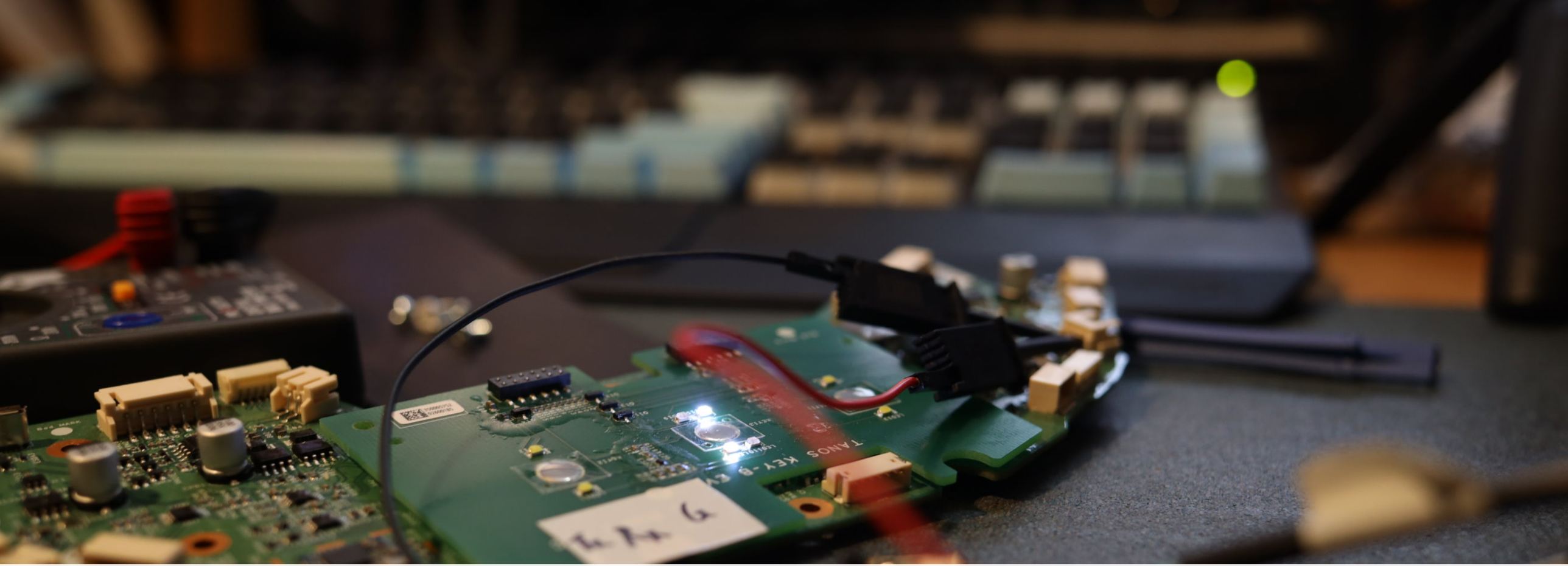


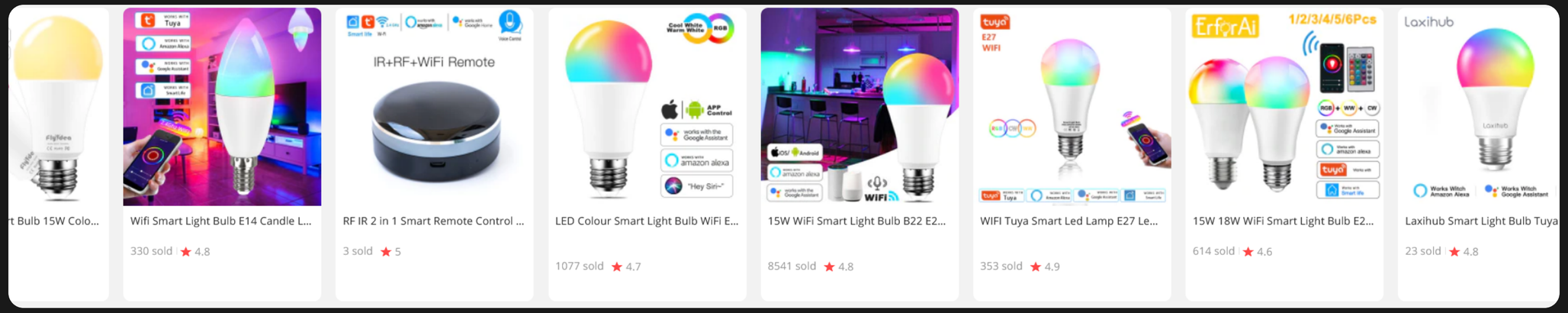
“Smart” Vacuum Cleaners

An Audit Into The Security and Integrity of IoT Systems

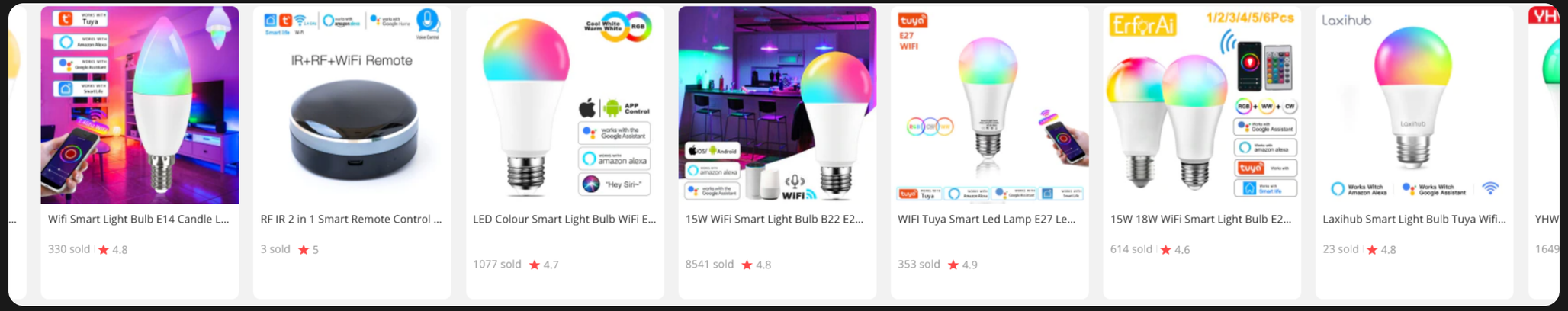
Andrew Wong | UNSW Sydney

Today’s Agenda

- Topic recap
- Thesis statement
- Thesis A and B results
- Where we left off (new progress)
- Discussion
- Conclusion



…so there are a lot of IOT devices and IOT brands out there…



Are competing products looking suspiciously similar to you?

Most are white-labelled products, the biggest ecosystem vendor being tuya

Pros

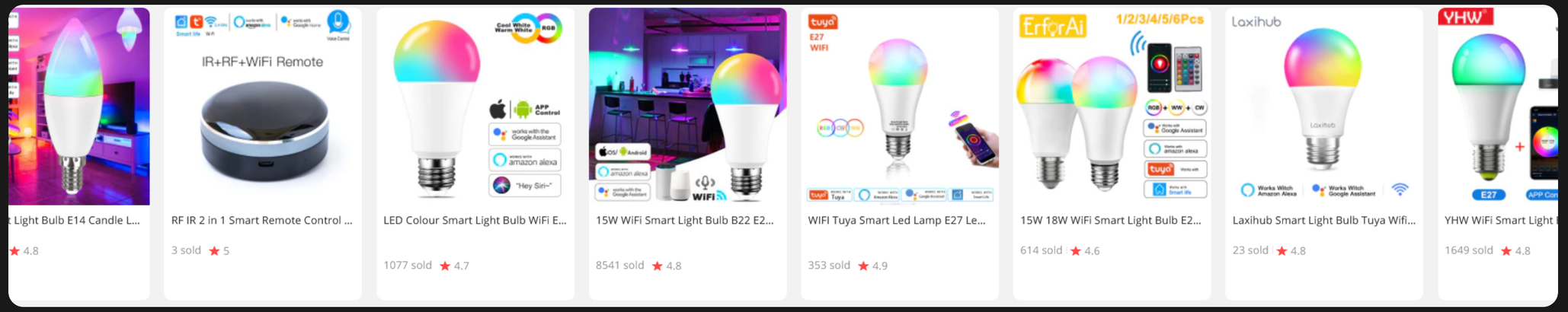
Use someone else's code

Fast profit turnaround

Cons

⚠ Use someone else's code

Potentially security vulnerabilities



IOT ecosystems often have a centralised system to manage their fleet (devices).

Pros

A centralised management is so much simpler/easier/faster/cheaper/‘better’ than a decentralised one.

Cons

⚠ Device functionality dependent on system availability
⚠ Little transparency about what/where/when/why data is transmitted

Statement

How have manufacturers of IoT / smart home devices addressed the increasing concerns of digital privacy and product security?

