Netwalker Ransomware – From Static Reverse Engineering to Automatic Extraction

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Netwalker ransomware has been around since at least 2019* and has recently been in the news from a TrendMicro report detailing it being leveraged embedded in a PowerShell script[1].

We will briefly go over how to recover the DLL files from the first script, it contains a large Base64 chunk of data that is base64 decoded and executed:

```
InVokE-ExPRESSIoN -COMmand $([StrinG]([SySTEM.TexT.ENcOdInG]::ASCII.GETStRiNG([SysTEM.CoNVErT]:
:FRomBAsE64StRiNG(“ICA <..snip..>
```

The next script layer then has an array of bytes which will be XOR decoded:

```
[bYTE[]]    $eFGCSjWKKPqLGPIYp     =
 @(0x67,0x67,0x1C,0x25,0x3e,0x33,0x22,0x1c,0x1A,0x1A,0x67,0x67,0x67,0x67,0x67,0x67,0x67,0x67,0x67,0x63,0x37,0x33,0x01,0x31,0x0C,0x
for  (  $qTOJScZVUn =   0;   $QTOjsCZvUn     -lt   $eFGCSjWKKPQLGpIYP.LeNgth;    $qtOJscZvUN++  )  {
     $EFGCSjWKKPqlGpIYP[$qtOJscZVUN] = $EFGCSJWkkPqLGPIYP[$QtOJscZvUN]   -BxOr 0x47
<..snip..>
```

Finally we are left with the main script layer that will load the DLL into memory:

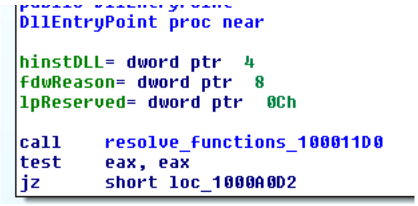
```
[bYTE[]]    $eFGCSjWKKPqLGPIYp     =
 @(0x67,0x67,0x1C,0x25,0x3e,0x33,0x22,0x1c,0x1A,0x1A,0x67,0x67,0x67,0x67,0x67,0x67,0x67,0x67,0x67,0x63,0x37,0x33,0x01,0x31,0x0C,0x
for  (  $qTOJScZVUn =   0;
$QTOjsCZvUn     -lt   $eFGCSjWKKPQLGpIYP.LeNgth;    $qtOJscZvUN++  )  {
     $EFGCSjWKKPqlGpIYP[$qtOJscZVUN] = $EFGCSJWkkPqLGPIYP[$QtOJscZvUN]   -BxOr 0x47
<..snip..>
```

Finally we are left with the main script layer that will load the DLL into memory:

```
  [byte[]]     $ptFvKdtq
=     @(0xad,0xde,0x90,0x00,0x03,0x00,0x00,0x00,0x04,0x00,0x00,0x00,0xff,0xff,0x00,0x00,0xb8,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x40,0x
```

Netwalker DLL

The first thing the DLL does is resolve all of its needed functions.

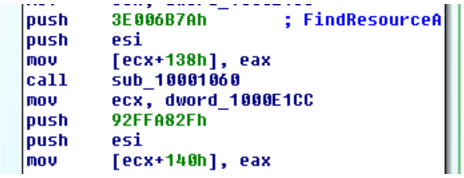


```
DllEntryPoint proc near

hinstDLL= dword ptr  4
fdwReason= dword ptr  8
lpReserved= dword ptr  0Ch

call    resolve_functions_100011D0
test    eax, eax
jz      short loc_1000A0D2
```

Dynamic function resolution such as this normally involves some form of string hashing, in this case it is CRC32.

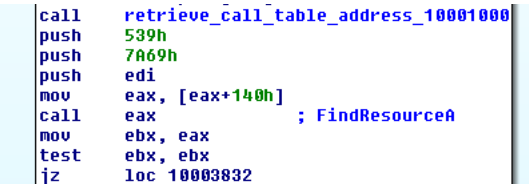


```
push    3E006B7Ah       ; FindResourceA
push    esi
mov     [ecx+138h], eax
call    sub_10001060
mov     ecx, dword_1000E1CC
push    92FFA82Fh
push    esi
mov     [ecx+140h], eax
```

In the picture above you can see the hash value for FindResourceA being passed to a function that will resolve it and then store it in an array.

