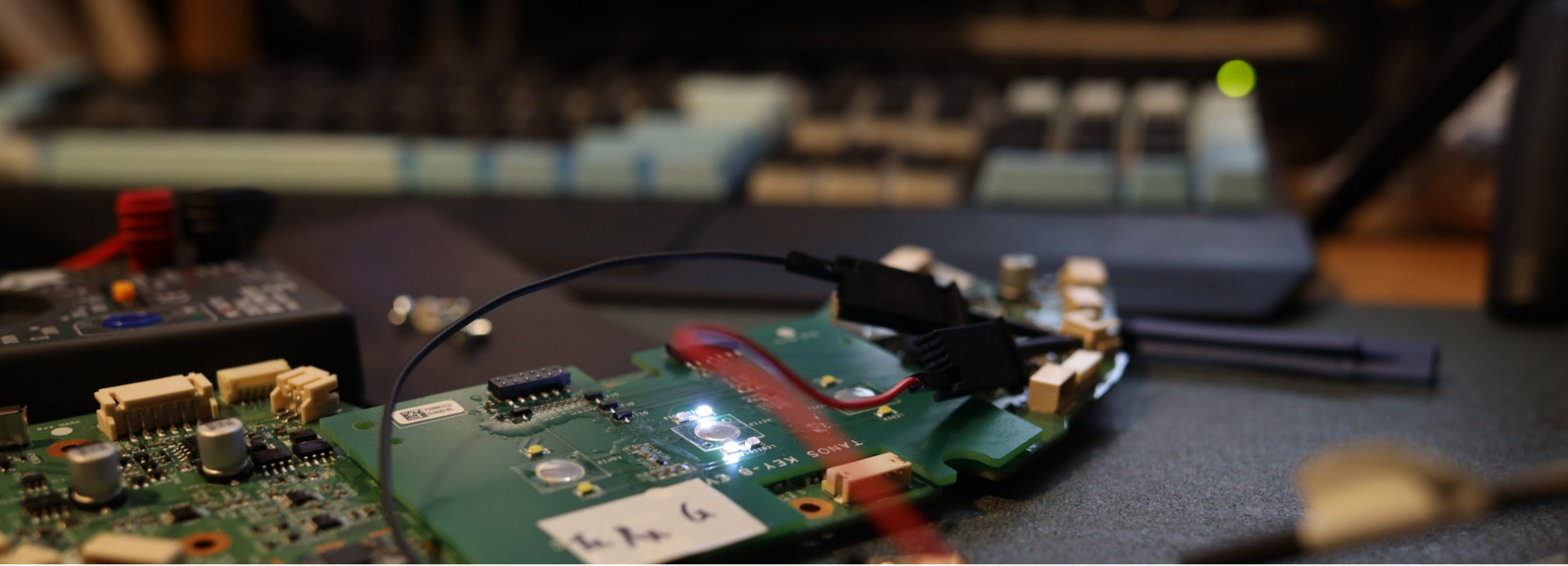


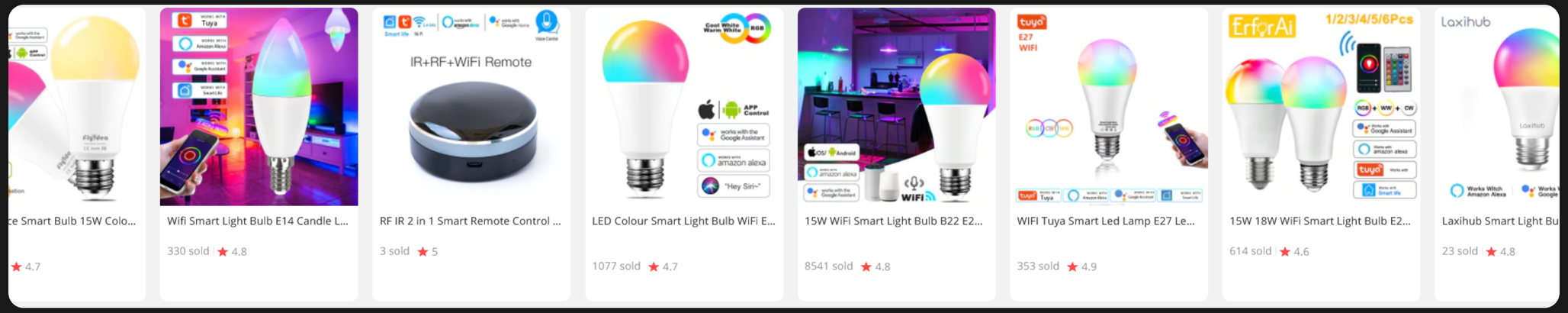
“Smart” Vacuum Cleaners

An Audit Into The Security and Integrity of IoT Systems

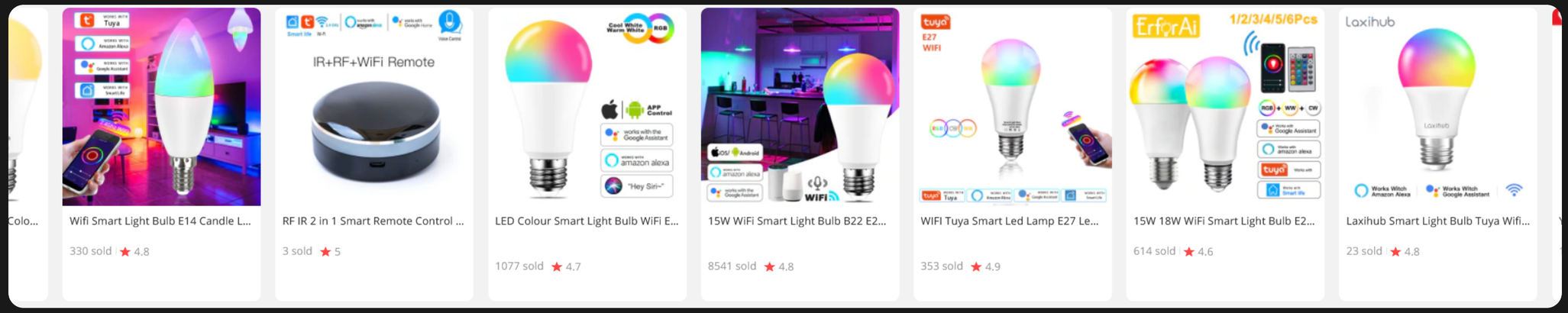
Andrew Wong | UNSW Sydney

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

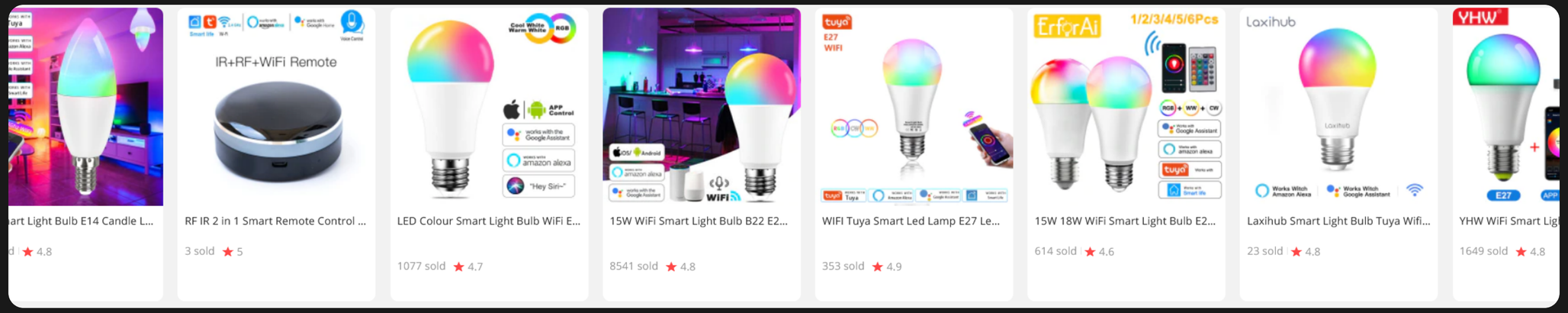
Use someone else's code

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)