(Specifically Roborock / Xiaomi / Tuya)

- Digital Privacy
  - Investigate the nature of network data
  - i.e. content, frequency, destination, usage
- Product Security
  - Investigate security vulnerabilities
  - Assess the effectiveness of security fortifications

Statement

Device in scope: Roborock S6 (2019)

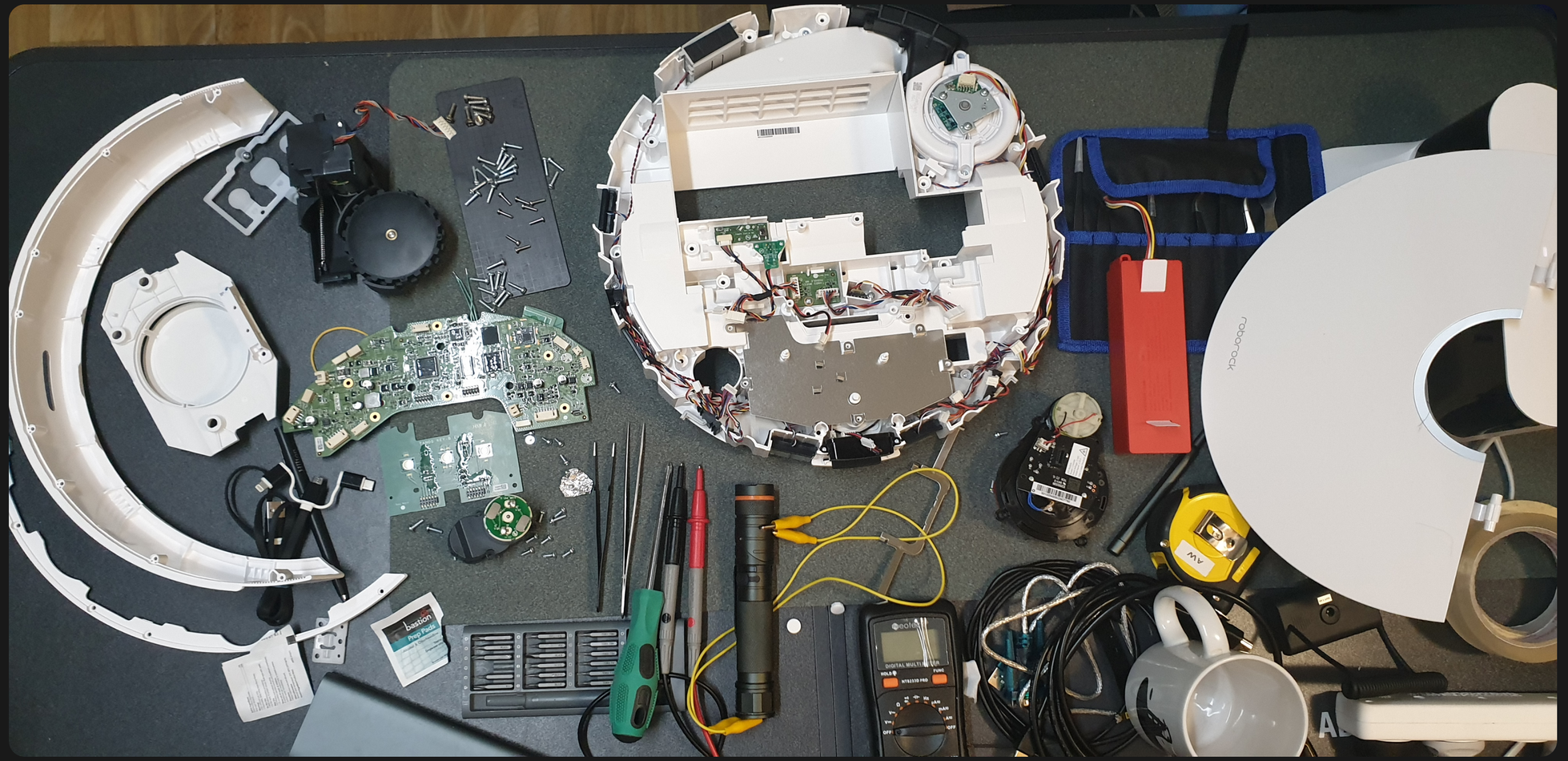
A smart vacuum cleaner, with integrations to both tuya and Mi (depending on model)

It works pretty well, according to reviews.
But is it safe to connect to your home?

Where we left off

Thesis A | Results

Thesis A - Disassembled the device (many, many screws)

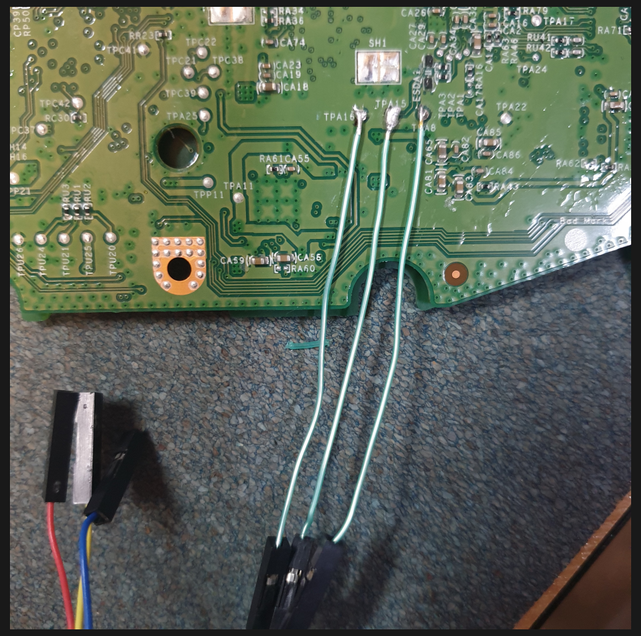


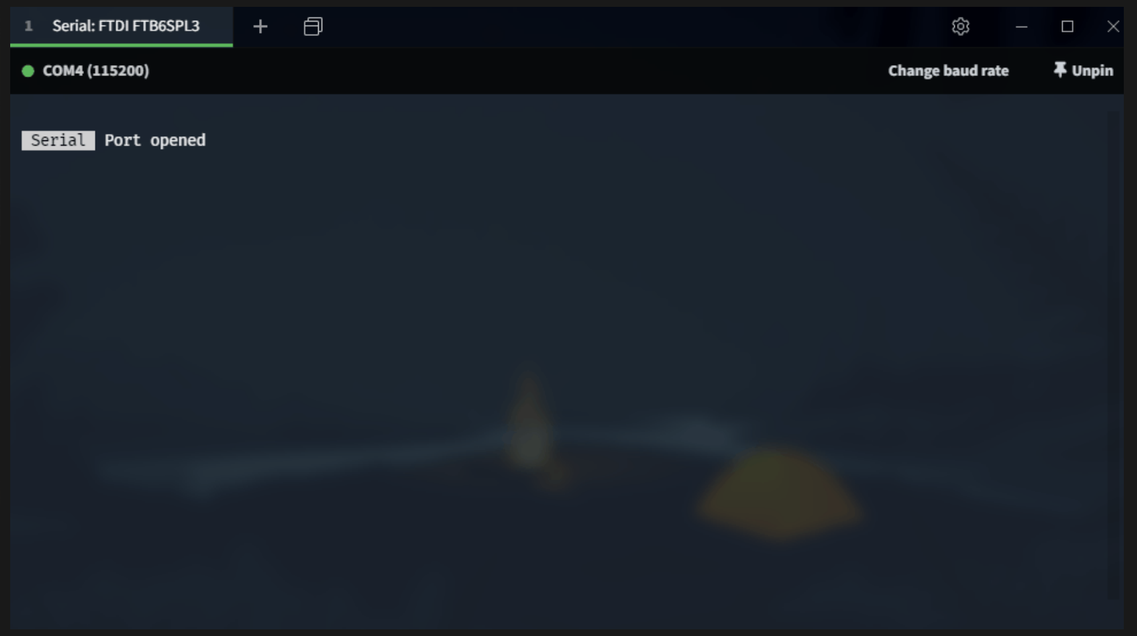
Thesis A - Found the UART pins and got some terminal

Preliminary Results

Serial Access

- Serial (baud=115200) gives us a shell!





Need a root password though…

Thesis A - Got root access (Device runs Ubuntu 14.04.3 LTS)

Preliminary Results

Root!

```
sunxi#ext4load
ext4load - load binary file from a Ext4 filesystem

Usage:
ext4load <interface> <dev[:part]> [addr] [filename] [bytes]
          - load binary file 'filename' from 'dev' on 'interface'
                to address 'addr' from ext4 filesystem
sunxi#ext4load mmc 2:6 0 vinda
Loading file "vinda" from mmc device 2:6
16 bytes read
sunxi#md 0 4
00000000: 5b415243 51454346 54505042 525f5655    CRA[FCEQBPPTUV_R
```

```
rockrobo login: root
Password:
Welcome to Ubuntu 14.04.3 LTS (GNU/Linux 3.4.39 armv7l)

 * Documentation:  https://help.ubuntu.com/

The programs included with the Ubuntu system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Ubuntu comes with ABSOLUTELY NO WARRANTY, to the extent permitted by
applicable law.

root@rockrobo:~#
```