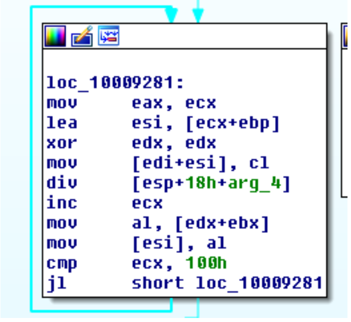
```
>>> hex(zlib.crc32(‘FindResourceA’) % (1<<32))’0x3e006b7a’
```

After resolving there is a function responsible for simply getting the beginning address of the previous table. Shortly after resolving the needed functions the DLL gets its resource section.



```
call    retrieve_call_table_address_10001000
push    539h
push    7A69h
push    edi
mov     eax, [eax+140h]
call    eax             ; FindResourceA
mov     ebx, eax
test    ebx, ebx
jz      loc_10003832
```

A little ways down this data is passed off to another function which has a noticeable loop inside of it that is RC4 KSA[2]. If you are wanting to be able to identify some of these common routines I frequently recommend that people compile some files themselves and then take a look at them in a debugger or a disassembler. Routines I would recommend becoming familiar with will be included at the end of this blog.



```
loc_10009281:
mov     eax, ecx
lea     esi, [ecx+ebp]
xor     edx, edx
mov     [edi+esi], cl
div     [esp+18h+arg_4]
inc     ecx
mov     al, [edx+ebx]
mov     [esi], al
cmp     ecx, 100h
jl      short loc_10009281
```

So since the the resource section appears to be RC4 decrypted, let’s take a look at the data.

```
>>> r = get_rsrc(pe)
>>> data = r[0][1]
>>> data[:100]"\x07\x00\x00\x00cZu-H!<\x9b\xc5E\xder\x88&D\xf0\xd7{@\x00\xa9m\xa1\x1e\x8b\xac\xf7Z\xb4|\xc9&
[\x03\x1cY\xde\xf5\x8dA\x97C:8y\xb5&\x07\xb8q\xed\xe1^\xfd<\x98\x92\x95\x1a\xa6\xf7\xea
\x07\xea\x18v\xe1\x0f\xa1\xdcmR\x8c\x85'I\t\xc9\x12\x8e\xe5\x9d+\xc2\x7f\x00G\x01-Jp\xd48 “
```

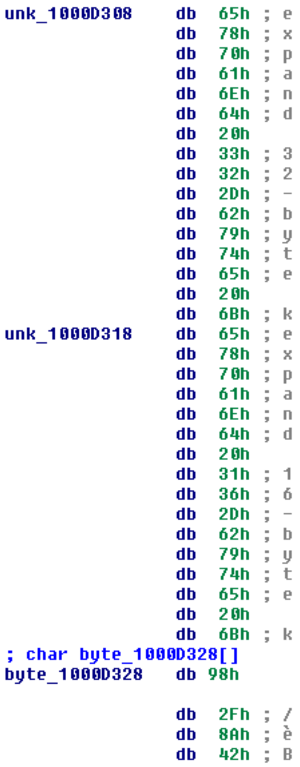
The first 4 bytes appear to be a DWORD value stored as little endian, since I didn’t see a reference to any hardcoded data being used as a RC4 key from the DLL and a small dword value is the first thing in this resource section I’m going to assume it is some sort of a length value. Perhaps a key length?

```
>>> import struct
>>> from Crypto.Cipher import ARC4
>>> import struct
>>> struct.unpack_from(‘<I’, data)(7,)
>>> key = data[4:4+7]
>>> rc4 = ARC4.new(key)
>>> t = rc4.decrypt(data[4+7:])
>>> t[:100]'{“mpk”:”+1KtL9ibbeqaChhoz4iEHeTtRtw8pNA5yC034\\/3kISA=”,”mode”:0,”spsz”:15360,”thr”:1500,”namesz”:8,”‘
```

It’s always nice when your hypothesis turns out to be correct on the first try, definitely isn’t the norm though.

Now that we have decrypted the config we need to find more samples and see if we can decode more configs, I use VirusTotal sometimes and I understand it’s not something everyone has access to so I will upload all the samples I end up going through onto MalwareBazaar.

