The evolution and future of supply chain attacks

Boris Larin
Alexander Liskin

kaspersky

During the presentation certain companies will be mentioned in relation to supply chain attacks

The fact that they became victims of such attacks shouldn't reflect badly on them – everyone could be compromised, as history has shown us

How the incident is handled and what measures are taken following it, is what matters most

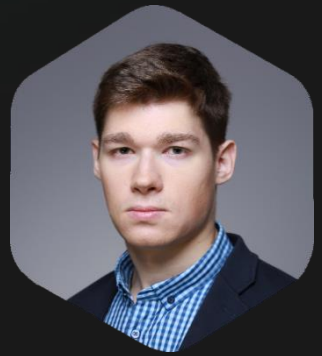
Alexander Liskin

Head of Heuristic Detection and Vulnerability Research Team

- Leads malware detection technologies and their development
- Implements SDL practices within the department
- Likes to analyze different file formats and packed executables

Twitter: **@0x1fffffffffff**

Boris Larin



Senior Malware Analyst

- Reverse engineer (multi-arch firmwares, kernels, etc.)
- Vulnerability and exploit detection research
- Finds zero-days exploited in the wild and supply chain attacks

Twitter: **@oct0xor**

WHAT IS A SUPPLY CHAIN ATTACK?

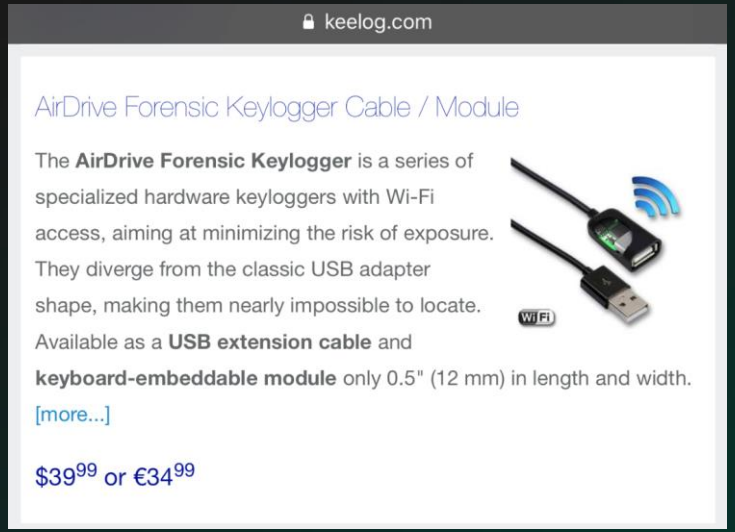
A supply chain attack compromises products or services before they are delivered to customers

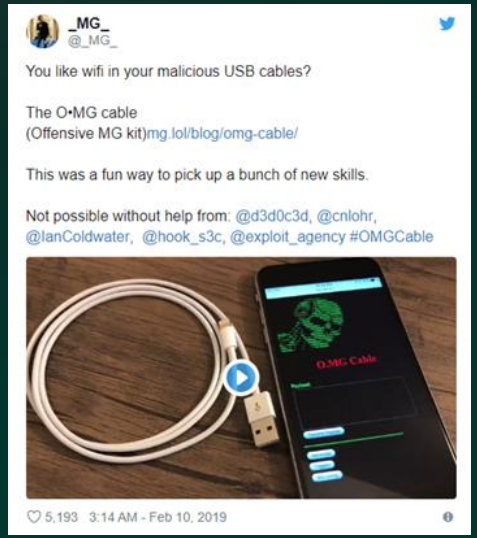
Generic supply chain attack

There are known cases when malicious implant was pre-installed on a device during manufacture and shipment

Different ways to hide implant

- Software implant (malware with persistence mechanism)
- Firmware implant (UEFI/BIOS rootkit, etc.)
- Hardware implant (BadUSB attack, sophisticated modification of IC, etc.)





Malicious implant can not only be pre-installed on a device
It may be installed through the update mechanisms of legitimate applications

Attack with man-in-the-middle:

(1) Software asks for update http://....

(2) Request hijacked, malware is delivered

“Flame” malware used Windows Update to spread within a network

Threat actors can infect millions of computers with a single attack
(including enterprises, governments, ...)

Average computer has many applications, some of which check updates daily

SUPPLY CHAIN ATTACKS ARE POISONING TRUSTED MECHANISMS

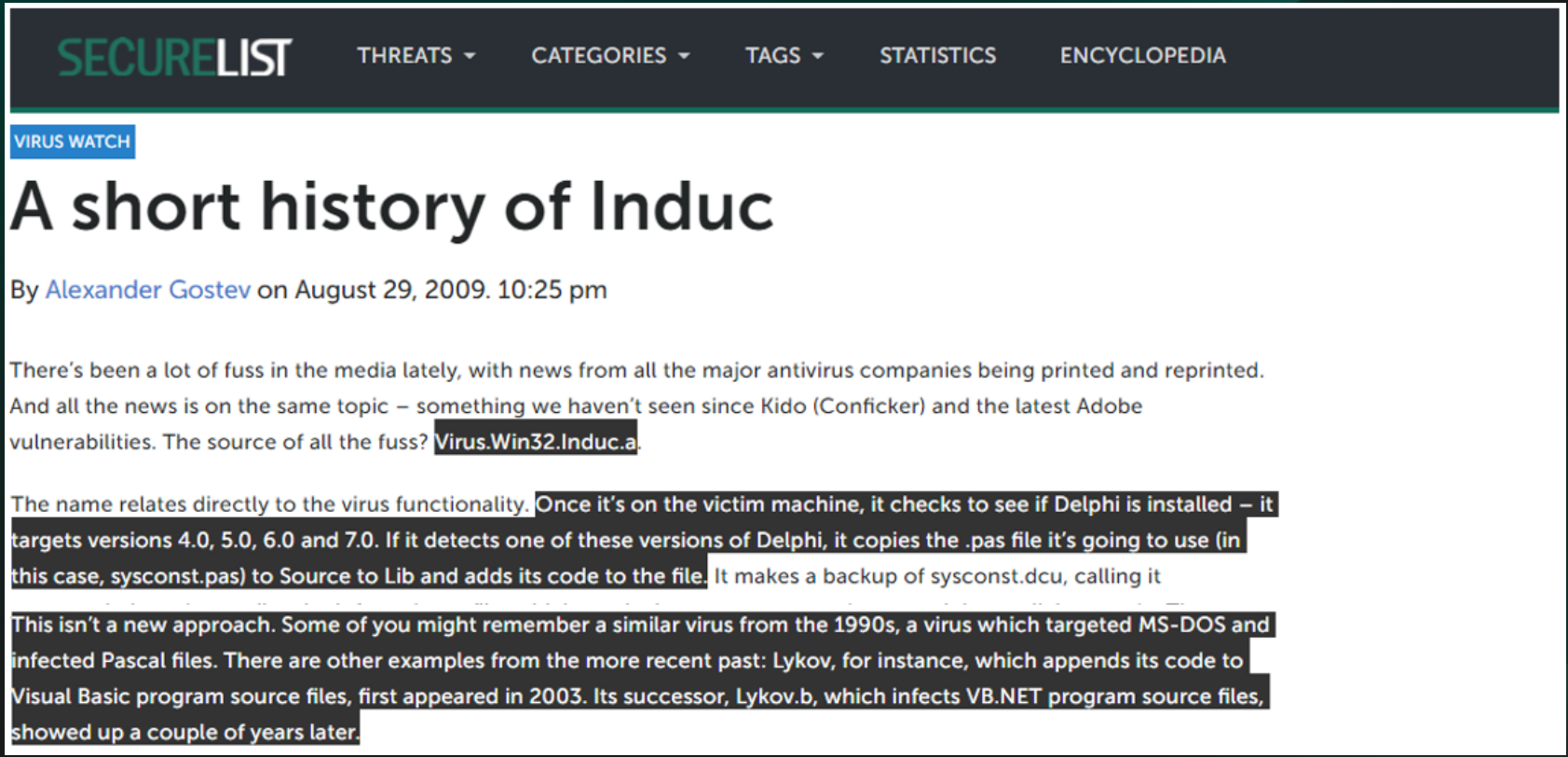
If you install updates:
You may became a victim of a supply chain attacks

If you not install updates:
You might be vulnerable to security issues

REALLY HUGE PROBLEM FOR SOFTWARE COMPANIES

You may be a target, but you may be a weapon

Is it a new phenomenon?



