

A journey in home automation

Part 1

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Why home automation?

- It's cool
- Good way to learn something new
- Leverage modern technology to make things easier in the home

- At the same time, it's kinda scary

- Lack of standards, lack of IoT security

Motivation and opportunity

- Building a new house
- Chance to do things more easily at frame stage while there are no walls



The plus side

- Already spending lots of money, so may as well make it stretch and spend some more

The down side

- Spending lots of money

What would you do with HA?

What I want to do with HA

- Respond to the environment and people in the home
- Alert me when there's a problem (fridge left open, oven left on!)
- Gather information about the home, e.g.
 - Temperature, humidity, CO2, light level
 - Open doors and windows and whether the house is locked
 - Electricity usage
- Manage lighting automatically, switches, PIR, mood, sunset, etc
- Control power circuits
- Manage access to the house via pin pad, proxy card, ~~voice activation, retina scans~~
- Control gadgets, door bell/intercom, hot water, AC heating/cooling, exhaust fans, blinds and curtains, garage door
- Automate security system
- Integrate media around the house (movie starts, dim the lights!)
- Water my garden, and more..

Requirements

- Open
- Secure
- Extensible
- Prefer DC only, no AC
- High WAF (Wife Acceptance Factor)
 - Didn't want my family to struggle using the system
 - Must be simple
 - Must be reliable

How to proceed?

- Install the standard open source IoT framework!

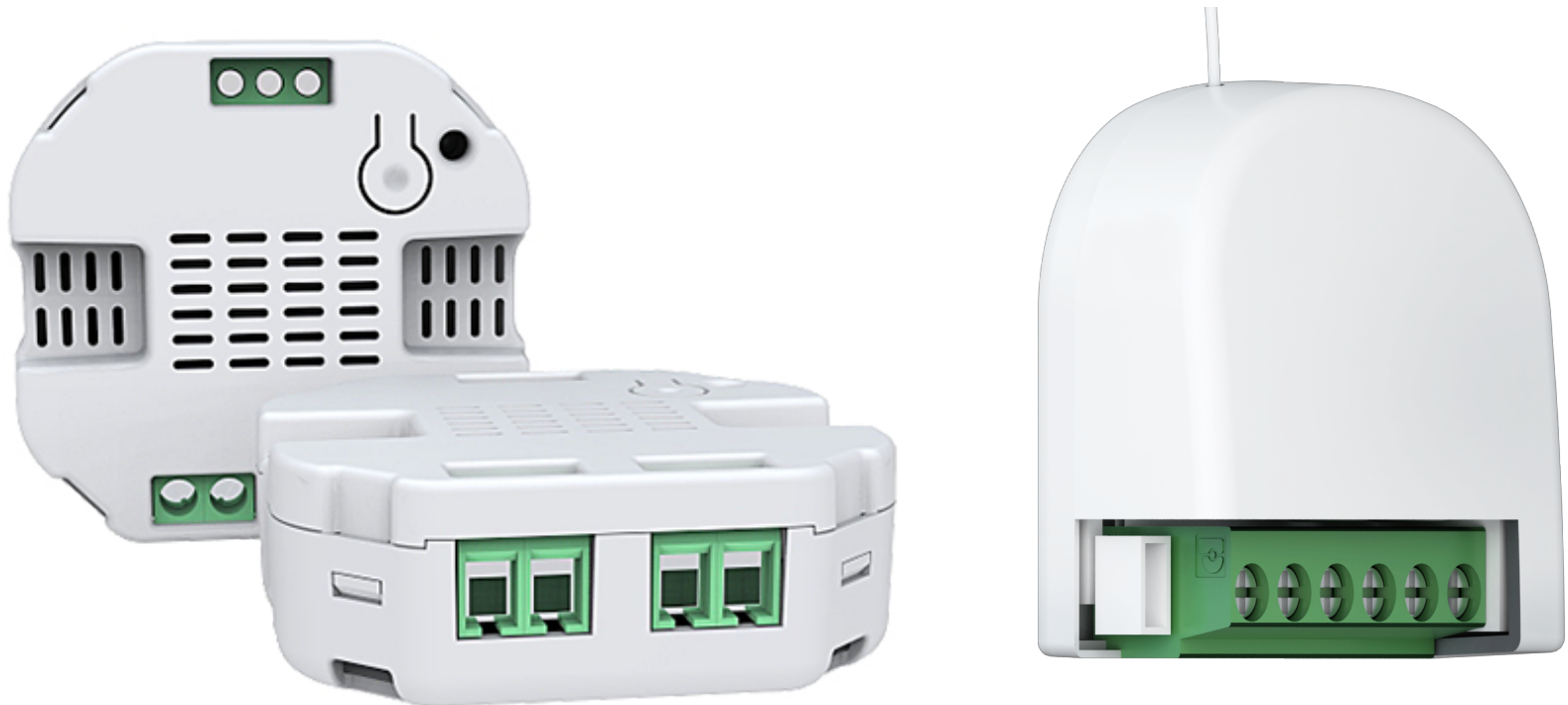
- Wake up to reality, no such system exists :-(

Research time!

