APT REPORTS

Operation AppleJeus: Lazarus hits cryptocurrency exchange with fake installer and macOS malware

By GReAT on August 23, 2018. 8:00 am

Overview

Lazarus has been a major threat actor in the APT arena for several years. Alongside goals like cyberespionage and cybersabotage, the attacker has been targeting banks and other financial companies around the globe. Over the last few months, Lazarus has successfully compromised several banks and infiltrated a number of global cryptocurrency exchanges and fintech companies.

Kaspersky Lab has been assisting with incident response efforts. While investigating a cryptocurrency exchange attacked by Lazarus, we made an unexpected discovery. The victim had been infected with the help of a trojanized cryptocurrency trading application, which had been recommended to the company over email. It turned out that an unsuspecting employee of the company had willingly downloaded a third-party application from a legitimate looking website and their computer had been infected with malware known as Fallchill, an old tool that Lazarus has recently switched back to. There have been multiple reports on the reappearance of Fallchill, including one from US-CERT.

To ensure that the OS platform was not an obstacle to infecting targets, it seems the attackers went the extra mile and developed malware for other platforms, including for macOS. A version for Linux is apparently coming soon, according to the website. It's probably the first time we see this APT group using malware for macOS.

The fact that the Lazarus group has expanded its list of targeted operating systems should be a wake-up call for users of non-Windows platforms.

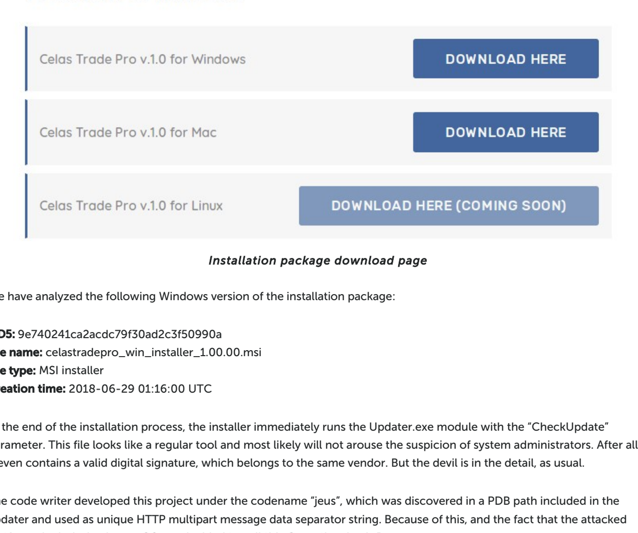
Trojanized cryptocurrency trading application

Thanks to Kaspersky Lab's malicious-behavior detection technology, implemented in its endpoint security software, we were able to reassemble the stages of infection and trace them back to their origin. This helped us understand that one of Lazarus' victims was infected with malware after installing a cryptocurrency trading program. We also confirmed that the user installed this program via a download link delivered over email.

Trojanized trading application for Windows

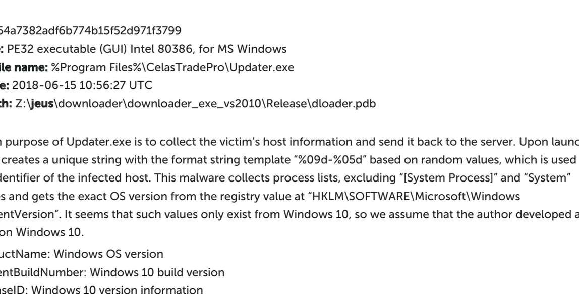
Including malicious code into distributed software and putting that on a website would be too obvious. Instead, the attackers went for a more elaborate scheme: the trojan code was pushed out in the form of an update for a trading application.

A legitimate-looking application called Celas Trade Pro from Celas Limited showed no signs of malicious behaviour and looked genuine. This application is an all-in-one style cryptocurrency trading program developed by Celas.