SECURELIST THREATS CATEGORIES TAGS STATISTICS ENCYCLOPEDIA

VIRUS WATCH

A short history of Induc

By Alexander Gostev on August 29, 2009. 10:25 pm

There's been a lot of fuss in the media lately, with news from all the major antivirus companies being printed and reprinted. And all the news is on the same topic – something we haven't seen since Kido (Conficker) and the latest Adobe vulnerabilities. The source of all the fuss? Virus.Win32.Induc.a.

The name relates directly to the virus functionality. Once it's on the victim machine, it checks to see if Delphi is installed – it targets versions 4.0, 5.0, 6.0 and 7.0. If it detects one of these versions of Delphi, it copies the .pas file it's going to use (in this case, sysconst.pas) to Source to Lib and adds its code to the file. It makes a backup of sysconst.dcu, calling it

This isn't a new approach. Some of you might remember a similar virus from the 1990s, a virus which targeted MS-DOS and infected Pascal files. There are other examples from the more recent past: Lykov, for instance, which appends its code to Visual Basic program source files, first appeared in 2003. Its successor, Lykov.b, which infects VB.NET program source files, showed up a couple of years later.

Some of recent examples

MALWARE + RECOMMENDED + SECURITY NEWS

Mac Users Hit by Rare Ransomware Attack, Spread via Transmission BitTorrent App

Posted on March 6th, 2016 by Graham Cluley

Mac owners who use the open source Transmission BitTorrent client are being warned that a version of the installer was distributed via the app's official website, infected with a new family of ransomware.

In this presentation we want talk about activity of an actor who is believed to be behind the most loud supply chain attacks

First supply chain attack of this group was observed by Kaspersky back in 2011

Hacking group with Chinese origin, interested in online video game industry:

- Theft of source code
- Theft of digital certificates
- Conversion of virtual in-game currency/“gold” into real money

Back then were identified 11 compromised certificates of gaming companies
They were shared with other hacking groups, presumably coming from China

Since initial Kaspersky GReAT report its possible to observe that this actor switched to broader set of targets, still using distinct techniques

- TeamViewer discovered attack in 2016, with the use of Winnti backdoor
- Winnti malware was used against ThyssenKrupp in 2016 and Bayer in 2018

As Winnti group was sharing compromised certificates before, its possible that multiple groups are using the same tools and techniques, but having different goals

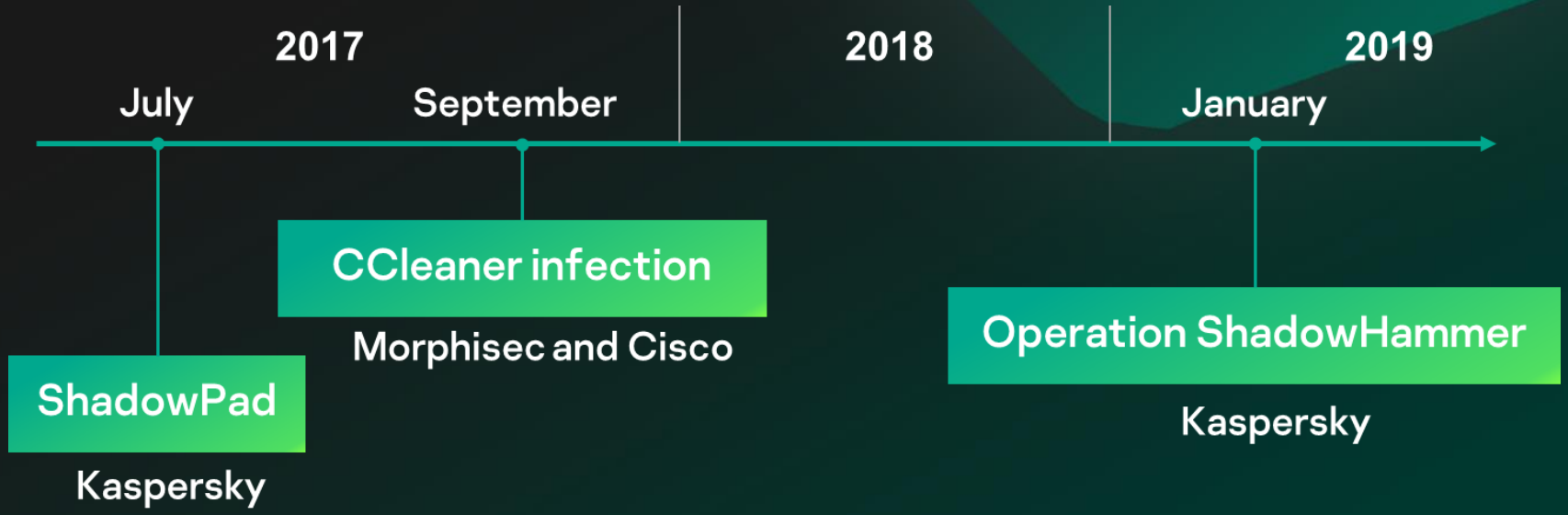
Microsoft distinguish two groups “Barium” and “Lead” using Winnti malware

Video game industry activity can be linked to “Barium”

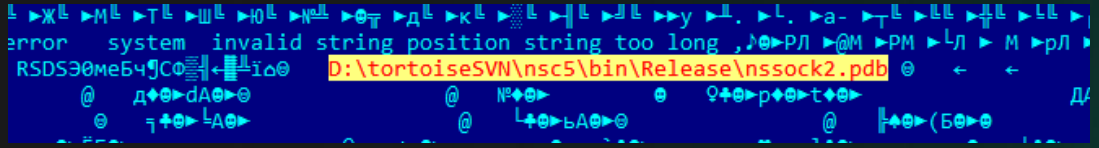
Our code similarity also identified links to “Axiom” APT umbrella

1. Compromise trough 3rd party software
   - Group is famous for stealthy supply chain attacks targeting only selected victims
2. Exploits for web services
3. Phishing
4. Stolen credentials

