

# LogoFAIL

Security implications  
of image parsing  
during system boot

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## Research Scientist @ Binarly

- ◆ Vulnerability and Threat Research
- ◆ Program analysis
  - Fuzzing, Dynamic analysis

## Academic background

- ◆ PostDoc @ UCSB SecLab
- ◆ Looked at binary code from different angles (binary similarity, fuzzing, forensics)

# Binarly REsearch Team



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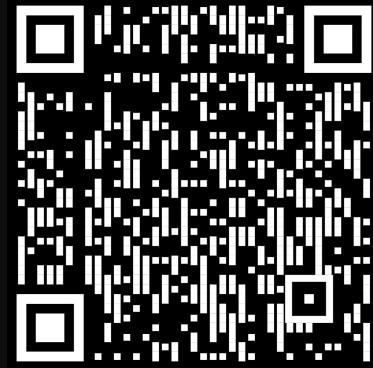
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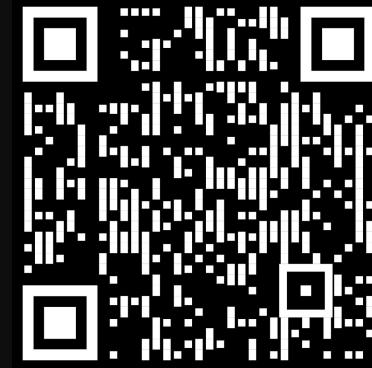
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LogoFAIL [edition]

# Scan



[The Far-Reaching Consequences of LogoFAIL \(Blog\)](#)

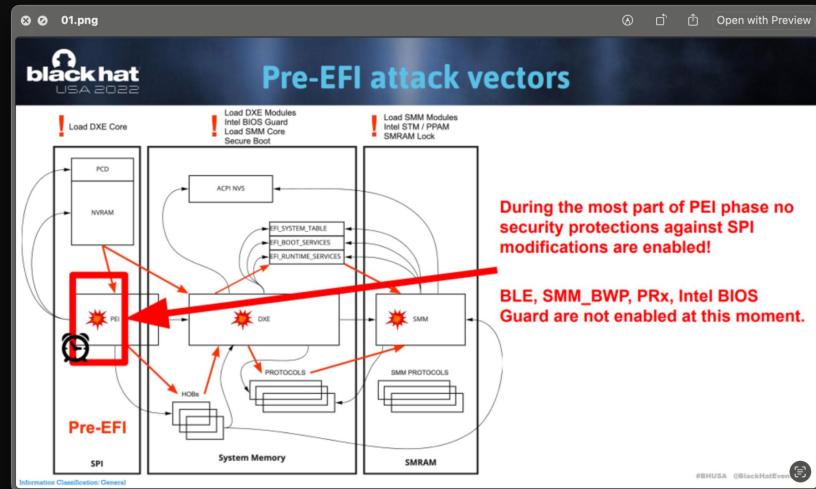


[Inside the LogoFAIL Vulnerabilities \(Video\)](#)

# Data-Only Attacks Against UEFI Firmware



- Insecure handling of content from R/W areas (NVRAM)
- Allow bypassing Secure Boot and hardware-based Verified Boot:
  - Intel Boot Guard
  - AMD Hardware-Validated Boot
  - ARM TrustZone-based verification
- Lead to compromise of other protections in Pre-UEFI like Intel PPAM



Breaking Firmware Trust From Pre-UEFI:  
Exploiting Early Boot Phases

<https://i.blackhat.com/USA-22/Wednesday/US-22-Matrosov-Breaking-Firmware-Trust-From-Pre-UEFI.pdf>

# Exploring new Attack Surfaces



While looking at vulnerabilities discovered by our platform, we observed that **image parsers in firmware** are actually quite common.



But why do we even  
need image parsers  
during boot?!

# History Repeats Itself

```
tiano_edk/source/Foundation/Library/Dxe/Graphics/Graphics.c:  
  
EFI_STATUS ConvertBmpToGopBlt ()  
{  
    ...  
    if (BmpHeader->CharB != 'B' || BmpHeader->CharM != 'M') {  
        return EFI_UNSUPPORTED;  
    }  
  
    BltBufferSize = BmpHeader->PixelWidth * BmpHeader->PixelHeight  
        * sizeof (EFI_GRAPHICS_OUTPUT_BLT_PIXEL);  
    IsAllocated = FALSE;  
    if (*GopBlt == NULL) {  
        *GopBltSize = BltBufferSize;  
        *GopBlt      = EfiLibAllocatePool (*GopBltSize);  
    }  
}
```



Attacking Intel BIOS at BlackHat USA 2009 by Rafal Wojtczuk and Alexander Tereshkin  
<https://www.blackhat.com/presentations/bh-usa-09/WOJTCZUK/BHUSA09-Wojtczuk-AtkIntelBios-SLIDES.pdf>

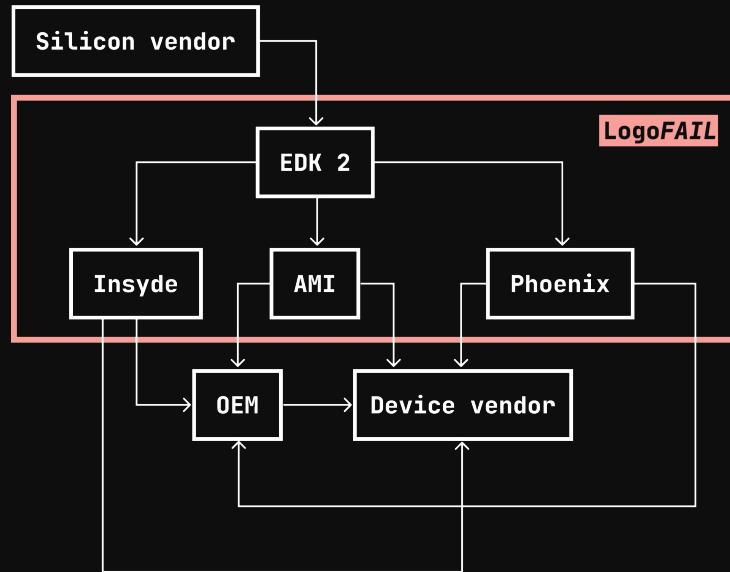
# History Repeats Itself (~15 years later)

- Different image parsers available in UEFI firmware
  - BMP, GIF, PNG, JPEG, PCX, and TGA
- User can pass image data to them
  - Various logo customization features are available
- Image parsing is done during boot
  - DXE phase
  - C-written code (3rd party)
  - No mitigations for exploitation of software vulnerabilities

What could go wrong?!

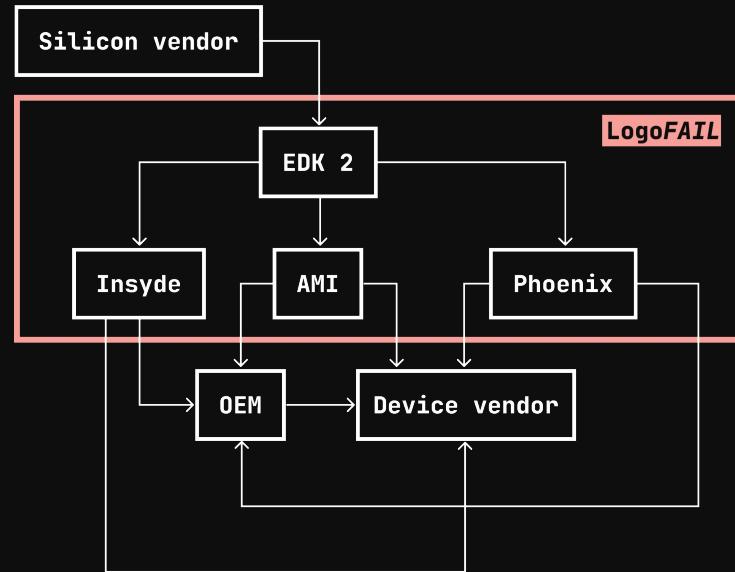
# Meet LogoFAIL

- New set of security vulnerabilities affecting image parsing libraries used during the device boot process
- LogoFAIL is cross-silicon and impacts x86 and ARM-based devices
- LogoFAIL is UEFI and IBV-specific
- Impacts the entire ecosystem across this reference code and device vendors



# Meet LogoFAIL

- New set of security vulnerabilities affecting image parsing libraries used during the device boot process
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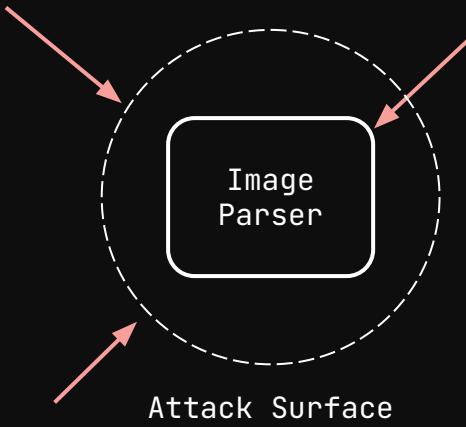
150+ days of embargo lifted 3 days ago!