For pivoting in order to find more samples I will normally turn to YARA and use a service that allows for scanning malware repositories, most of these services are either paid or private so you will normally obtain access to them as you progress into the world of malware research. VirusTotal has a convenient way to quickly search for hex strings using content searching so I pick a string that looks like it will remain static in this malware stub or template but will not give me a bunch of false positives. Sometimes this is harder than not and in this case the string I went with was actually my 3rd attempt.



```
unk_1000D308    db  65h ; e
                db  78h ; x
                db  70h ; p
                db  61h ; a
                db  6Eh ; n
                db  64h ; d
                db  20h
                db  33h ; 3
                db  32h ; 2
                db  2Dh ; -
                db  62h ; b
                db  79h ; y
                db  74h ; t
                db  65h ; e
                db  20h
                db  6Bh ; k
unk_1000D318    db  65h ; e
                db  78h ; x
                db  70h ; p
                db  61h ; a
                db  6Eh ; n
                db  64h ; d
                db  20h
                db  31h ; 1
                db  36h ; 6
                db  2Dh ; -
                db  62h ; b
                db  79h ; y
                db  74h ; t
                db  65h ; e
                db  20h
                db  6Bh ; k
; char byte_1000D328[]
byte_1000D328   db 98h

                db  2Fh ; /
                db  8Ah ; è
                db  42h ; B
```

Here we have two constant strings associated with SALSA20 or CHACHA20 encryption and following it is a dword value associated with hashing, kind of odd to see them back to back that way in the binary.

We can convert this to a hexlified string for doing VT content searching:

```
content:”{657870616e642033322d62797465206b657870616e642031362d62797465206b982f8a42}”
```

Searching in VirusTotal shows this to be a pretty good string for finding Netwalker related samples! Surprisingly enough it turns up lots of samples as well.

So now we need a decoder, or a way to automate decoding the config data from the files.

Let's build out a decoder, we need to:

- Read a file in
- Fix up MZ stomping
- Retrieve the resources
- Find the key length
- RC4 decode
- Print config

Let's setup for the first part for retrieving the resources:

*The full script can be found as part of the **Zero2Automated Advanced Malware Analysis Course***

Taking our script and the files from our content pivoting we will check the first 25 files and find that our script seems to work, we found a number of samples with new ‘mpk’ values but also one of the mailto samples instead of using onion domains:

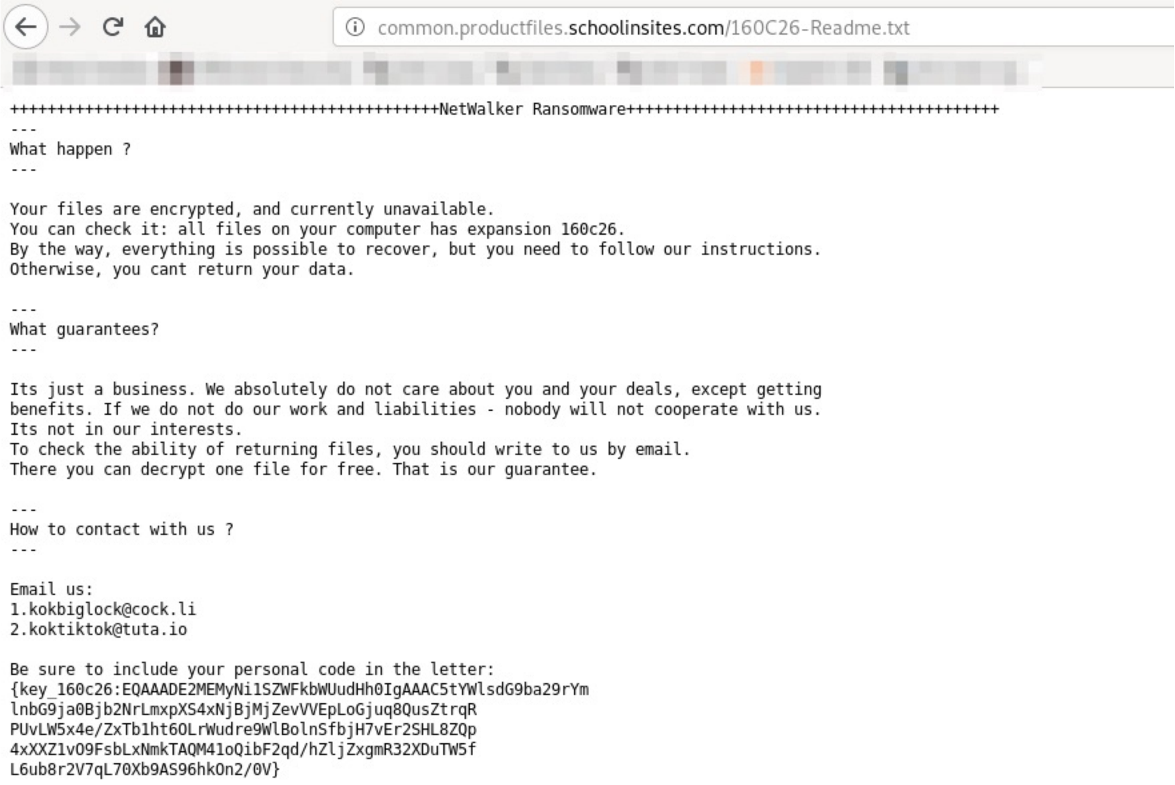
```
{“mpk”:”ESw9E\/AaTiQ9oZfLKNquj2dHV3TqTFU8c4zjg7HLHRc=”,”mode”:0,”spsz”:15360,”thr”:1500,”namesz”:8,”idsz”:6,”pers”:false,”onion1″:”pb
Readme.txt”,<..snip..>
```

```
{“mpk”:”9WMeeC/lNogGtJPPRqQRzty2DMwgPRBWyU7mLzp992E=”,”mode”:0,”thr”:1500,”spsz”:51200,”namesz”:8,”idsz”:5,
“crmask”:”.mailto[{mail1}].{id}”,”mail”:[“pripripri@tuta.io”,”praparapra@cock.li”],”lfile”:”{ID}-Readme.txt”,<..snip..>
```