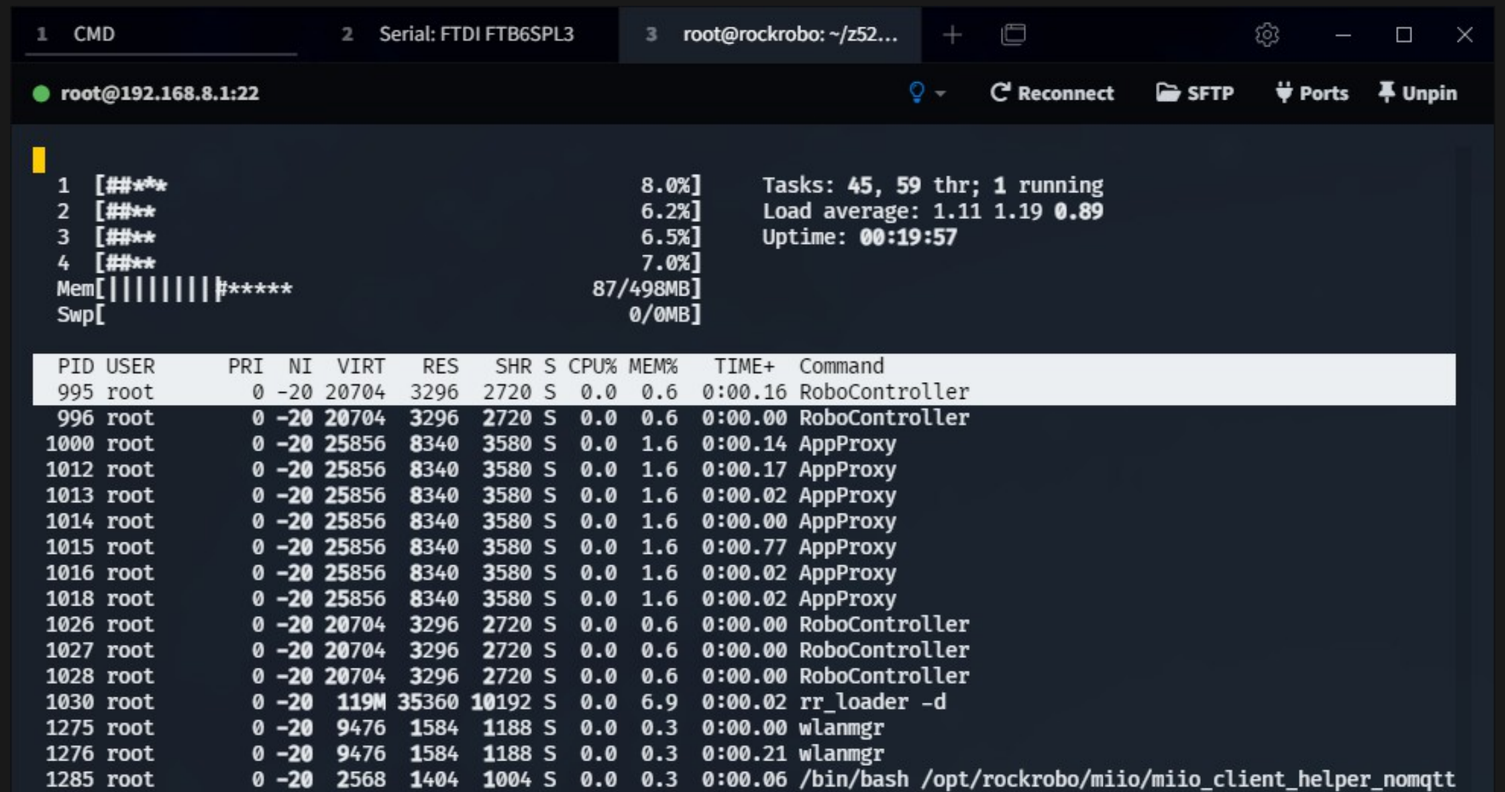
Thesis B | Results

Thesis B - Firmware dump (dd) for offline/static analysis

Fingerprinting

Processes

Everything is running as root



Thesis B - Recovery partition manipulation (see proof of concept)

Issues, thoughts & discussions

How have manufacturers of IoT / smart home devices addressed the increasing concerns of digital privacy and product security?

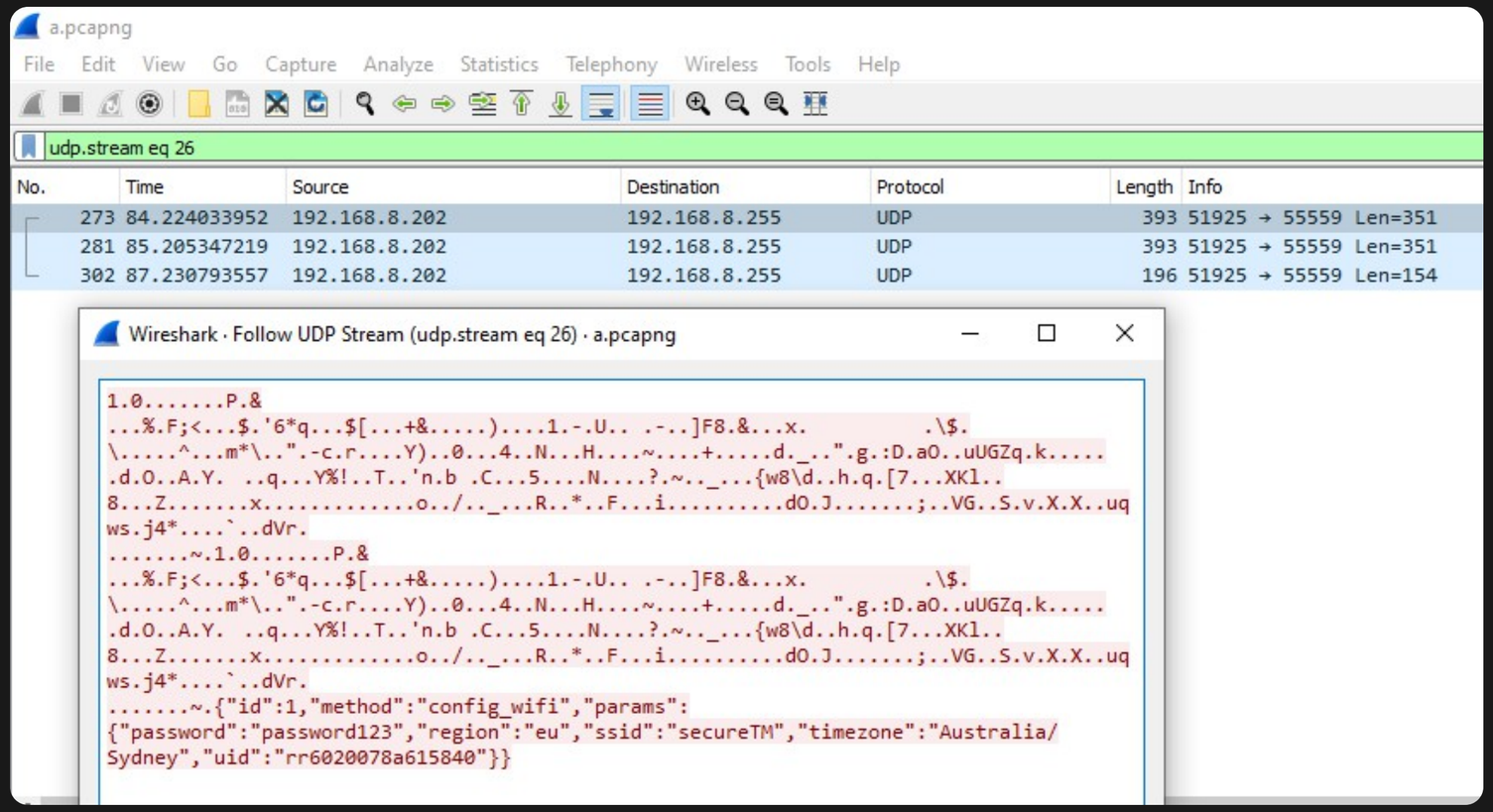
Recovery partition is modifiable

- Can be modified to contain malicious software that persists a factory reset
- Mountable - `mount /dev/mmcblk0p7 ...`
- Why? Allows easy updates of the ‘factory image’
- But the partition could somehow be encrypted

Thesis B - Capture of device traffic (port-mirroring)

Speaking of packets...

