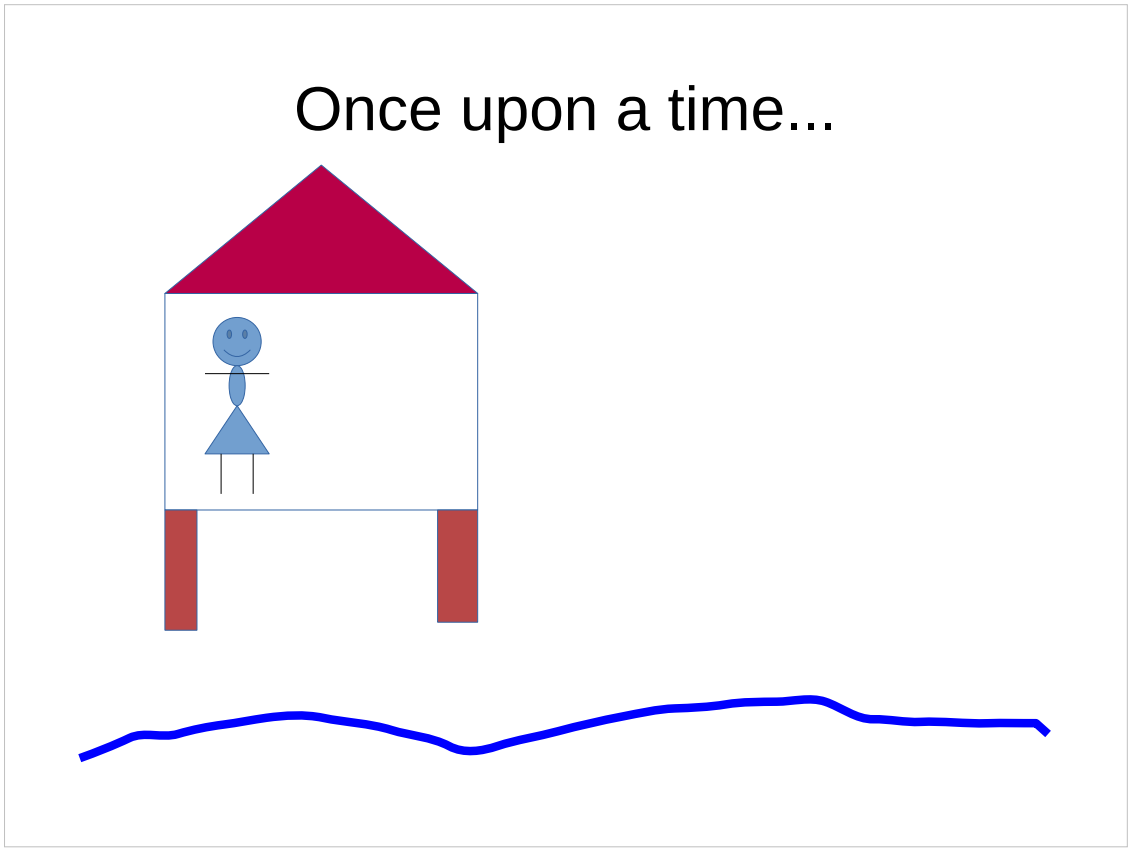
Monitoring Mum

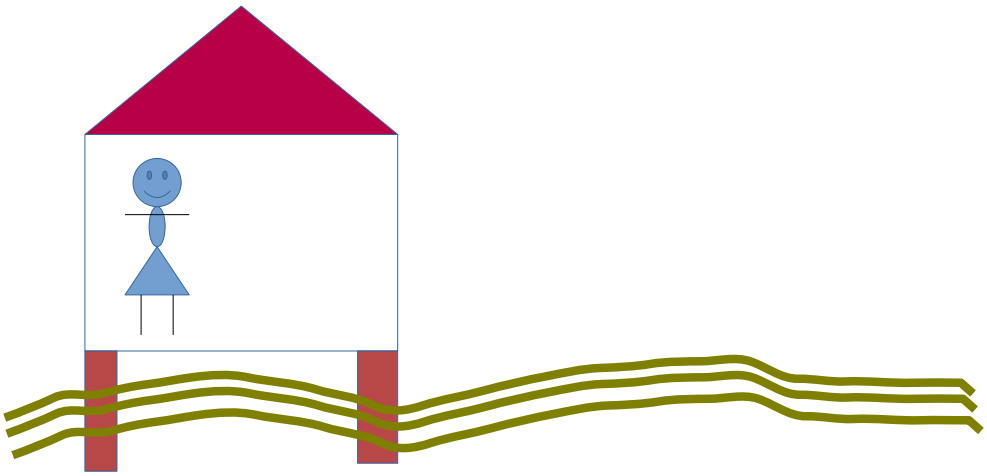
Open-source Telecare

Andrew Findlay
April 2017



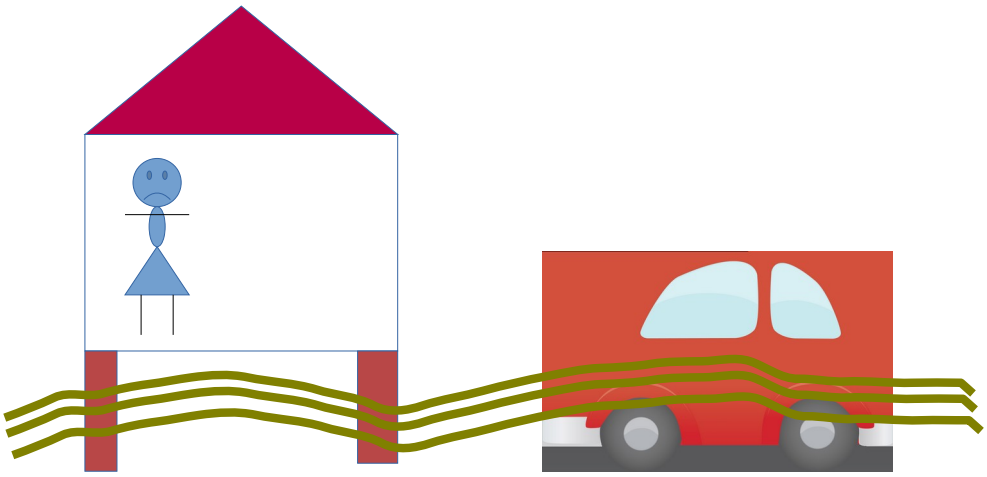
Once upon a time...
Mother lives by the river
Most of the time this is very pleasant
But sometimes the rain falls