# Implications of LogoFAIL



Attack Vector	Vulnerability ID	Exploited in-the-wild	Impact	CVSS Score	CWE
	VU#811862 CVE-2023-40238 CVE-2023-5058 CVE-2023-39539 CVE-2023-39538 and more ...	Unknown	HW-based Verified Boot and Secure Boot Bypass x86 and ARM	8.2 High 6.7 Medium	CWE-122: Heap-based Buffer Overflow  CWE-125: Out-of-bounds Read
Baton Drop	CVE-2022-21894 CVE-2023-24932		Secure Boot Bypass x86	6.7 Medium	CWE-358: Improperly Implemented Security Check for Standard
3rd-party Bootloaders	VU#309662	Unknown	Secure Boot Bypass x86	6.7 Medium	CWE-358: Improperly Implemented Security Check for Standard
BootHole	VU#174059	Unknown	Secure Boot Bypass x86	8.2 High	CWE-120: Buffer Copy without Checking Size of Input

# Attack Surface



# Different Shades of UEFI Image Parsers



BmpDecoderDxe-A9F634A5-29F1-4456-A9D5-6E24B88BDB65  
TgaDecoderDxe-ADCCA887-5330-414A-81A1-5B578146A397  
PngDecoderDxe-C1D5258B-F61A-4C02-9293-A005BEB3EAA1  
JpegDecoderDxe-2707E46D-DBD7-41C2-9C04-C9FDB8BAD86C  
PcxDecoderDxe-A8F634A5-28F1-4456-A9D5-7E24B99BDB65  
GifDecoderDxe-1353DE63-B74A-4BEF-80FD-2C5CFA83040B

SystemImageDecoderDxe-5F65D21A-8867-45D3-A41A-526F9FE2C598

AMITSE-B1DA0ADF-4F77-4070-A88E-BFFE1C60529A

MdeModulePkg/Library/BaseBmpSupportLib/BmpSupportLib.c

insyde®

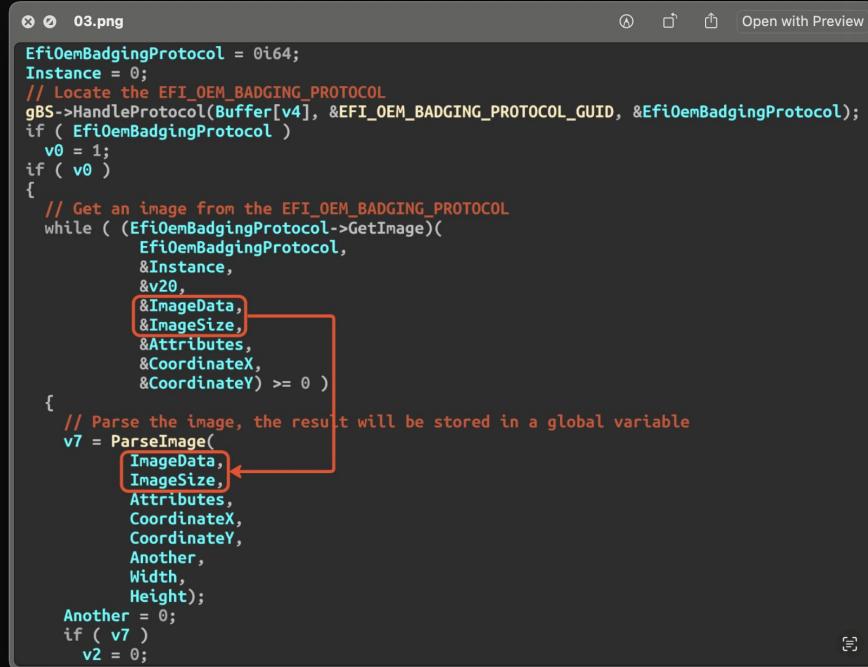
phoenix  
technologies

ami

 tianocore

# Identifying the Attack Surface

- All the channels used by firmware to read a logo image
- A lot of reversing with efiXplorer
- Start from image parsers, then looks “backwards”



```
EfiOemBadgingProtocol = 0i64;
Instance = 0;
// Locate the EFI_OEM_BADGING_PROTOCOL
gBS->HandleProtocol(Buffer[v4], &EFI_OEM_BADGING_PROTOCOL_GUID, &EfiOemBadgingProtocol);
if ( EfiOemBadgingProtocol )
    v0 = 1;
if ( v0 )
{
    // Get an image from the EFI_OEM_BADGING_PROTOCOL
    while ( (EfiOemBadgingProtocol->GetImage)(  

        EfiOemBadgingProtocol,  

        &Instance,  

        &v20,  

        &ImageData,  

        &ImageSize,  

        &Attributes,  

        &CoordinateX,  

        &CoordinateY) >= 0 )  

    {  

        // Parse the image, the result will be stored in a global variable  

        v7 = ParseImage(  

            ImageData,  

            ImageSize,  

            Attributes,  

            CoordinateX,  

            CoordinateY,  

            Another,  

            Width,  

            Height);  

        Another = 0;  

        if ( v7 )  

            v2 = 0;
```

<https://github.com/binarly-io/efiXplorer>

# Attack Surface

## Several OEM-specific customizations:

1. Logo is read from a fixed location (e.g., “\EFI\OEM\Logo.jpg”)
2. Logo is stored into an unsigned volume of a firmware update
3. An NVRAM variable contains the path of the logo
4. An NVRAM variable contains the logo itself

Name	Action	Type	Subtype	Text
UEFI image	Image	UEFI		
AmlNvramMainRomAreaGu...	Volume	FFSv2		
Padding	Padding	Empty (0xFF)		Unsigned Section
D264B94D-3D8D-4DC0-B1...	Volume	FFSv2		
05CA020B-0FC1-11DC-9...	File	Raw		AMI ROM hole
Volume free space	Free space			
4F1C52D3-D824-4D2A-A2...	Volume	FFSv2		
AFDD39F1-19D7-4501-A7...	Volume	FFSv2		
5B08A058-784F-4938-9A...	Volume	FFSv2		
EfiFirmwareFileSystem...	Volume	FFSv2		
14E428FA-1A12-4875-B6...	Volume	FFSv2		
EfiFirmwareFileSystem...	Volume	FFSv2		
7BEBD21A-A1E5-4C4C-9C...	Volume	FFSv2		
52F1AFB6-78A6-448F-82...	Volume	FFSv2		
61C0F511-A691-4F54-97...	Volume	FFSv2		
7BEBD21A-A1E5-4C4C-9C...	Volume	FFSv2		
52F1AFB6-78A6-448F-82...	Volume	FFSv2		
61C0F511-A691-4F54-97...	Volume	FFSv2		
9F8B1DEF-B62B-45F3-82...	Volume	FFSv2		

<https://binarly.io/advisories/BRLY-2023-006>

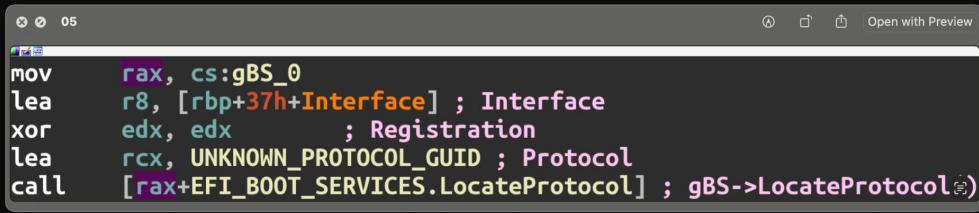
<https://binarly.io/advisories/BRLY-2023-018>