So now we just need to decode more files, after decoding a larger data set I found that they all seemed to be using the same onion domains but managed to find a number of samples using email addresses as well:

```
2Hamlampampom@cock.liGalgalgalgalk@tutanota.comHariliuios@tutanota.comkavariusing@tutanota.comkazkavkovkiz@cock.likokbiglock@co
```

A quick web search of one of the emails, ‘koktiktok@tuta.io’, leads to a ransomed website immediately:



common.productfiles.schoolinsites.com/160C26-Readme.txt

```
+++++++++++++++++++++++++++++++++++++++++++++++NetWalker Ransomware+++++++++++++++++++++++++++++++++++++++++
---
What happen ?
---

Your files are encrypted, and currently unavailable.
You can check it: all files on your computer has expansion 160c26.
By the way, everything is possible to recover, but you need to follow our instructions.
Otherwise, you cant return your data.

---
What guarantees?
---

Its just a business. We absolutely do not care about you and your deals, except getting
benefits. If we do not do our work and liabilities - nobody will not cooperate with us.
Its not in our interests.
To check the ability of returning files, you should write to us by email.
There you can decrypt one file for free. That is our guarantee.

---
How to contact with us ?
---

Email us:
1.kokbiglock@cock.li
2.koktiktok@tuta.io

Be sure to include your personal code in the letter:
{key_160c26:EQAAADE2MEMyNi1SZWFkbWUudHh0IgAAAC5tYWlsdG9ba29rYm
lnbG9ja0Bjb2NrLmxpXS4xNjBjMjZevVVEpLoGjuq8QusZtrqR
PUvLW5x4e/ZxTb1ht6OLrWudre9WlBolnSfbjH7vEr2SHL8ZQp
4xXXZ1vO9FsbLxNmkTAQM41oQibF2qd/hZljZxgmR32XDuTW5f
L6ub8r2V7qL70Xb9AS96hkOn2/0V}
```

Going through the files that didn’t decode out configs shows that we have found a number of decryptors that were uploaded to VirusTotal:

```
346fdff8d24cbb7ebd56f60933beca37a4437b5e1eb6e64f7ab21d48c862b5b744b5d24e5e8fd8e8ee7141f970f76a13c89dd26c44b336dc9d6b61fda
```

Also a DLL file that left the name embedded of ‘Netwalker_dll.dll’:

```
55870437ee97984ef461438777635b53eb52f8d83048ce3a825d95cabc2065f2
```

Mine the data

Now that we have a bunch of decoded configs we can do a bit of data mining as well.