We can cope with this



And sometimes the river rises...
But we knew that when we built the house
OK for a day or two, but sometimes it lasts longer

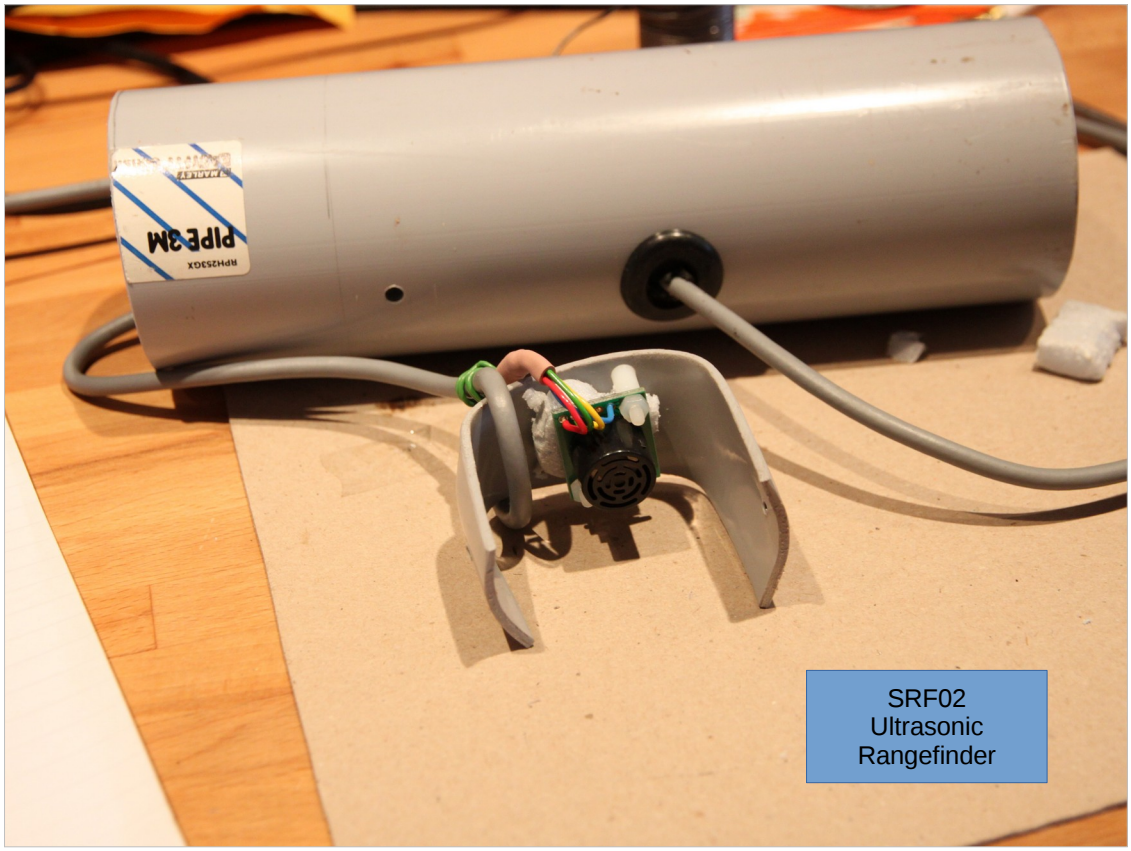
But not this

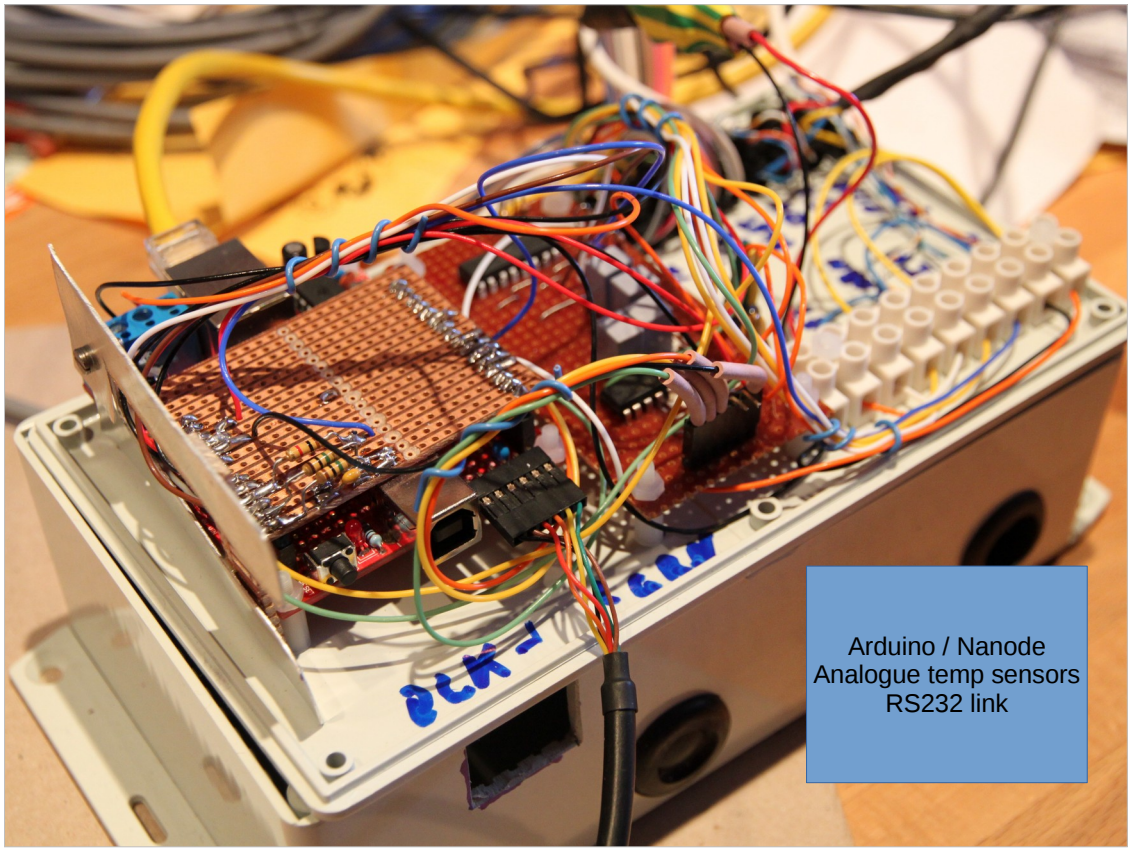


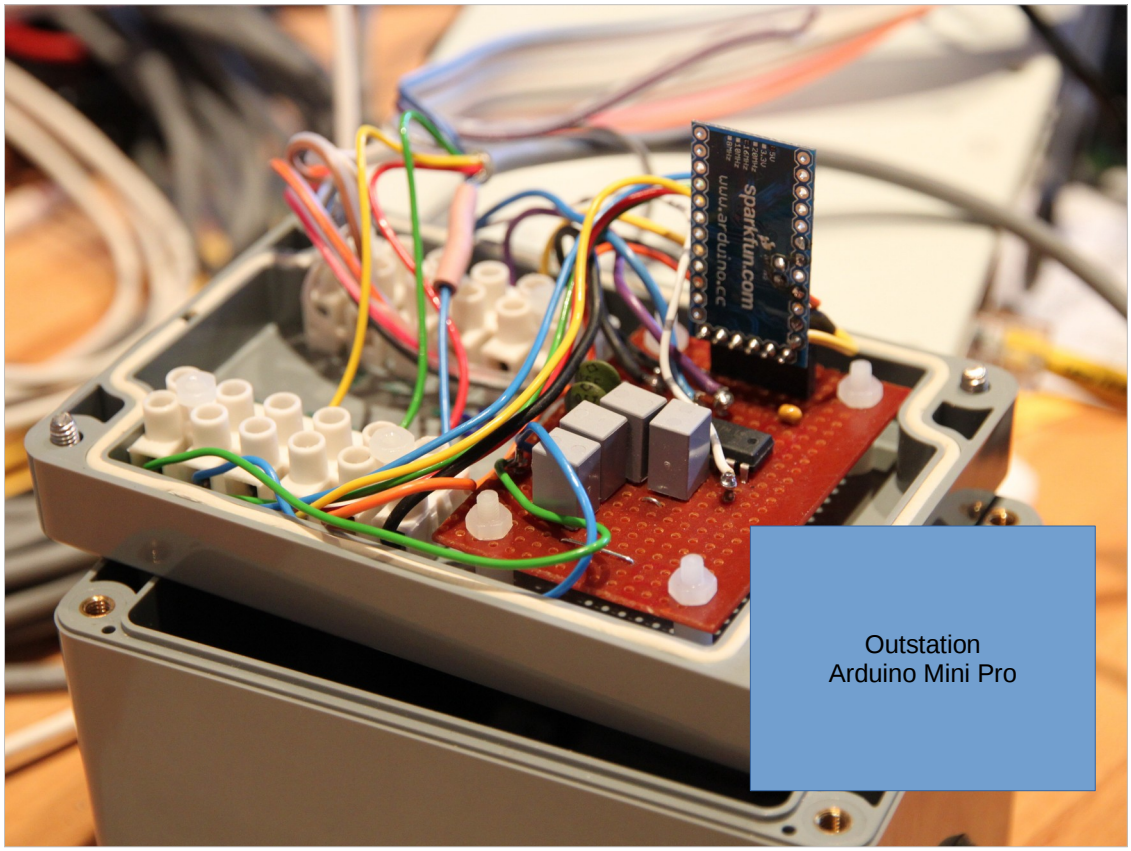
If we had better warning, maybe...