Timeline of discovery

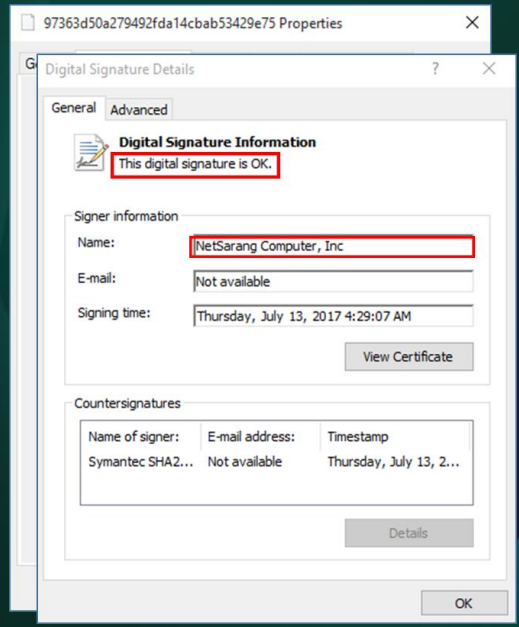


Server management tools by NetSarang (Xmanager, Xshell, Xftp, etc.)
Backdoor embedded into legitimate nssock2.dll




```
void *__thiscall execute_backdoor(void *this)
{
  void *v2; // [esp+0h] [ebp-18h]
  int (__stdcall *decrypted_shellcode)(_DWORD); // [esp+8h] [ebp-10h]
  unsigned int i; // [esp+10h] [ebp-8h]
  unsigned int v5; // [esp+14h] [ebp-4h]

  v2 = this;
  decrypted_shellcode = (int (__stdcall *)(_DWORD))VirtualAlloc(0, 0xFB48u, 0x1000u, 0x40u);
  v5 = encrypted_shellcode;
  for ( i = 0; i < 0xFB44; ++i )
  {
    *((_BYTE *)decrypted_shellcode + i) = v5 ^ *((_BYTE *)&encrypted_shellcode + i + 4);
    v5 = 0xC9BED351 * ((v5 >> 16) + (v5 << 16)) - 0x57A25E37;
  }
  if ( (unsigned int)decrypted_shellcode(0) < 0x1000 )
    MessageBoxA(0, "###ERROR###", 0, 0);
  return v2;
}
```



API name hash

```
loc_492569:
movsx   eax, al
ror     ebx, 8
add     ebx, eax
xor     ebx, 7C35D9A3h
inc     ecx
```

```
; hash = __ROR4__(hash, 8)
; hash += *name
; hash ^= 0x7C35D9A3
```

Anti-analysis

```
loc_F52B:                               ; CODE XREF: sub_F51F+1↑p
                push    ebp
                mov     ebp, esp
                sub     esp, 434h
                push    ebx
                push    esi
                push    edi
                js      short loc_F53C
                jns     short loc_F53C
; ---------------------------------------------------------------------------
                db 0E9h                 ; jmp     near ptr
; ---------------------------------------------------------------------------
```

```
; =============== S U B R O U T I N E ===

kernel32_Sleep  proc near

                mov     eax, 892745BAh
                neg     eax
                jmp     eax
kernel32_Sleep  endp

; ---------------------------------------------------------------------------
                db  75h ; u

; =============== S U B R O U T I N E ===

kernel32_lstrcpy proc near
```

Obfuscated imports

```
v2 = encrypted_string;
v3 = output;
v9 = 0;
v4 = (_BYTE *)LocalAlloc(4096);
v5 = *v2 | (unsigned __int16)(v2[1] << 8);
v6 = v4;
v7 = v2 + 2 - v4;
do
{
  *v6 = v5 ^ v6[v7];
  v5 = 0x41120000 * v5 - 0x434CBEEE * (v5 >> 16) - 0x2F878E0F;
  if ( !*v6 )
    break;
  ++v9;
  ++v6;
}
```

Encrypted strings

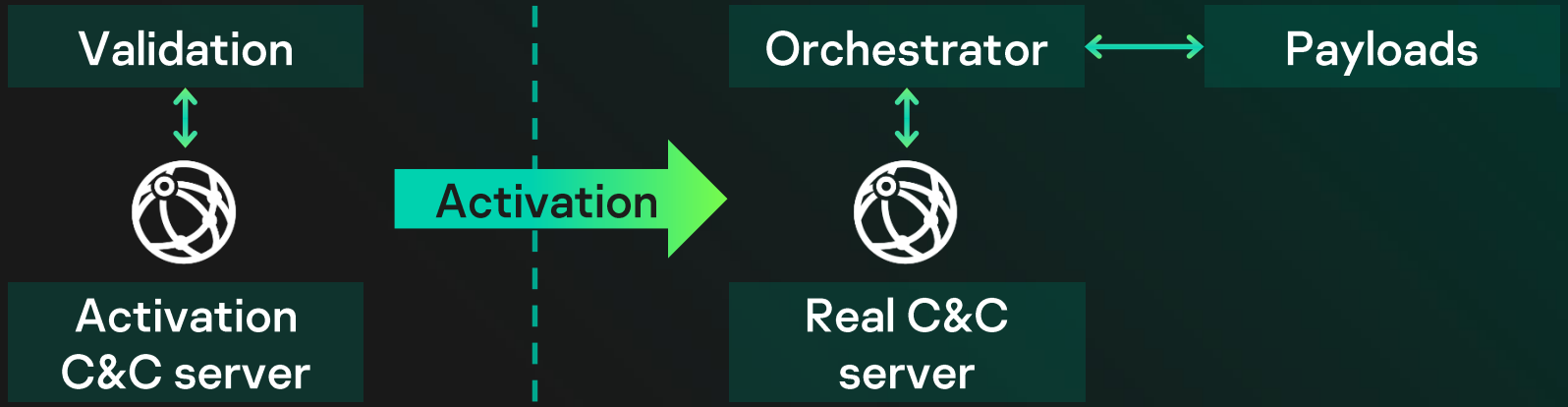
Modular backdoor platform:

Communication based on the DNS protocol

Download and execute arbitrary code provided from the C&C server

Maintain a virtual file system (VFS) inside the registry

VFS and additional files are encrypted and stored uniquely for each victim



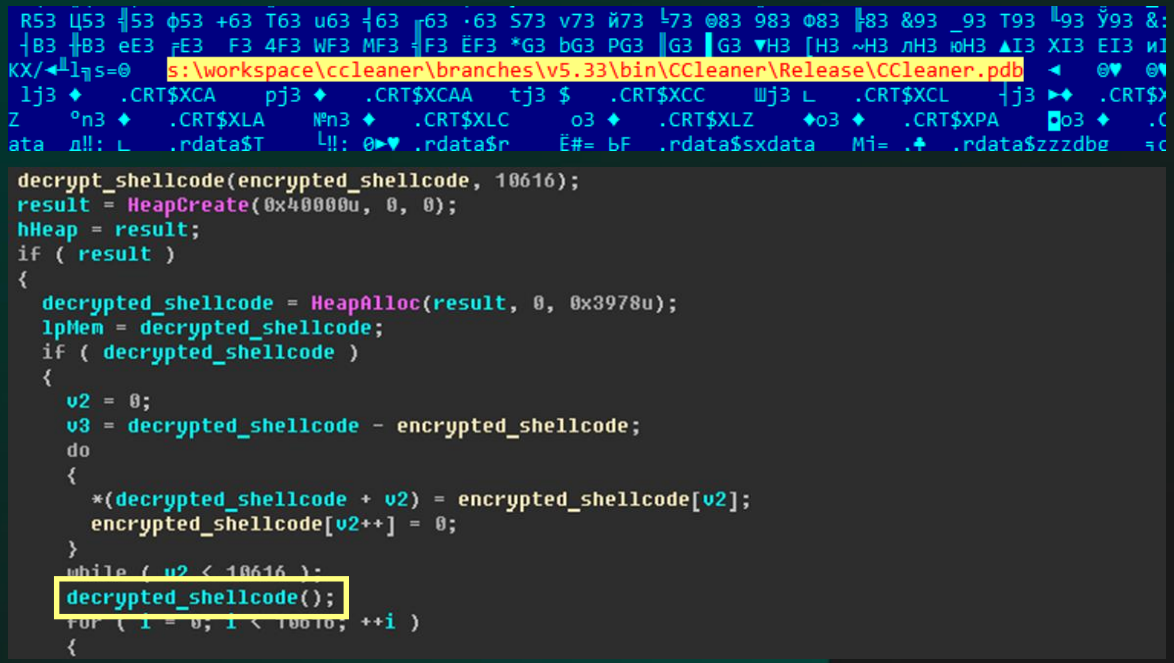
Domains for C&C servers registered covering July to December 2017