WiFi credentials in plain text during setup



Fingerprinting

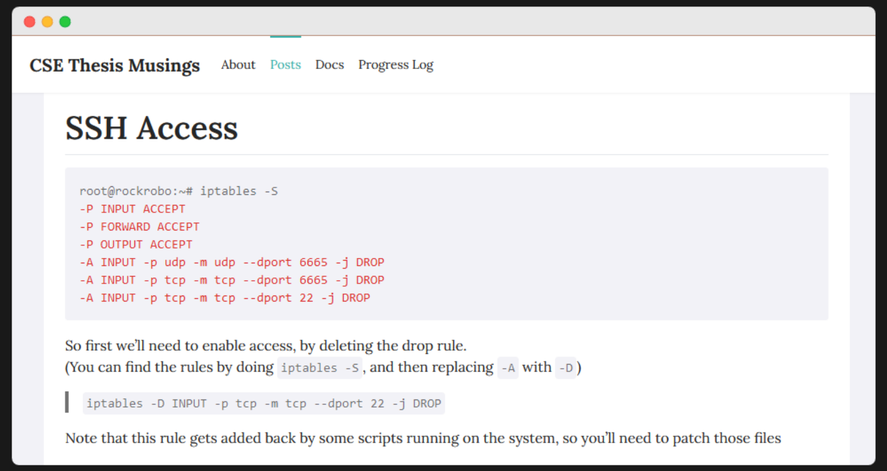
Ports

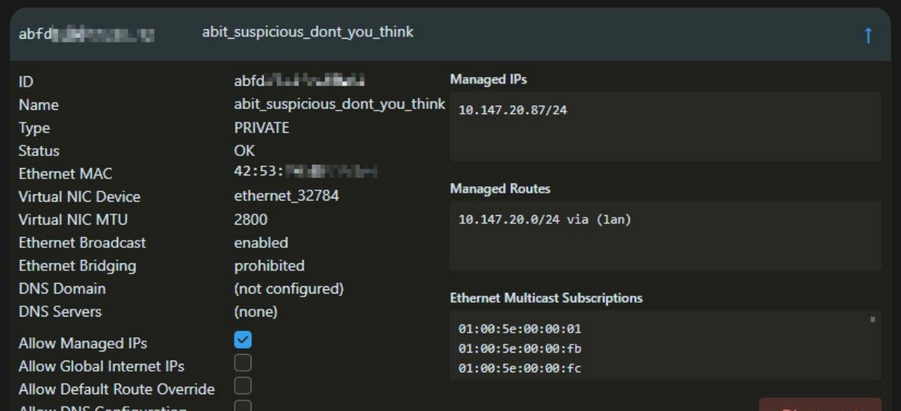
```
root@rockrobo:~# netstat -nltp
Active Internet connections (only servers)
Proto Recv-Q Send-Q Local Address           Foreign Address         State       PID/Progra
tcp        0      0 127.0.0.1:54322         0.0.0.0:*               LISTEN      991/miio_c
tcp        0      0 127.0.0.1:54323         0.0.0.0:*               LISTEN      991/miio_c
tcp        0      0 0.0.0.0:22              0.0.0.0:*               LISTEN      1644/sshd
tcp        0      0 127.0.0.1:55551         0.0.0.0:*               LISTEN      998/rriot_
tcp        0      0 0.0.0.0:6668            0.0.0.0:*               LISTEN      998/rriot_
tcp6       0      0 :::22                   :::*                    LISTEN      1644/sshd
```

`tcp/22` and `tcp/6668` are exposed

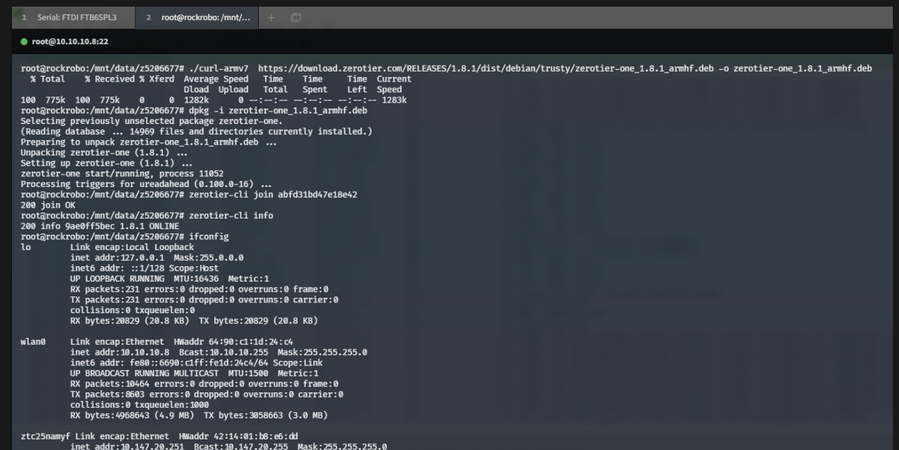
Thesis B - Remote access persistence (see proof of concept)

Going wireless - establishing SSH





- Remove iptables rule to gain access
  - (and so could an attacker)
- Can I add persistent access?
  - Yes, modify `rrwatchdoge.conf`
- Can also add remote access
  - e.g. ZeroTier



(some) Interesting Files

/var/log/apt/history.log

Installed packages that are not part of the base system

```
Start-Date: 2016-01-25  11:18:05
Commandline: /usr/bin/apt-get install rsync
Install: rsync:armhf (3.1.0-2ubuntu0.2)
End-Date: 2016-01-25  11:18:11

Start-Date: 2016-04-05  12:30:59
Commandline: /usr/bin/apt-get install ccrypt
Install: ccrypt:armhf (1.10-4)
End-Date: 2016-04-05  12:31:01

Start-Date: 2016-04-25  09:58:29
Commandline: /usr/bin/apt-get install tcpdump
Install: tcpdump:armhf (4.5.1-2ubuntu1.2), libpcap0.8:armhf (1.5.3-2, automatic)
End-Date: 2016-04-25  09:58:33
```

- Why does a vacuum cleaner need `rsync` or `tcpdump`?

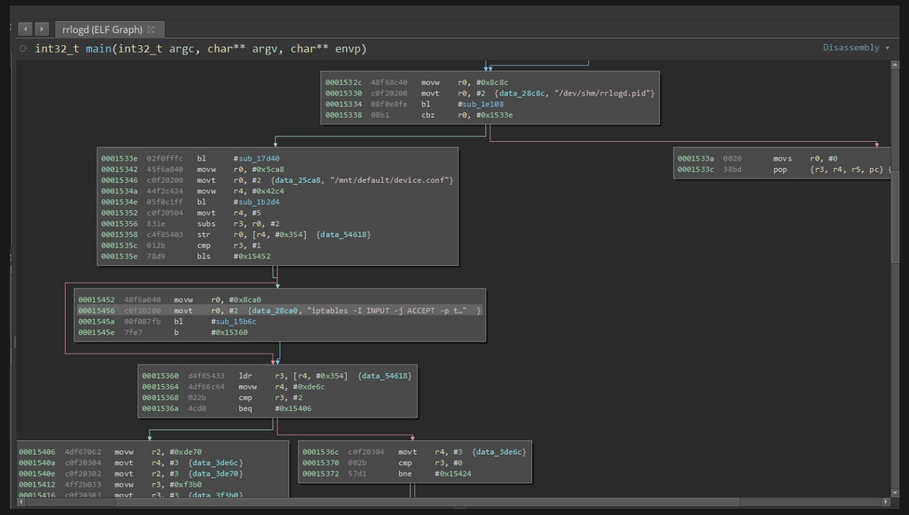
(some) Interesting Files

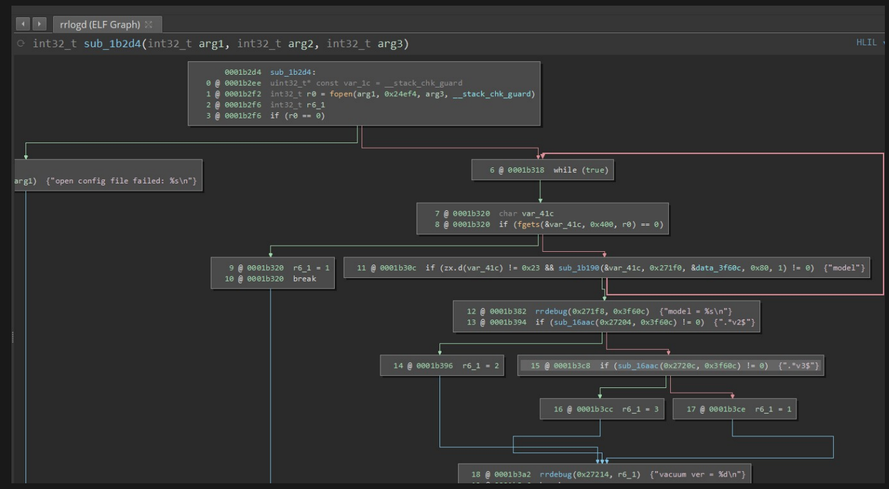
`mmcblk0p8/opt/rockrobo/rrlog/rrlogd`

Logs are encrypted at rest (after being packed)

Originally used to be a symmetric key, now using a public key

😕 Logging program has the functionality to unblock port 22?





(some) Interesting Files

mmcblk0p7/usr/bin/adbd

- Custom ADB binary
- Had a brief look (more)

```
locksec_init_key: can not find the prefix str from adb conf file, use default
locksec_init_key: can not find the suffix str from adb conf file, use default
locksec_init_serial: adb read 465 bytes from /proc/cpuinfo
locksec_init_key: locksec_init_key, rockrobo%()+-[]_8a80ab8936d76c118000:;<=>?@{}rubyde
locksec_apply_key: locksec_apply_key, erI09cyW%()+-[]_8a80ab8936d76c118000:;<=>?@{}CzD2
locksec_apply_passwd: adb source str: erI09cyW%()+-[]_8a80ab8936d76c118000:;<=>?@{}CzD2
locksec_apply_passwd: locksec_apply_passwd, passwd: 0y[ad8@w
```

Related files

- mmcblk0p6/vinda
- mmcblk0p6/adb.conf
- mmcblk0p8/var/log/upstart/adbd.log

Where we left off

From Thesis B (security)

- Finish analysing firmware binaries
- Comparing files against the stock Ubuntu OS
- Check if an IPv6 address is assigned (hence SSH)
  - ans: no.

From Thesis C (privacy)

- LAN/WAN traffic analysis
  - Look at network behaviour
  - Hook into transmit and receive functions (pre-encrypt / post-decrypt)
- Update to latest version (and hope we don't get locked out)
  - disclaimer: we got locked out. hahah….
  - Compare file changes
- Factory reset device, check for remnant files

Firmware Comparison

```
$> cat /etc/OS_VERSION
ro.product.device=MI1558_TANOS_MP_S2020032500REL_M3.3.0_RELEASE_20200325-204847
$> #              ^^^^^^           ^^^^^^^^
$> #              \/\\//           \\\\////
$> #          Xiaomi v01.15.58  25th March 2020
$> #
```

Aside

- The Roborock S6 was released in June 2019
- The unit I have was manufactured June 2020
  - My unit has a newer base firmware (25th March 2020)
- Note the presence of “MI” at the start of the product string

Firmware Comparison

Stock Ubuntu 14.04.3 LTS

Performed a `diff` check against the Ubuntu 14.04.3 Core LTS (armhf) OS.