- Three main options
 - Wireless
 - Wired
 - Combination of both

Wireless

- Dominated by proprietary Z-Wave
- Although open standards based also exist, like ZigBee



Wireless - Pros

- Lots of different gadgets available
- Gadgets are pretty cheap and easy to find
- Easy to get up and running
- Widely supported by all kinds of systems

Wireless - Cons

- Wireless gadgets are pretty cheap and nasty
- Most are not open
- Often not updateable, potentially insecure
- Connect to AC
- Replace or install a unit requires an electrician
- Often talk to the “cloud”

Wireless

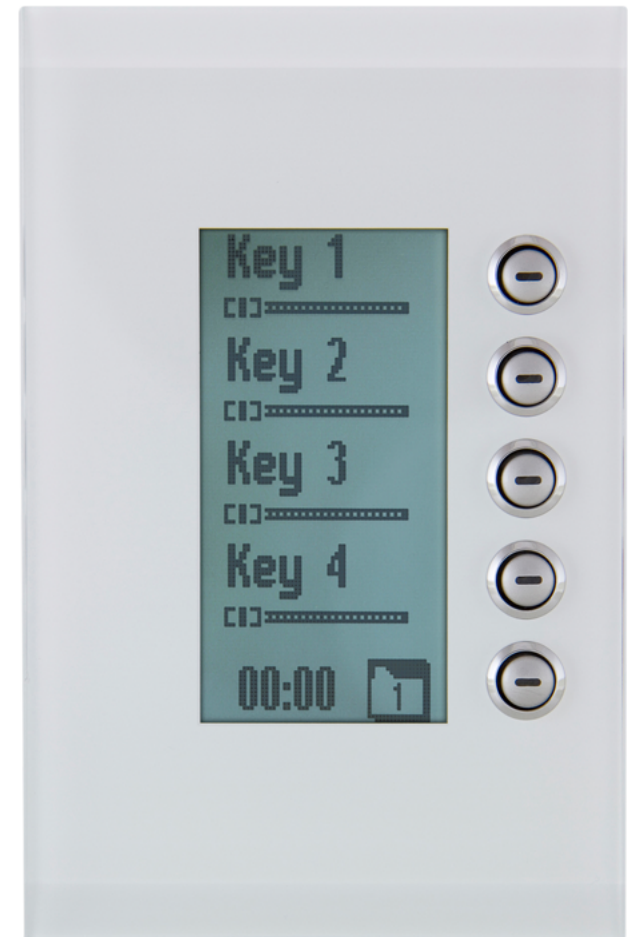
- So yeah I could whack these up around my house
- Install a bridge
- Move on with my life
- But...

Wireless

- Not as much fun!
- Don't want to rely on wireless
- Don't want to rely on an electrician (AC)
- Don't really want to touch AC
- Cheap gadgets that are never updated
- Security vulnerabilities makes it high risk

Wired

- Proprietary systems like Clipsal's C-Bus
- Open standards based systems like KNX
- Custom hardware
- Expensive
- :-)



Custom wired system

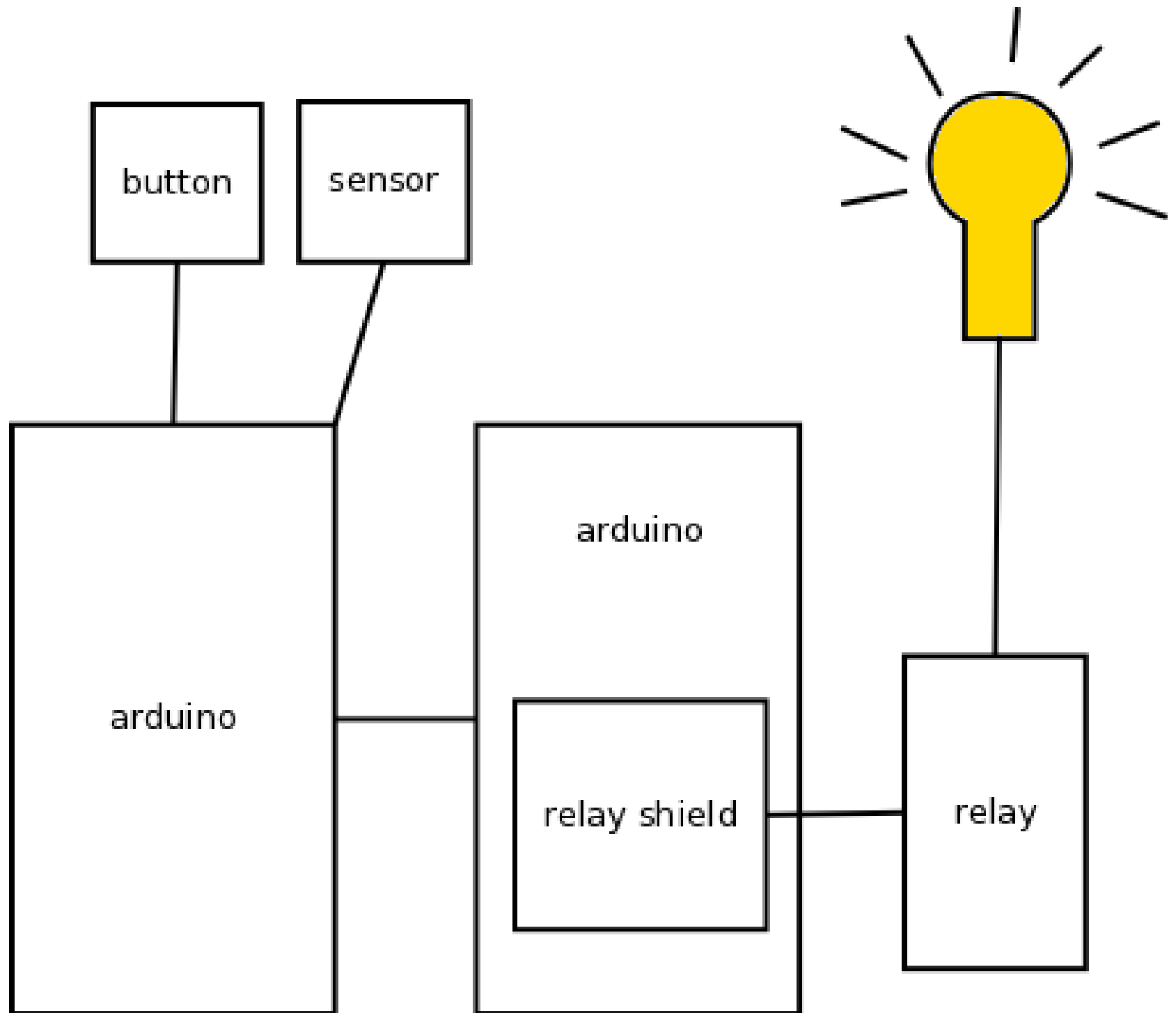
- Much more fun! (I think)

Wired design

- Inspired by Jon Oxaer's SuperHouse.tv
- Individual light and some GPO circuits
- Bank of relays control the circuits
- Arduinos and Raspberry Pis control the relays

Wired design

- One Arduino/Embedded Linux device per room
- Run C-Bus cat5e cable to light switches to power Arduino, provide access to HA network
- Room Arduino takes buttons (lights, fans, etc) and sensors (temp, humidity, reed switch, PIR, etc) as inputs
- Room Arduino sends network message to relay Arduino
- Arduino with relay shield fires relay to enable/disable power to device (such as a light, fan, etc)



So, it comes down to two main options

- 1) Buy an expensive proprietary system that just works™. Sit back and enjoy.
- 2) Build some bespoke open source system that I'll probably never finish.