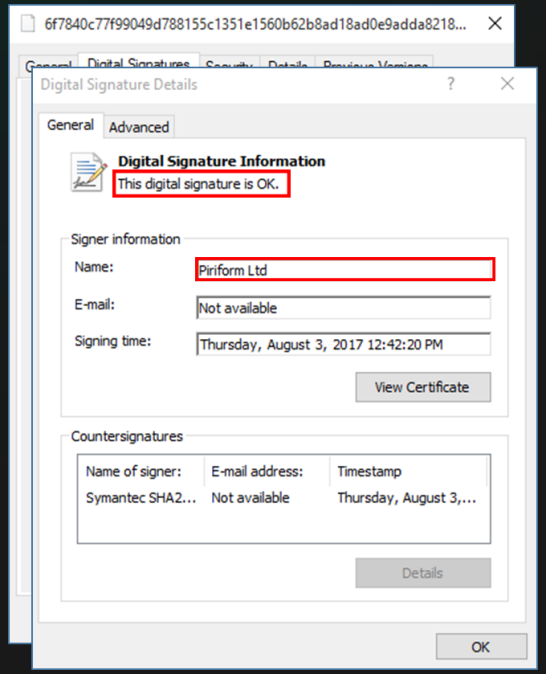
It confirms alleged start date of the attack as around mid July 2017

Found by Kaspersky GReAT team in July 2017 and reported to NetSarang

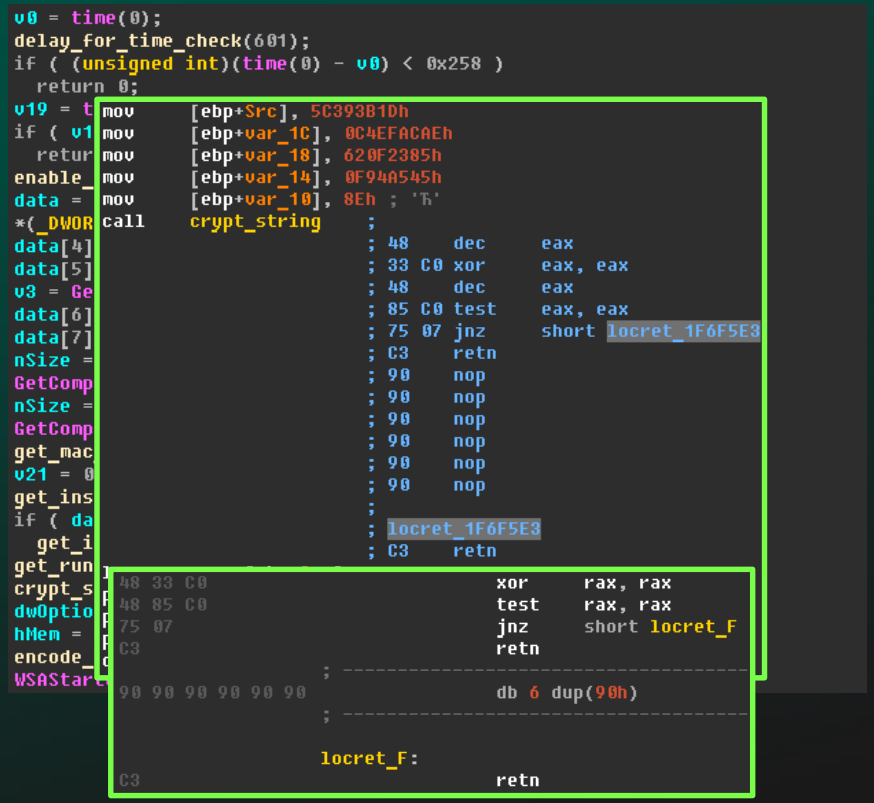
One activated payload found in a company in Hong Kong

Utility to cleanup a potentially unwanted files and Windows Registry entries
Backdoor is located inside main executable





CCleaner infection



Checks IcmpSendEcho execution time

Checks that current user is administrator

Reads or generates infection ID, and stores it in structure with other system information:

- NtVersion
- IsWow64
- Arch (x86/x64)
- Computer name and DNS domain
- Mac addresses of network adapters
- Software installed on system
- Processes running on system

Data is sent to C&C server which returns 2nd stage of payload only to specific victims

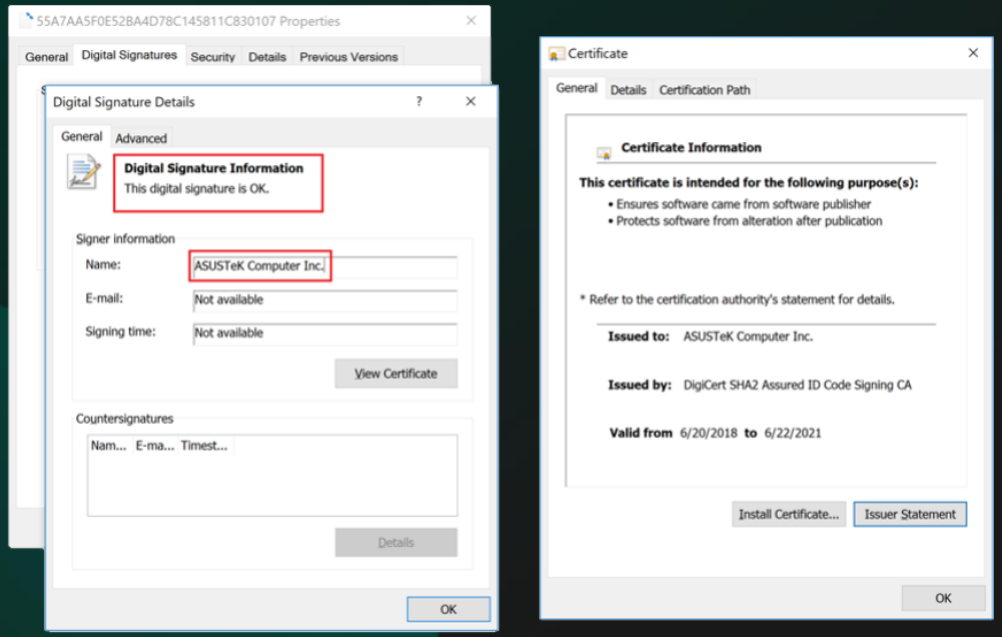
According to Avast:

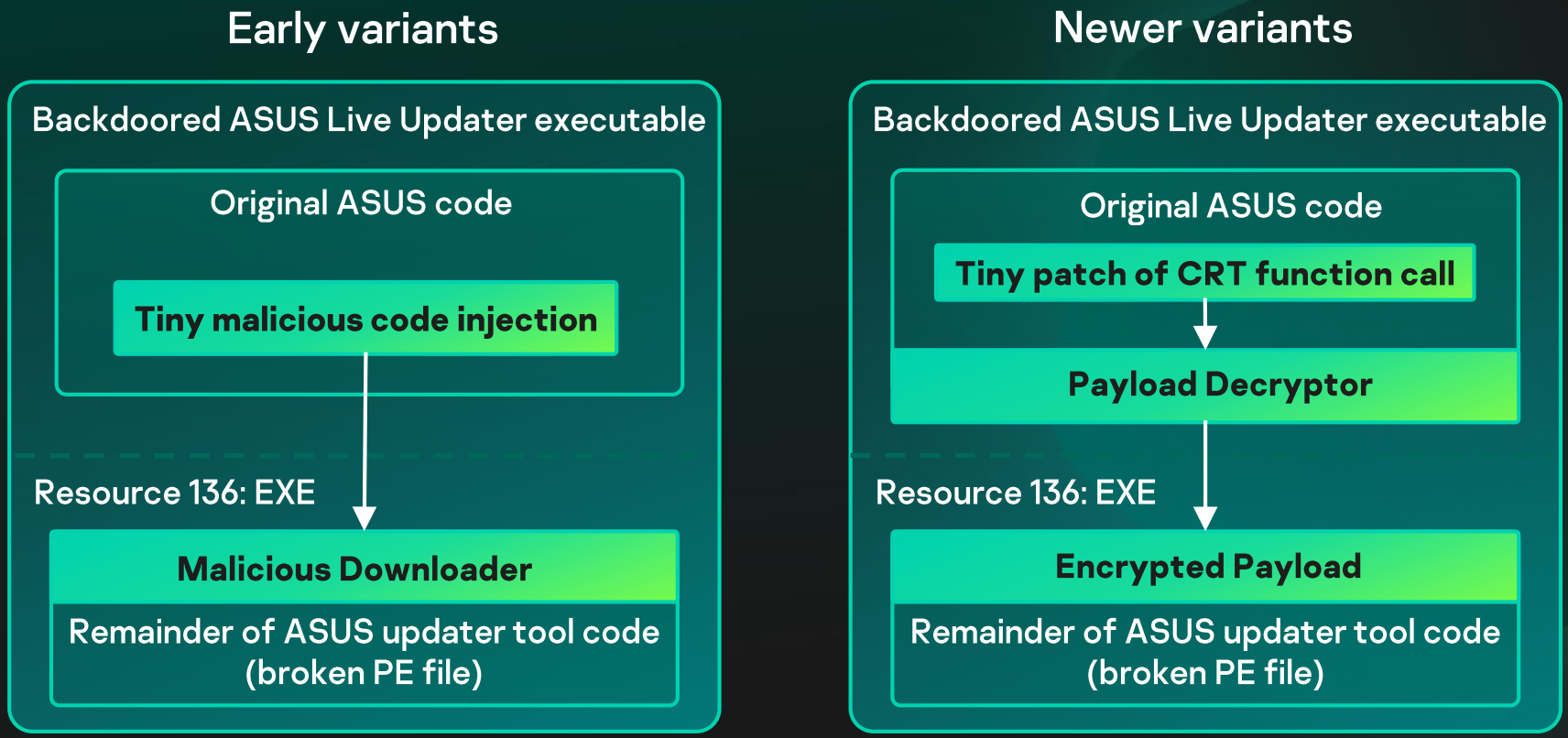
- The altered installation file was downloaded by 2.27 million CCleaner customers worldwide
- Second stage binary was downloaded to 40 PCs
- In addition, Avast researchers found ShadowPad installed on four Piriform computers

Domain	Industry	Country	Number of impacted PCs
cht.com.tw	Telco	Taiwan	13
nsl.ad.nec.co.jp	Tech	Japan	10
samsung samsung.sk samsung.sepm	Tech	Korea	5
corpnet.asus paskey.corpnet.asus	Tech	Taiwan	2
ad.fip.fujitsu.com domain.ftsp.ten.fujitsu.com	Tech	Japan	2
am.sony.com	Tech	Japan	2
infoview2u.dvrdns.org	Internet	USA	1
uk.pri.o2.com	Telco	UK	1
gg.gauselmann.com	Gaming	Germany	1
singtel	Telco	Singapore	1
intel.com	Tech	USA	1
vmware.com	Tech	USA	1

"Complete list of companies / domains affected, together with the number of impacted PCs"
Image copyright: Avast
https://blog.avast.com/additional-information-regarding-the-recent-ccleaner-apt-security-incident

Downloaded from the official ASUS Update server:
hxxps://liveupdate01s[.]asus[.]com/... .../Liveupdate_Test_VER*.zip



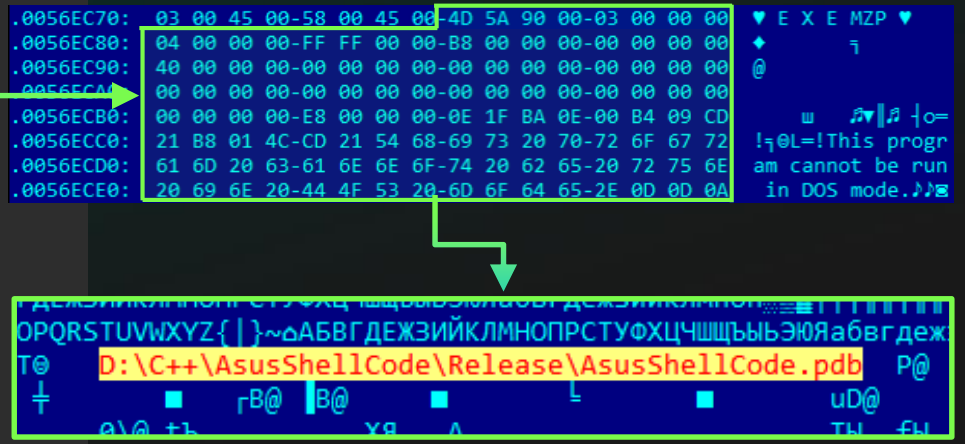

Early variants
Backdoored ASUS Live Updater executable
Original ASUS code
Tiny malicious code injection
Resource 136: EXE
Malicious Downloader
Remainder of ASUS updater tool code (broken PE file)
Newer variants
Backdoored ASUS Live Updater executable
Original ASUS code
Tiny patch of CRT function call
Payload Decryptor
Resource 136: EXE
Encrypted Payload
Remainder of ASUS updater tool code (broken PE file)

Operation ShadowHammer - Backdoor 1


```
int __stdcall __noreturn wWinMain(HINSTANCE hInstance, HINSTANCE hPre
{
  // [COLLAPSED LOCAL DECLARATIONS. PRESS KEYPAD CTRL-"+" TO EXPAND]

  savedregs = &savedregs;
  v13 = v5;
  v12 = v4;
  buf = VirtualAlloc(0, 0x80000u, 0x1000u, 0x40u);
  if ( buf )
  {
    payload = buf;
    input = (int *)0x56EC78;
    output = buf;
    size = 0xBC00;
    do
    {
      data = *input;
      ++input;
      *output = data;
      ++output;
      --size;
    }
    while ( size );
    ((void (__cdecl *)(int, int))(payload + 0x302))(v12, v13);
  }
  ExitProcess(0);
}
```

Payload in resources
(in place of original executable)



Operation ShadowHammer - Backdoor 2


```
; Attributes: library function noreturn bp-based frame

; void __cdecl __noreturn __crtExitProcess(UINT uExitCode)
___crtExitProcess proc near

uExitCode= dword ptr  8

mov     edi, edi
push    ebp
mov     ebp, esp
push    [ebp+uExitCode]
call    execute_shellcode
pop     ecx
push    [ebp+uExitCode] ; uExitCode
call    ds:ExitProcess
___crtExitProcess endp
```

```
int __stdcall decrypt_shellcode(BYTE *input, int size, BYTE *output)
{
  int result; // eax
  unsigned int d; // [esp+D0h] [ebp-44h]
  unsigned int c; // [esp+DCh] [ebp-38h]
  unsigned int b; // [esp+E8h] [ebp-2Ch]
  unsigned int a; // [esp+F4h] [ebp-20h]
  int i; // [esp+10Ch] [ebp-8h]

  i = 0;
  a = *(_DWORD *)input;
  b = *(_DWORD *)input;
  c = *(_DWORD *)input;
  d = *(_DWORD *)input;
  do
  {
    a = a + (a >> 3) - 0x11111111;
    b = b + (b >> 5) - 0x22222222;
    c += 0x33333333 - (c << 7);
    d += 0x99999999 - (d << 9);
    output[i] = (d + c + b + a) ^ input[i];
    result = ++i;
  }
  while ( i < size );
  return result;
}
```

