#### Fixing Bugs in Binaries

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#### Agenda



- Introduction
- Feasibility of binary fixes
- Current third party patches
- Strategy
- Working Example
- Future of third party patches
- Questions

#### Introduction



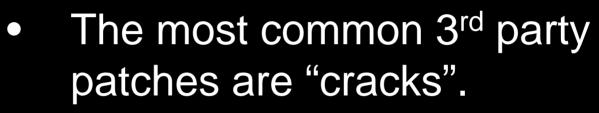
- Is the src available?
- What dependencies do we have?

# Don't wait for a vendor to get around to it, fix vendor bugs yourself!

## Feasibility of binary fixes

- Consider !/\$
- Complexity of fix relative to the bug.
- Fixing an "off by one" is easy
- Adding class members can get complicated.

#### **Current third party patches**



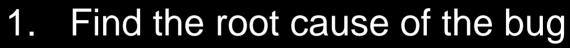
- Ilfak's WMF patch
  - Determina's and Eeye's CreateTextRange() patch



## Mantra : "least amount of change that gets the job done"

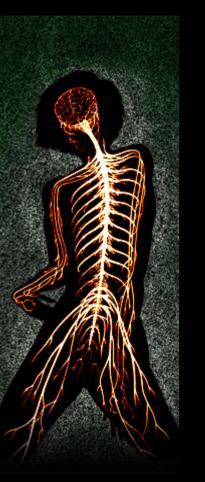


## Strategy



- 2. Locate the problem code in disassembly
- 3. Make a fix
- 4. Test, test, and test
- 5. Refine/Refactor the fix
- 6. Test, test, and test

## Applying fixes



Patching the file on disk/storage Patching at runtime. – injecting code, dll, hooks, etc.

Hybrid – Loaders (packers)

#### **Working Example**

#### Verizon xv6700





#### xv6700 specs

ightarrow



- Windows Mobile 2005
- 416Mhz pxa270 ARM Processor
  - 1.3 Mega pixel Camera
- EVDO
- WIFI
- Bluetooth
- USB ActiveSync Access

#### WM2005 Intro



- Part of the WinCE 5.0 familyWinCE 5.0
- Windows Mobile 2005 Pocket PC
- Windows Mobile 2005 Smartphone
- Windows Mobile 2005 Pocket PC
   with Phone

#### WM2005 Intro



- Little Endian
- Very close to Win32
- Portable Executables
  - Same style hooking
- Debugging with VS2005 and IDA ARM debugger

## The Bug



- Reported on forums, pictures can't be mailed through Gmail pop3.
- Google is performing file validation.
- JPEG corruption

#### Virtual G – PPC imaging software







- Images opened and saved from Virtual G pass the Gmail test.
- File changes only in Exif section



#### JPEG and Exif use markers for data. ex. FFxx

SOI Marker	APP1 Marker	APP1 Data	Other Marker
FFD8	FFE1	SSSS 457869660000 TTTT	FFXX SSSS DDDD

E1 – Start of the Exif Header SSSS – Size field (includes 2 bytes for size field) 45786966 – ASCII for 'Exif'



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Exif header is too large. "Off by one"

 Manually changing the size field passes the Gmail file check.

• The bug is identified!

#### **ARM assembly intro**



- RISC 32 bit
- Little/Big Endian
- 16 bit Thumb code
- Load/Store Architecture

http://blogs.msdn.com/windowsmobile/archive/200 5/05/10/ArmTutorial.aspx

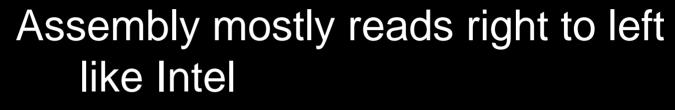
#### Registers



RO-R3 General, functions args R4-R11, R12 General SP Stack Pointer PC Program Counter LR Link Register



#### Instructions



mov reg, reg mov reg, #0x00

Idrb reg, address

strb reg, address

#### **Camera.exe Analysis**

- Copy it to PC using ActiveSync connection
- IDA identifies file as an ARM PE
  Flirt recognizes WinCE libs



#### **Bug in Disassembly**

- Need to locate the bug in disassembly
- Locate construction of Exif header
  "Exif" not found in strings list



#### **Bug in Disassembly**

 Look for individual letters being written out.
 mov register, #0x45 ; 'E' strb register, buffer