We can use some bash magic to dump out the counts for ‘mpk’ values:

```
   1 0OQuf4tSKXtXERycfxzsWvcWPE2xayXH1rBpyAwyhVw=   1 1B+hUSlP+KcLFtZn5q0ND6WzFyQPIHxtM1vv1zlm4TE=   4
 +1KtL9ibbeqaChhoz4iEHeTtRtw8pNA5yC034\/3klSA=   1 2ofyizDC65TzCiTW6SHYlP0mHF8VHklx5\/FFIECTOWE=   1
 3ZVt8Qrdiimm/8OxCtmqUBZhZJ6DxqheQQ0wf9dIvU4=   1 7gkgNrgVvnSdnUifXmoRclyQU1tmmH9uLXZQ+mrJq1Y=   1
 8kQrJzFg\/OugByxLk1JyT1cstH0gAQa6EmbRTJYIPyA=   1 9m56vLIZOlxhDtqMpZBLLOB21rKNaqnfMZmAICgbHB8=   1
 9qQgCpjzg9Gg4R4QntJaXdyqbeK7tBKkyatX6U809B8=   1 9rekeP1eSTG+1alJX084XEnZkNZbMI2i7f7xMARuYG0=   1
 9WMeeC/lNogGtJPPRqQRzty2DMwgPRBWyU7mLzp992E=   1 AopcQZuT8iGQsDBOQ5vum9rCosprWR4HAtyoDLBe2jk=   1
 B1zaW+rgS4zOpn9MVHL0SXpAgmPx9992cw/zrjTStUQ=   1 bd9dpX2CspQ65wRiTP1TjN1cqwk8dSdJehbmYTNMxEY=   1
 cePAiKEieIEsWYzINEJe7\/M7yXm+i6y\/Y+fjupgPdhc=   1 cT9cjcSYKMZMSxEObt0H0djsPtEVOW6Pfy0IU20uCEc=   1
 EsvRQAFnerbfU8Z+27XyeJD82IPjl7PL62KSSzYOVUM=   2 ESw9E\/AaTiQ9oZfLKNquj2dHV3TqTFU8c4zjg7HLHRc=   1
 EXgCIpycIJzspm07Loi9L5uOcxC+VZ/NjxWfOn7UqVE=   1 fXe6IoRs263eE42xnNF\/L5vYmC81qAS5F08zqHShBnE=   1
 i3XpDekYmaDR5/C8gssEfc4BdgWSoKrU/RLtK10V4x8=   1 IrZwVI2HoRerwgd99xkmdIL3g0tfJOU1GoXMIPq5gkA=   1
 izndhmDBfqQMxnbJX3rwRXETOO7hXuPRUrw91jUeuCE=   4 JgQzhhhjdTmwJuFlSWQ99dolV6sNRQWfNdqTbxulxCc=   1
 JgRipXGeK7D6diXrdsBTdT\/o4ps0NS+6uUQ2K+lrmns=   1 JXrdFkPUAEVVROz8EN45wkOUGupEphGPQz4GoMLXwAk=   1
 jZOEXL4Vyq413gNYUVSUuiJyvFvII63YSv3LMTm6YSQ=   1 kRmTz3GjStQDqVIO35VbP2DX5HzhQKd5bZJ5fkuQp2o=   1
 LCiJ44QQcMh5P1jJtpV7XaJoMezvQc0D8bxdK97oWHM=   1 lxd4WwFEl80nASzXFosZNWY0+M3\/ljFwqXGcQ7C3Jmg=   1
 O7iv5p+9M2xSENzUqbH2q4hEPiISh KQON7UQJZ\/qhxs=   1 pLcj6adbJHIyhEWwUd+Wht4pAXQMi4MhYXb1DmSE5Uc=   1
 p+V4T581H2IJPowJP7b9Laa4P0cAfDgyREsFNhpETDw=   2 qGFBYhyYzmg5jkJh0giXpwDfUdbopaCdj4Zcxsdab0c=   1
 RQfrkb+zP4wEDw4UerO5Xqwm/5R3zHSuTHD12cRuBTM=   4 srj15Yy9UFP\/jvwiLyCiEWXRb\/8RwnuHqGtdJCQzWk0=   1
 sVMyZQe7xbAMYsKdX7B\/RmV92sc+Qd9YL7EmRVCZDnI=   1 TPeyvEhWusttXBNAkbii\/6tocN5IWcOl+O2JCMyXtWA=   2
 uHbQk+xn3zyr9HAJIbR6wDKpszDZC2Dri\/D8cdZCPBU=   2 uMDlH\/VVLunARbKVQ4kKse+8Mdxbk00Pf+NSkoDASW0=   1
 U+P1u\/vlAgiFK\/NnScZbuLtNbohxu\/65\/XiNMHzV82E=   1 usVG0ZPeGZRvG5clAh81RbrG7Whq9b3dtQ2tmoYf2iI=   1
 vWdriuVFhHBNk87xEzAlkZNfVRnPIIn1PsCx8s/+Uj8=   1 w2nejMQFYibyk97OISK8vcRcoUeJz2c024P98feVuXs=   2
 XfwHXZw5ITJ/PB4tTJaJCa9cbigLKwS1hlNyMvT3CnQ=   1 XQixjtCbv3GHOcOGAAnHAO2rJFTbq8jr4j6bkajSWjU=   1
 YisAjypwt6EuV8PeHBflq\/sQwAWgo+Y6CI9NKu3Fu10=   1 z2qgNTBTz6Ff6XQROdTvmEiBJn+b+HV3+Gw97n0rZxk=   1
 zxbaxrewir3mRzNnoTP5NYvdhQNmFKwczCHzih9Kig0=
```