"Famous" algorithm from PlugX

1. Get MAC addresses with iphlpapi.dll's GetAdaptersAddresses API function
2. Use MD5 API from ntdll.dll to calculate MD5 of six raw bytes of physical address
3. Check that MAC hashes belong to table that was assembled on stack
4. In the event of a match, next stage will be downloaded from hxxps://asushotfix.com/logo.jpg (logo2.jpg in newer variants)
   Otherwise create an INI file "idx.ini" which will be located two directory levels up from the current executable

Targets only very specific computers with surgical precision

Operation ShadowHammer - Victims

We identified 230 unique backdoored samples

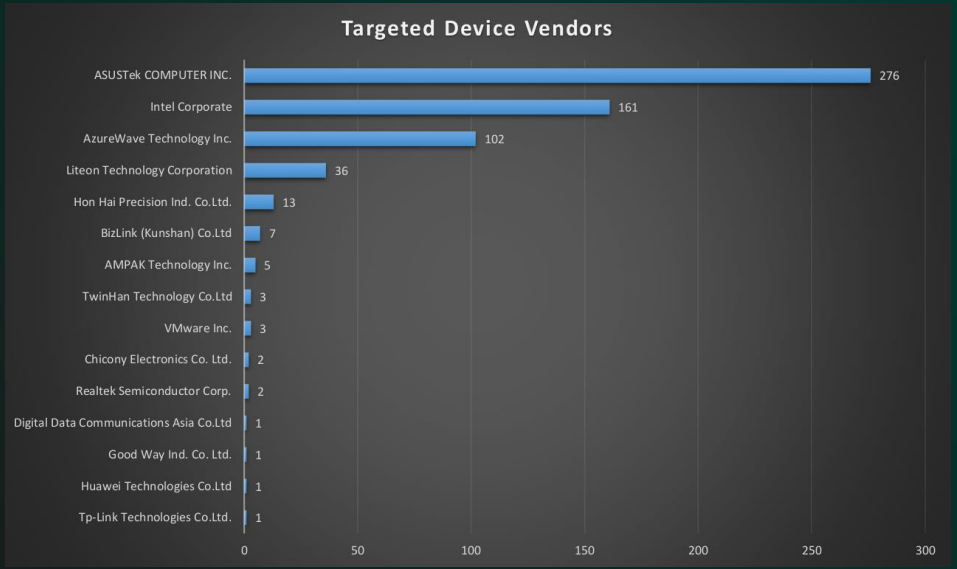
Containing 14 unique hash tables:

- Smallest table – eight entries
- Biggest table – 307 entries

Some hashes are present in all tables

In total we found:

- 205 entries of Type 1
- 209 entries of Type 2



Over 400 machines were targeted by Operation ShadowHammer

ASUS was not the only victim of “Operation ShadowHammer”

While we were working on report our supply chain attack detection technology caught a number of other cases:

- Digitally signed binaries from three other vendors in Asia
- All cases are very similar to each other and can be clustered together
- All victims were from the gaming industry
- All new cases had the same backdoor but it was different from ASUS case

Operation ShadowHammer - Gaming industry


```
int __stdcall start(int a1, int a2, int a3, int a4)
{
  int result; // eax
  HANDLE v5; // eax
  struct WSAData WSAData; // [esp+0h] [ebp-190h]

  adjust_privileges();
  result = is_backdoor_uninstalled();
  if ( !result )
  {
    WSAStartup(0x202u, &WSAData);
    v5 = CreateThread(0, 0, main_thread, 0, 0, 0);
    result = CloseHandle(v5);
  }
  return result;
}
```

Supported commands:

DownUrlFile - download data to file
DownRunUrlFile - download data to file and execute it
RunUrlBinInMem - download data and run as shellcode
UnInstall - set registry flag to prevent malware start

Configuration contains:

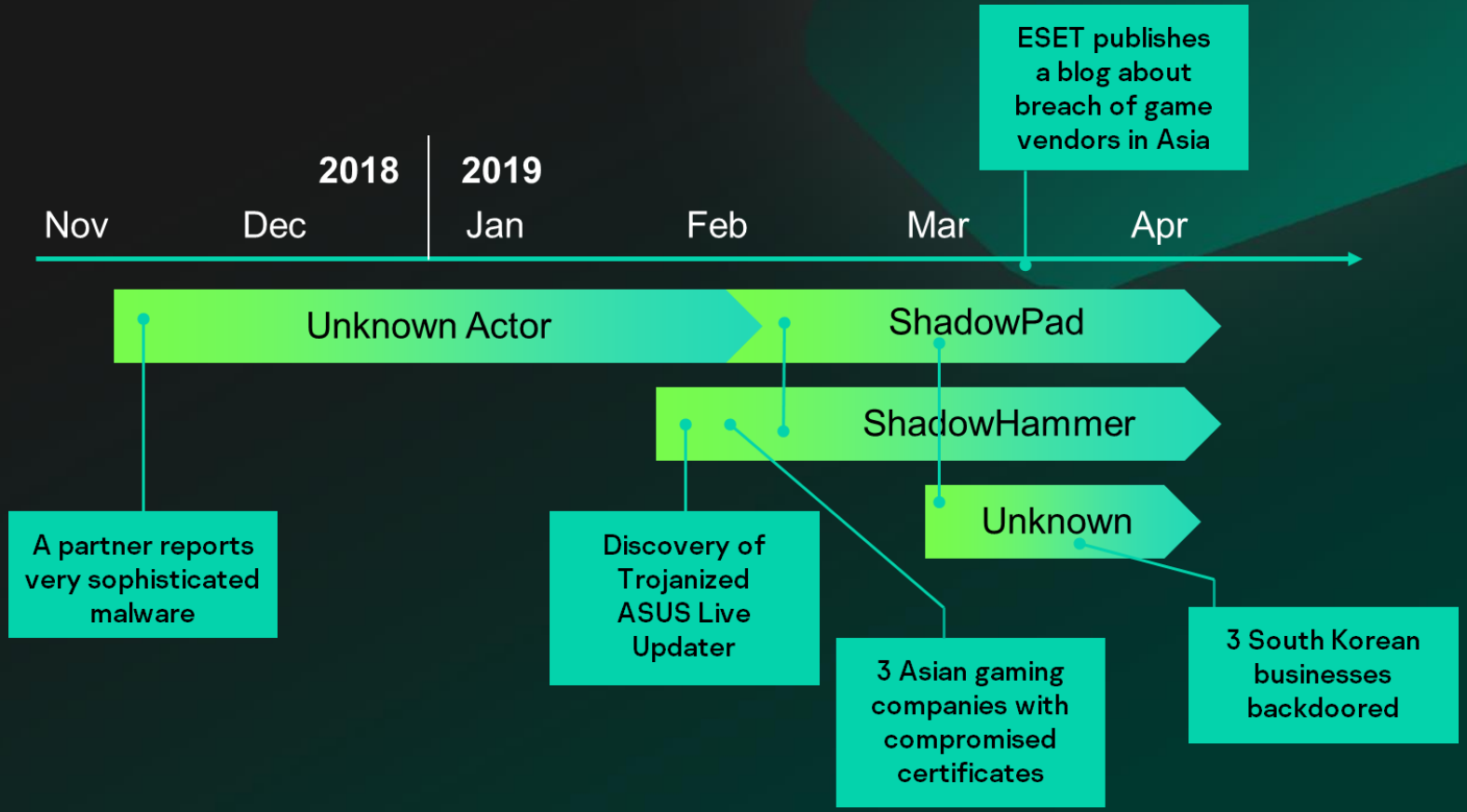
- C2 URL
- Sleep timeout
- Target keyword
- List of unwanted processes

Doesn't start on Chinese and Russian systems

Collects basic system information including:

- MAC address
- Drive C: serial number
- Screen resolution
- System locale
- Hostname, domain, IP, etc.