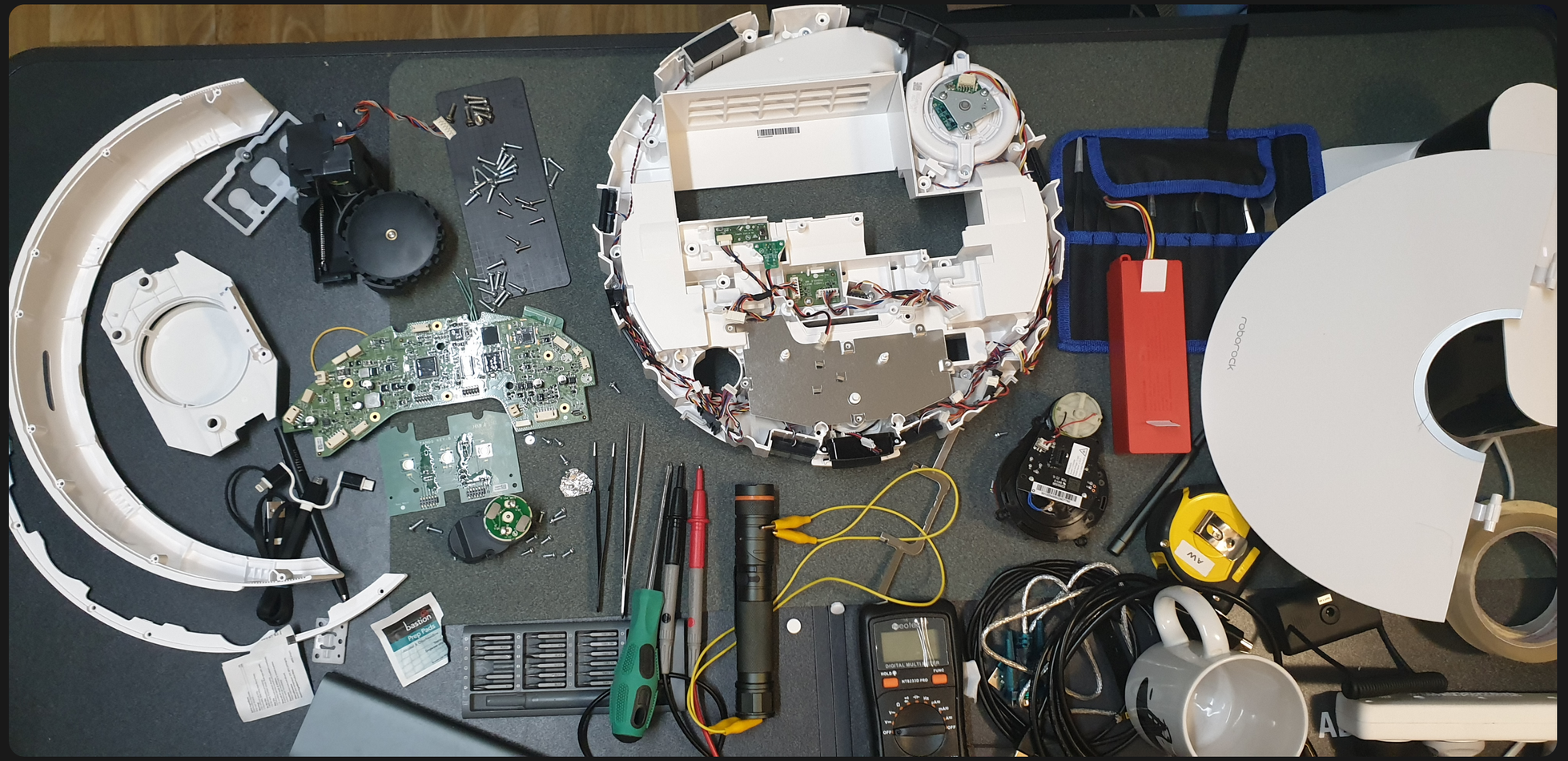
A smart vacuum cleaner, with integrations to both tuya and Mi (depending on model)

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)