IoT to the rescue

- Monitor the river
- Monitor the mother
- Raise the alarm
- Keep the trend data


PIPE-3M
SRF02
Ultrasonic
Rangefinder


Arduino / Nanode
Analogue temp sensors
RS232 link

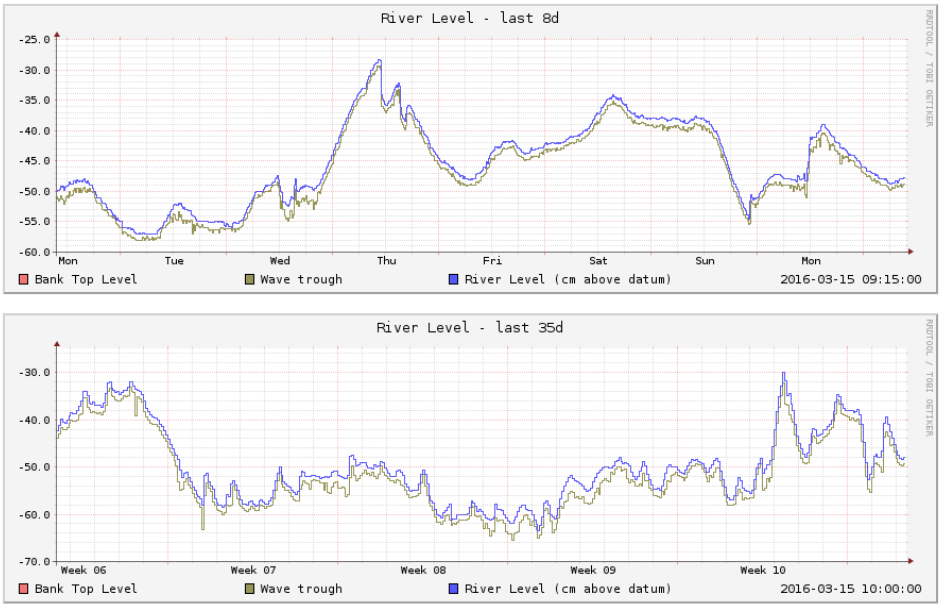

Outstation
Arduino Mini Pro

Other bits

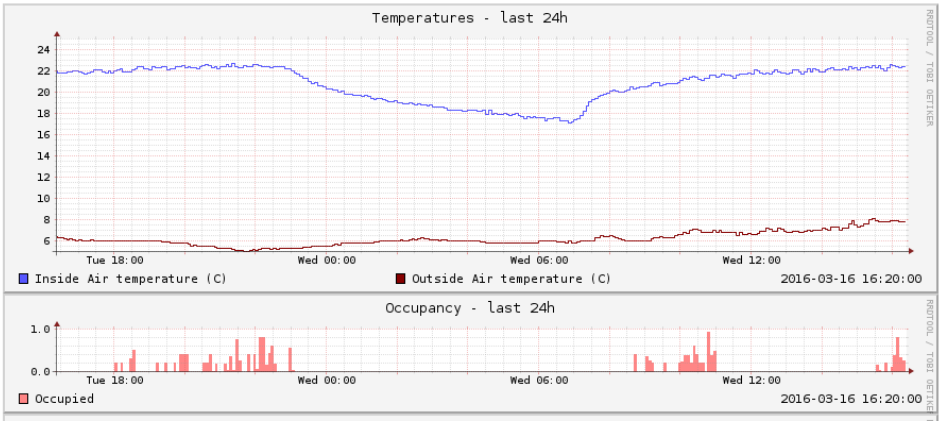
- Linux webserver
- Arduino IDE
- RRDTool
- Movement sensors