So, it comes down to two main
options

Of course, I go with option number 2



Cabling benefits

- Secure
- Future proof
- DC only, no need to touch AC
- Provides PoE for devices and motors
- Can still use wireless (e.g. ZigBee) if I want to
- Convert to proprietary system (C-Bus) if I fail
- My brother is a certified cabler :-)

Technology overview

- Z-Wave = OUT
- ZigBee = MAYBE IN
- C-Bus = OUT (unless I screw up)
- KNX = OUT
- Arduino, Raspberry Pi = IN

Prototype

- Got some Freeduinos and relay boards
- Hacked around with some ideas, was able to control the relays
- Basic concept seems doable
- More on that later..

Prototype

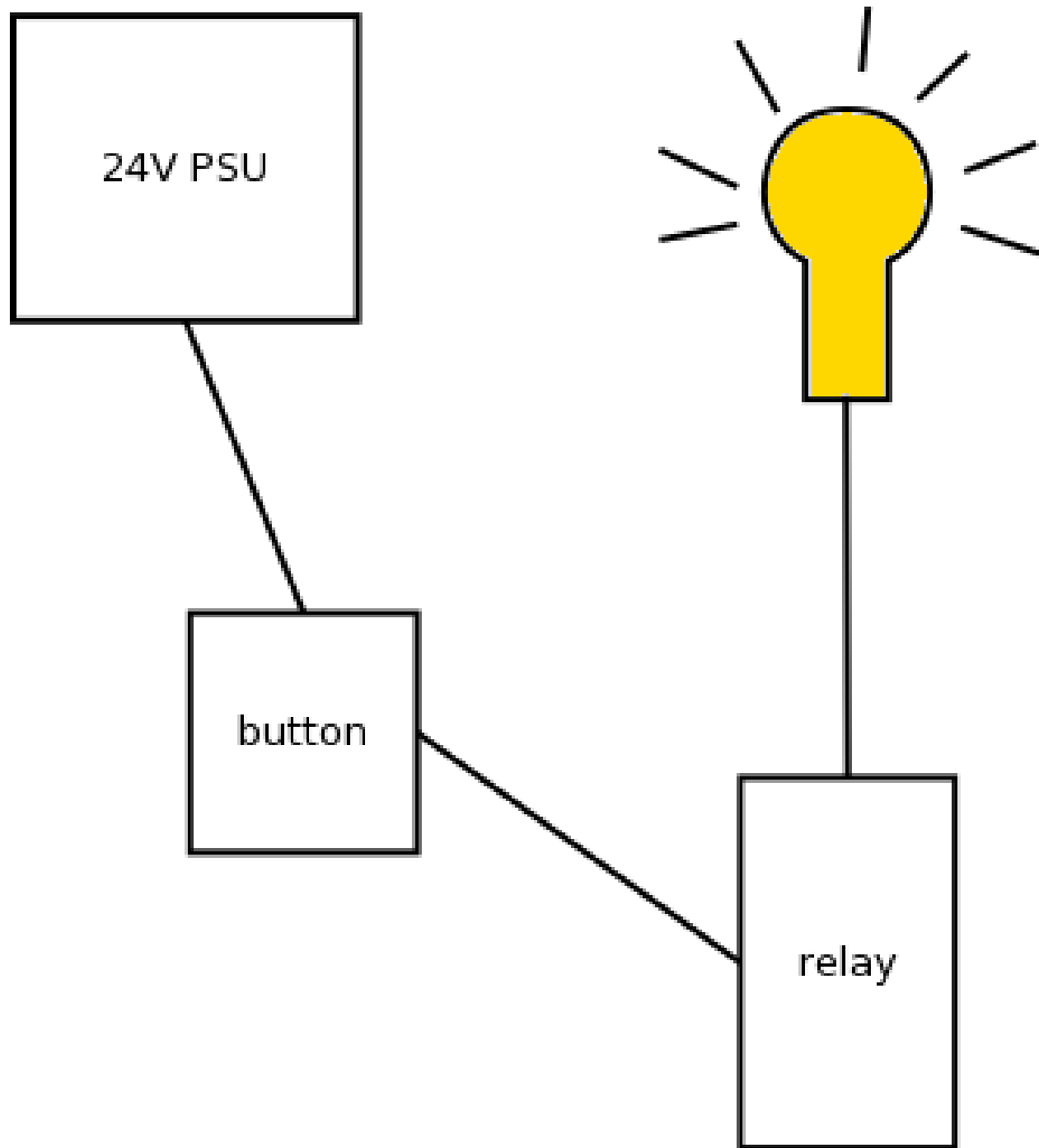
- Realised I'm not going to get this working in time
- Need a “dumb” mode that doesn't require any computers so that we can turn on the lights