Success at function 0x05BCC0



#### **Bug in Disassembly**

R1, #0x45 ; E 0005BD38 MOV 0005BD3C STRB R1, [R2,#2] [ snip ] 0005BD58 MOV R0, #0x78 ; X R0, [R2] 0005BD5C STRB [snip] MOV R0, #0x69 ; i 0005BD78 0005BD7C STRB R0, [R2] [ snip ] 0005BD98 R0, #0x66 ; f MOV R0, [R2] 0005BD9C STRB

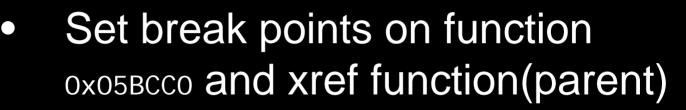
#### **Runtime Analysis**



- Combining runtime and static analysis speeds up the process
- Visual Studio 2005 debugger can connect to devices over ActiveSync

http://www.airscanner.com/security/WM5debugVS2005.pdf

#### **Runtime Analysis**



'E' gets written to a buffer identifying the location of size "Watch" for the size being written

#### **Runtime Analysis**



Size v	writing	iden	tified:
05BF7C			R3, #0xFF00
05BF80	ADD	R1,	RO, #OxFE
05BF84	MOV	R2,	R1, LSL#16
05BF88	MOV	RO,	R2, LSR#16
05BF8C	MOV	R1,	RO, LSR#8
05BF90	ADD	RO,	R3, #OxFE
05BF94	STRB	R1,	[R4] ; size write
05BF98	AND	R2,	R1, #OxFF
05BF9C	STRB	RO,	<pre>[R4,#1] ; size write</pre>

Fix



The fix can divert execution before the last write (lsb).

A branch is put in, but first space to put in code must be found.

#### Where to patch?

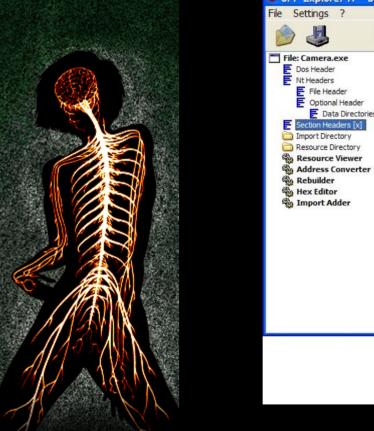


Code caves between functions
 Extending sections

• New sections



#### **Extending a Section**



	Name	Virtual Size	Virtual Ad	Raw Size	Raw Address	Relo
e: Camera.exe	Rvtel 81	Dword	Dword	Dword	Dword	Dwo
Dos Header Nt Headers	.text	(00089BB4)	00001000	00089000	00000400	000
File Header	CSC.	00000F3C	0008B000	00001000	0008A000	000
Optional Header	RszRotCs	00001AB8	0008C000	00001C00	0008B000	000
🔄 🛃 Data Directories [15]	Preview	00001B0C	0008F000	00001C00	0008CC00	000
Section Headers [x]	.rdata	00004760	00090000	00004800	0008F800	000
Import Directory Resource Directory	.data	0000D8FC	00095000	00008A00	00093000	000
Resource Viewer	.ndata	00002DE0	000A3000	00002F00	0009BA00	000
Address Converter	rsrc	00013A14	000A6000	00013C00	0009F800	00
a Hex Editor a Import Adder	<	10				

#### **Extending a Section**



.text section virtual size = 0x89BB4

.text section raw size = 0x89C00

Virtual size can be increased to 0x89C00 Producing 0x4C of extra space

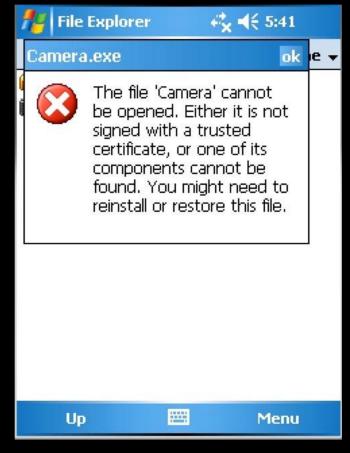
#### The Fix



05BFAC	ADD BL MOV	R1, R0, #0xFF R0, SP, #0x10+arg_4 sub_48400	MOV MOV MOV MOV	R9, R9 R9, R9 R9, R9
09ABC8 09ABCC 09ABD0 09ABD4	STRB AND ADD BL MOV	R11, [R4,#1] R1, R0, #0xFF R0, SP, #0x10+arg	_4	

#### Signed Code Error





# Signed Code Fix

Signed code is pointed to by the Security Data Directory in the PE header.