- All binaries present on the device matched, except for `ntpdate` (synchronise computer time via NTP)
- Still functionally equivalent

Firmware Comparison

A new firmware

```
-ro.product.device=MI1558_TANOS_MP_S2020032500REL_M3.3.0_RELEASE_20200325-204847
+ro.product.device=TANOS_V2902-2022042802REL_M3.5.8_T4.1.4-2_RELEASE_20220428-202811
-ro.build.display.id=TANOS_MP_R16_RELEASE_20200325-204847
+ro.build.display.id=TANOS_MP_R16_RELEASE_20220428-202811
 ro.sys.cputype=R16.STM32.A3.G1
-ro.build.version.release=1558
+ro.build.version.release=V2902
-ro.build.date.utc=1585140527
+ro.build.date.utc=1651148891
```

The update process performed several incremental updates..
finally updating to v02.29.02 (28th April 2022)

Firmware Comparison

The Official Changelog

```
> 01.17.08 (17th April 2020)
- Supports multi-floor map saving and robot knows which floor it is
- Update to new structured SLAM algorithm to make map more reliable
- Support customised room cleaning sequence
- Support no-mop zone

> 01.19.98 (9th June 2020)
* Improvised Wi-Fi Easy Connect
* overall improvements
* bug fixes
* UX fixes

> 01.20.76 (23rd June 2020)
* Obstacle avoidance enhancements
* Bug fixes and UI optimisation

> probably more updates (got locked out)

> 02.29.02 (28th April 2022)
* Optimized the quick mapping experience
```

Firmware Comparison

The Changelog I Actually Care About

```
> 01.17.08 (17th April 2020)
* /opt/rockrobo/watchdog/WatchDoge iptables drop SSH
* /opt/rockrobo/rrlog/rrlogd iptables drop SSH
* Utilities change to busybox
* SSH server changed to dropbear
* /opt/rockrobo/rriot/rriot_rr added (but not enabled)

> 01.19.98 (9th June 2020)
* Serial handler changed to /sbin/rr_login

> 01.20.76 (23rd June 2020)
-

> probably more updates (got locked out)

> 02.29.02 (28th April 2022)
* /opt/rockrobo/rriot/rriot_rr enabled
```

Firmware Comparison

Getting locked out - `rr_login`

```
1 ...
2 * /opt/rockrobo/rriot/rriot_rr added (but not enabled)
3
4 > 01.19.98 (9th June 2020)
5 * Serial handler changed to /sbin/rr_login
6
7 > 01.20.76 (23rd June 2020)
8 -
9 ...
```

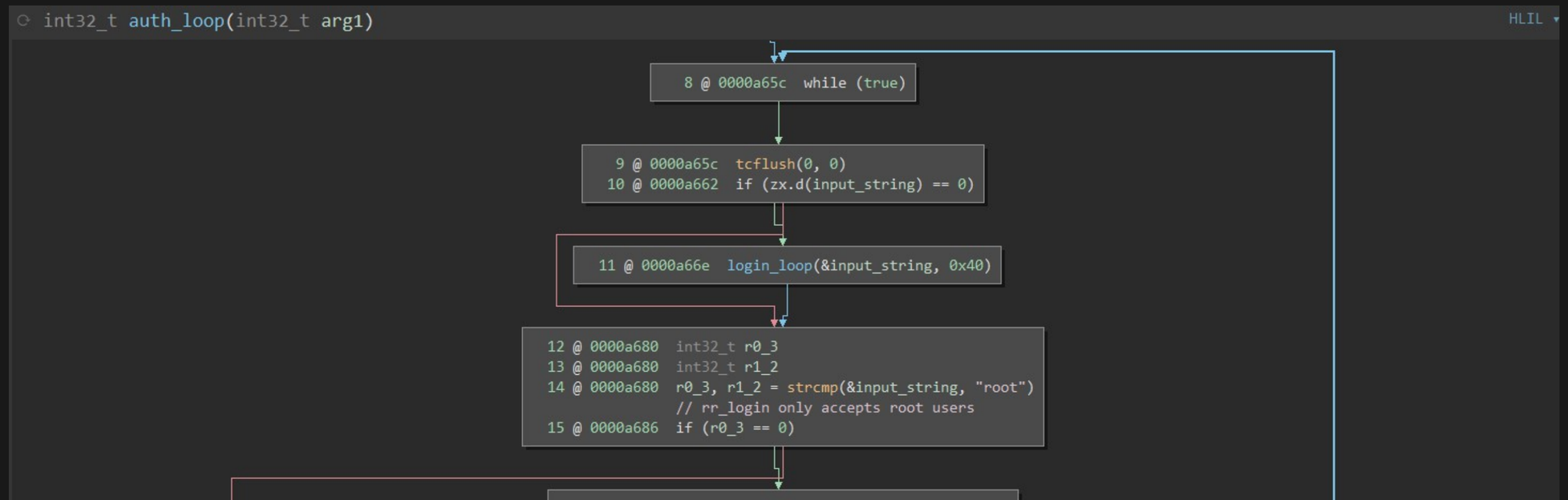
After the v01.19.98 update, serial shell access was denied, uh oh!

Firmware Comparison

Lockdown: Shell

- Serial handler no longer uses `getty`
  - Now uses modified version called `rr_login`
- OpenSSH server was replaced with modified version of `dropbear`

Both only allow login as the `root` user



Firmware Comparison

Lockdown: Authentication

The `vinda` file is no longer used for auth!

Login attempts now verify against

- `[mmcblk0p6]/shadow`
- `[mmcblk0p6]/shadow.sign`.

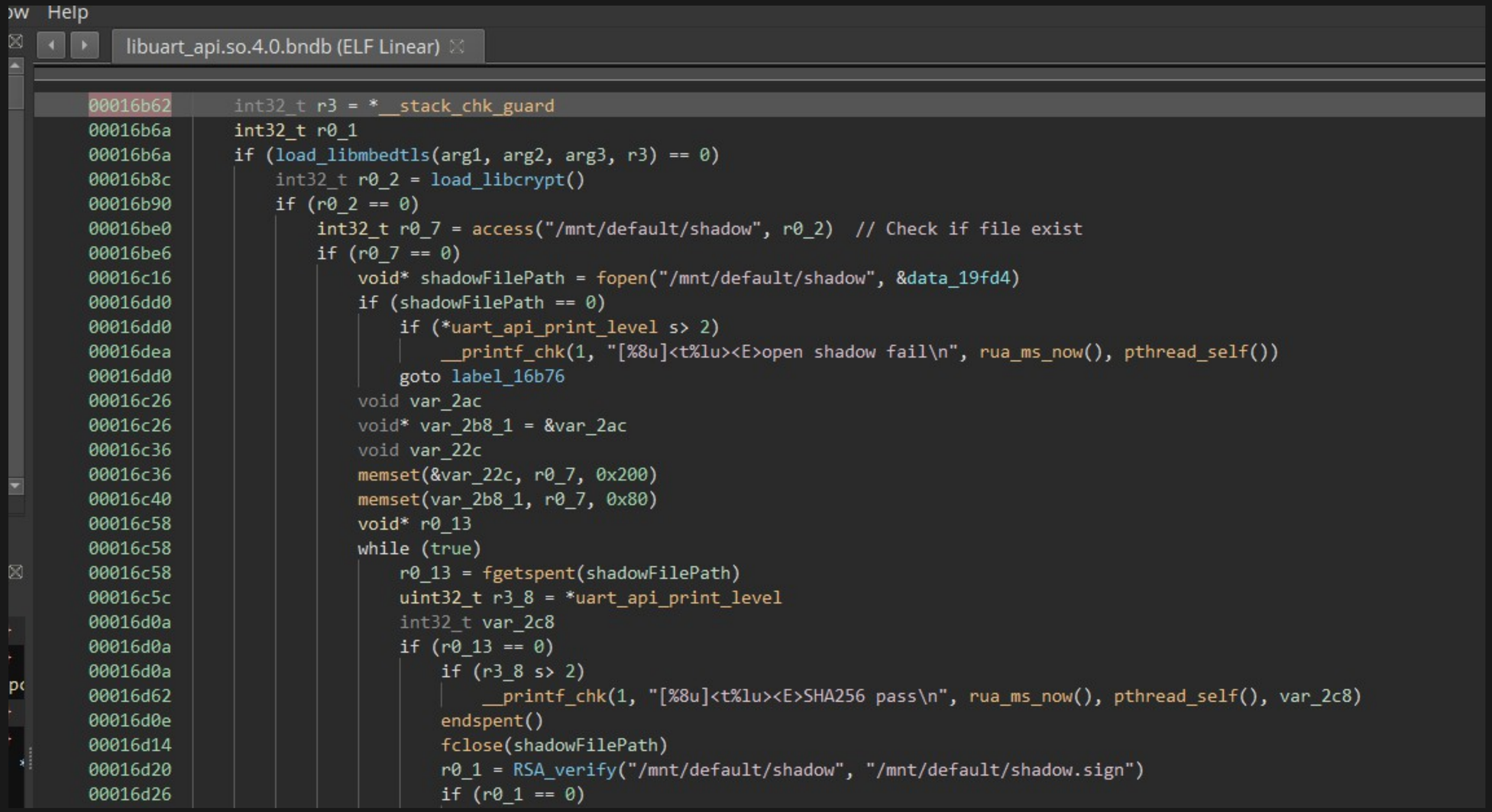
> *But these files don't exist on my device…*

