       if 0x41 <= char_code <= 0x5A:
           normalized_char = (char_code + 0x20) & MASK_32BIT
       else:
           normalized_char = char_code

       if char_index == 0:
           index_modifier = 0
       else:
           index_modifier = (char_index ^ 0x14bf) & MASK_32BIT

       hash_value = (index_modifier * (((char_index + 0x14bf) * normalized_char + (hash_value ^ normalized_char

       char_index += 1

   return hash_value
```

In the following sequence of images, we can observe the use of HashDB for resolving DLL/API Hashing in Lockbit4.0.







A good example of the Hashing resolution process flow is the code below from Lockbit4.0, where we first see the resolution of the **ntdll.dll** Hash and the collection of its offset, followed by the resolution of the ***EtwEventWrite*** API Hash, storing them in a Lockbit4.0 custom structure. This piece of code is the beginning of the execution of the **ETW Patching** technique, where Lockbit4.0 will collect the address of the *EtwEventWrite* API, to overwrite the initial API code for the **ret** opcode (**0xc3**), thus applying the patch.

```
int64_t addr_EtwEventWrite =
    lockbit4_hashing_resolution(lockbit4_take_a_dll_hash(0x6cd4f028), 0xbbd86119)
lockbit4_calc_fake_api_addr(&lockbit4_struct)
lockbit4_struct.q = addr_EtwEventWrite
lockbit4_calc_real_addr(&lockbit4_struct, lockbit4_struct.b)
var_5e8 = 0
int64_t* etw_event_write_addr = lockbit4_struct.q
ret_opcode = 0xc3
```

As we can see above, after the resolution, we can see that a function is executed that *calculates a fake API address* through the **lockbit4_calc_fake_api_addr** function, and then the real address is calculated and stored once again in the Lockbit4.0 custom struct. Below, we can see that the calculation for the correct resolution of the API address is a simple *XOR* operation, with values present within the Lockbit4.0 custom struct.

```
int64_t lockbit4_calc_real_addr(char* arg1, char arg2)

    *arg1 ^= arg2
```

Continuing the analysis of the implementation of the *EDR Evasion* technique via *ETW Patching*, and using it as an example, to demonstrate the repeatability of the DLL/API resolution technique dynamically, below we can observe the execution of **zwWriteVirtualMemory**, overwriting the **EtwEventWrite** API with the *opcode ret* (**0xc3**).

```
// NtDLL / ZwWriteVirtualMemory Hash Resolution
if (ZwWriteVirtualMemory_fake_addr_1 == 0)
    int64_t ZwWriteVirtualMemory_fake_addr_2 = lockbit4_hashing_resolution(
        lockbit4_take_dll_hash(ntdll.dll), ZwWriteVirtualMemory)
    ZwWriteVirtualMemory_fake_addr = ZwWriteVirtualMemory_fake_addr_2
    sub_14000431a(ZwWriteVirtualMemory, ZwWriteVirtualMemory_fake_addr_2)

// Performs ETW Patching by placing a ret (opcode 0xc3) at the
// beginning of the EtwEventWrite API address
lockbit4_calc_fake_api_addr(&lockbit4_struct)
lockbit4_struct.q = ZwWriteVirtualMemory_fake_addr
lockbit4_calc_real_addr(&lockbit4_struct, lockbit4_struct.b)
char* ptr_return_opcode = &ret_asm_opcode
// Manually Call ZwWriteVirtualMemory to Perform ETW Patching
lockbit4_struct.q(0xffffffffffffffff, api_etweventwrite_addr, &ret_asm_opcode, 1,
    0)
```

As we saw with the implementation of *ETW Patching*, all other capabilities depend on this same DLL/API resolution technique via *Hashing*. Capabilities such as:

- Disabling DLL Notification via the **LdrUnRegisterDllNotification** API.
- Deleting Volume Shadows via the **IVssBackupComponents** interface with the **DeleteSnapshots** API.
- Disabling the Volume Shadows Management Service via the **OpenSCManager**, **OpenService** and **ChangeServiceConfig** APIs.
- Enumerating Networks via APIs such as **GetIpNetTable**, **inet_ntoa**, **gethostbyaddr** and **NetShareEnum**.
- Log deletion through APIs, **EvtOpenSession**, **EvtOpenChannelEnum**, **EvtNextChannelPath** and **EvtClearLog**.
- And so on.

Analysis of Cryptographic Algorithms for Obfuscation Implemented in Lockbit 4.0

Unlike version **3.0**, Lockbit 4.0 implements two algorithms to decrypt Strings and the *README* that will be created throughout the system. The algorithm to decrypt strings is very simple, being just a logical operation with **XOR**, while the algorithm used to decrypt the *README* is the well-known **RC4**.

Below, we can see an example of a moment when Lockbit4.0 implements the algorithm to decrypt multiple strings, necessary for later actions.