Tip

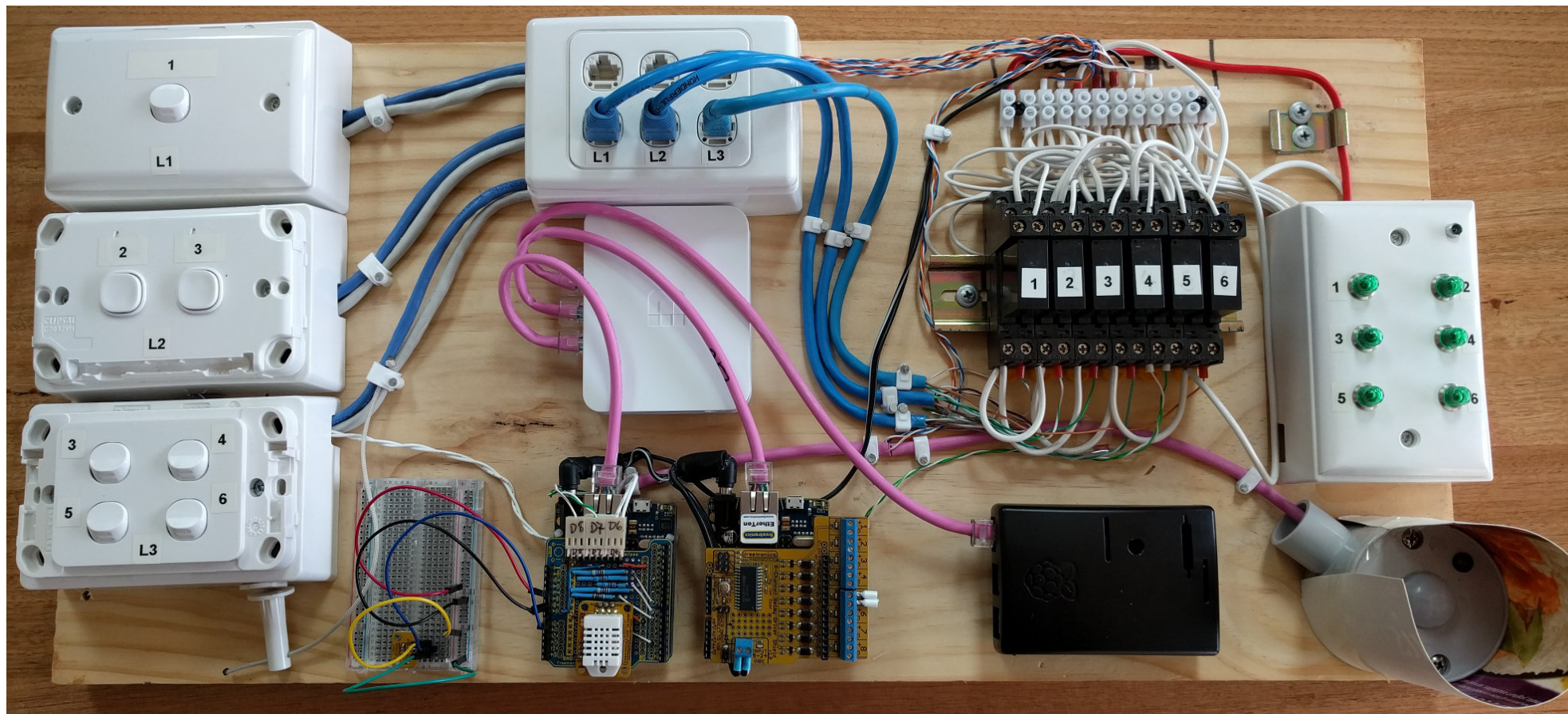
- Using SSH to manually turn on a light is not practical

Dumb mode prototype

- Use the same cabling idea so that devices can be installed later
- Use standard off the shelf Clipsal light switches
 - Support one, two, three and four way switching
- Run 24 volts over the cat5e
- Light switch completes the circuit which feeds 24 volts into the relay
- Relay fires the circuit and light turns on!



Smart and Dumb Prototype



- Demo time!

More playing

- Also played with PWM for LED downlights
 - Most LEDs come with smart dimmable drivers (power packs) that use leading or trailing edge on AC
 - Wanted to control brightness via DC
 - Used an arduino to program a small ATTiny for PWM
 - Worked, but only with non-smart driver
 - Got electrician to install manual dimmers for now where needed, such as family room