Affected: `rr_login` (serial), `dropbear` (SSH), `adbd` (USB)

Fix
(1) Enter bootloader and force entrypoint to a shell
(2) Patch `/etc/inittab` to revert back to a normal login shell

Firmware Comparison

Lockdown: Authentication (`verify_shadow`)

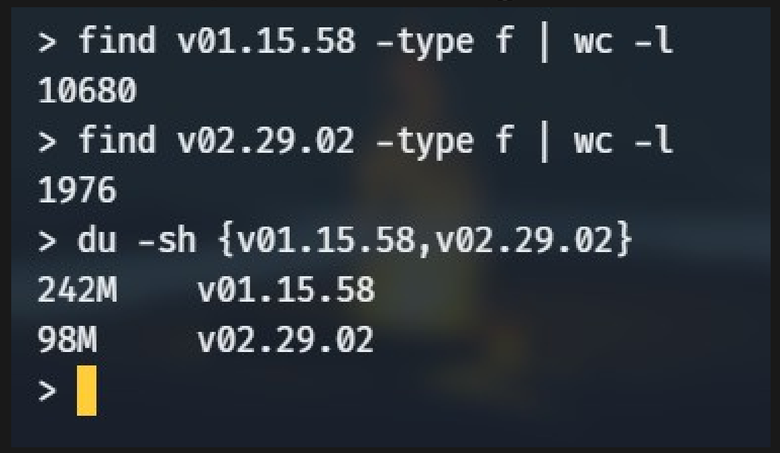


Firmware Comparison

Lockdown: Authentication (SSH auth attempt trace with `strace`)

Firmware Comparison

System Changes

- Are we still using Ubuntu?
  - Maybe?
  - `apt-get` and `dpkg` removed
- Lots of tools were replaced with BusyBox (v1.24.1)
  - Also a space-saving measure
  - 

- Effectively now running embedded Linux

Download git diff

Firmware Comparison

Lockdown: Firewall

- There are now `ip6tables` rules to drop all packets
  - Apps also no longer perform IPv6 (AAAA) DNS requests

- Processes have calls to reinstate dropping SSH access
  - `rrlogd` now drops access on bad version match
    - (previously *only* allowed access on correct version match)
  - `WatchDoge` immediately drops access on start

Firmware Comparison

`rrlogd` and `wlanmgr`

`wlanmgr` now has the functionality to call `tcpdump`

`rrlogd` will upload the following

Content	Description
`/etc/resolv.conf`	DNS resolvers
`netstat -anp`	All sockets and their PIDs
`ifconfig`	Network interface status
PCAP	Packet capture

File Persistence (Upgrade and Reset)

Test untouched directories during a factory reset and firmware update

Reset Persistent

- [mmcblk0p11] `/mnt/reserve`

Upgrade Persistent

- [mmcblk0p1] `/mnt/data`
- [mmcblk0p11] `/mnt/reserve`

Partition	Purpose
`mmcblk0p1`	Device registration, WiFi, map data, logs
`mmcblk0p11`	Statistics, calibration data

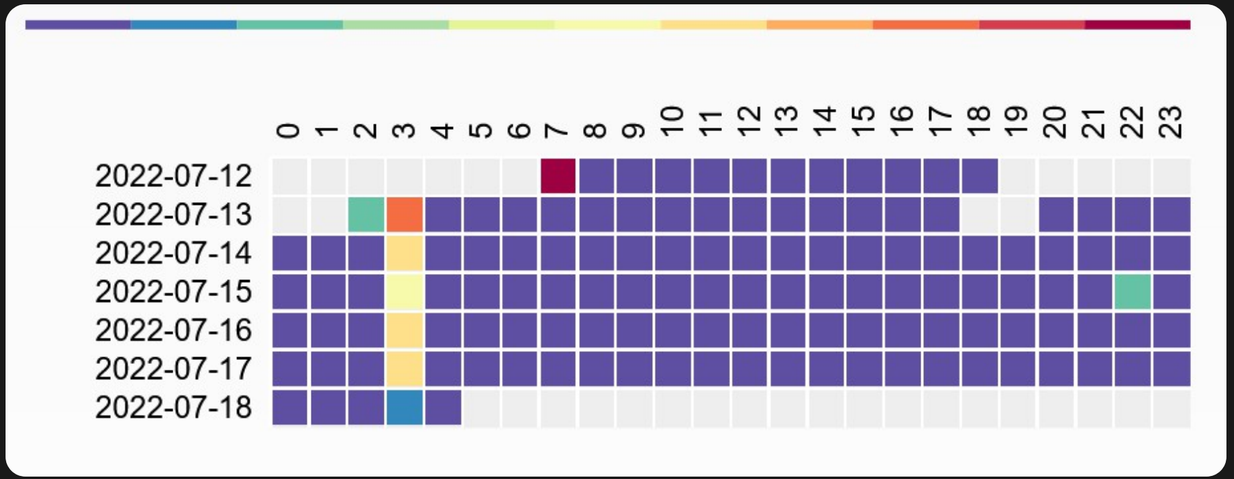
Network Inspection

Setup

- Isolated sandbox network
  - Router, switch, access point, Vacuum Cleaner
  - Additional NUC to simulate peer data
- Captured packets (unattended) for a month
- Captured packets (interactive) for several sessions
- Filter out network noise
- Compare network activity between old and new firmware

Network Inspection

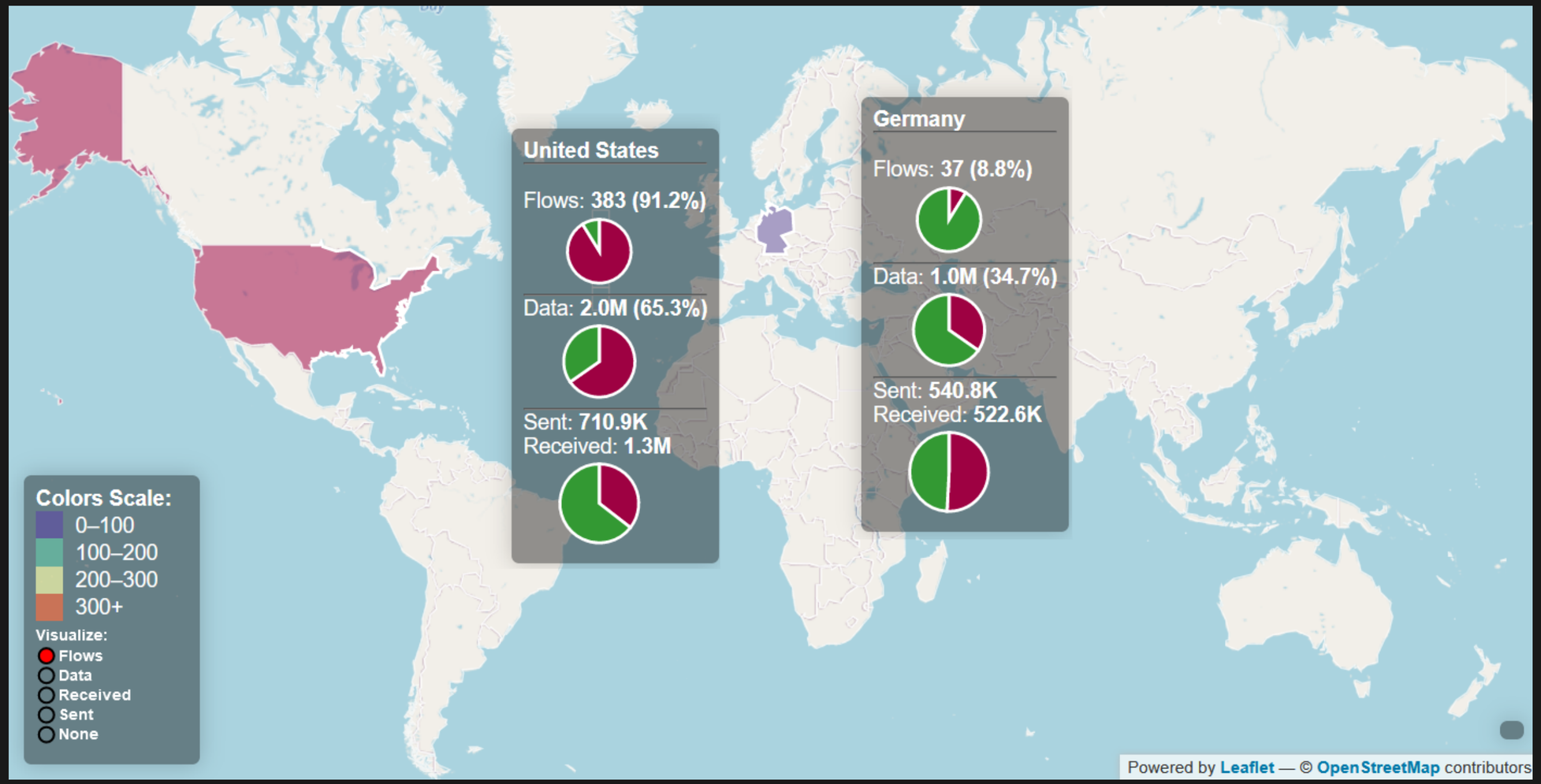
Network Behaviour (FW v02.29.02) (exc FDS) (1 week)



Endpoint	Protocol	Description
`m2.tuyaeu.com`	MQTT	Inbound requests
`a2.tuyaeu.com`	HTTPS	Outbound requests
`awsde0.fds.api.xiaomi.com`	FDS	Logs upload

Network Inspection

Network Geomap (FW v02.29.02) (exc FDS) (1 week)



Network Inspection

Observations

- Local traffic - DHCP (5min), Tuya Discovery (5s)
- Connections to America, Germany, China
  - America, Germany - AWS - `fds`, `a2`, `ms`, `m2`
  - China - Mi IO Cloud (v01.15.58 only)
- Increased network activity at 3am
  - 3am AEDT is 12am in Beijing
  - Connections are being established - possible timeout/reconnect

Changes

- New FW uses `m2.tuyaeu.com` instead of `ms.tuyaeu.com`
- New FW no longer polls `xx.ot[t].io.mi.com`

Network Inspection

What's in the packet?