```
lockbit4_struct.q = 0x3a00660000006b
encrypted_str_I = lockbit4_str_decrypt_setup(
    encrypted_str: &lockbit4_struct)
encrypted_str_3 = 0x3a00660000006d
var_7f0 = lockbit4_str_decrypt_setup(encrypted_str:
    &encrypted_str_3)
ret_asm_opcode.q = 0x3a00660000007f
void* var_7e8_2 = lockbit4_str_decrypt_setup(
    encrypted_str: &ret_asm_opcode)
encrypted_str = 0x3a006600000068
var_7e0.q = lockbit4_str_decrypt_setup(&encrypted_str)
encrypted_str_1 = 0x3a00660000006e
var_7d8.q = lockbit4_str_decrypt_setup(encrypted_str:
    &encrypted_str_1)
encrypted_str_2 = 0x3a006600000063
var_7d8:8.q = lockbit4_str_decrypt_setup(
    encrypted_str: &encrypted_str_2)
encrypted_str_5 = 0x3a00660000006f
void* var_7c8_1 = lockbit4_str_decrypt_setup(
    encrypted_str: &encrypted_str_5)
encrypted_str_4 = 0x3a006600000073
void* var_7c0_1 = lockbit4_str_decrypt_setup(
    encrypted_str: &encrypted_str_4)
int64_t encrypted_str_23 = 0x3a006600000075
void* var_7b8_1 = lockbit4_str_decrypt_setup(
    encrypted_str: &encrypted_str_23)
int64_t encrypted_str_22 = 0x3a00660000006a
void* var_7b0_1 = lockbit4_str_decrypt_setup(
    encrypted_str: &encrypted_str_22)
int64_t encrypted_str_21 = 0x3a00660000007b
void* var_7a8_1 = lockbit4_str_decrypt_setup(
    encrypted_str: &encrypted_str_21)
int64_t encrypted_str_20 = 0x3a006600000069
void* var_7a0_1 = lockbit4_str_decrypt_setup(
    encrypted_str: &encrypted_str_20)
int64_t encrypted_str_19 = 0x3a00660000007e
void* var_798_1 = lockbit4_str_decrypt_setup(
    encrypted_str: &encrypted_str_19)
int64_t encrypted_str_18 = 0x3a00660000007c
void* var_790_1 = lockbit4_str_decrypt_setup(
    encrypted_str: &encrypted_str_18)
int64_t encrypted_str_17 = 0x3a00660000007d
void* var_788_1 = lockbit4_str_decrypt_setup(
    encrypted_str: &encrypted_str_17)
int64_t encrypted_str_16 = 0x3a006600000072
void* var_780_1 = lockbit4_str_decrypt_setup(
    encrypted_str: &encrypted_str_16)
```

Below you can see the algorithm itself, which involves logical operations with an *XOR* that starts with the key **0x3a**, and is changed by the counter in each round of the loop, making each byte have a different *XOR* key.

```
void lockbit4_str_decrypt_function(int64_t arg1, int64_t arg2)

    for (int32_t counter_idx = 0; counter_idx s< 4; counter_idx += 1)
        *(arg1 + (sx.q(counter_idx) << 1)) = *(arg2 + (sx.q(counter_idx) << 1))
            ^ ((mods.dp.d(sx.q(counter_idx), 1)).w + 0x3a)
```

Below is my implementation of this algorithm in Python, followed by the output of its execution.