Screenshot of Celas Trade Pro

When we started this research, any user could download the trading application from the Celas website. Checking the installation package downloaded from the website confirmed the presence of a very suspicious updater.



Installation package download page

We have analyzed the following Windows version of the installation package:

MD5: 9e740241ca2acdc79f30ad2c3f50990a
File name: celastradepro_win_installer_1.00.00.msi
File type: MSI installer
Creation time: 2018-06-29 01:16:00 UTC

At the end of the installation process, the installer immediately runs the Updater.exe module with the "CheckUpdate" parameter. This file looks like a regular tool and most likely will not arouse the suspicion of system administrators. After all, it even contains a valid digital signature, which belongs to the same vendor. But the devil is in the detail, as usual.

The code writer developed this project under the codename "jeus", which was discovered in a PDB path included in the updater and used as unique HTTP multipart message data separator string. Because of this, and the fact that the attacked platforms include Apple macOS, we decided to call this Operation AppleJeus.

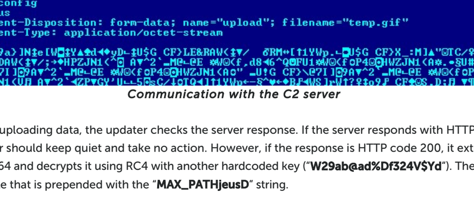
Properties of the shady updater tool included in the package are:

MD5: b054a7382adf6b774b15f52d971f3799
File Type: PE32 executable (GUI) Intel 80386, for MS Windows
Known file name: %Program Files%\CelasTradePro\Updater.exe
Link Time: 2018-06-15 10:56:27 UTC
Build path: Z:**jeus**\downloader\downloader_exe_vs2010\Release\dloader.pdb

The main purpose of Updater.exe is to collect the victim's host information and send it back to the server. Upon launch, the malware creates a unique string with the format string template "%09d-%05d" based on random values, which is used as a unique identifier of the infected host. This malware collects process lists, excluding "[System Process]" and "System" processes and gets the exact OS version from the registry value at "HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion". It seems that such values only exist from Windows 10, so we assume that the author developed and tested it on Windows 10.

- ProductName: Windows OS version
- CurrentBuildNumber: Windows 10 build version
- ReleaseID: Windows 10 version information
- UBR: Sub version of Windows 10 build
- BuildBranch: Windows 10 build branch information

The code encrypts the collected information with the hardcoded XOR key ("**Moz&Wie;#t/6T!2y**") before uploading it to the server.



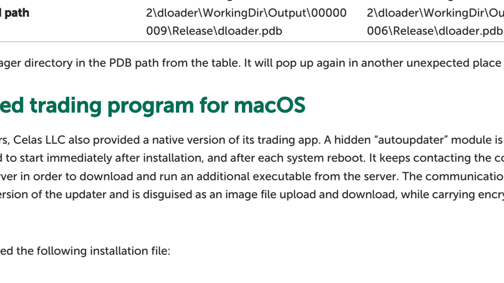
Data encryption routine

The code sends the victim's information to a webserver using HTTP and the following URL:
www.celasllc[.]com/checkupdate.php

The server is a legitimate looking website owned by the developer of the program: Celas LLC. At this point we were not able to conclude with high confidence whether the server was compromised by the threat actor or had belonged to the threat actor from the beginning. To learn more about the server, please read the "Infrastructure" section below.

The malware used a hardcoded User-Agent string "**Mozilla/5.0 (compatible; MSIE 10.0; Windows NT 6.1; Trident/6.0)**" and fixed a multipart form data separator string "**jeus**".

Using encryption, the custom separator string wouldn't be a red flag for a legitimate application, but sending a request with the context-irrelevant string "get_config", as well as uploading collected system information as "temp.gif", mimicking a GIF image with a magic number in the header, definitely made us raise our eyebrows.