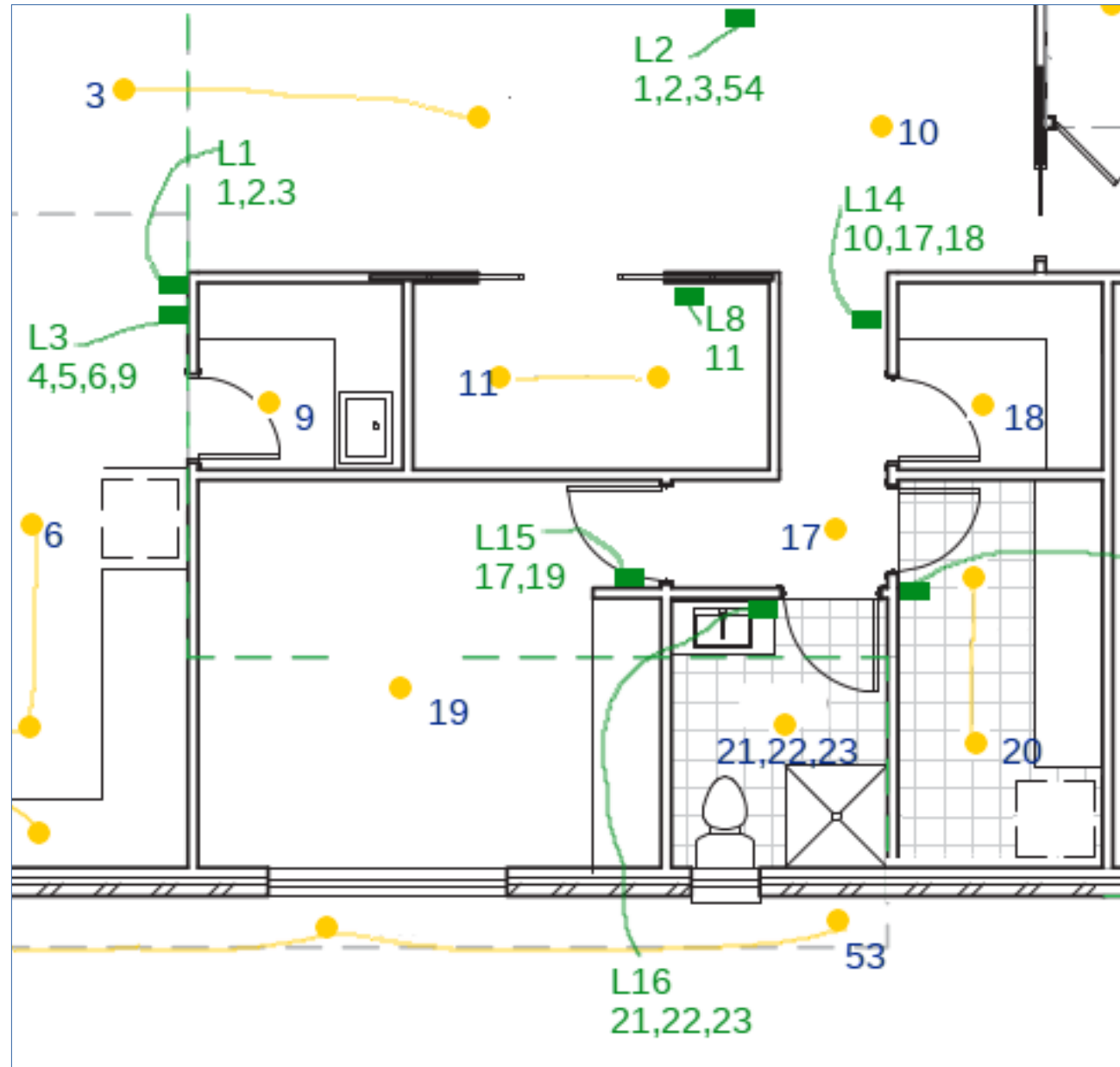


Doors

- Need to also work with physical key
- Need to be fire-able from an Arduino
 - Work with multiple smart inputs, e.g. RFID, pin pad
- Once in, door should be unlocked from inside
- Played with wireless rolling q-code, Arduino can fire the remote (Jon Oxer has done this)
- Pair this with deadlock and electric strike

Operation “dumb mode, Smart house” begins

Design and map the cabling



Dumb mode install

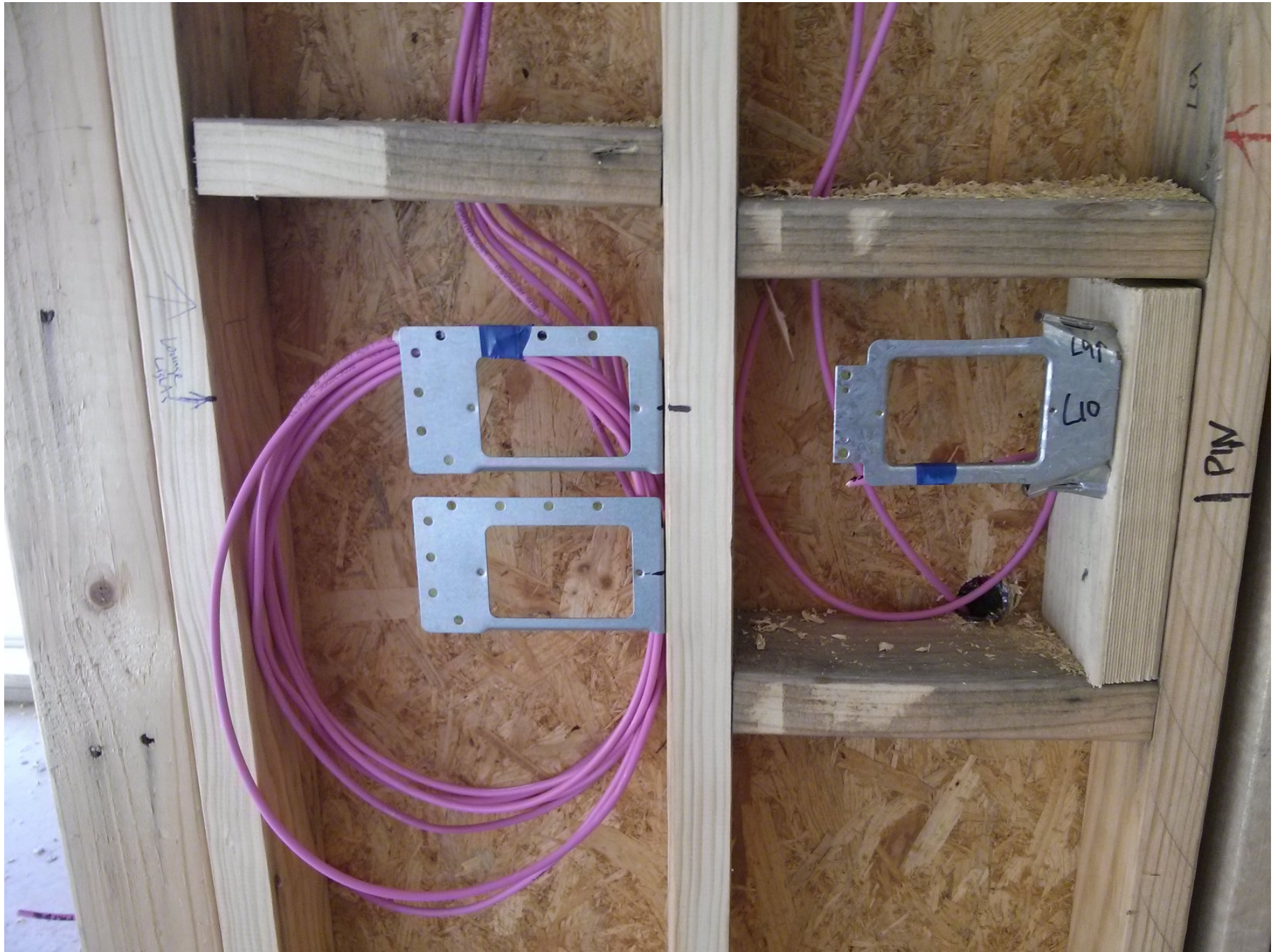
- Step 1:
 - Cable ALL THE THINGS
 - Cat5e (sometimes multiple runs) for room Arduinos
 - Cat5e to windows for future curtain motors
 - Reed switch cables to light switch
 - Regular cat6 data cabling too, of course!
 - Whatever else we thought we might need down the track
 - **Ran almost 2 km of cable in total**
 - This was a LOT of work and took a LOT of time



My brother with the drill of doom



Me running some cables



Cabled up wall plates, ready for sheeting. We find them later with a magnet.