The ‘lend’ value usually contains the ransom message so we can dump out the values and see how often it has changed. When doing this I noticed that most of the samples contained a generic message but there were lots of samples that had slightly custom messages including victim names.

c21ecd18f0bbb28112240013ad42dad5c01d20927791239ada5b61e1c6f5f010

```
 Hello, O2MICRO.
 Your files are encrypted by Netwalker.All encrypted files for this computer has extension: .{id}
```

3ba905e1cda7307163d4c8fe3fd03c2fbce7eda030522084e33d0604c204630e

```
 Hi University of Seattle,
 Your files are encrypted.All encrypted files for this computer has extension: .{id}
```

0d7ee7ce88e790ad66aa53589f5a2638207bc3adf2eb4f8a813fd52b5b22ba27

```
 Hi Stellar,
 Your files are encrypted.All encrypted files for this computer has extension: .{id}
```

b2d68a79a621c3f9e46f9df52ed19b8fec22c3cf5f4e3d8630a2bc68fd43d2ee

```
 Hi InventUsPower,
 Your files are encrypted by Netwalker.All encrypted files for this computer has extension: .{id}
```

29aef790399029029e0443455d72a8b928854a0706f2e211ae7a03bba0e3d4f4

```
 Hi Bolloré,
 Your files are encrypted.All encrypted files for this computer has extension: .{id}
```

Also a version that warns of releasing stolen data:

26dfa8512e892dc8397c4ccbbe10efbcf85029bc2ad7b6b6fe17d26f946a01bb

```
Hi!Your files are encrypted.All encrypted files for this computer has extension: .{id}
–If for some reason you read this text before the encryption ended,this can be understood by the fact that the computer slows down,and
your heart rate has increased due to the ability to turn it off,then we recommend that you move away from the computer and accept that you
have been compromised.Rebooting/shutdown will cause you to lose files without the possibility of recovery.
–Our  encryption algorithms are very strong and your files are very well protected,the only way to get your files back is to cooperate with us
and get the decrypter program.
Do not try to recover your files without a decrypter program, you may damage them and then they will be impossible to recover.
For us this is just business and to prove to you our seriousness, we will decrypt you one file for free.Just open our website, upload the
encrypted file and get the decrypted file for free.
Additionally, your data may have been stolen and if you do not cooperate with us, it will become publicly available on our blog.
—
Steps to get access on our website:
1.Download and install tor-browser: https://torproject.org/
2.Open our website: {onion1}If the website is not available, open another one: {onion2}
3.Put your personal code in the input form:
{code}
```

Routines

This is not an exhaustive list by any means but is listed in the most common to least common order and are probably the algorithms I find most often inside of malware.

Encoding:

Base64

Encryption:

- RC4
- XTEA
- AES
- RC6

Hashing:

- CRC32
- MD5
- SHA256
- SHA512

Compression:

- APLIB
- FLATE
- GZIP
- ZLIB
- LZ

References

1: https://blog.trendmicro.com/trendlabs-security-intelligence/netwalker-fileless-ransomware-injected-via-reflective-loading/

2: https://en.wikipedia.org/wiki/RC4