Operation ShadowHammer - Timeline of research



Advanced backdoor (deployed to selected victims):

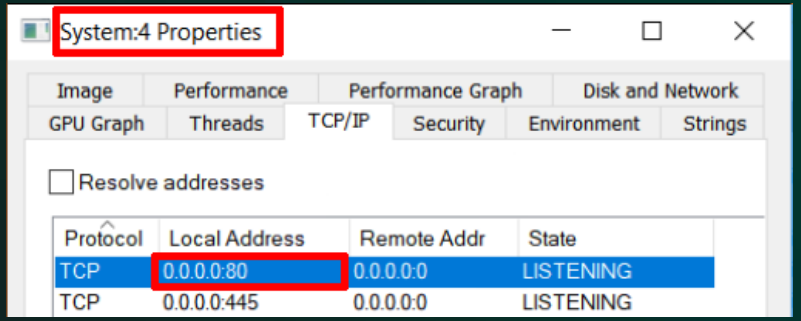
- Plugin-based backdoor
- Depends on Drive C: serial number for code execution
- Multi-threaded object-oriented shellcode design
- Extra protection of crypto algorithms
- Multiple transport providers

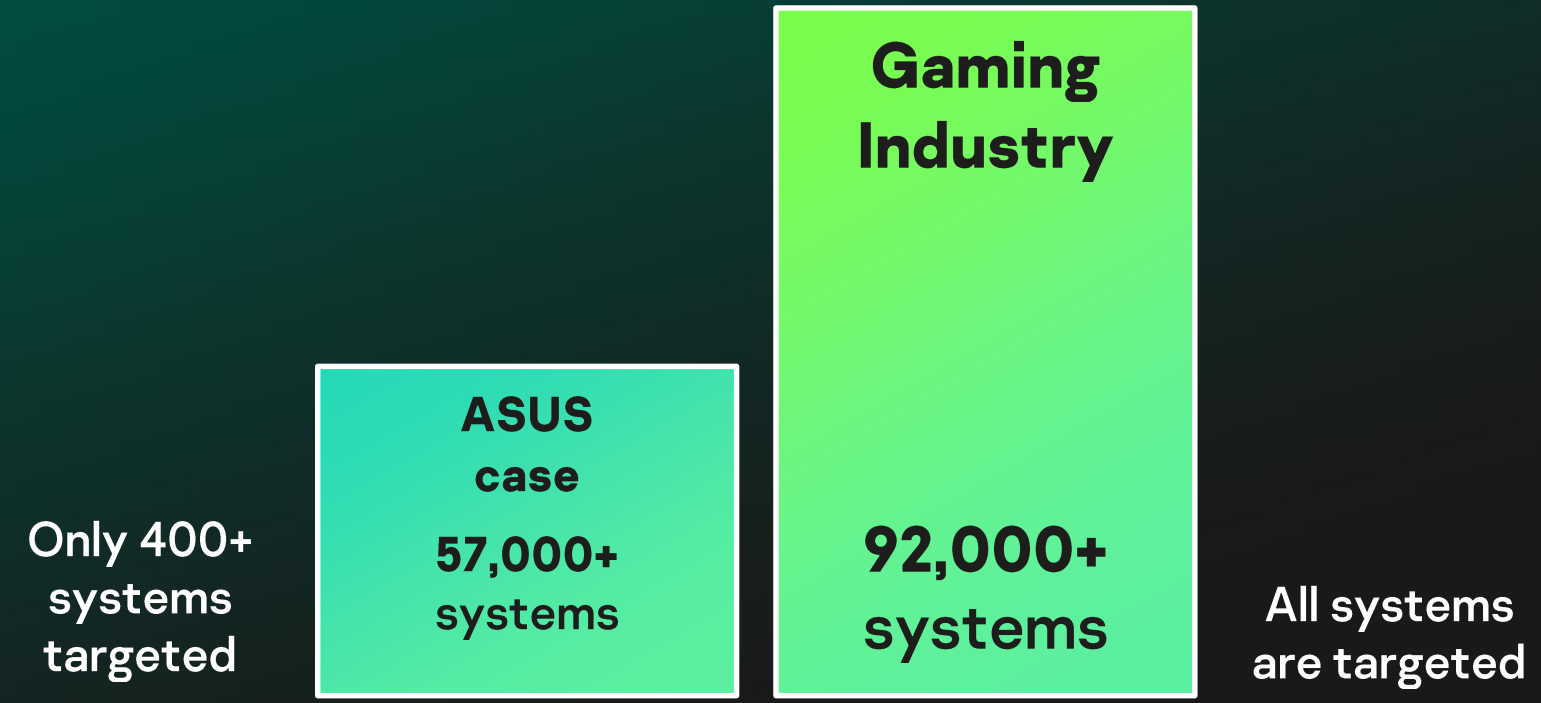
DLL packed with VMprotect

Focus on anti-analysis: anti-reversing, anti-debugging, system-specific binding

Border gateway backdoor

- Starts a web service leveraging Windows HTTP Server API
- Indirectly opens common HTTP port 80
- Imitates Microsoft IIS 10.0
- Responds only to specific URL schema
- Uses custom encryption, mimics large file transfer
- Extendable via similar mechanism as Power Backdoor





* According to our statistics

Supply chain attacks can lead to devastating consequences

Its very hard to detect supply chain attack if it carried cautiously

There is a very sophisticated threat actor out there

- Active for a decade up to this day
- Had a long history of successful supply chain attacks
- Set of targets is much larger than just gaming industry

HOW TO MITIGATE THE RISKS?

Code injection techniques

ShadowPad	Source code and/or build environment modification Code added to the '.text' section, data added to the '.rdata' section Injected code is called as part of the program's normal initialization sequence, without any hooks or patches
CCleaner incident	Source code and/or build environment modification Code added at the beginning of the '.text' section, data added into the '.data' section. Body of '__scrt_get_dyn_tls_init_callback‘ is modified to call into injected code
Operation ShadowHammer	Binary patch (Signed). Resource item is partially overwritten payload data Case 1: WinMain function is overwritten with injected code Case 2: Code added to unused bytes at the end of the '.text' section. Body of '___crtExitProcess' modified to call into injected code Source code and/or build environment modification Case 3: Code and data added at the beginning of the '.text' section. Jump to '___tmainCRTStartup' from the CRT entry point function modified to jump into the injected code

- Malicious code is embedded into source code
- Malicious code is embedded into an executable at compile time with an infected compiler / linker
- Malicious code is distributed with the software update infrastructure (which can be signed with stolen code signing certificates)
- Malicious code is delivered through vulnerabilities into update mechanisms (man-in-the-middle)