Ceiling plate for wireless access point.



Some cables, rack will go here.

All that cable basically turned my house into a Faraday cage ;-)



Source wikipedia https://en.wikipedia.org/wiki/File:Cage_de_Faraday.jpg

Tip

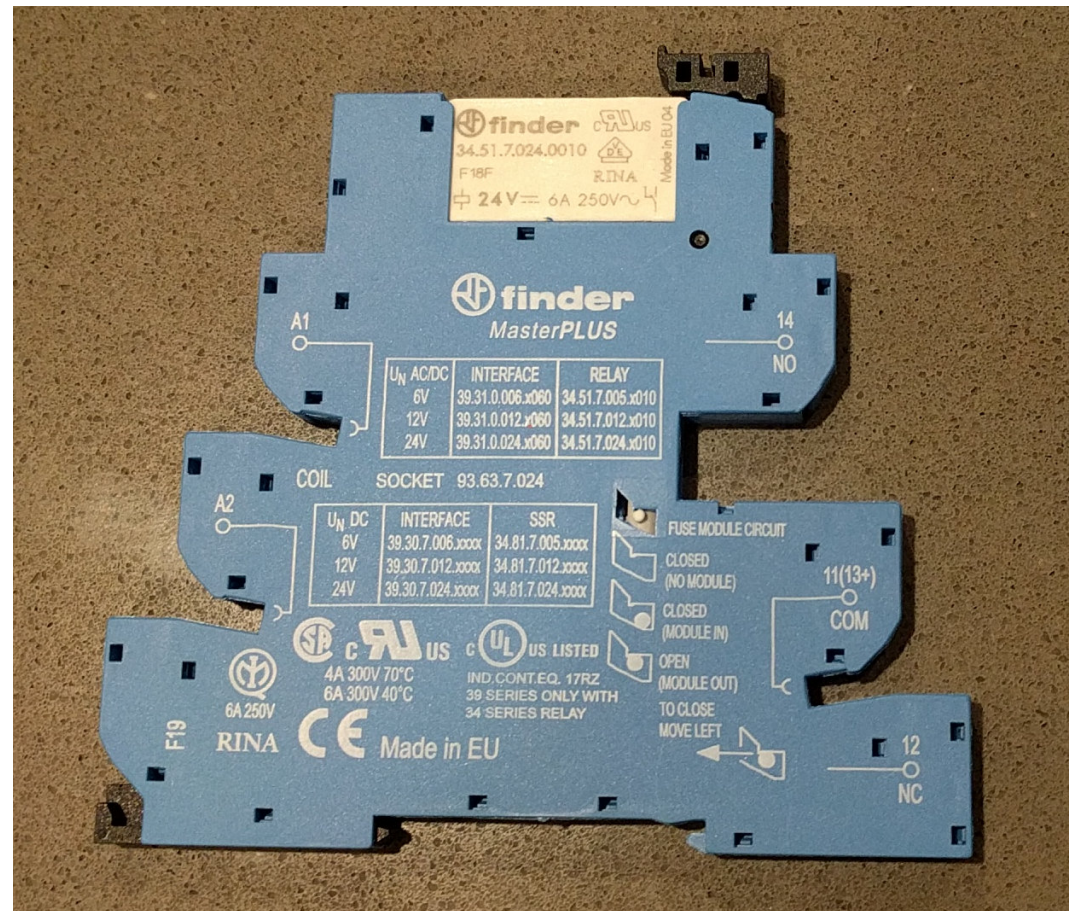
Don't do this at night during Winter in a house with few walls and no insulation. Brrrr.