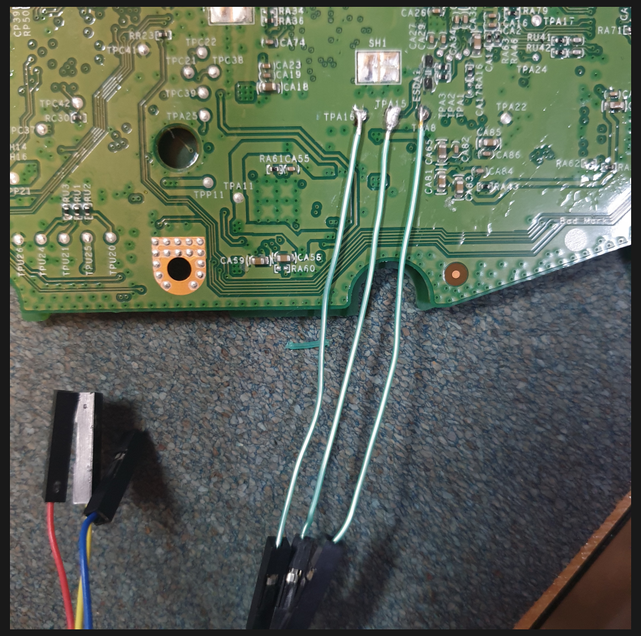


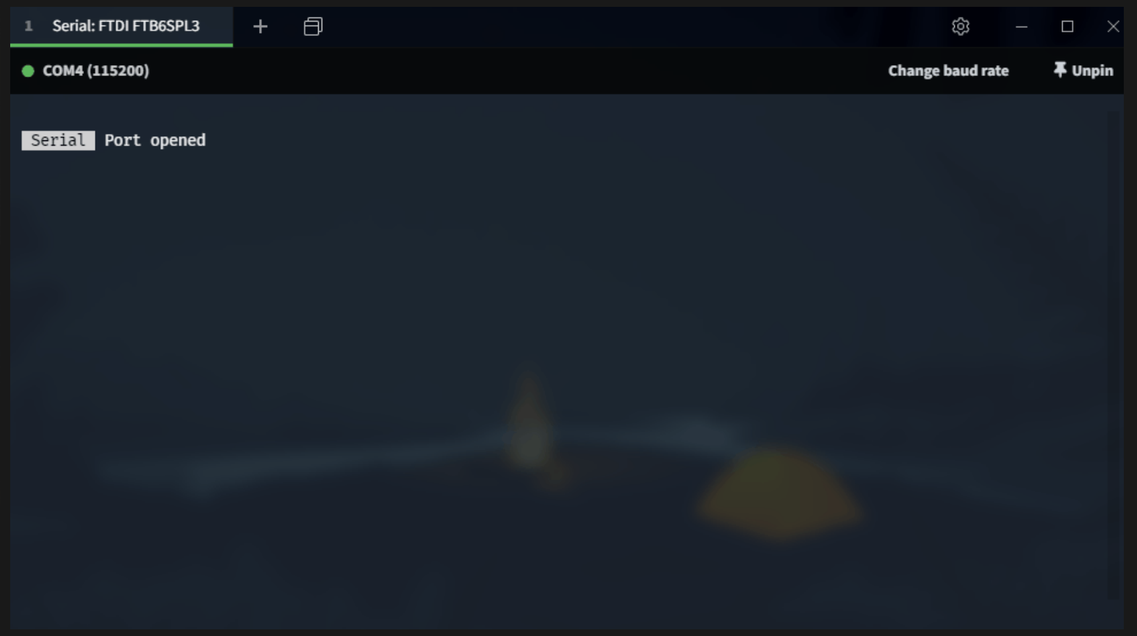
Thesis A - Found the UART pins and got some terminal