We consider products of known SW&HW providers benign

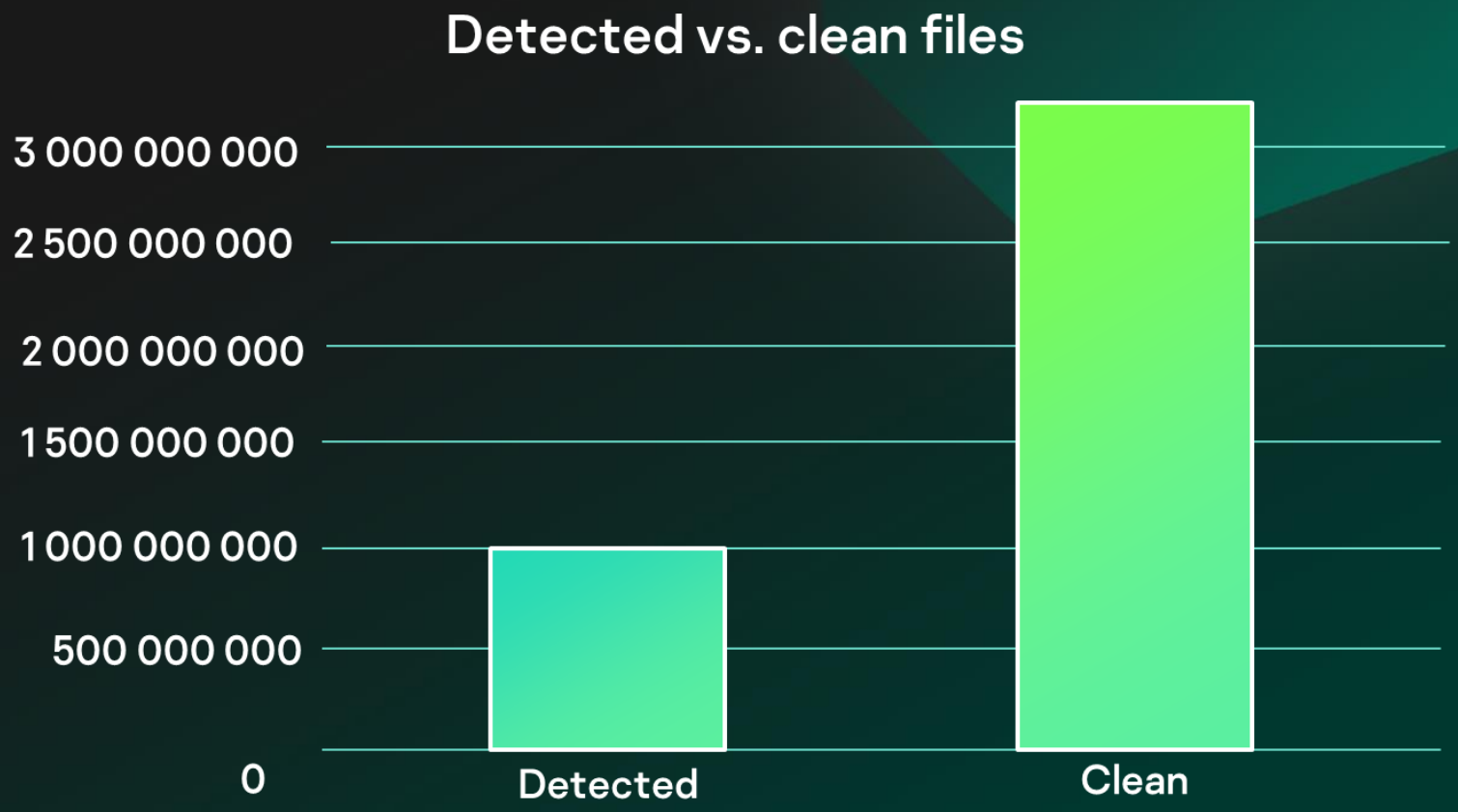
- But sometimes they are not

We trust hashes and digital signatures

Such trustworthy objects are usually only lightly processed by security solutions

- Security solutions speed
- False positives problems

Number of supposedly trustworthy objects is much greater than malicious objects
To process them, more computing power and human resources are required


Detected vs. clean files
3 000 000 000
2 500 000 000
2 000 000 000
1 500 000 000
1 000 000 000
500 000 000
0
Detected
Clean

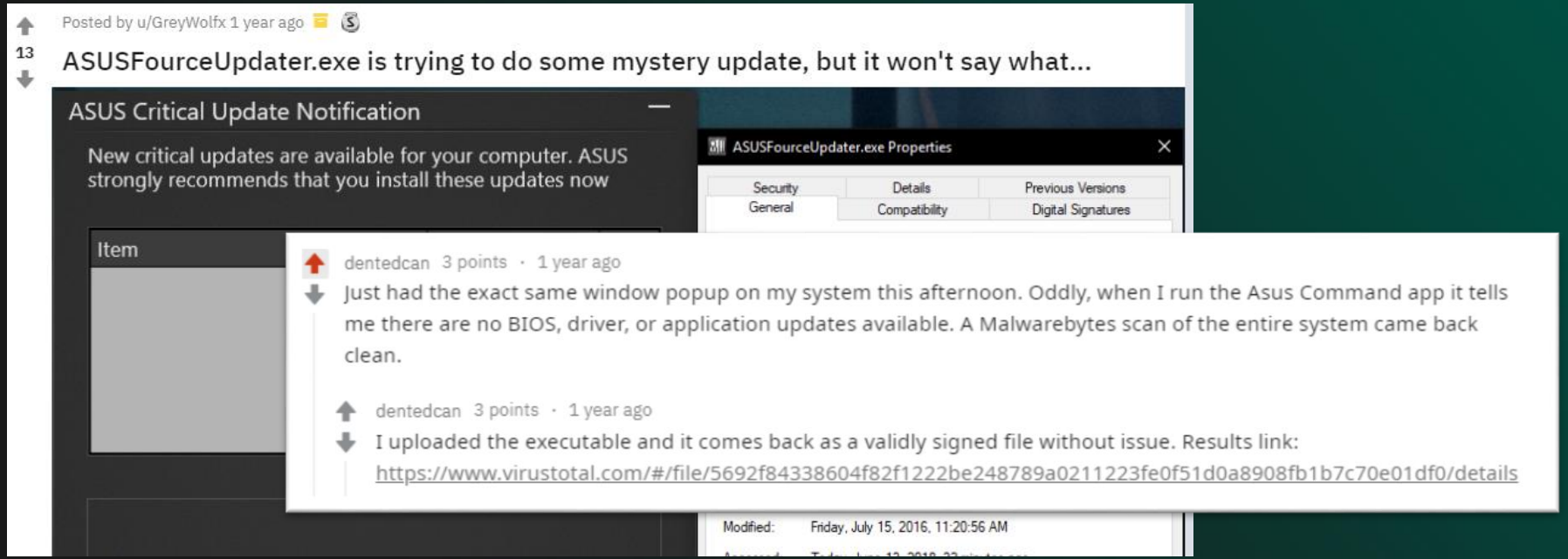
We can confirm that in at least two cases attackers modified build environment:

1. Your product always contains a backdoor regardless of the source code
2. The code smoothly gets digital signature automatically
3. The injection looks like developer created it on purpose
4. Source code review does NOT reveal anything
5. Compiling dummy project does NOT let you discover alien code: the malware is planted only into selected projects

How many code signing certificates are used in your company?
Who has access to them?

Learn from real examples

https://www.reddit.com/r/ASUS/comments/8qznaj/asusfourceupdaterexe_is_trying_to_do_some_mystery/



Huge thanks to:

- Costin Raiu @craiu
- Vitaly Kamluk @vkamluk
- Noushin Shabab @NoushinShbb
- Others Kaspersky GReAT and Kaspersky AMR teams members

For their contribution to this research

Thank you!

Boris Larin @oct0xor
Alexander Liskin @0x1fffffffffff