# Fuzzing



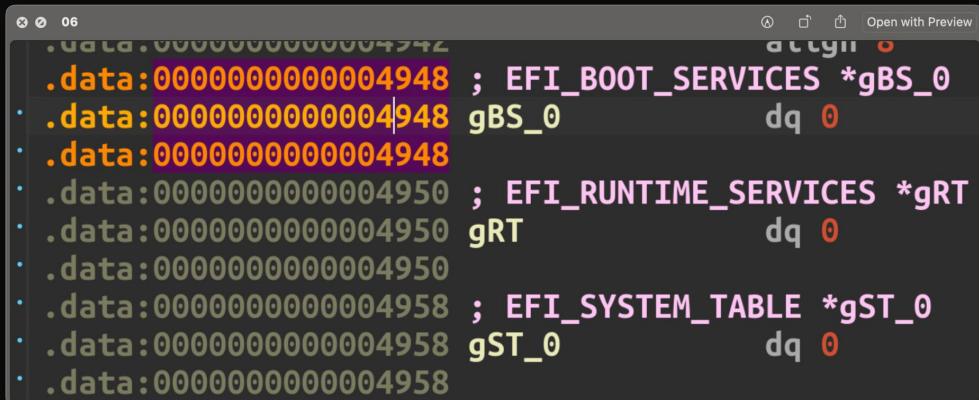
# Fuzzing UEFI Image Parsers

- UEFI DXE modules are normal PE files
- Minimal UEFI runtime environment needs to be re-hosted
- Fuzzer based on newly-developed emulation capabilities which we integrated with LibAFL



Assembly code (likely Intel x86-64):

```
mov    rax, cs:gBS_0
lea    r8, [rbp+37h+Interface] ; Interface
xor    edx, edx      ; Registration
lea    rcx, UNKNOWN_PROTOCOL_GUID ; Protocol
call   [rax+EFI_BOOT_SERVICES.LocateProtocol] ; gBS->LocateProtocol()
```



Memory dump (likely Intel x86-64):

```
.data:0000000000004948 ; EFI_BOOT_SERVICES *gBS_0
.data:0000000000004948 gBS_0          dq 0
.data:0000000000004948
.data:0000000000004950 ; EFI_RUNTIME_SERVICES *gRT
.data:0000000000004950 gRT           dq 0
.data:0000000000004950
.data:0000000000004958 ; EFI_SYSTEM_TABLE *gST_0
.data:0000000000004958 gST_0         dq 0
.data:0000000000004958
```

# Fuzzing Harness

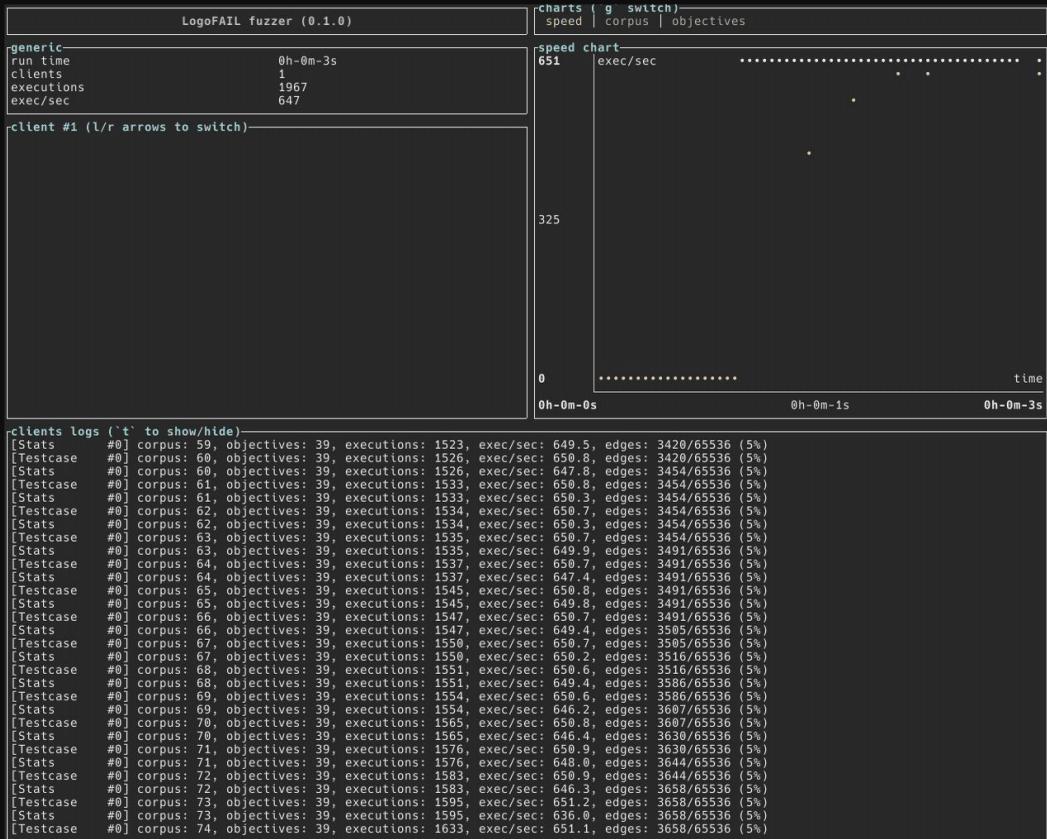
**A bridge between the fuzzer and the fuzzed module:**

- Module initialization (protocols are installed)
- Prepare call to parsing function
- Forwards fuzzer-generated data to the target module

**We are ready to fuzz!**

# Root Causes

- We found hundreds of crashes
- Extended Binarly's internal program analysis framework to support us in this task



# Root Causes (Excerpt)

We found 29 unique root causes, 15 of which are likely exploitable

BRLY ID	CERT/CC ID	Affected IBV	Image Library	Impact	CVSS Score	CWE
BRLY-LOGOFAIL-2023-001	VU#811862	Insyde	BMP	DXE Memory Content Disclosure	Medium	CWE-200: Exposure of Sensitive Information
BRLY-LOGOFAIL-2023-007	VU#811862	Insyde	GIF	DXE Memory Corruption	High	CWE-122: Heap-based Buffer Overflow
BRLY-LOGOFAIL-2023-016	VU#811862	AMI	PNG	DXE Memory Corruption	High	CWE-122: Heap-based Buffer Overflow CWE-190: Integer Overflow
BRLY-LOGOFAIL-2023-022	VU#811862	AMI	JPEG	DXE Memory Corruption	High	CWE-787: Out-of-bounds Write
BRLY-LOGOFAIL-2023-025	VU#811862	Phoenix	BMP	DXE Memory Corruption	High	CWE-122: Heap-based Buffer Overflow
BRLY-LOGOFAIL-2023-029	VU#811862	Phoenix	GIF	DXE Memory Corruption	High	CWE-125: Out-of-bounds Read

# BRLY-LOGOFAIL-2023-006: Memory Corruption

- PixelHeight and PixelWidth are attacker controlled
- When PixelHeight and i are 0:  
BltBuffer[PixelWidth \* -1]
- Arbitrary write anywhere below BltBuffer