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:~#
```

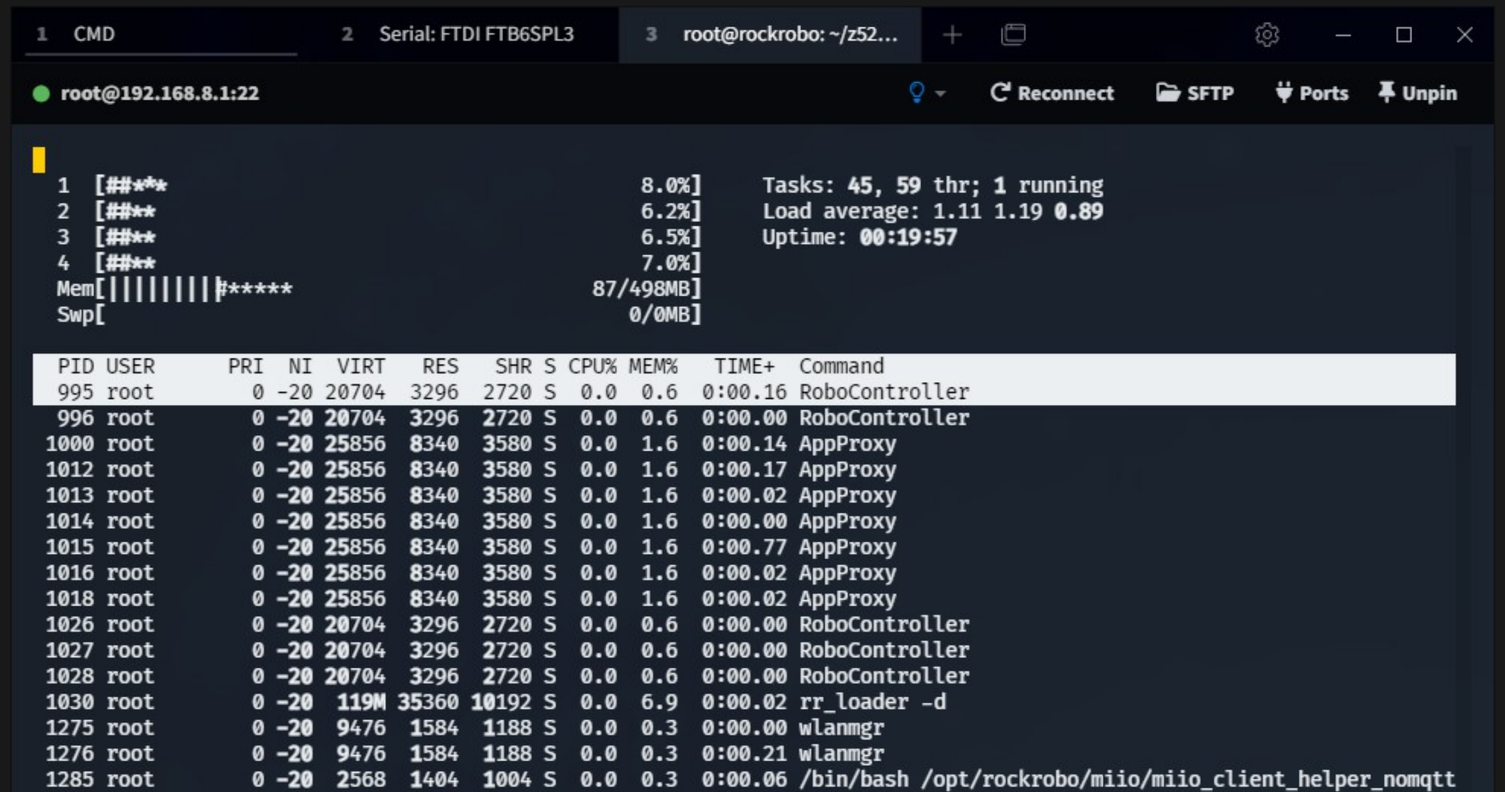
Thesis B | Results

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?

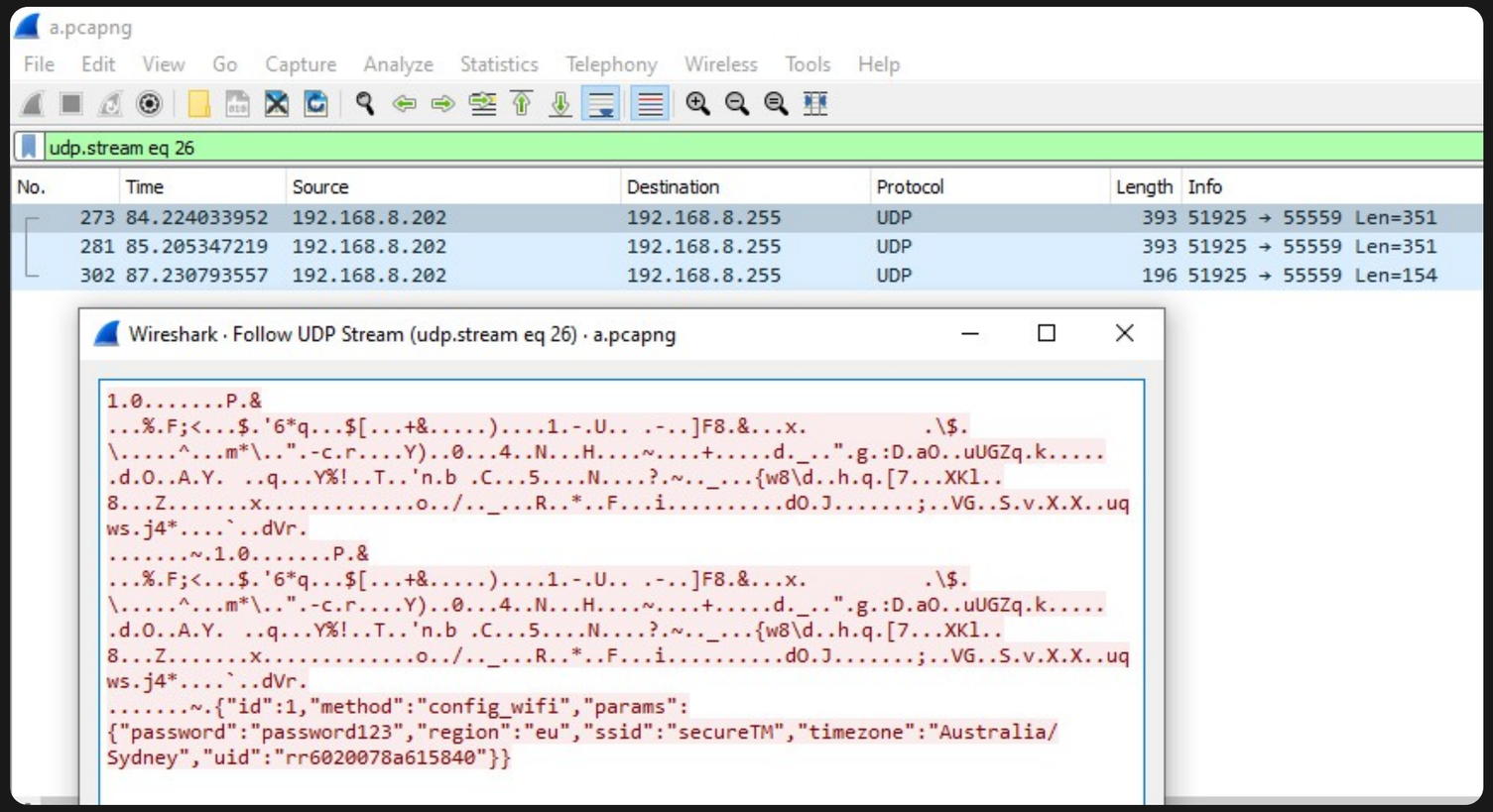
Recovery partition is modifiable

- 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

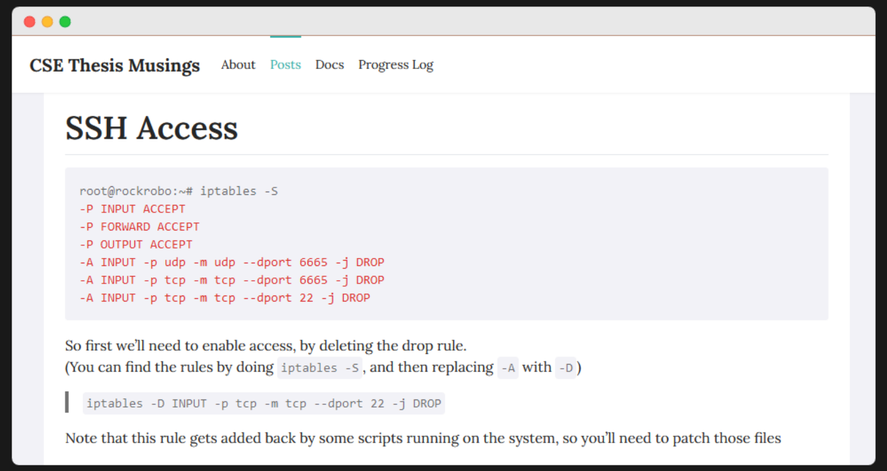
Ports