Communication with the C2 server

After successfully uploading data, the updater checks the server response. If the server responds with HTTP code 300, it means the updater should keep quiet and take no action. However, if the response is HTTP code 200, it extracts the payload with base64 and decrypts it using RC4 with another hardcoded key ("**W29ab@ad%Df324V$Yd**"). The decrypted data is an executable file that is prepended with the "**MAX_PATHjeusD**" string.

During our research, we found other similar files. One was created on August 3rd and another on August 11th. The PDB path shows that the author keeps improving this updater tool, apparently forked from some stable version released on July 2, 2018 according to the internal directory name.

	Additional trojanized sample #1	Additional trojanized sample #1
Installation package MD5	4126e1f34cf282c354e17587bb6e8da3	0bdb652bbe15942e866083f29fb6dd62
Package creation date	2018-08-03 09:57:29	2018-08-13 0:12:10
Dropped updater MD5	ffae703a1e327380d85880b9037a0aeb	bbbcf6da5a4c352e8846bf91c3358d5c
Updater creation date	2018-08-03 09:50:08	2018-08-11 7:28:08
Updater Build path	H:\DEV**TManager**\DLoader\20180702\dloader\WorkingDir\Output\00000009\Release\dloader.pdb	H:\DEV**TManager**\DLoader\20180702\dloader\WorkingDir\Output\00000006\Release\dloader.pdb

Note the TManager directory in the PDB path from the table. It will pop up again in another unexpected place later.

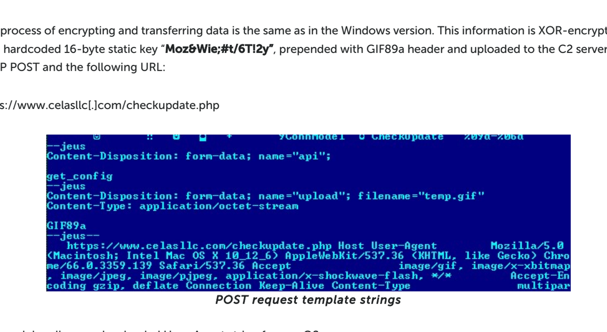
Trojanized trading program for macOS

For macOS users, Celas LLC also provided a native version of its trading app. A hidden "autoupdater" module is installed in the background to start immediately after installation, and after each system reboot. It keeps contacting the command and control (C2) server in order to download and run an additional executable from the server. The communication conforms to the Windows version of the updater and is disguised as an image file upload and download, while carrying encrypted data inside.

We have analyzed the following installation file:

MD5: 48ded52752de9f9b73c6bf9ae81cb429
File Size: 15,020,544 bytes
File Type: DMG disk image
Known file name: celastradepro_mac_installer_1.00.00.dmg
Date of creation: 13 July 2018

Once the Cellas Trade Pro app is installed on macOS, it starts the Updater application on the system load via a file named ".com.celastradepro.plist" (note that it starts with a dot symbol, which makes it unlisted in the Finder app or default Terminal directory listing). The "Updater" file is passed the "CheckUpdate" parameter on start.



Celas Trade Pro app plist file (Apple Property List)

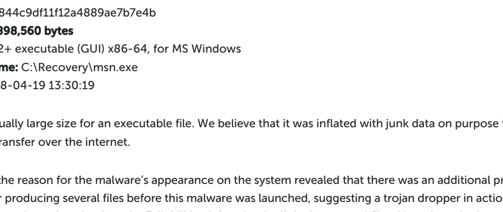
The command-line argument "CheckUpdate" looks redundant from a code analysis perspective: there is no other argument that the application expects. In the absence of all arguments, it doesn't do anything and quits. This may or may not be way to trick sandboxes that could automatically execute this trojan updater, with no suspicious activity produced without such a "secret" extra argument. The choice of a benign string such as "CheckUpdate" helps it to hide in plain sight of any user or administrator looking into running processes.