Electrical cable

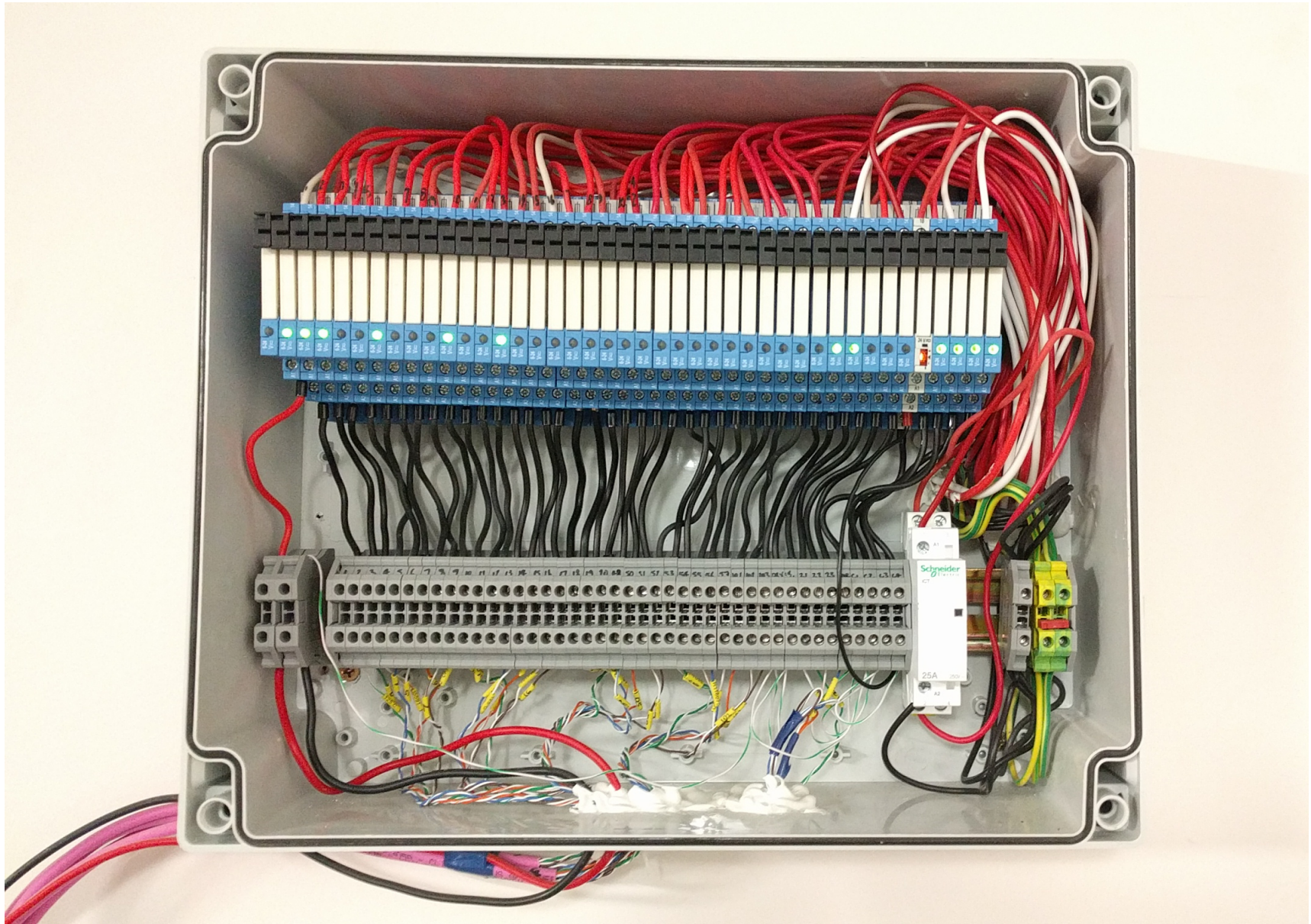
- Electrician ran each bank of lights on their own circuit
- Multiple additional electrical circuits
 - HA on its own electrical circuit, UPS backed
 - Study/computers on own circuit, UPS backed
 - Various others like dryer, ironing board, entertainment unit, alarm, ceiling fans, ovens, etc
- Can leave the house and turn everything off (except essentials)

Relays

- Choose off-the-shelf Finder relays
- Very thin profile
- Built in fuses
- Common bus bars



Bank of relays (downstairs)



UPS backed GPO circuits



House setup

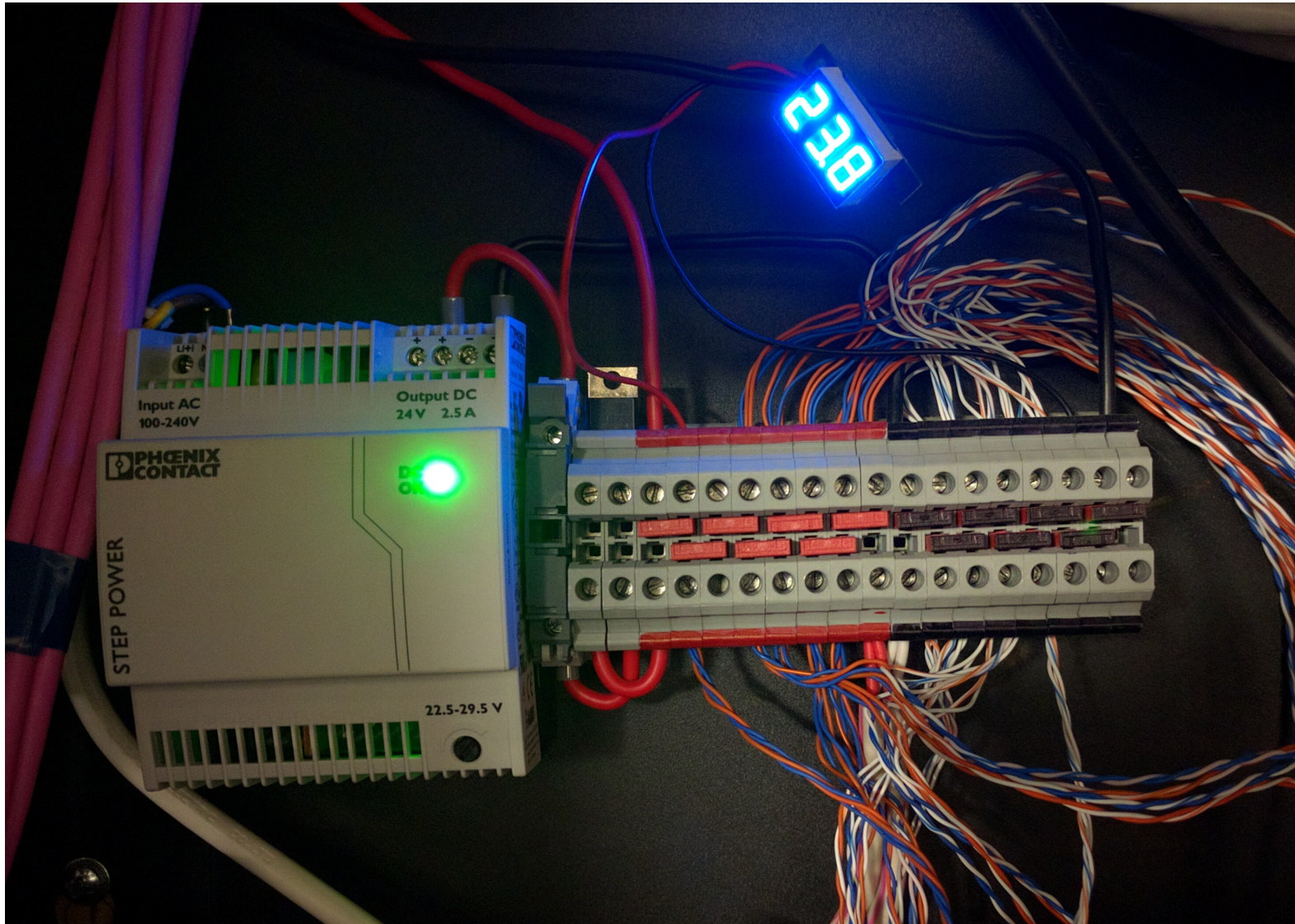
- Two racks, one downstairs and one upstairs
 - House HA and data networks
- Two PSUs in parallel provide redundancy for dumb network

Rack, HA and data (downstairs)



Beautiful pink HA cabling is my brother's work, messy data cabling is mine!