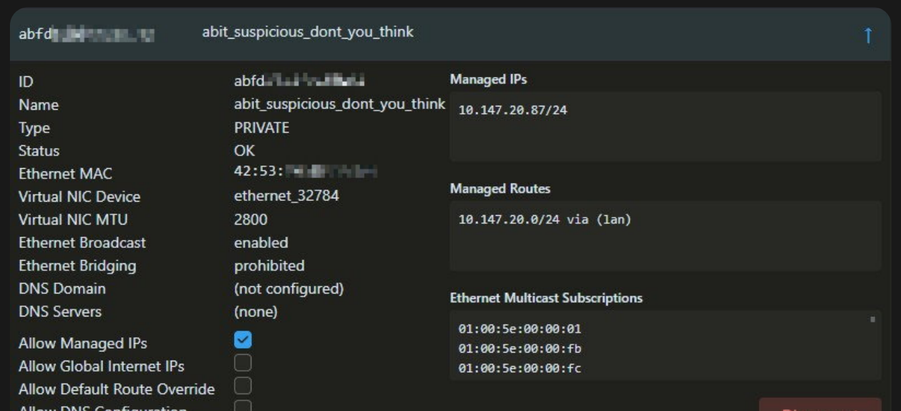
```
root@rockrobo:~# netstat -nltp
Active Internet connections (only servers)
Proto Recv-Q Send-Q Local Address           Foreign Address         State       PID/Progra
tcp        0      0 127.0.0.1:54322         0.0.0.0:*               LISTEN      991/miio_c
tcp        0      0 127.0.0.1:54323     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