```
def lb4_str_decrypt(data: bytes) -> str:
    if len(data) % 2 != 0:
        raise ValueError("[-] Error [-]")

    decrypted_chars = []
    key = 0x3a

    for i in range(0, len(data), 2):
        encrypted_word = int.from_bytes(data[i:i+2], byteorder='little')
        decrypted_word = encrypted_word ^ key

        if decrypted_word == 0:
            break

        decrypted_chars.append(chr(decrypted_word))

    return ''.join(decrypted_chars)

if __name__ == "__main__":
    encrypted_data = b'\x6b\x00\x00\x00\x66\x00\x3a\x00'
    result = lb4_str_decrypt(encrypted_data)
    print("Decrypted String:", result)
```

```
PS C:\Users\0x0d4y\Desktop\Research\Malware Research\Ransomwares\Lockbit4.0> python .\lb4_decrypt_string.py
Decrypted String: Q:\
PS C:\Users\0x0d4y\Desktop\Research\Malware Research\Ransomwares\Lockbit4.0>
```

In addition to the *XOR* algorithm above used for string decryption, Lockbit4.0 also implements the well-known **RC4** algorithm, with the aim of decrypting the *README* that will be written throughout the system during the execution of the Ransomware. Below we can see the in-line implementation of the *RC4* Algorithm present in Lockbit4.0, within the Main function itself.

```
// Vector Initialization Phase from 0 to 255
for (int64_t rc4_ksa_idx = 0; rc4_ksa_idx != 256; rc4_ksa_idx += 1)
    *(&lockbit4_struct + rc4_ksa_idx) = rc4_ksa_idx.b

int64_t rc4_prga_idx = 0
char r10_3 = 0

// KSA Phase of RC4 Algorithm
for (; rc4_prga_idx != 256; rc4_prga_idx += 1)
    char r11_4 = *(&lockbit4_struct + rc4_prga_idx)
    r10_3 =
        r10_3 + r11_4 + *(zx.q(mods.dp.d(sx.q(rc4_prga_idx.d), 0x10)) + &rc4_key)
    uint64_t rax_168 = zx.q(r10_3)
    uint64_t rdx_91
    rdx_91.b = *(&lockbit4_struct + rax_168)
    *(&lockbit4_struct + rc4_prga_idx) = rdx_91.b
    *(&lockbit4_struct + rax_168) = r11_4

int64_t rc4_data_decrypt_idx = 0
char* encrypted_readme = data_14001eeb8
char rdx_92 = 0
uint64_t idx = 0

// PRGA and RC4 Algorithm Decryption Phase
for (; rc4_data_decrypt_idx != 0x1853; rc4_data_decrypt_idx += 1)
    idx = zx.q(idx.b + 1)
    void* rc4_key
    rc4_key.b = *(&lockbit4_struct + idx)
    rdx_92 += rc4_key.b
    uint64_t r10_4 = zx.q(rdx_92)
    *(&lockbit4_struct + idx) = *(&lockbit4_struct + r10_4)
    *(&lockbit4_struct + r10_4) = rc4_key.b
    rc4_key.b += *(&lockbit4_struct + idx)
    rc4_key.b = *(&lockbit4_struct + zx.q(rc4_key.b))
    encrypted_readme[rc4_data_decrypt_idx] ^= rc4_key.b
```

Without any extra obfuscation layers, we are able to identify the *RC4 key* and the encrypted *README*.

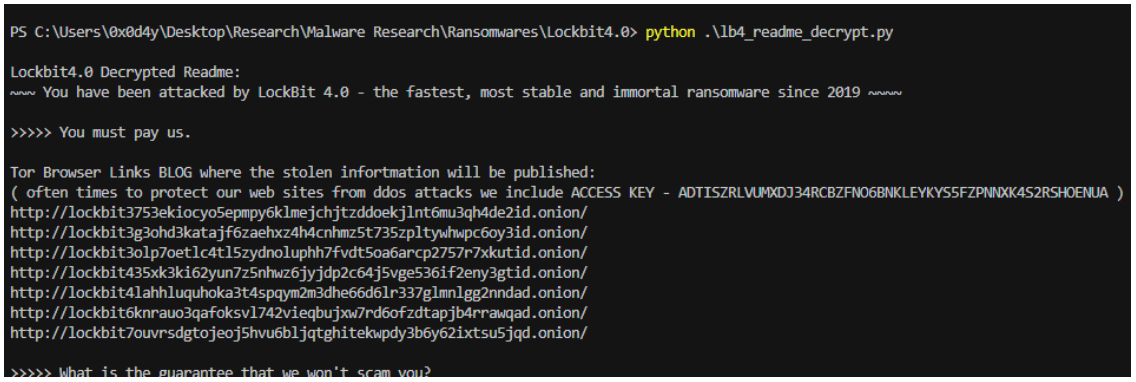
```
14001cb70  rc4_key:
14001cb70                                          ca 7e 7b 2b 60 8c 2d 32-31 03 b7 7e d4 9e 1f 8e   .~{+`.-21..~....
14001cb80  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00  ................................
```