Most (if not all) communications were encrypted

~~1. Break the encryption~~ too much effort

1. Hook into the pre-encryption / post-decryption stages

```
/* Send test to 10.251.252.253:28422 */
void hook(void* data, uint data_len) {
  int sock = create_udp4_connection(IPV4_ADDR(10,251,252,253), 28422);
  send(sock, data, data_len, 0);
}
```

2. Just look at the app logs*

*: Application logs are less verbose in newer FW versions
However they communicate the same way as the older FW versions

Network Inspection

Example MQTT conversation (`{m2,ms}.tuyaeu.com`)

Server Request

```
{
  "id": 889,
  "method": "get_prop",
  "params": [ "get_status" ]
}
```

Device Response

```
{
  "id": 889,
  "result": [{
    "msg_ver": 2,
    "msg_seq": 275,
    "state": 8,
    "battery": 100,
    "clean_time": 0,
    "clean_area": 0,
    "error_code": 3,
    "map_present": 1,
    "in_cleaning": 0,
    "in_returning": 0,
```

Network Inspection

Example Control conversation (`a2.tuyaeu.com`)

Device Request

```
HTTP POST
https://a2.tuyaeu.com/d.json?a=tuya.device.timer.count&devId=...&et=1&t=...&v=4.0&sign=

{"devId":"...","lastFetchTime":"0","t":1657046157}
```

Server Response

```
{
  "result": {
    "devId": "...",
    "count": 0,
    "lastFetchTime": 0
  },
  "t": 1657046159,
  "success": true
}
```

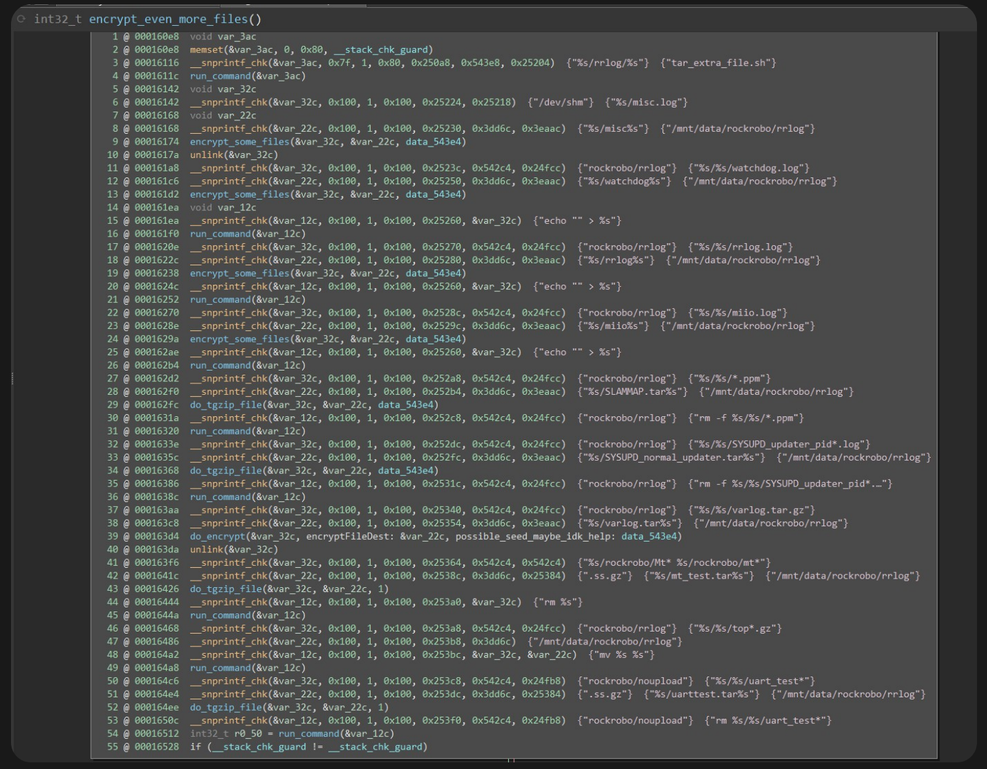
Network Inspection

Log data (Xiaomi FDS)