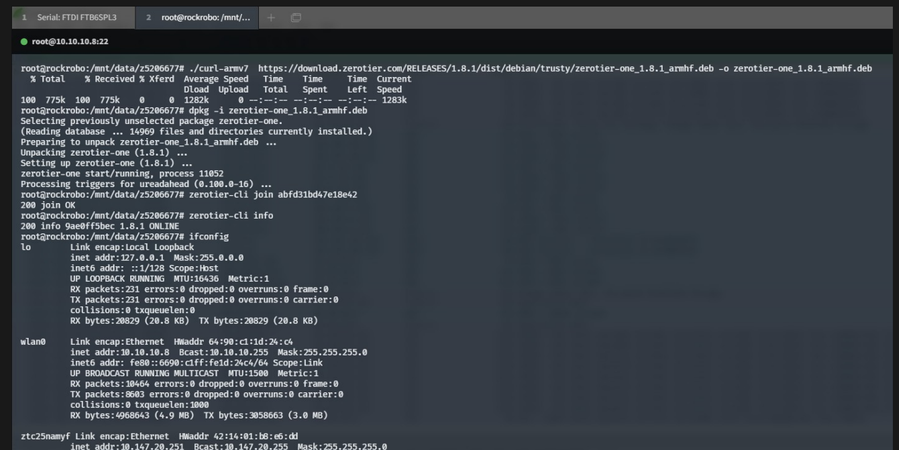
Thesis B - Remote access persistence (see proof of concept)

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`?