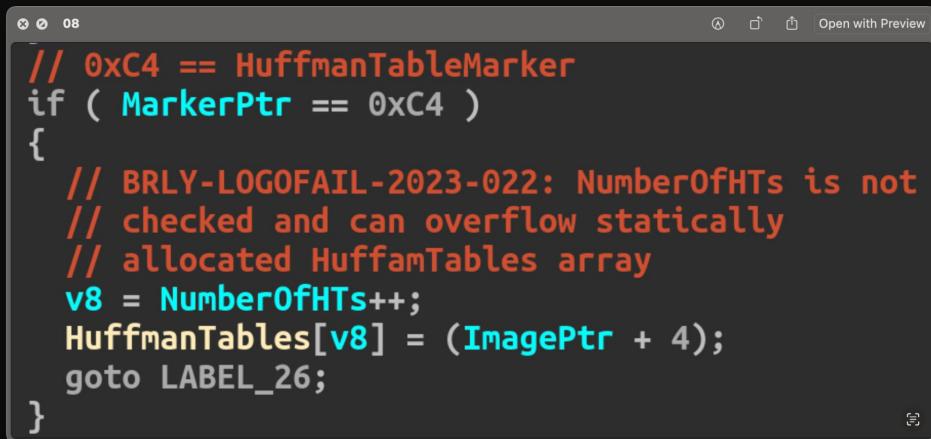
The screenshot shows a debugger window with assembly code. A red box highlights a section of code involving a do-loop and a conditional jump. Another red box highlights a series of arbitrary writes to memory locations Blt->Red, Blt->Green, and Blt->Blue.

```
PixelHeight = BmpHeader->PixelHeight;
EndOfBMP = 0;
for ( i = 0i64; i <= PixelHeight; ++i )
{
    if ( EndOfBMP )
        break;
    PixelWidth = BmpHeader->PixelWidth;
    v11 = 0i64;
    v12 = 0;
    // BRLY-LOGOFAIL-2023-003
    // when BmpHeader->PixelHeight is 0 Blt will be below BltBuffer
    // (0 - 0 - 1) * BmpHeader->PixelWidth = - BmpHeader->PixelWidth
    // then, writes to the Blt buffer will happen
    Blt = &BltBuffer[PixelWidth * (PixelHeight - i - 1)];
    do
    {
        if ( v12 )
            break;
        FirstByte = *RLE8Image;
        v15 = RLE8Image + 1;
        SecondByte = RLE8Image[1];
        RLE8Image += 2;
        if ( FirstByte )
        {
            Count = FirstByte;
            v11 += FirstByte;
            do
            {
                Blt->Red = BmpColorMap[SecondByte].Red;// arbitrary write
                Blt->Green = BmpColorMap[SecondByte].Green;// arbitrary write
                Blt->Blue = BmpColorMap[SecondByte].Blue;// arbitrary write
                Blt++;
                --Count;
            } while ( Count );
        }
    }
```

BMP parser developed by Insyde

# BRLY-LOGOFAIL-2023-022: Memory Corruption

- Assumption that JPEG can contain only 4 Huffman Tables
- NumberOfHTs variable is unchecked
- Overflow on global data with pointers to our image



```
// 0xC4 == HuffmanTableMarker
if ( MarkerPtr == 0xC4 )
{
    // BRLY-LOGOFAIL-2023-022: NumberOfHTs is not
    // checked and can overflow statically
    // allocated HuffmanTables array
    v8 = NumberOfHTs++;
    HuffmanTables[v8] = (ImagePtr + 4);
    goto LABEL_26;
}
```

JPEG parser developed by AMI

# Takeaways from Fuzzing

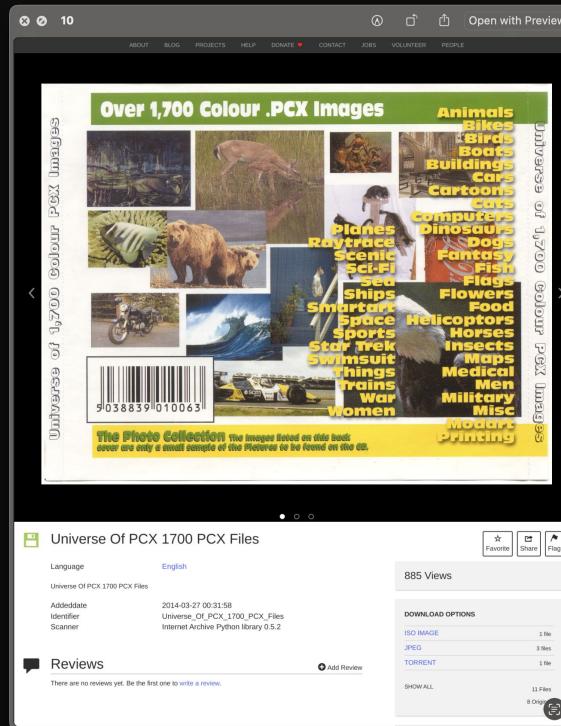
**None of these libraries where ever fuzzed by IBVs/OEMs:**

- We found crashes in every parser
- First crashes where found after seconds of fuzzing
- Some parsers even crash with images downloaded from the Internet :-)



# Thanks to the Internet Archive!

- One of the parsers is for PCX images
- Finding good corpus for the fuzzer turned out to be more difficult than expected
- Until..



[https://archive.org/details/Universe\\_Of\\_PCX\\_1700\\_PCX\\_Files](https://archive.org/details/Universe_Of_PCX_1700_PCX_Files)

# Proof of Concept

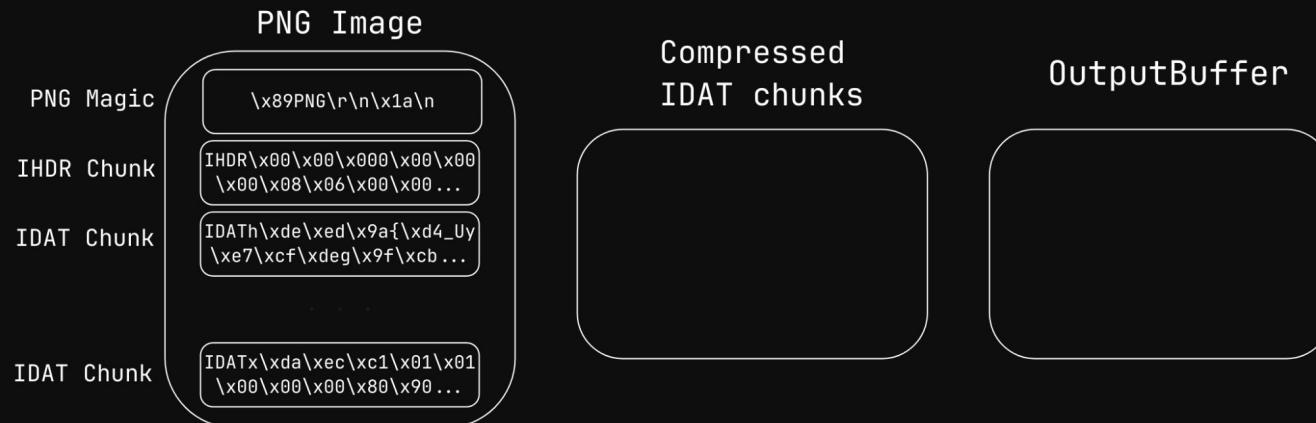


# Let's PWN a Real Device



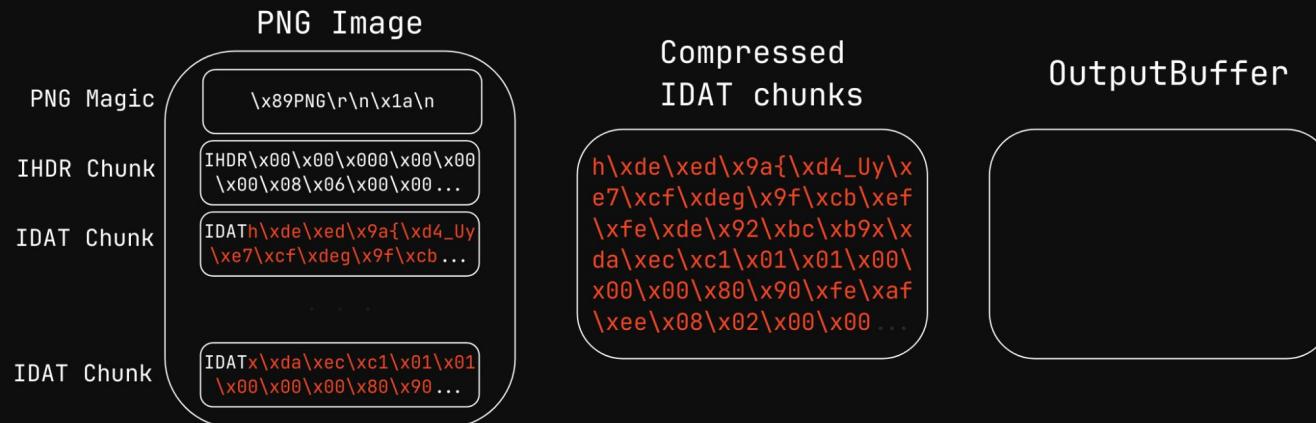
- **Lenovo ThinkCentre M70s Gen 2**
- **11<sup>th</sup> Gen Intel Core (Tiger Lake)**
- **BIOS released on June 2023**