RRDTool – constant-size time-series database with graph-generation tools

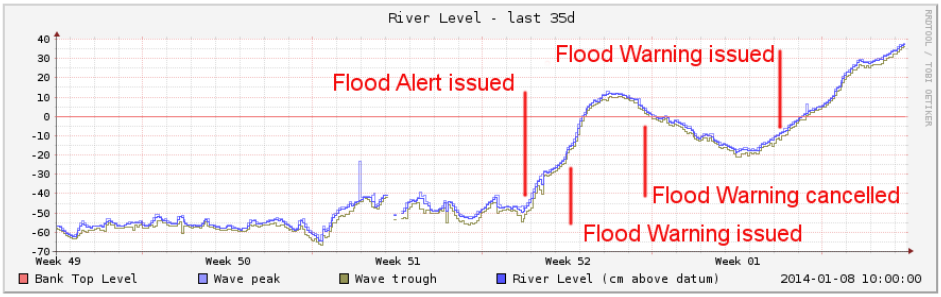
Web page for the river



Web page for Mum

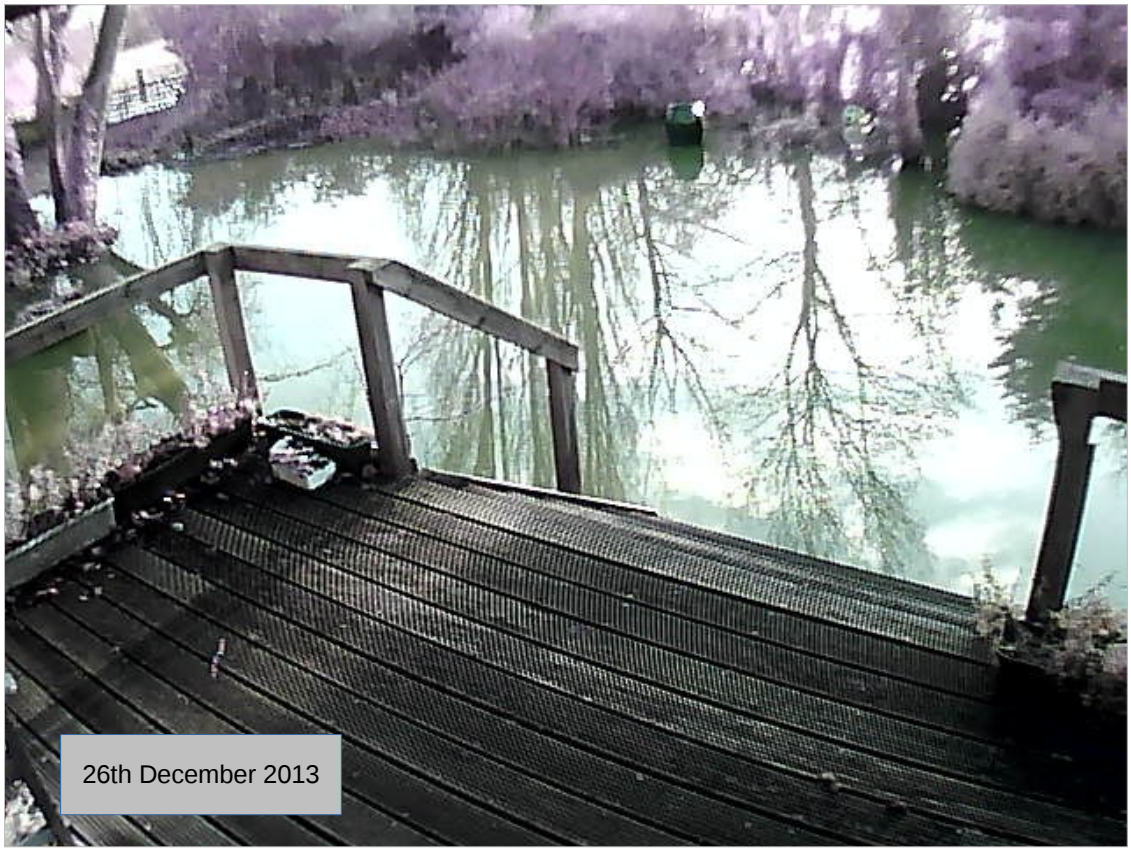