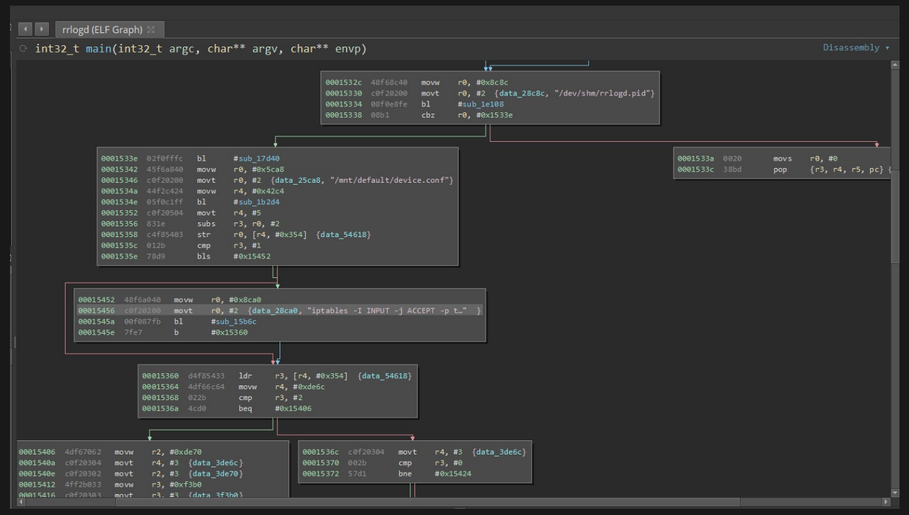
(some) Interesting Files

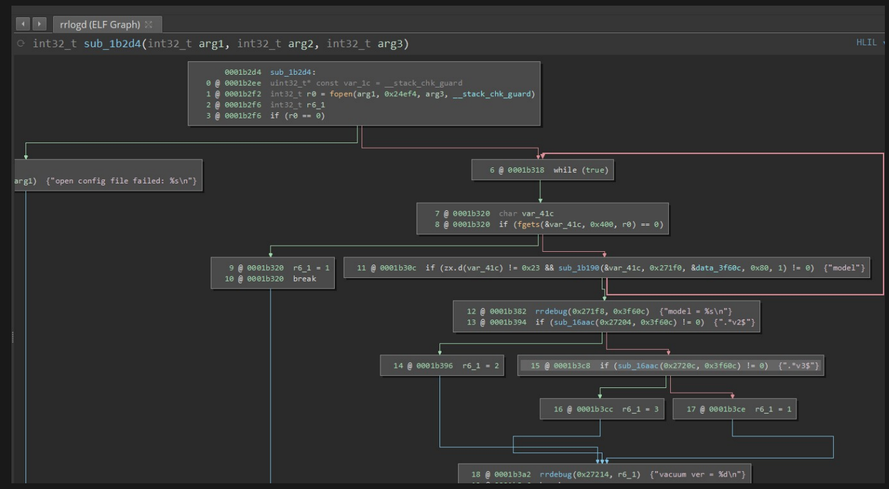
`mmcblk0p8/opt/rockrobo/rrlog/rrlogd`

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 did. hahah….
  - Compare file changes
- Factory reset device, check for remnant files

Let’s Talk Threats

Talk about threat models

-
-
-
-
-

Firmware Comparison

/etc/OS_VERSION
ro.product.device=MI1558_TANOS_MP_S2020032500REL_M3.3.0_RELEASE_20200325-204847

Notes

- The Roborock S6 was released in June 2019
- The device I was working on was manufactured June 2020
- There has since been firmware upgrades since 2019
  - As a result my device has a firmware from 25th March 2020
- Note the presence of “MI” at the start of the product string

Stock Ubuntu 14.04.3 LTS

Performed an md5 + diff between the firmware and the stock Ubuntu 14.04.3 Core LTS (armhf) firmware.

All binaries that were present on the device matched the stock firmware, except for `ntpdate` (synchronise computer time via NTP)

Whilst somewhat dissimilar in signature, still functionally equivalent.
Just has less function exports than the stock version.

Firmware Upgrade

```
-ro.product.device=MI1558_TANOS_MP_S2020032500REL_M3.3.0_RELEASE_20200325-204847
-ro.build.display.id=TANOS_MP_R16_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_20220428-202811
 ro.sys.cputype=R16.STM32.A3.G1
-ro.build.version.release=1558
-ro.build.date.utc=1585140527
+ro.build.version.release=V2902
+ro.build.date.utc=1651148891
```

Remember this?

> *Update to latest version (and hope we don't get locked out)*

no longer use vinda

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

We got locked out 😔 https://featherbear.cc/UNSW-CSE-Thesis/posts/upgraded-accessing-the-shell/

Lockdown: Admin

`[mmcblk0p6]/vinda` is no longer used!
Programs now request a verification from `[mmcblk0p6]/shadow` and `[mmcblk0p6]/shadow.sign`.

But these don’t exist on my device…

So they fail

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

System Changes

```
-aa
+Linux rockrobo 3.4.39 #1 SMP PREEMPT Thu Apr 28 20:27:25 CST 2022 armv7l GNU/Linux
```

*: Also an optimisation to reduce space

Lockdown: Shell

- Serial handler no longer uses `getty` - now a modified version called `rr_login`
- OpenSSH replaced with modified `dropbear` - `root` access only
- rr_login - root only https://featherbear.cc/UNSW-CSE-Thesis/posts/sbin-rr_login/
  - used to be getty

Lockdown: Firewall

- ipv6 blocked!
  - apps also no longer ping for AAAA records (fds)
- several processes re-run iptables block
  - rrlogd, watchdoge

Analysis of binaries Hooking into pre-encryption / post-decryption routines

The IPv6 World

No IPv6 lease was assigned Regardless, there are now `ip6tables` rules to drop all Firewall