# Selecting a Target



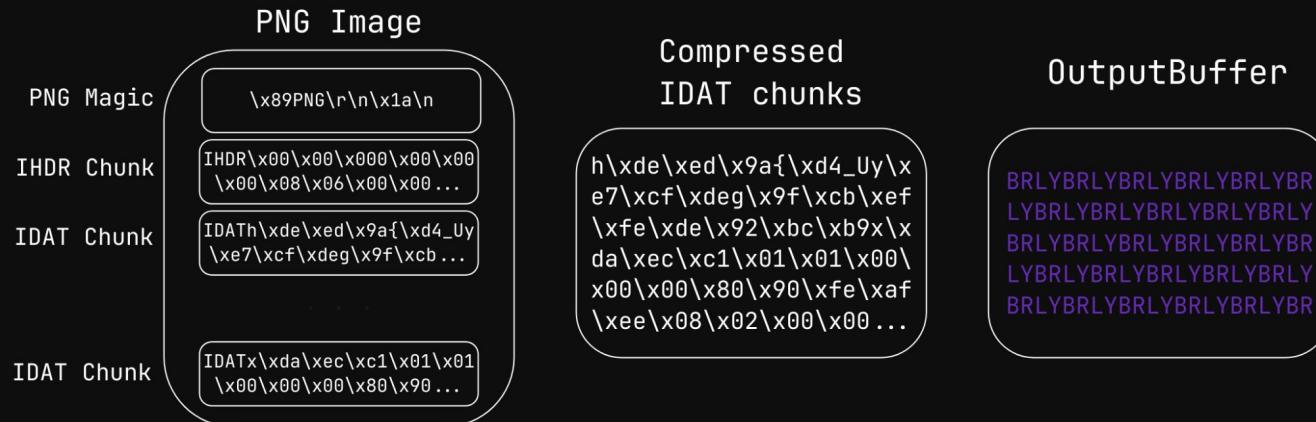
Simple format + exploitable crash: PNG parser from AMI

# Selecting a Target



## Simple format + exploitable crash: PNG parser from AMI

# Selecting a Target



## Simple format + exploitable crash: PNG parser from AMI

# Integer Overflow to Heap Overflow

**Integer overflow on 32 bit  
value used as allocation size:**

- $2 * 0x20 = 0x40$
- $2 * 0x60 = 0xc0$
- $2 * 0x80000040 = 0x80$

```
// BRLY-LOGOFAIL-2023-016: Integer overflow
// on the argument of EfiLibAllocateZeroPool
OutputBuffer = EfiLibAllocateZeroPool(2 * PngWidth);
v7 = &OutputBuffer[PngWidth];
GlobalInfo.OutputBuffer = OutputBuffer;
```

Compressed  
IDAT chunks

```
h\xde\xed\x9a{\xd4_uy\x
e7\xcf\xdeg\x9f\xcb\xef
\xfe\xde\x92\xbc\xb9\x\x
da\xec\xc1\x01\x01\x00\
x00\x00\x80\x90\xfe\xaf
\xee\x08\x02\x00\x00...
```

OutputBuffer

```
BRLYBRLYBRLYBRLYBRLYBR
LYBRLYBRLYBRLYBRLYBRLY
BRLYBRLYBRLYBRLYBRLYBR
LYBRLYBRLYBRLYBRLYBRLY
BRLYBRLYBRLYBRLYBRLYBR
```

# Integer Overflow to Heap Overflow

## Integer overflow on 32 bit value used as allocation size:

- $2 * 0x40 = 0x80$
- $2 * 0x60 = 0xc0$
- $2 * 0x80000040 = 0x80$

```
// BRLY-LOGOFAIL-2023-016: Integer overflow
// on the argument of EfiLibAllocateZeroPool
OutputBuffer = EfiLibAllocateZeroPool(2 * PngWidth);
v7 = &OutputBuffer[PngWidth];
GlobalInfo.OutputBuffer = OutputBuffer;
GlobalInfo.OutputBuffer[GlobalInfo.idx] = a1;
```

Compressed  
IDAT chunks

h\xde\xed\x9a{\xd4\_Uy\x  
e7\xcf\xde\x9f\xcb\xef  
\xfe\xde\x92\xbc\xb9x\x  
da\xec\xc1\x01\x01\x00\x  
x00\x00\x80\x90\xfe\xaf  
\xee\x08\x02\x00\x00...

OutputBuffer

BRLYBRLYBRLYBRLYBRLYB  
LYBRLYBRLYBRLYBRLYBRLY  
BRLYBRLYBRLYBRLYBRLYB  
LYBRLYBRLYBRLYBRLYBRLY  
BRLYBRLYBRLYBRLYBRLYB  
00000000000000000000000  
00000000000000000000000  
00000000000000000000000



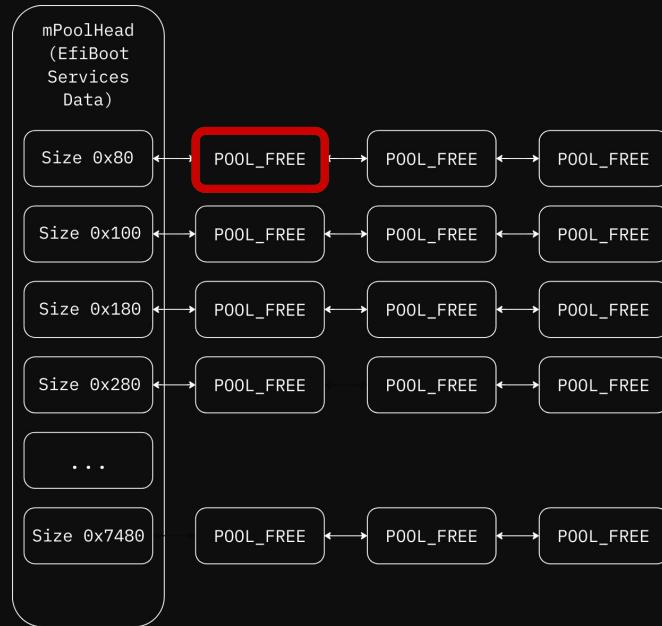
# Wait a Minute..

- How does heap exploitation even work for UEFI?
  - No debugging capabilities:
    - Intel DCI doesn't work on new CPU models
    - Intel Boot Guard prevents replacing modules
  - Not even output on crash :(