The trojanized updater works similar to the Windows version in many ways. Both applications are implemented using a cross-platform QT framework. Upon launch, the downloader creates a unique identifier for the infected host using a "%09d-%06d" format string template. Next, the app collects basic system information, which for macOS is done via dedicated QT classes:

- Host name
- OS type and version
- System architecture
- OS kernel type and version

The process of encrypting and transferring data is the same as in the Windows version. This information is XOR-encrypted with hardcoded 16-byte static key "**Moz&Wie;#t/6T!2y**", prepended with GIF89a header and uploaded to the C2 server via HTTP POST and the following URL:

https://www.celasllc[.]com/checkupdate.php



POST request template strings

The module relies on a hardcoded User-Agent string for macOS:
User-Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_12_6) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/66.0.3359.139 Safari/537.36

Once the server replies, it checks the HTTP response code. HTTP response code 300 indicates that the server has no task for the updater and the application terminates immediately. If the HTTP response is code 200, then the updater gets the data in the response, decodes it from base64 encoding and decrypts it using RC4 with the hardcoded static key "**W29ab@ad%Df324V$Yd**". It calculates the MD5 of the decoded and decrypted data, which is compared to a value stored inside, to verify the integrity of the transferred file. After that, the payload is extracted and saved to a hardcoded file location "**/var/zdiffsec**", sets executable permissions for all users and starts the app with another secret hardcoded command-line argument "**bf6a0c760cc642**". Apparently the command-line argument is the way to prevent the detection of its malicious functionality via sandboxes or even reverse engineering. We have previously seen this technique adopted by Lazarus group in 2016 in attacks against banks. As of 2018, it is still using this in almost every attack we investigated.

Downloaded payload

According to data from Kaspersky Security Network, the threat actor delivered the malicious payload using one of the shadowy updaters described above. We found a malicious file created at the same host:

MD5: 0a15a33844c9df11f12a4889ae7b7e4b
File Size: 104,898,560 bytes
File Type: PE32+ executable (GUI) x86-64, for MS Windows
Known file name: C:\Recovery\msn.exe
Link time: 2018-04-19 13:30:19

Note the unusually large size for an executable file. We believe that it was inflated with junk data on purpose to prevent easy download or transfer over the internet.

Searching for the reason for the malware's appearance on the system revealed that there was an additional process responsible for producing several files before this malware was launched, suggesting a trojan dropper in action. The main function of this malware is to implant the Fallchill backdoor loader linked to several files. Upon launch, the malware checks one of the command-line arguments passed to it. The malware chooses one of the service names located in the following registry value as a disguise:

HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Svchost\netsvcs

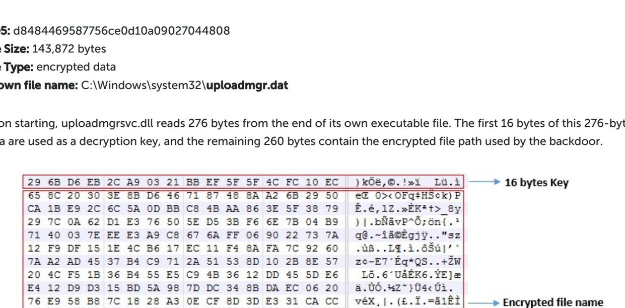
This value includes a list of several dozen standard system service names.

The randomly chosen service name is used to name the dropped file and newly registered Windows service. Let's refer to this randomly chosen service name as *[service]*. The malware contains references to several files inside:

- The file passed as argument: contains a 16-byte key
- msncf.dat: Encrypted configuration data
- msndll.tmp: Encrypted Fallchill loader
- msndll.dat: Encrypted Fallchill backdoor (payload for the loader)
- *[service]*svc.dll: Fallchill backdoor loader
- *[service]*.dat: Copy of msndll.dat

A mix of the above-mentioned files produces the final backdoor known as Fallchill. A more detailed procedure for technical specialists is as follows:

1. Check whether the command-line argument points to a file of 16 byte size.
2. Read the file passed via the command-line argument. The contents of this file contains a crypto key, which we will call the main key.
3. Open the msncf.dat file (configuration file). If the file size equals 192 bytes, read the content of the file.
4. Open msndll.tmp file and decrypt it using the main key.
5. Create the *[service]*svc.dll file and fill it with pseudo-random data.
   1. The malware fills the file with 10,240 bytes of pseudo-random data, and iterates (rand() % 10 + 10240) times. This is why it produces files which are at least 104,851,000 bytes.
6. Copy the 16-byte main key at the end of the *[service]*svc.dll file.
7. Encrypt the *[service]*.dat file name with the main key and append it at the end of *[service]*svc.dll.
8. Overwrite the beginning of *[service]*svc.dll with data decrypted from msndll.tmp.
9. Move msndll.dat file to *[service]*.dat.
10. Delete temporary files: msndll.tmp, msncf.dat, msndll.log.
11. Timestamp *[service]*svc.dll and *[service]*.dat files.
12. Register *[service]*svc.dll as a Windows service.
13. Save a copy of data from msncf.dat file in the following registry value **HKLM\SOFTWARE\Microsoft\Windows\CurrentVersion\TaskConfigs\Description.**



Infection process diagram

Fallchill backdoor loader

We confirmed that the following malware was created on the infected host using the method described above:

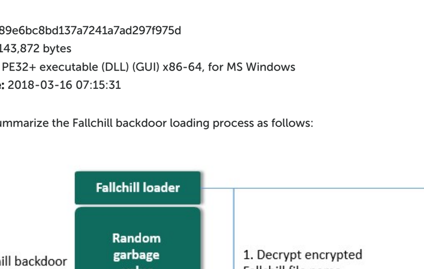
Fallchill backdoor loader:

MD5: e1ed584a672cab33af29114576ad6cce
File Size: 104,878,356 bytes
File Type: PE32+ executable (DLL) (console) x86-64, for MS Windows
Known file name: C:\Windows\system32**uploadmgrsvc.dll**
Link time: 2018-01-18 01:56:32

Encrypted Fallchill backdoor:

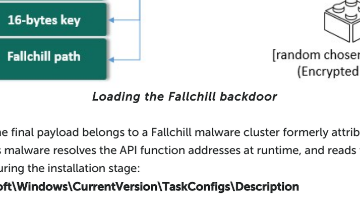
MD5: d8484469587756ce0d10a09027044808
File Size: 143,872 bytes
File Type: encrypted data
Known file name: C:\Windows\system32**uploadmgr.dat**

Upon starting, uploadmgrsvc.dll reads 276 bytes from the end of its own executable file. The first 16 bytes of this 276-byte data are used as a decryption key, and the remaining 260 bytes contain the encrypted file path used by the backdoor.



Data at the end of the loader module

After decryption of the last 260-bytes, the malware retrieves the name or path of the file that contains the actual backdoor body in encrypted form.

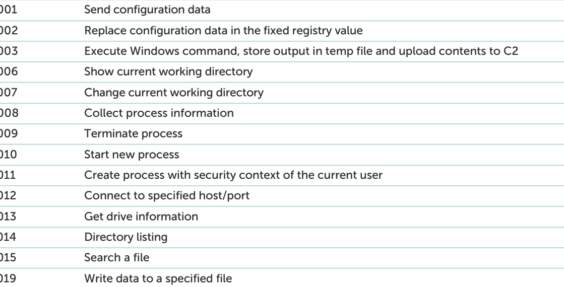


Decrypted file name in the end of loader module

The malware reads the specified file and decrypts it using the same decryption routine. This is how the executable code of the backdoor is produced in memory and executed by the loader. Below is the meta information about the decrypted final payload in memory:

MD5: d7089e6bc8bd137a7241a7ad297f975d
File Size: 143,872 bytes
File Type: PE32+ executable (DLL) (GUI) x86-64, for MS Windows
Link Time: 2018-03-16 07:15:31

We can summarize the Fallchill backdoor loading process as follows:



Loading the Fallchill backdoor

As mentioned previously, the final payload belongs to a Fallchill malware cluster formerly attributed to the Lazarus APT group. Upon launching, this malware resolves the API function addresses at runtime, and reads the C2 server address from the registry value created during the installation stage:
HKLM\SOFTWARE\Microsoft\Windows\CurrentVersion\TaskConfigs\Description

If there is no configuration value, the malware falls back to a default C2 server address.