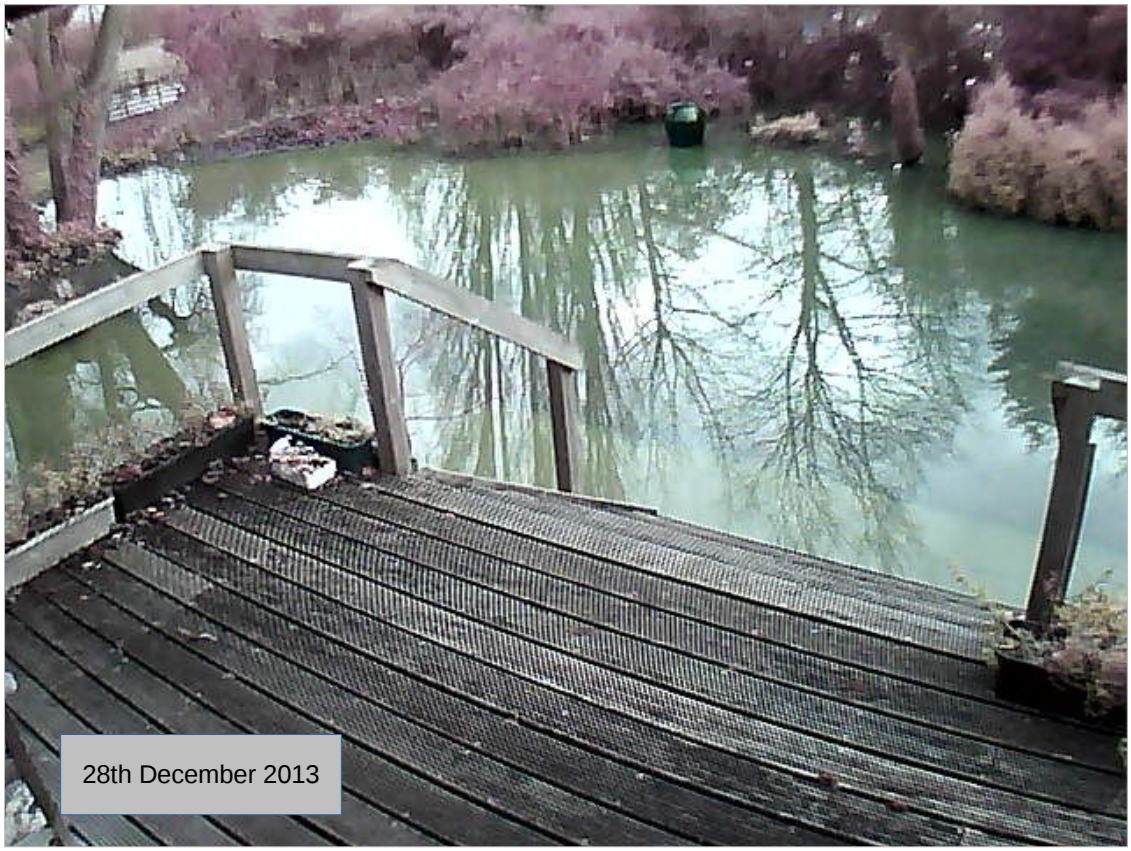
December 2013

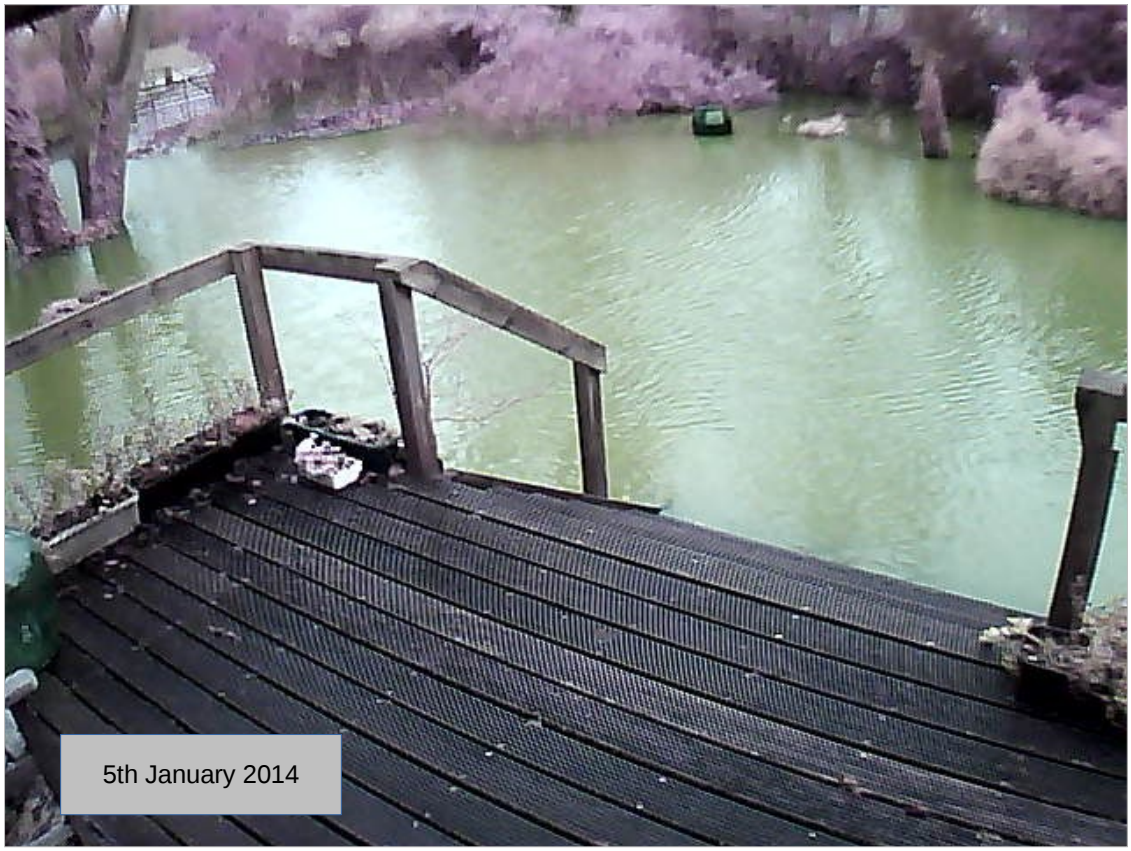


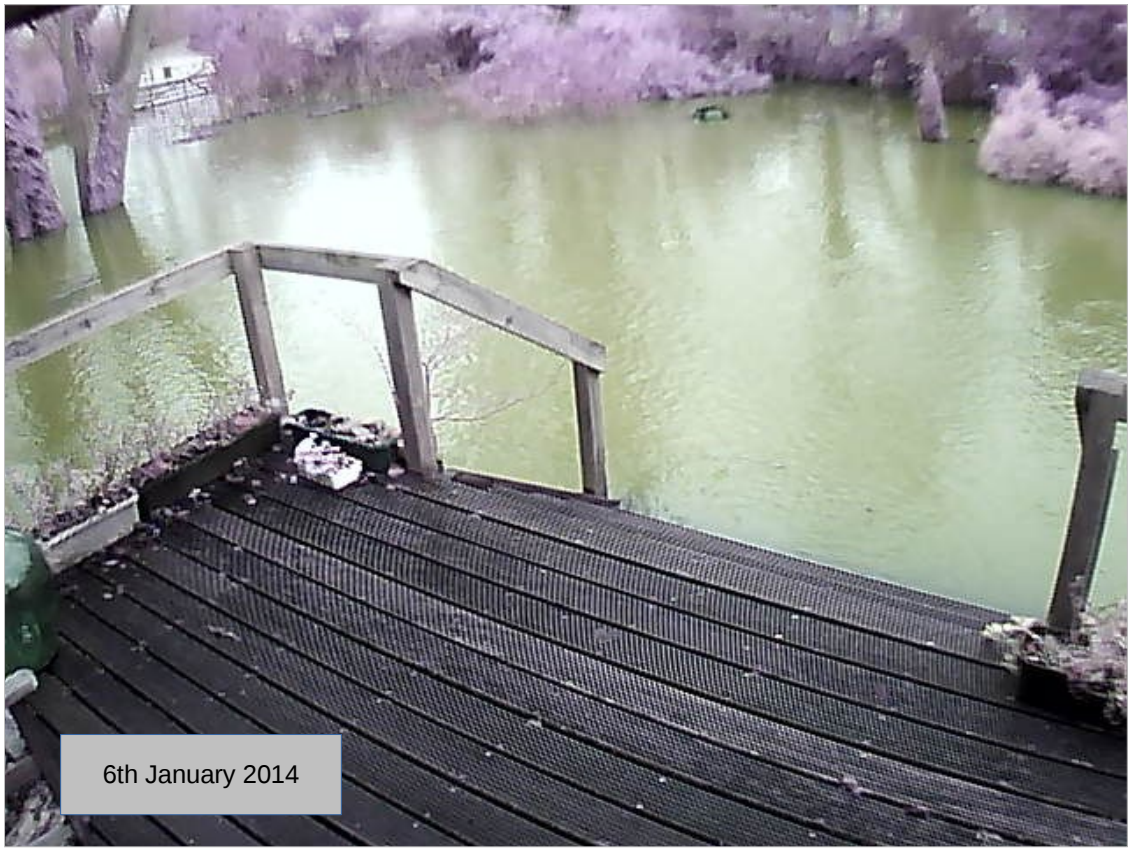
Christmas eve 2013
A flood warning has just been issued
Watch the green pot – it is waist-high