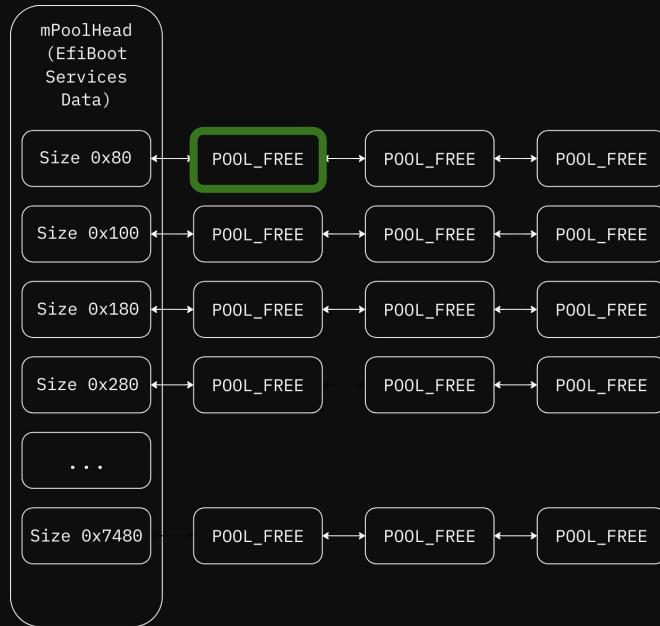
# UEFI Heap Internals

- Pool-based heap

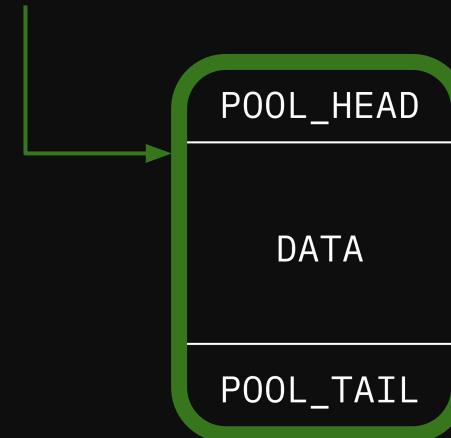


# UEFI Heap Internals

- Pool-based heap

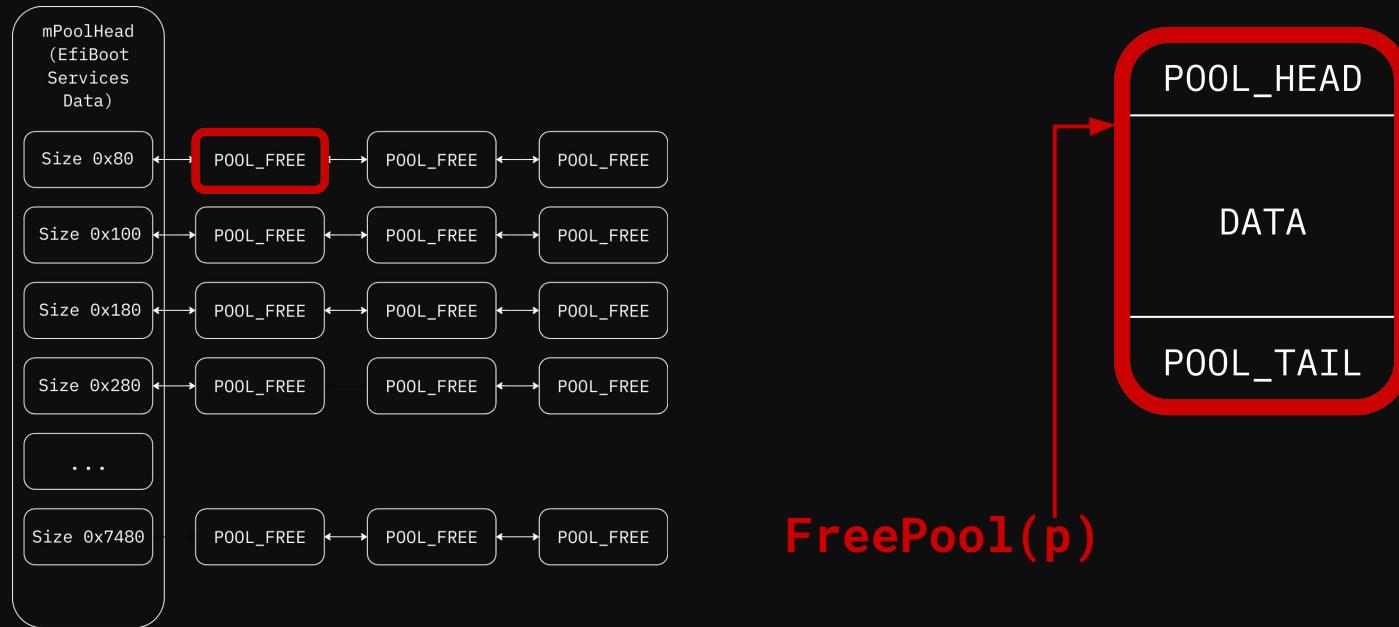


**VOID \*p = AllocatePool(0x40)**

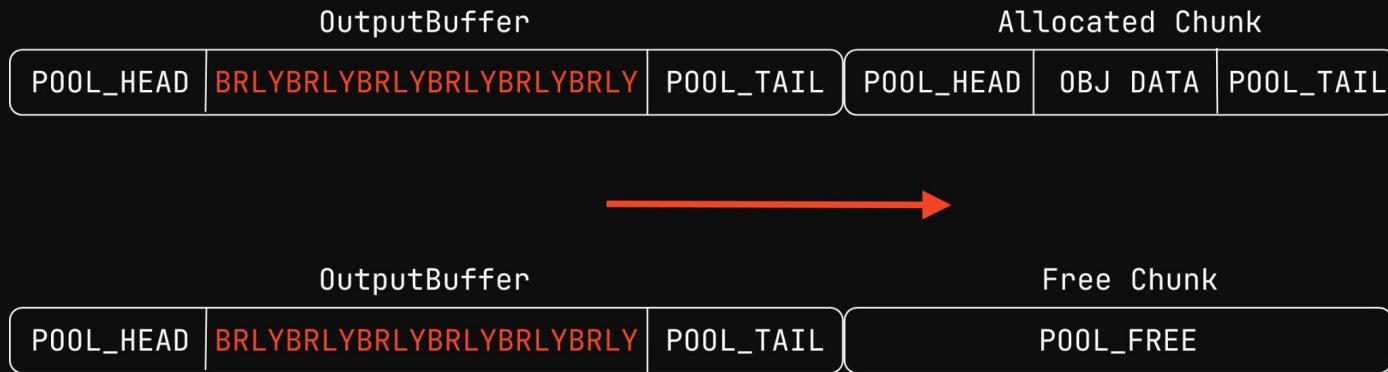


# UEFI Heap Internals

- Pool-based heap



# What Are We Even Corrupting?



We don't know!!



# Long Live UEFI Memory

- Memory used by UEFI is not cleared
- If the OS doesn't overwrite it, we can dump it after boot
- `OutputBuffer` is not freed, so it's somewhere in memory!

```
82c83f10: 7068 6430 0000 0000 0400 0000 0000 0000 phd0....  
82c83f20: 8000 0000 0000 0000 4252 4c59 4252 4c59 .....BRLYBRLY  
82c83f30: 4252 4c59 4252 4c59 4252 4c59 4252 4c59 BRLYBRLYBRLYBRLY  
82c83f40: 4252 4c59 4252 4c59 4252 4c59 4252 4c59 BRLYBRLYBRLYBRLY  
82c83f50: 4252 4c59 4252 4c59 4252 4c59 4252 4c59 BRLYBRLYBRLYBRLY  
82c83f60: 4252 4c59 4252 4c59 4252 4c59 4252 4c59 BRLYBRLYBRLYBRLY  
82c83f70: 4252 4c59 4252 4c59 4252 4c59 4252 4c59 BRLYBRLYBRLYBRLY  
82c83f80: 7074 616c 0000 0000 8000 0000 0000 0000 ptal.....  
82c83f90: 7068 6430 0000 0000 0400 0000 0000 0000 phd0.....  
82c83fa0: 6800 0000 0000 0000 6869 7370 0000 0000 h.....his...  
82c83fb0: 98b7 af82 0000 0000 98a6 af82 0000 0000 .....  
82c83fc0: 60b8 af82 0000 0000 60b8 af82 0000 0000 `.....`.....
```

# Long Live UEFI Memory

- Memory used by UEFI is not cleared
- If the OS doesn't overwrite it, we can dump it after boot
- `OutputBuffer` is not freed, so it's somewhere in memory!

```
82c83f10: 7068 6430 0000 0000 0400 0000 0000 0000 phd0.....
82c83f20: 8000 0000 0000 0000 4252 4c59 4252 4c59 .....BRLYBRLY
82c83f30: 4252 4c59 4252 4c59 4252 4c59 4252 4c59 BRLYBRLYBRLYBRLY
82c83f40: 4252 4c59 4252 4c59 4252 4c59 4252 4c59 BRLYBRLYBRLYBRLY
82c83f50: 4252 4c59 4252 4c59 4252 4c59 4252 4c59 BRLYBRLYBRLYBRLY
82c83f60: 4252 4c59 4252 4c59 4252 4c59 4252 4c59 BRLYBRLYBRLYBRLY
82c83f70: 4252 4c59 4252 4c59 4252 4c59 4252 4c59 BRLYBRLYBRLYBRLY
82c83f80: ptal.....
82c83f90: This is NOT the object
82c83fa0: we can corrupt!
82c83fb0: h.....hisp...
82c83fc0: .....  