- **196.38.48[.]121**
- **185.142.236[.]226**

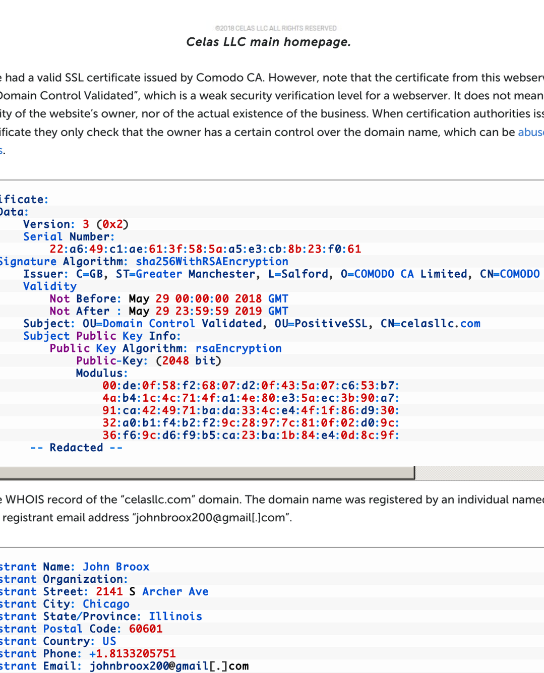
This is a full-featured backdoor that contains enough functions to fully control the infected host. Some of its network protocol commands are described below.

Command ID	Description
0x8000	Write current time and configuration data to registry key
0x8001	Send configuration data
0x8002	Replace configuration data in the fixed registry value
0x8003	Execute Windows command, store output in temp file and upload contents to C2
0x8006	Show current working directory
0x8007	Change current working directory
0x8008	Collect process information
0x8009	Terminate process
0x8010	Start new process
0x8011	Create process with security context of the current user
0x8012	Connect to specified host/port
0x8013	Get drive information
0x8014	Directory listing
0x8015	Search a file
0x8019	Write data to a specified file
0x8020	Read contents of specified file and upload to C2 server
0x8021	Compress multiples files to a temp file (name start with ZD) and upload to C2
0x8023	Wipe specific file
0x8025	Copy file time from another file time (timestamping)
0x8026	Shutdown malware service and self-delete
0x8043	Send "Not Service" unicode string to C2 server (communication test?).

This set of capabilities is very common for many Lazarus backdoors, which have been seen in other attacks against banks and financial industry in the past years.

Infrastructure

While working on the incident of the cryptocurrency company's breach, we were curious about the legal status of the Celas LLC company that developed this trojanized trading application.



Celas LLC main homepage.

The website had a valid SSL certificate issued by Comodo CA. However, note that the certificate from this webserver mentions "Domain Control Validated", which is a weak security verification level for a webserver. It does not mean validation of the identity of the website's owner, nor of the actual existence of the business. When certification authorities issue this kind of certificate they only check that the owner has a certain control over the domain name, which can be abused in certain ways.

```
Certificate:
    Data:
        Version: 3 (0x2)
        Serial Number:
            22:a6:49:c1:ae:61:3f:58:5a:a5:e3:cb:8b:23:f0:61
    Signature Algorithm: sha256WithRSAEncryption
        Issuer: C=GB, ST=Greater Manchester, L=Salford, O=COMODO CA Limited, CN=COMODO RSA Doma
        Validity
            Not Before: May 29 00:00:00 2018 GMT
            Not After : May 29 23:59:59 2019 GMT
        Subject: OU=Domain Control Validated, OU=PositiveSSL, CN=celasllc.com
        Subject Public Key Info:
            Public Key Algorithm: rsaEncryption
                Public-Key: (2048 bit)
                Modulus:
                    00:de:0f:58:f2:68:07:d2:0f:43:5a:07:c6:53:b7:
                    4a:b4:1c:4c:71:4f:a1:4e:80:e3:5a:ec:3b:90:a7:
                    91:ca:42:49:71:ba:da:33:4c:e4:4f:1f:86:d9:30:
                    32:a0:b1:f4:b2:f2:9c:28:97:7c:81:0f:02:d0:9c:
                    36:f6:9c:d6:f9:b5:ca:23:ba:1b:84:e4:0d:8c:9f:
      -- Redacted --
```