Set RVA and size to NULL.

### **Signed Code Fix**



#### 

File Settings ?	
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	Memher	Offset	Size	Value	^
	Export Directory RVA	00000180	Dword	0000000	
File: Camera.exe	Export Directory Size	00000184	Dword	0000000	
Dos Header	Import Directory RVA	00000188	Dword	00093628	
Nt Headers File Header	Imnort Directory Size	0000018C	Dword	00000168	
File Header	Resource Directory RVA	00000190	Dword	000A6000	
Data Directories [15]	Resource Directory Size	00000194	Dword	00013A14	
E Section Headers [x]	Exception Directory RVA	00000198	Dword	000A3000	
import Directory	Excention Directory Size	00000190	Dword	00002DE0	
Resource Directory     Resource Viewer	Security Directory RVA	000001A0	Dword	000B2400	
Address Converter	Security Directory Size	000001A4	Dword	00000370	
🐁 Rebuilder	Relocation Directory RVA	000001A8	Dword	0000000	
Hex Editor	Relocation Directory Size	000001AC	Dword	00000000	
import Adder 🖏	Debug Directory RVA	000001B0	Dword	00090000	
	Debug Directory Size	000001R4	Dword	0000001C	
	Architecture Directory RVA	000001B8	Dword	0000000	
	Architecture Directory Size	000001BC	Dword	00000000	
	Reserved	000001C0	Dword	0000000	
	Reserved	000001C4	Dword	00000000	
	TIS Directory RVA	000001C8	Dword	0000000	
	TLS Directory Size	00000100	Dword	00000000	
	Configuration Directory	000001D0	Dword	0000000	<b>~</b>

#### Results



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# **Bug in the Fix**



# The fix contains a bug if the size is: 0xXX00

For example: 0x0100 becomes 0x01FF

#### **A Better Fix**

A better fix can be done without extending a section.

Changing only 2 bytes

### **A Better Fix**



05BF80 ADD 05BF84 MOV 05BF88 MOV 05BF8C MOV 05BF90 ADD 05BF94 STRB 05BF98 AND 05BF9C STRB

R1, R0, #0xFE ; OxFD R2, R1, LSL#16 R0, R2, LSR#16 R1, R0, LSR#8 R0, R3, #0xFE ; OxFD R1, [R4] R2, R1, #0xFF R0, [R4, #1]

#### **A Better Fix**



On the file patch:

#### Offset 0x4B380: 0xFE -> 0xFD Offset 0x4B390: 0xFE -> 0xFD



Exif header contains various fields: Date/time **Camera Vendor Camera Model** Artist Name aka your name in every image

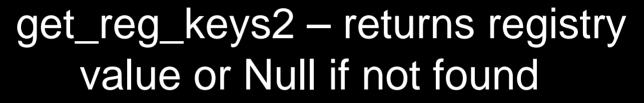


- Artist name comes from the Owner name stored on the phone.
- Camera.exe accesses name through the registry.
- From IDA string list:
   "ControlPanel\Owner\Owner"



#### Within the disassembly:

000481AC LDR R0, =aControlpanelOw 000481B0 MOV R3, #0x80000001 000481B4 MOV R2, #0x280 000481B8 MOV R1, R5 000481BC BL get\_reg\_key2 000481C0 CMP R0, #0 000481C4 BEQ done\_with\_regkeys



Change: 000481C0 00 00 50 E3 CMP R0, #0 To 000481C0 00 00 50 E1 CMP R0, R0; always equal

000481C4 BEQ done\_with\_regkeys



On the file patch:

#### Offset 0x0375C3: 0xE3 -> 0xE1





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# Future of 3<sup>rd</sup> party patches

- Continued release of 3<sup>rd</sup> party security patches
- Advisories released with binary fix diffs
- Vulnerability market consisting of both 0day exploit and 0day patches

#### **Questions**?





#### **Shameless Self-Promotion**

Automating Exploit Detection: Cutting-edge Tools and Techniques Matt Hargett & Luis Miras Blackhat Training USA

Bridging the Gap between Static & Dynamic Reversing Defcon 14