```

# Preserving Heap Chunks

- New technique to preserve chunks
- Corrupting the signature ensures a chunk is not reused



```
EFI_STATUS  
CoreFreePoolI (  
    IN VOID           *Buffer,  
    OUT EFI_MEMORY_TYPE *PoolType OPTIONAL  
)  
{  
  
    POOL_HEAD  *Head;  
    ...  
  
    ASSERT (Buffer != NULL);  
    //  
    // Get the head & tail of the pool entry  
    //  
    Head = BASE_CR (Buffer, POOL_HEAD, Data);  
    ASSERT (Head != NULL);  
  
    if ((Head->Signature != POOL_HEAD_SIGNATURE) &&  
        (Head->Signature != POOLPAGE_HEAD_SIGNATURE))  
    {  
        ASSERT (  
            Head->Signature == POOL_HEAD_SIGNATURE ||  
            Head->Signature == POOLPAGE_HEAD_SIGNATURE  
        );  
        return EFI_INVALID_PARAMETER;  
    }  
}
```

# Preserving Heap Chunks

```
82c83f10: 4252 4c59 4252 4c59 4252 4c59 4252 4c59 BRLYBRLYBRLYBRLY
82c83f20: 4252 4c59 4252 4c59 4252 4c59 4252 4c59 BRLYBRLYBRLYBRLY
82c83f30: 4252 4c59 4252 4c59 4252 4c59 4252 4c59 BRLYBRLYBRLYBRLY
82c83f40: 4252 4c59 4252 4c59 4252 4c59 4252 4c59 BRLYBRLYBRLYBRLY
82c83f50: 4252 4c59 4252 4c59 4252 4c59 4252 4c59 BRLYBRLYBRLYBRLY
82c83f60: 4252 4c59 4252 4c59 4f4f 4f4f 4f4f 4f4f BRLYBRLY00000000
82c83f70: 00000000Xhd0.....
82c83f80: .....X.....
This IS the object we can
corrupt!!
82c83f90: prtn....iL.....
82c83fa0: (.....(kL.....
82c83fb0: .~.....|.....
82c83fc0: ptal....X.....
```



# Little Recap

What we achieved so far:

- We have arbitrary overflow on the heap
- We can prevent the next chunk from being freed
- We can inspect the object stored in the next chunk

What's left?

- Finding a good target for corruption
- Get code execution out of it

# Enter the UEFI Heap Feng Shui

- Heap exploitation often requires strong allocation and deallocation primitives
- We can influence the heap by adding PNG chunks or changing their sizes

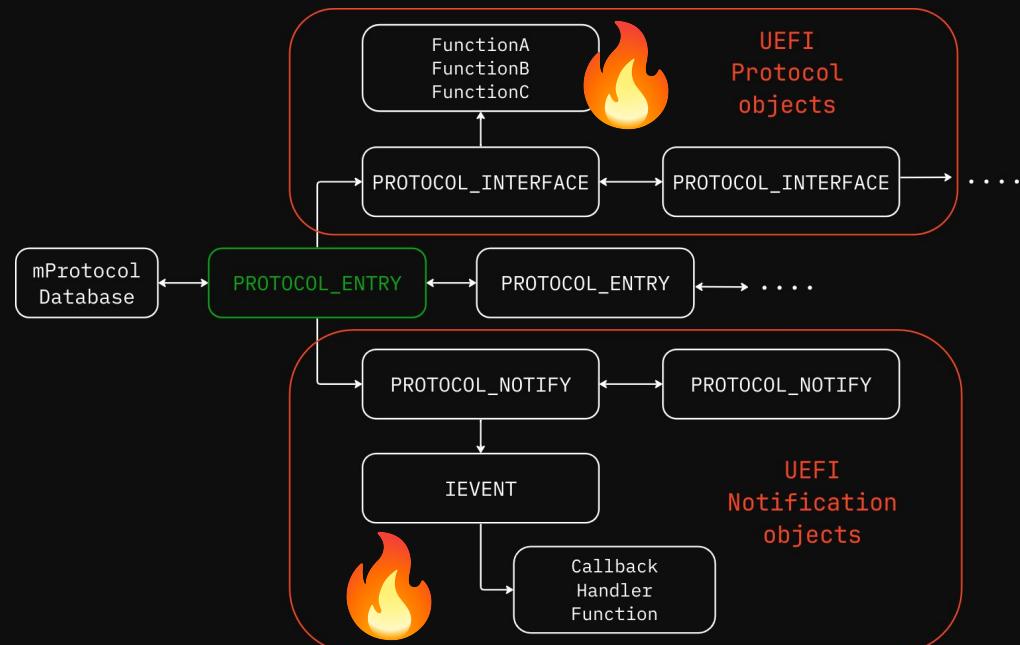
# Enter the UEFI Heap Feng Shui

- Heap exploitation often requires strong allocation and deallocation primitives
- We can influence the heap by adding PNG chunks or changing their sizes

```
83119a00: 4252 4c59 4252 4c59 4252 4c59 4252 4c59 BRLYBRLYBRLYBRLY
83119a10: 4252 4c59 4252 4c59 4252 4c59 4252 4c59 BRLYBRLYBRLYBRLY
83119a20: 4252 4c59 4252 4c59 4252 4c59 4252 4c59 BRLYBRLYBRLYBRLY
83119a30: 4252 4c59 4252 4c59 4252 4c59 4252 4c59 BRLYBRLYBRLYBRLY
83119a40: 4252 4c59 4252 4c59 4252 4c59 4252 4c59 BRLYBRLYBRLYBRLY
83119a50: 4252 4c59 4252 4c59 4f4f 4f4f 4f4f 4f4f BRLYBRLY00000000
83119a60: 4f4f 4f4f 4f4f 5859 5a68 6430 0400 0000 0000000XYZhd0....
83119a70: 0400 0000 0000 0000 7000 0000 0000 0000 ....p.....
83119a80: 7072 7465 0000 0000 205f 1183 0000 0000 prte.... _.....
83119a90: 20b4 PROTOCOL_ENTRY fd4c .....X..mI..L
83119aa0: 99aa 0000 .....H...8.....
83119ab0: 389e 1183 0000 0000 509b 1183 0000 0000 8.....P.....
83119ac0: 509b 1183 0000 0000 7074 616c 0000 0000 P.....ptal....
```

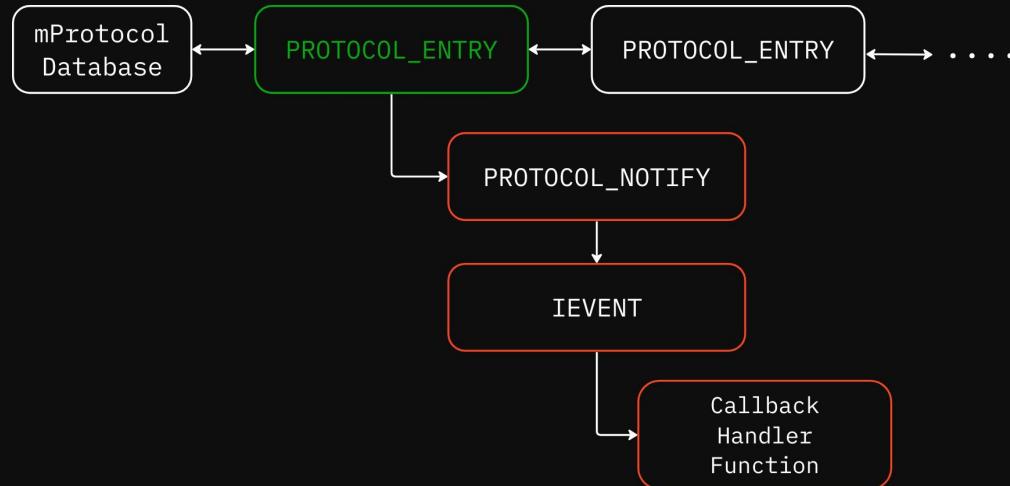
# PROTOCOL\_ENTRY, tell me more..