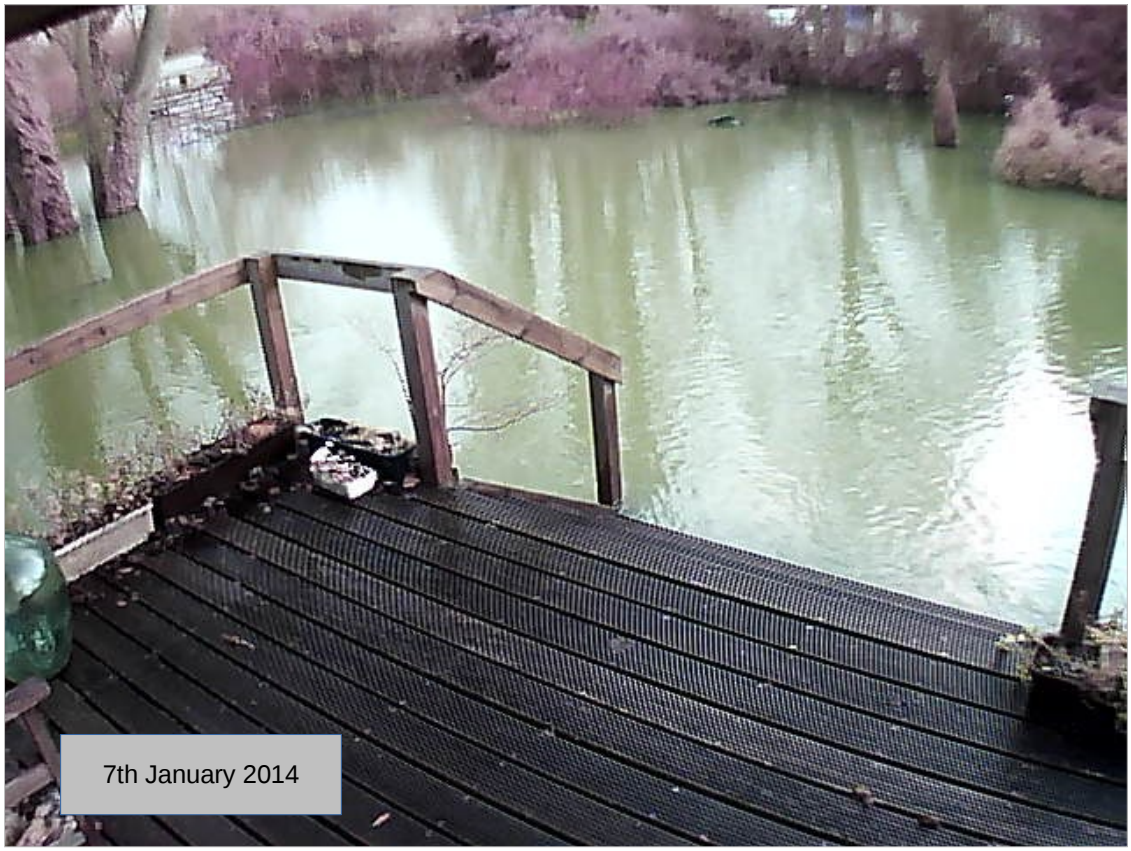

25th December 2013

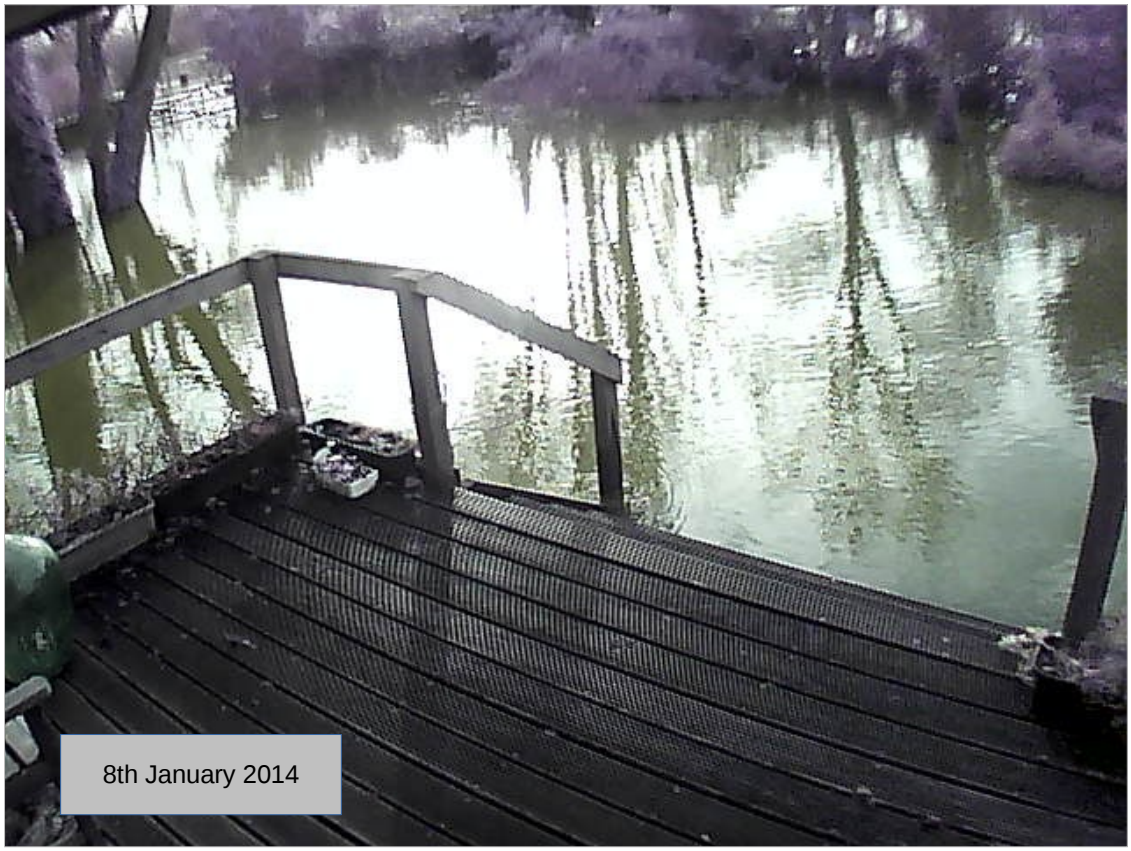

26th December 2013


28th December 2013


5th January 2014

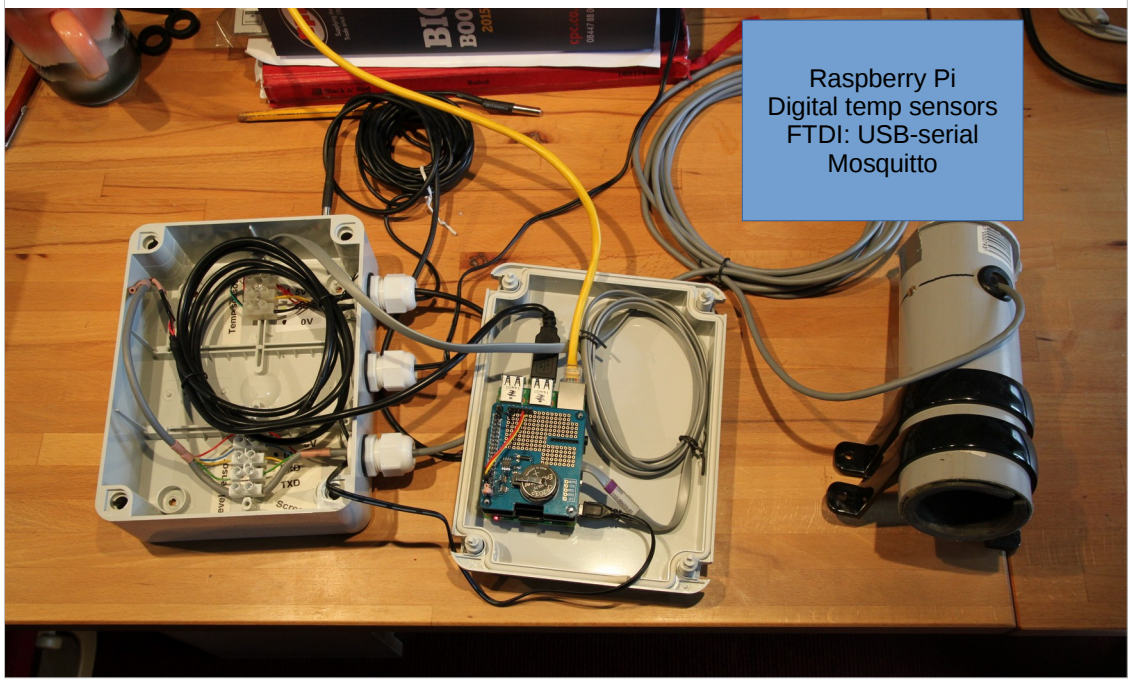

6th January 2014


7th January 2014



It stayed like this for weeks...

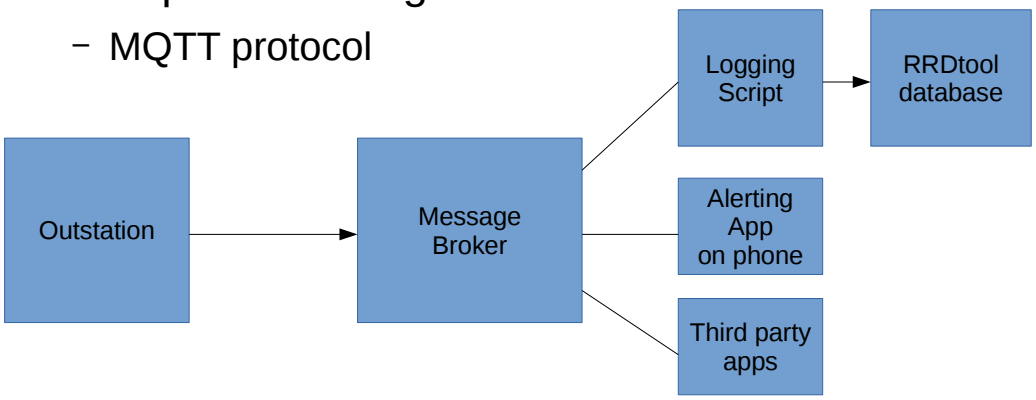
Datalogger Version 2



2015
Built for a neighbour on the other river
Raspberry Pi now easily available
Encapsulated DS18B20 temp sensors
Ultrasonic rangefinder giving more trouble this time

Publishing live data

- Message Queues
  - Publish/Subscribe model
  - Allows multiple consumers to use the data
- Mosquitto message broker
  - MQTT protocol



MQTT: Topic and Data

Topic	Data
sensor/thames1/temp/air	11.5
sensor/thames1/temp/river	11.75
sensor/thames1/level/river	{ "count" : 10, "max" : -55, "time" : 1493046748, "mean" : -55, "min" : -56 }
sensor/loddon1/temp/air	12.5

We have data

- dl1.findlays.net
- River data is public – Oct 2012 onwards
- House data protected by ACLs
- Achievements