```
14001b310  encrypted_readme:
14001b310                                          e6 6e 22 1d 66 b2 0c 12-e7 c7 cd a4 47 b3 c4 53                .n".f.......G..S
14001b320  bf b7 84 d8 2a 8f d0 2b-42 19 08 d8 99 e2 44 df-e8 06 4c a8 0b 13 08 57-25 e4 92 4a 8d 01 bd 76  ....*..+B.....D...L....W%..J...v
14001b340  69 69 20 04 98 57 af 98-b3 81 ad 52 84 aa d0 b7-36 a3 8e 2a cf 28 30 eb-4a f6 28 85 fc b4 01 3d  ii ..W.....R....6..*.(0.J.(....=
14001b360  85 ee d6 e4 0e 40 c9 80-85 9b 46 ca 77 92 30 52-b7 79 56 70 71 71 8b ac-a3 26 39 1d b6 5d 6e 1b  .....@....F.w.0R.yVpqq...&9..]n.
14001b380  e5 2b 32 29 71 14 44 79-83 c8 39 47 85 ad 1d d1-2b 3a 07 6f 7a 71 74 74-7e 0e 17 1d 2d 1a 61 d8  .+2)q.Dy..9G....+:.ozqtt~...-.a.
14001b3a0  c4 6c 27 d0 a4 59 28 0a-b6 67 76 33 25 e0 52 8e-a8 f0 7b 76 85 79 68 1e-b4 a2 33 12 45 08 df b5  .l'..Y(..gv3%.R...{v.yh...3.E...
14001b3c0  ec c2 0f 11 0e 71 bc 27-ee 73 f8 18 2c dd 88 fd-6d 45 8d 80 f3 2c 0d 9b-f3 61 3e 20 13 88 da c2  .....q.'.s..,...mE...,...a> ....
14001b3e0  81 24 1d 08 5b 81 5f b2-c9 45 1f f7 83 a0 ae 82-fc 3e 4a 6e c5 46 c3 44-e0 2a 67 82 f1 b7 9a 25  .$..[._..E.....>Jn.F.D.*g....%
```

Since it is a well-known algorithm, and widely used by Malware, it is easy to implement this algorithm in Python. Below is my implementation, followed by the output of its execution (*I removed the values of the RC4 key and the large block of data from the encrypted README, to keep the visual appearance cleaner*).

```
def rc4(key: bytes, data: bytes) -> bytes:
    # KSA Phase
    S = list(range(256))
    j = 0
    key_length = len(key)
```

```
    # PRGA Phase
    for i in range(256):
        j = (j + S[i] + key[i % key_length]) % 256
        S[i], S[j] = S[j], S[i]


    # Decryption Phase
    i = 0
    j = 0
    result = bytearray()
    for byte in data:
        i = (i + 1) % 256
        j = (j + S[i]) % 256
        S[i], S[j] = S[j], S[i]
        K = S[(S[i] + S[j]) % 256]
        result.append(byte ^ K)

    return bytes(result)


if __name__ == "__main__":
    rc4_key = "RC4_KEY"

    encrypted_lb4_readme = (
        "ENCRYPTED_README_DATA"
    )

    rc4_key_bytes = bytes.fromhex(rc4_key)
    encrypted_readme_bytes = bytes.fromhex(encrypted_lb4_readme)

    decrypted_bytes = rc4(rc4_key_bytes, encrypted_readme_bytes)

    try:
        decrypted_lb4_readme = decrypted_bytes.decode("utf-8")
    except UnicodeDecodeError:
        decrypted_lb4_readme = decrypted_bytes.decode("latin1", errors="replace")

    print("\nLockbit4.0 Decrypted Readme:")
    print(decrypted_lb4_readme)
```



Detection Engineering - Yara Rules

Below, contains the YARA rules I produced during the analysis of Lockbit4.0, focused on detecting code patterns from the packed sample, and the unpacked sample.