- Protocols are a core concept in UEFI
- PROTOCOL\_ENTRY has multiple pointers to objects with function pointers



# UEFI Event System

- Events are generated when protocols are installed

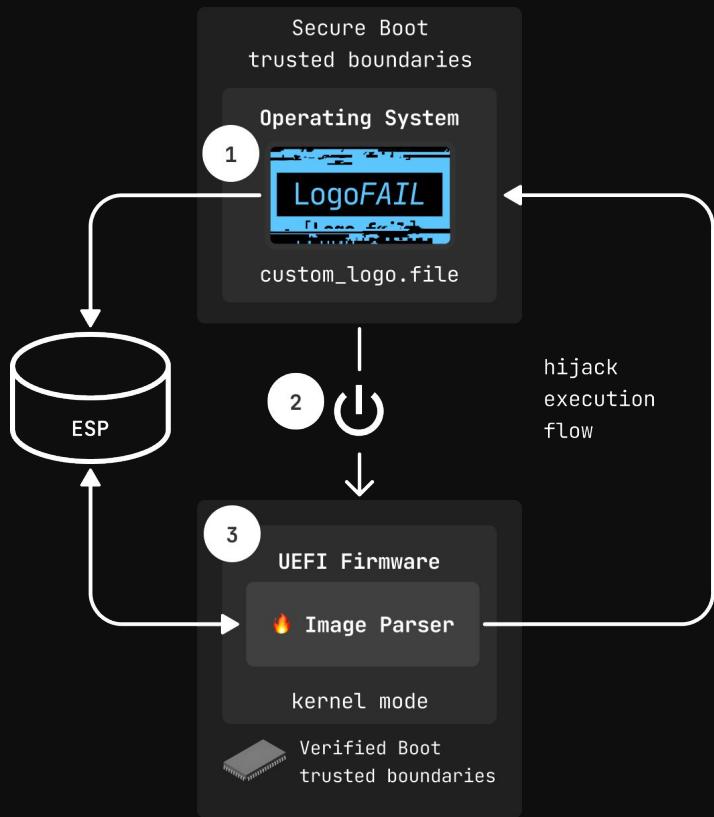


# Arbitrary Code Exec in UEFI

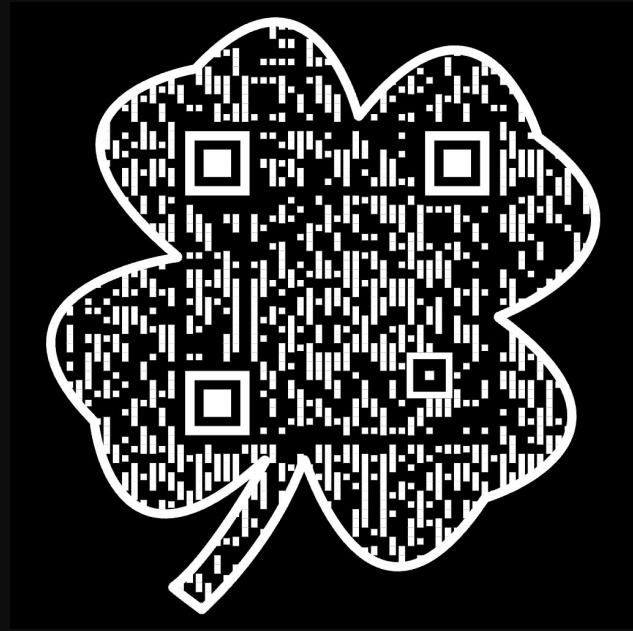
- Memory region where NVRAM variables is often **executable** and always mapped at the same **fixed address**
- We can just store a shellcode there
- Our shellcode can:
  - Disable Secure Boot (zero a global variable)
  - Start a second-stage payload from disk:
    - Unload current NTFS driver (no write support)
    - Load new NTFS driver (with write support)
    - Creates a file on the Windows filesystem

# Putting it All Together

- Preparation:
  1. Malicious PNG on the ESP (or in NVRAM)
  2. PROTOCOL\_NOTIFY, IEVENT and Shellcode in NVRAM
  3. Second-stage payload on disk:  
\\Users\\user\\LogoFAIL\\SecondStageWin.efi
- Reboot the system
- UEFI firmware will parse our PNG
- Heap overflow corrupts a PROTOCOL\_ENTRY with pointers to PROTOCOL\_NOTIFY and IEVENT
- When the protocol will be installed, we achieve arbitrary code execution
- Shellcode + Second stage payload execution



# Demo



<https://www.youtube.com/watch?v=Eufe0Pe6eqk>

```
Microsoft Windows [Version 6.1]
Copyright © Microsoft Corporation. All rights reserved.

DISPLAY THE IMAGE FILENAME. BY THE WAY IT'S NOT AN IMAGE FILE, IT'S A LOGFILE.

BY C:\Windows\system32\cmd.exe
BY C:\Windows\system32\cmd.exe
Title
BY C:\Windows\system32\cmd.exe - tasklist.exe [1].txt - Notepad - Notepad
Notepad.txt.                               Disabled      Enabled

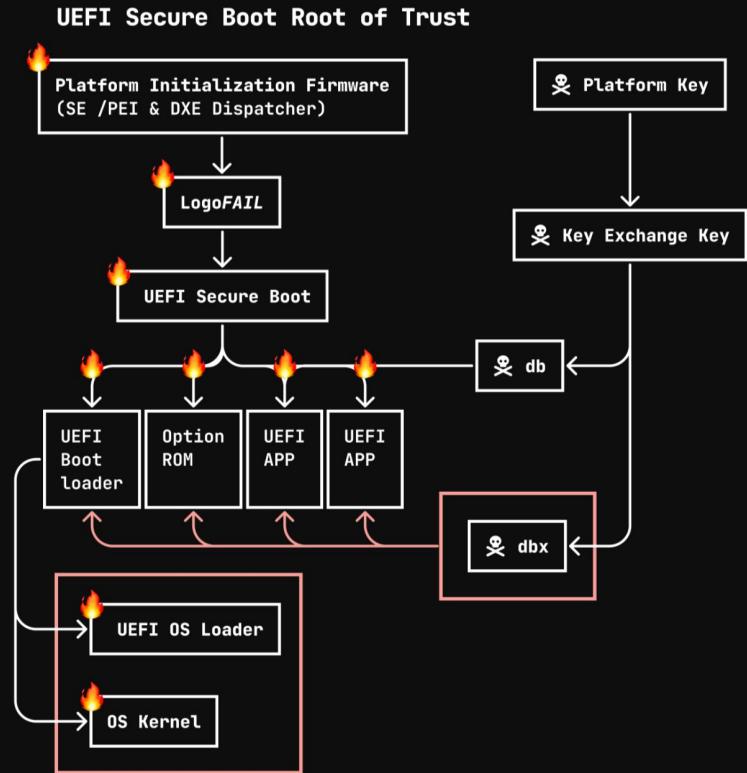
BY C:\Windows\system32\cmd.exe
Warning: This command may be used to harm your system!
Warning: It should not be used to display or access systems.
Warning: See warning.txt
Warning: This command may be used to harm your system!
Warning: It should not be used to display or access systems.
Warning: See warning.txt

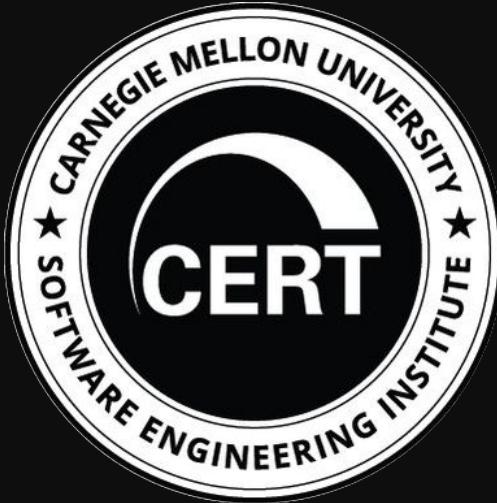
((+) Building the LRU using SystemTable & notepad.txt
```

Running the PoC

# LogoFAIL

- Majority of UEFI firmware contains vulnerable images parsers
- Hundreds of devices from Lenovo, Intel and Acer allow logo customizations thus are exploitable
- Doesn't require any physical access to the device
- Targets UEFI specific code that affects both x86 and ARM devices
- Modern "below-the-OS" defenses, such as Secure Boot are completely ineffective against it





Thanks to CERT/CC for coordinating this massive industry-wide disclosure!



# Phoenix Technology



Jake Williams  
@MalwareJake

...

Shame on you @PhoenixFirmware - embargoes exist for a reason.

If you're a hardware or software vendor not openly shaming them for this behavior, you're not playing the long game.

You want full disclosure? This is how you get full disclosure...

Alex Matrosov @matrosov · Dec 1

It looks like Phoenix Technologies (@PhoenixFirmware) has jumped the gun and broken the #LogoFAIL embargo.

It's interesting and disappointing they don't credit @Binarly.io with the free research work....

Show more





**That's all folks, thank you  
for your attention...**

**... and don't forget to update your firmware!**