Below is the WHOIS record of the "celasllc.com" domain. The domain name was registered by an individual named "John Broox" with registrant email address "johnbroox200@gmail[.]com".

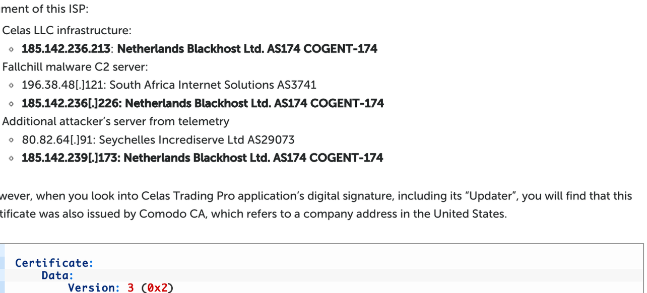
```
Registrant Name: John Broox
Registrant Organization:
Registrant Street: 2141 S Archer Ave
Registrant City: Chicago
Registrant State/Province: Illinois
Registrant Postal Code: 60601
Registrant Country: US
Registrant Phone: +1.8133205751
Registrant Email: johnbroox200@gmail[.]com
...
Name Server: 1a7ea920.bitcoin-dns.hosting
Name Server: a8332f3a.bitcoin-dns.hosting
Name Server: ad636824.bitcoin-dns.hosting
Name Server: c358ea2d.bitcoin-dns.hosting
```

The same name of "John Broox" was used inside the installation package of the macOS version of the trading application. The Info.plist properties file describes the package as follows:

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE plist PUBLIC "-//Apple//DTD PLIST 1.0//EN" "http://www.apple.com/DTDs/PropertyList-1.
<plist version="1.0">
<dict>
        <key>CFBundleVersion</key>
        <string>1.00.00</string>
        <key>CFBundleName</key>
        <string>Celas Trade Pro</string>
        <key>CFBundleIconFile</key>
        <string>CelasTradePro</string>
        <key>CFBundlePackageType</key>
        <string>APPL</string>
        <key>CFBundleGetInfoString</key>
        <string>Developed by John Broox. CELAS LLC</string>
        <key>CFBundleSignature</key>
        <string>QTCELASTRADE</string>
        <key>CFBundleExecutable</key>
        <string>CelasTradePro</string>
        <key>CFBundleIdentifier</key>
        <string>com.celasllc.CelasTradePro</string>
        <key>NSPrincipalClass</key>
        <string>NSApplication</string>
        <key>NSHighResolutionCapable</key>
        <string>True</string>
        <key>LSMinimumSystemVersion</key>
        <string>10.10.0</string>
</dict>
</plist>
```

It looks at first sight like a legitimate WHOIS record, but something doesn't really add up here. The domain celasllc.com was the only domain registered with this email address and was exclusively used for domain registration.

The registrant used the Domain4Bitcoins service to register this domain, apparently paying with cryptocurrency. According to open-source intelligence, the address of the WHOIS information is fake, unless it's the owner of a ramen shop running a cryptocurrency exchange software development studio on the side.



View of the location referred in the WHOIS record. Image source: Google Maps.

The server hosting celasllc.com (185.142.236.213) belongs to the Blackhost ISP in the Netherlands.

IP Information for 185.142.236.213

— Quick Stats

IP Location	Netherlands Amsterdam Blackhost Ltd.
ASN	AS174 COGENT-174 - Cogent Communications, US (registered May 16, 1996)
Whois Server	whois.ripe.net
IP Address	185.142.236.213
Reverse IP	2 websites use this address.

WHOIS record of cellasllc.com server

Coincidentally, the Fallchill malware authors also preferred to use the same hosting company to host their C2 server. Moreover, the Celas LLC web server and one of the C2 servers of the Fallchill malware are located in the same network segment of this ISP:

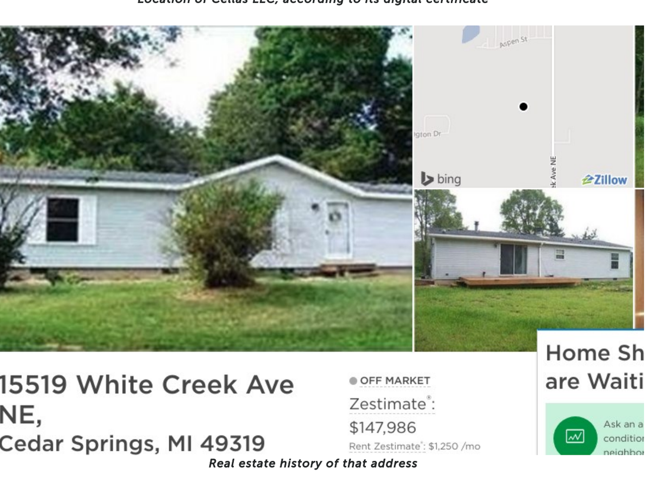
- Celas LLC infrastructure:
  - **185.142.236.213**: **Netherlands Blackhost Ltd. AS174 COGENT-174**
- Fallchill malware C2 server:
  - 196.38.48[.]121: South Africa Internet Solutions AS3741
  - **185.142.236[.]226: Netherlands Blackhost Ltd. AS174 COGENT-174**
- Additional attacker's server from telemetry
  - 80.82.64[.]91: Seychelles Incrediserve Ltd AS29073
  - **185.142.239[.]173: Netherlands Blackhost Ltd. AS174 COGENT-174**

However, when you look into Celas Trading Pro application's digital signature, including its "Updater", you will find that this certificate was also issued by Comodo CA, which refers to a company address in the United States.

```
Certificate:
    Data:
        Version: 3 (0x2)
        Serial Number:
            9a:73:55:0b:83:76:86:3b:d9:43:0f:aa:8b:5a:29:87
    Signature Algorithm: sha256WithRSAEncryption
        Issuer: C=GB, ST=Greater Manchester, L=Salford, O=COMODO CA Limited, CN=COMODO RSA Code
        Validity
            Not Before: May 21 00:00:00 2018 GMT
            Not After : May 21 23:59:59 2019 GMT
        Subject: C=US/postalCode=49319, ST=Michigan, L=Cedar Springs/street=15519 WHITE CREEK A
        Subject Public Key Info:
            Public Key Algorithm: rsaEncryption
                Public-Key: (2048 bit)
                Modulus:
                    00:b6:31:7a:c6:68:2f:d2:03:f2:e9:61:c4:86:4f:
                    46:62:e7:a6:d7:7c:bd:e6:9f:a8:83:2c:a6:44:43:
                    92:da:b7:ea:cc:3d:3e:35:20:3f:9c:57:46:1c:d1:
                    65:b8:28:50:29:cd:29:11:e8:56:59:85:e5:0f:19:
```

According to open-source data, this address doesn't belong to a real business, and looks on maps like a meadow with a small forest and small real estate offering nearby.

Location of Cellas LLC, according to its digital certificate



Real estate history of that address