24V HA lines



Pairs coming back from light switches, out again to relay inputs.

Switches

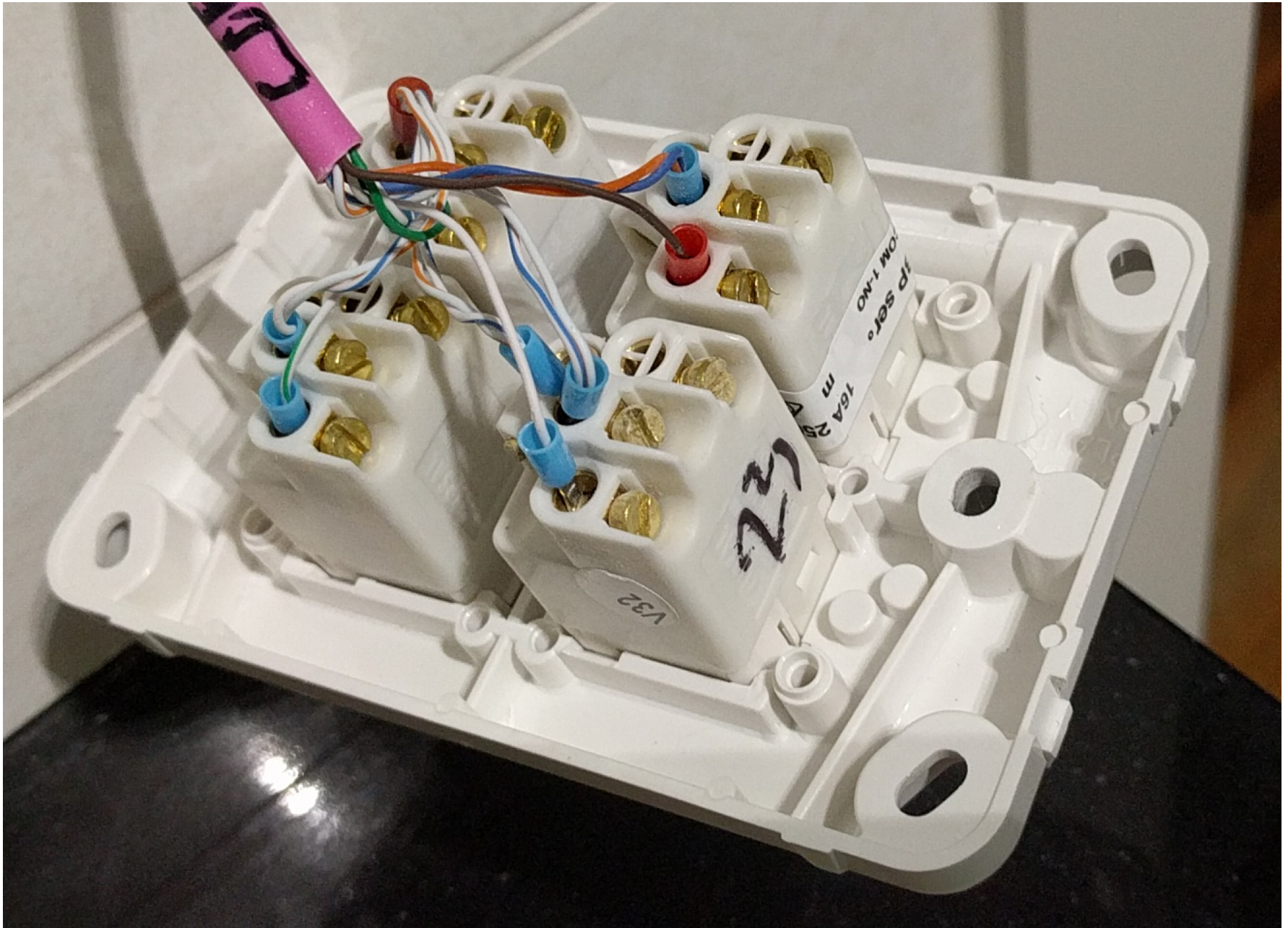
- Playing with light switches (yay DC!)
- Cabling up the switches using standard Clipsal gear
- Single Cat5e cable can power up to 4 switches
- Support one, two, three and four way switches
- Bedroom switches use switch with LED (can see where the switch is at night)

Bathroom light switch



- Blue and orange = +ve
- White-blue and white-orange = -ve
- Green = switch 1
- White-green = switch 2
- Brown = switch 3
- White-brown = switch 4

Example of switch (bathroom)



- Play video

Timers

- Heated towel racks are bell press switches
- Uses a Finder timer relay to auto turn off
- Modes and delay configurable via dip switches on relay
- Otherwise, setup is the same

Hallway PIRs

- Upstairs hallway uses two PIRs in parallel
- Either one turns on lights
- Connected to dumb mode network so fire relay as everything else
- Can be overridden by switch on the wall
- Adjustable for sensitivity, light level and length of time

Hallway PIRs



Hallway PIRs



Dumb mode results

- Works!
- Reliable!
- Very minimal voltage drop!

SMART HOUSE



RUNNING DUMB MODE

Questions?