Data is compressed and encrypted

- `/mnt/data/rrlog/**`
- `/dev/shm/**`
- `/mnt/reserve/...`

- App logs
- Updater logs
- ‘Anonymous’ statistics
- `wlanmgr tcpdump`



```
int32_t encrypt_even_more_files()
1 @ 000160e8  void var_3ac
2 @ 000160e8  memset(&var_3ac, 0, 0x80, __stack_chk_guard)
3 @ 00016116  __snprintf_chk(&var_3ac, 0x7f, 1, 0x80, 0x250a8, 0x543e8, 0x25204)  {"%s/rrlog/%s"}  {"tar_extra_file.sh"}
4 @ 0001611c  run_command(&var_3ac)
5 @ 00016142  void var_32c
6 @ 00016142  __snprintf_chk(&var_32c, 0x100, 1, 0x100, 0x25224, 0x25218)  {"/dev/shm"}  {"%s/misc.log"}
7 @ 00016168  void var_22c
8 @ 00016168  __snprintf_chk(&var_22c, 0x100, 1, 0x100, 0x25230, 0x3dd6c, 0x3eaac)  {"%s/misc%s"}  {"/mnt/data/rockrobo/rrlog"}
9 @ 00016174  encrypt_some_files(&var_32c, &var_22c, data_543e4)
10 @ 0001617a  unlink(&var_32c)
11 @ 000161a8  __snprintf_chk(&var_32c, 0x100, 1, 0x100, 0x2523c, 0x542c4, 0x24fcc)  {"rockrobo/rrlog"}  {"%s/%s/watchdog.log"}
12 @ 000161c6  __snprintf_chk(&var_22c, 0x100, 1, 0x100, 0x25250, 0x3dd6c, 0x3eaac)  {"%s/watchdog%s"}  {"/mnt/data/rockrobo/rrlog"}
13 @ 000161d2  encrypt_some_files(&var_32c, &var_22c, data_543e4)
14 @ 000161ea  void var_12c
15 @ 000161ea  __snprintf_chk(&var_12c, 0x100, 1, 0x100, 0x25260, &var_32c)  {"echo "" > %s"}
16 @ 000161f0  run_command(&var_12c)
17 @ 0001620e  __snprintf_chk(&var_32c, 0x100, 1, 0x100, 0x25270, 0x542c4, 0x24fcc)  {"rockrobo/rrlog"}  {"%s/%s/rrlog.log"}
18 @ 0001622c  __snprintf_chk(&var_22c, 0x100, 1, 0x100, 0x25280, 0x3dd6c, 0x3eaac)  {"%s/rrlog%s"}  {"/mnt/data/rockrobo/rrlog"}
19 @ 00016238  encrypt_some_files(&var_32c, &var_22c, data_543e4)
20 @ 0001624c  __snprintf_chk(&var_12c, 0x100, 1, 0x100, 0x25260, &var_32c)  {"echo "" > %s"}
21 @ 00016252  run_command(&var_12c)
22 @ 00016270  __snprintf_chk(&var_32c, 0x100, 1, 0x100, 0x2528c, 0x542c4, 0x24fcc)  {"rockrobo/rrlog"}  {"%s/%s/miio.log"}
23 @ 0001628e  __snprintf_chk(&var_22c, 0x100, 1, 0x100, 0x2529c, 0x3dd6c, 0x3eaac)  {"%s/miio%s"}  {"/mnt/data/rockrobo/rrlog"}
24 @ 0001629a  encrypt_some_files(&var_32c, &var_22c, data_543e4)
25 @ 000162ae  __snprintf_chk(&var_12c, 0x100, 1, 0x100, 0x25260, &var_32c)  {"echo "" > %s"}
26 @ 000162b4  run_command(&var_12c)
27 @ 000162d2  __snprintf_chk(&var_32c, 0x100, 1, 0x100, 0x252a8, 0x542c4, 0x24fcc)  {"rockrobo/rrlog"}  {"%s/%s/*.ppm"}
28 @ 000162f0  __snprintf_chk(&var_22c, 0x100, 1, 0x100, 0x252b4, 0x3dd6c, 0x3eaac)  {"%s/SLAMMAP.tar%s"}  {"/mnt/data/rockrobo/rrlog"}
29 @ 000162fc  do_tgzip_file(&var_32c, &var_22c, data_543e4)
30 @ 0001631a  __snprintf_chk(&var_12c, 0x100, 1, 0x100, 0x252c8, 0x542c4, 0x24fcc)  {"rockrobo/rrlog"}  {"rm -f %s/%s/*.ppm"}
31 @ 00016320  run_command(&var_12c)
32 @ 0001633e  __snprintf_chk(&var_32c, 0x100, 1, 0x100, 0x252dc, 0x542c4, 0x24fcc)  {"rockrobo/rrlog"}  {"%s/%s/SYSUPD_updater_pid*.log"}
33 @ 0001635c  __snprintf_chk(&var_22c, 0x100, 1, 0x100, 0x252fc, 0x3dd6c, 0x3eaac)  {"%s/SYSUPD_normal_updater.tar%s"}  {"/mnt/data/rockrobo/rrlog"}
34 @ 00016368  do_tgzip_file(&var_32c, &var_22c, data_543e4)
35 @ 00016386  __snprintf_chk(&var_12c, 0x100, 1, 0x100, 0x2531c, 0x542c4, 0x24fcc)  {"rockrobo/rrlog"}  {"rm -f %s/%s/SYSUPD_updater_pid*…"}
36 @ 0001638c  run_command(&var_12c)
37 @ 000163aa  __snprintf_chk(&var_32c, 0x100, 1, 0x100, 0x25340, 0x542c4, 0x24fcc)  {"rockrobo/rrlog"}  {"%s/%s/varlog.tar.gz"}
38 @ 000163c8  __snprintf_chk(&var_22c, 0x100, 1, 0x100, 0x25354, 0x3dd6c, 0x3eaac)  {"%s/varlog.tar%s"}  {"/mnt/data/rockrobo/rrlog"}
39 @ 000163d4  do_encrypt(&var_32c, encryptFileDest: &var_22c, possible_seed_maybe_idk_help: data_543e4)
40 @ 000163da  unlink(&var_32c)
41 @ 000163f6  __snprintf_chk(&var_32c, 0x100, 1, 0x100, 0x25364, 0x542c4, 0x542c4)  {"%s/rockrobo/Mt* %s/rockrobo/mt*"}
42 @ 0001641c  __snprintf_chk(&var_22c, 0x100, 1, 0x100, 0x2538c, 0x3dd6c, 0x25384)  {".ss.gz"}  {"%s/mt_test.tar%s"}  {"/mnt/data/rockrobo/rrlog"}
43 @ 00016426  do_tgzip_file(&var_32c, &var_22c, 1)
44 @ 00016444  __snprintf_chk(&var_12c, 0x100, 1, 0x100, 0x253a0, &var_32c)  {"rm %s"}
45 @ 0001644a  run_command(&var_12c)
46 @ 00016468  __snprintf_chk(&var_32c, 0x100, 1, 0x100, 0x253a8, 0x542c4, 0x24fcc)  {"rockrobo/rrlog"}  {"%s/%s/top*.gz"}
47 @ 00016486  __snprintf_chk(&var_22c, 0x100, 1, 0x100, 0x253b8, 0x3dd6c)  {"/mnt/data/rockrobo/rrlog"}
48 @ 000164a2  __snprintf_chk(&var_12c, 0x100, 1, 0x100, 0x253bc, &var_32c, &var_22c)  {"mv %s %s"}
49 @ 000164a8  run_command(&var_12c)
50 @ 000164c6  __snprintf_chk(&var_32c, 0x100, 1, 0x100, 0x253c8, 0x542c4, 0x24fb8)  {"rockrobo/noupload"}  {"%s/%s/uart_test*"}
51 @ 000164e4  __snprintf_chk(&var_22c, 0x100, 1, 0x100, 0x253dc, 0x3dd6c, 0x25384)  {".ss.gz"}  {"%s/uarttest.tar%s"}  {"/mnt/data/rockrobo/rrlog"}
52 @ 000164ee  do_tgzip_file(&var_32c, &var_22c, 1)
53 @ 0001650c  __snprintf_chk(&var_12c, 0x100, 1, 0x100, 0x253f0, 0x542c4, 0x24fb8)  {"rockrobo/noupload"}  {"rm %s/%s/uart_test*"}
54 @ 00016512  int32_t r0_50 = run_command(&var_12c)
55 @ 00016528  if (__stack_chk_guard != __stack_chk_guard)
```

Network Inspection

Network Map

Let’s Talk Threats

Talk about threat models

-
-
-
-
-

Reset Persistence

Patch the recovery partition `mmcblk0p7`

Upgrade Persistence

https://featherbear.cc/UNSW-CSE-Thesis/posts/achieving-upgrade-persistence/

Remote Access

ZeroTier, etc

OTA Rooting

```
{
  "method": "miIO.ota",
```

Reset Persistence

Patch the recovery partition `mmcblk0p7`

Upgrade Persistence

https://featherbear.cc/UNSW-CSE-Thesis/posts/achieving-upgrade-persistence/

Remote Access

ZeroTier, etc

OTA Rooting

Security Response

https://featherbear.cc/UNSW-CSE-Thesis/posts/disclosures/ Response to disclosures tuya and roborock only have one disclosure listed on their site? Hard to find

xiaomi paper

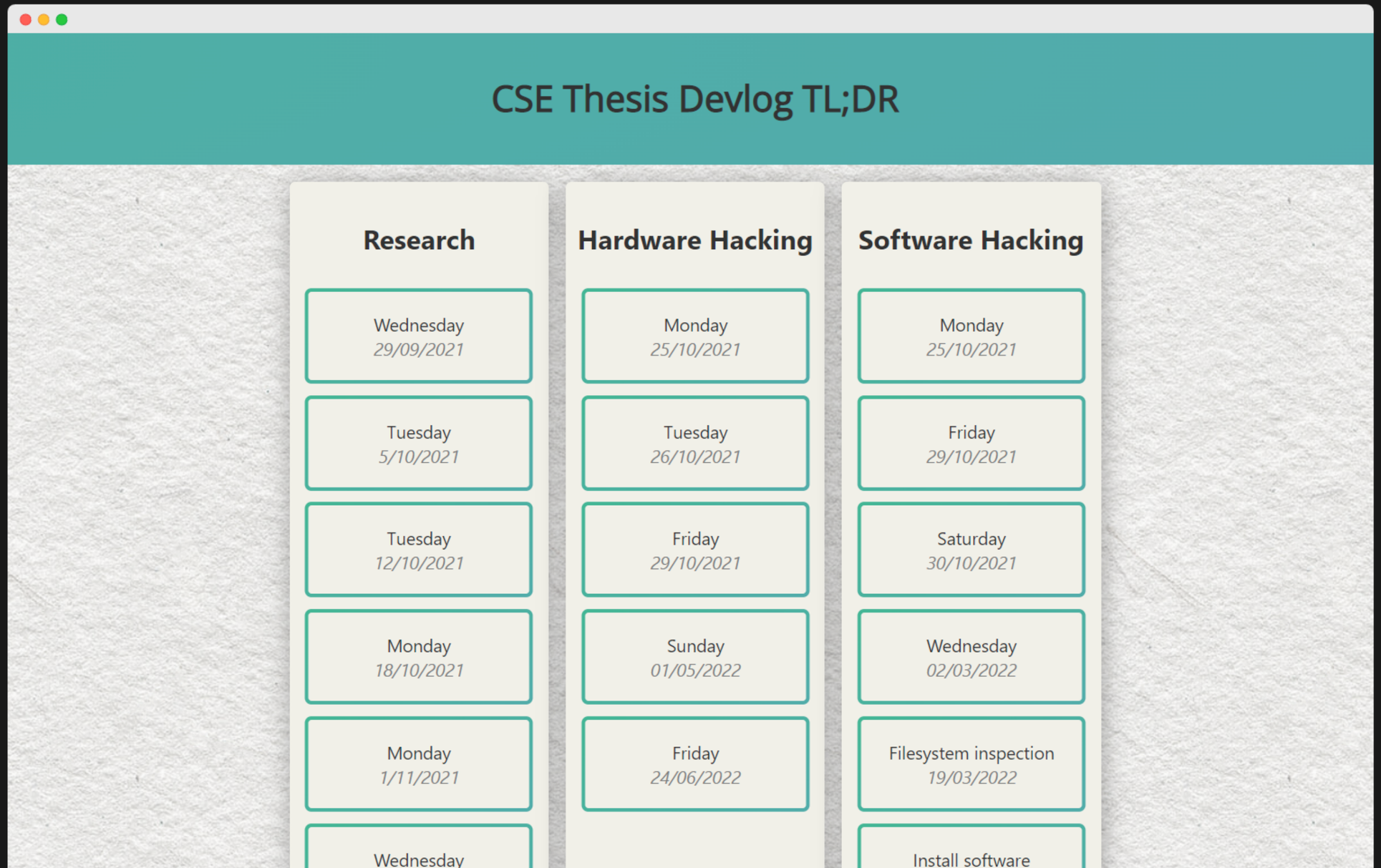
- UNSW Elec - MUD - they could do this to heighten security
  - note - doesn’t prevent them from being malicious from within their own C2 server, but will mitigate modified devices

Takeaway Summary (answer main point)

tldr Who What When Why Where How

Address the statement

Thesis in a Year



Thank You

Andrew Wong

w: featherbear.cc/UNSW-CSE-Thesis

e: andrew.j.wong@student.unsw.edu.au