```
 rule lb4_packer_was_detected
{
    meta:
        author = "0x0d4y"
        description = "Detect the packer used by Lockbit4.0"
        date = "2024-02-16"
        score = 100
        yarahub_reference_md5 = "15796971D60F9D71AD162060F0F76A02"
        yarahub_uuid = "f6f57eca-314b-4657-906e-495ea9b92def"
        yarahub_license = "CC BY 4.0"
        yarahub_rule_matching_tlp = "TLP:WHITE"
        yarahub_rule_sharing_tlp = "TLP:WHITE"
        malpedia_family = "win.lockbit"
    strings:
        $unpacking_loop_64b = { 8b 1e 48 83 ee fc 11 db 8a 16 72 e5 8d 41 01 41 ff d3 11 c0 01 db 75 0a }
        $jump_to_unpacked_code_64b = { 48 8b 2d 16 0f ?? ?? 48 8d be 00 f0 ?? ?? bb 00 ?? ?? ?? 50 49 89 e1 41 b
        $unpacking_loop_32b = { 8A 06 46 88 07 47 01 DB 75 ?? 8B 1E 83 EE ?? 11 DB 72 ?? 9C 29 C0 40 9D 01 DB 75
        $jump_to_unpacked_code_32b = { 8b ae ?? ?? ?? ?? 8d be 00 f0 ?? ?? bb 00 ?? ?? ?? 50 54 6a 04 53 57 ff d

    condition:
        uint16(0) == 0x5a4d and
        1 of ($jump_to_unpacked_code_*) and
        1 of ($unpacking_loop_*)
}
```

```
 rule lb4_rc4_alg
{
    meta:
        author = "0x0d4y"
```

```
        description = "Detect the implementation of RC4 Algorithm by Lockbit4.0"
        date = "2024-02-13"
        score = 100
        yarahub_reference_md5 = "062311F136D83F64497FD81297360CD4"
        yarahub_uuid = "4de48ced-b9fa-4286-aac4-c263ad20d67d"
        yarahub_license = "CC BY 4.0"
        yarahub_rule_matching_tlp = "TLP:WHITE"
        yarahub_rule_sharing_tlp = "TLP:WHITE"
        malpedia_family = "win.lockbit"
    strings:
        $rc4_alg = { 48 3d 00 01 00 00 74 0c 88 84 04 ?? ?? ?? ?? 48 ff c0 eb ec 29 c9 41 b8 ?? ?? ?? ?? 4c 8d (

    condition:
        uint16(0) == 0x5a4d and
        $rc4_alg
}
```

```
 rule lb4_hashing_alg
{
    meta:
        author = "0x0d4y"
        description = "This rule detects the custom hashing algorithm of Lockbit4.0 unpacked"
        date = "2024-02-16"
        score = 100
        yarahub_reference_md5 = "062311F136D83F64497FD81297360CD4"
        yarahub_uuid = "d1a6d555-626d-4625-9da6-e4478cb7a142"
        yarahub_license = "CC BY 4.0"
        yarahub_rule_matching_tlp = "TLP:WHITE"
        yarahub_rule_sharing_tlp = "TLP:WHITE"
        malpedia_family = "win.lockbit"
    strings:
        $hashing_alg = { 41 89 d0 46 0f be 04 00 45 09 c0 74 ?? 45 8d 48 ?? 45 8d 50 ?? 41 80 f9 ?? 45 0f 43 d0

    condition:
        uint16(0) == 0x5a4d and
        $hashing_alg
}
```

Detection Engineering - Yara Hunts

With the YARA rules produced, I carried out a Yara Hunt on UnpacMe and below is the link shared with the matches produced by the Hunt with the YARA rules above.

- `lb4_packer_was_detected` ;
- `lb4_rc4_alg` ;

- `lb4_hashing_alg`.

Conclusion

Throughout the analysis, Lockbit4.0 presents us with a version that is much more concerned with implementing *Obfuscation* techniques, such as the *DLL/API Hashing* technique and the *DLL/API* address resolution technique divided into phases, with the clear purpose of obfuscating its intentions and slowing down the analysis. And we can also observe its concern with implementing Endpoint Protection Software Evasion techniques, through techniques such as *ETW Patching* and *Disabling DLL Loading Notifications*. In addition, it is also possible to observe the introduction of the network enumeration technique in an autonomous manner, through the collection of IP addresses from the *ARP Table* and the *Routing Table*, through the IPs mentioned in the research. There is no secret in the implementation of this technique, since it is entirely done through the use of Windows APIs, with the only layer of complexity being the implementation of the DLL/API resolution technique dynamically.

Therefore, unlike the previous version, this new version of Lockbit ransomware is focused on staying under the radar.

Source: https://0x0d4y.blog/lockbit4-0-evasion-tales/