OTA Rooting

OTA Update After 11/2019 (remember the product was release 06/2019, ours was manufactuered 06/2020) - OTA was blocked Beforehand - we could remotely root it

https://featherbear.cc/UNSW-CSE-Thesis/posts/ota-updates-blocked-as-of-late-2019/

rrlogd (RSA + AES)

rriot_rr /dev/shm/.migrate_to_rriot

encrypts the files before sending. Instead of decrypting this we can just look at the log files that it extracts

rriot_tuya - used to have `tuya_iot_impl_upload_file` function but no longer has

Threat models

talk about miIO vuln miIO ota - patched

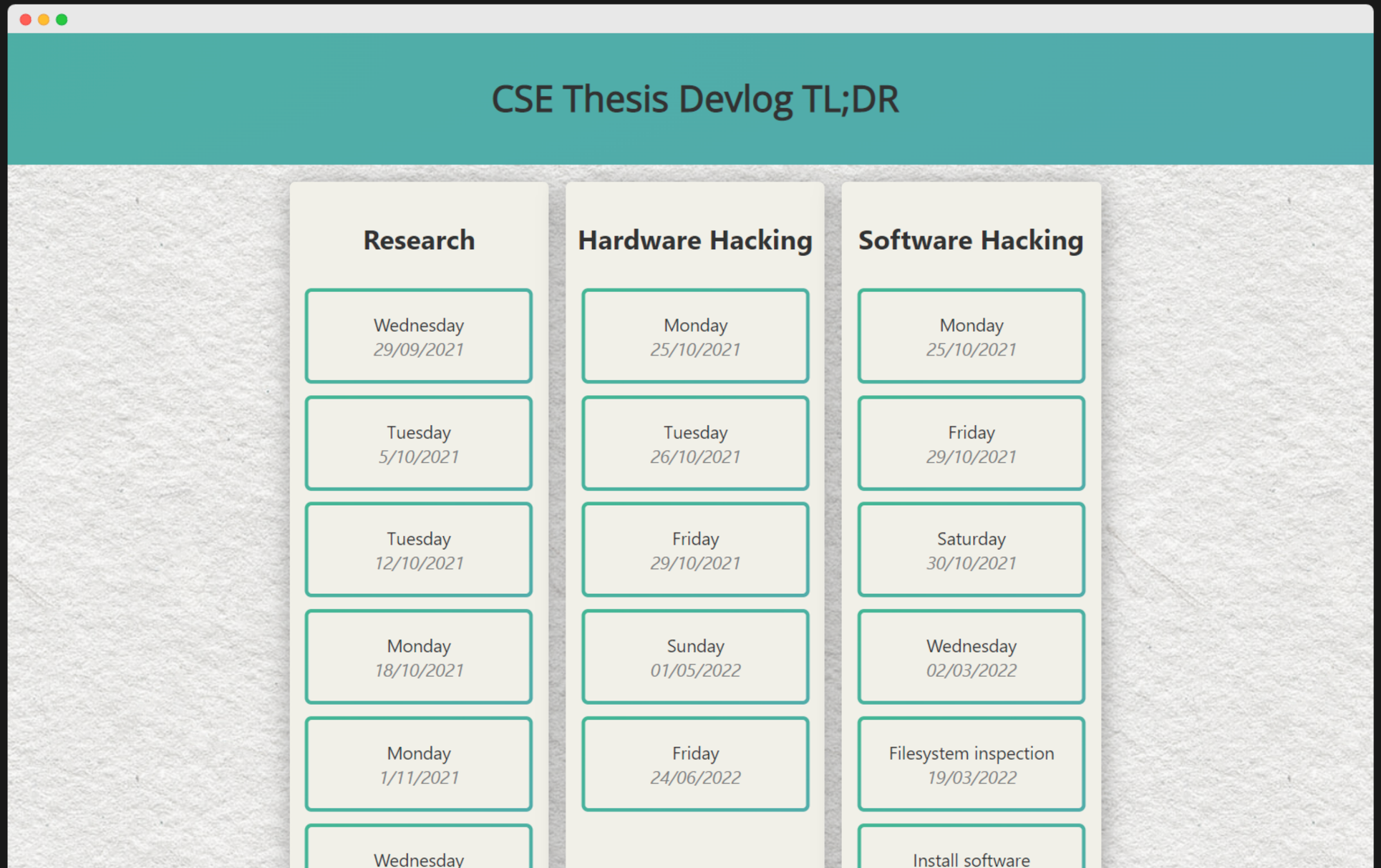
https://featherbear.cc/UNSW-CSE-Thesis/posts/disclosures/ Response to disclosures tuya and roborock only have one disclosure listed on their site? Hard to find xiaomi has a

Takeaway Summary (answer main point)

tldr Who What When Why Where How

Address the statement

Thesis in a Year



Thank You

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