  - Detected several heating failures
  - Helped to get mother out before some floods
  - Provided data series for heat-pump project planning at Henley Management College

Started describing the datalogger at technical conferences

Jan-Piet Mens got interested and started making suggestions

Mother is getting older

- More forgetful
  - Sometimes forgets to eat
  - Family worry more about falls
  - Family worry more about cooking accidents
  - Family worry more about unscrupulous visitors and phone-calls
  - Refuses to carry phone or panic button
- Mother is not worried at all!
  - *We* need reassurance that she remains safe...
  - Resist pressure to move her to 'a home'

Fix the phone

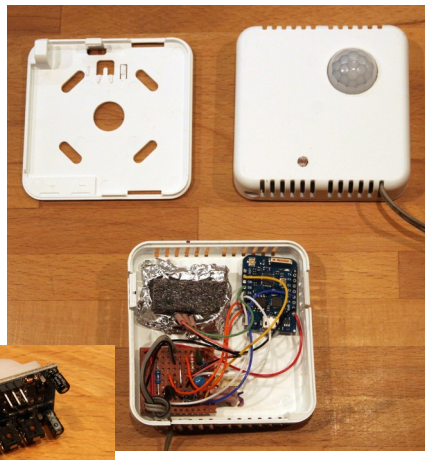
- Commercial product: TrueCall Care
  - Fit between master socket and house phones
  - Transparent to calls from registered numbers
  - Can intercept or block calls by rule
  - Optional Web-based management service
  - Downloads numbers and rules each night using dial-up modem

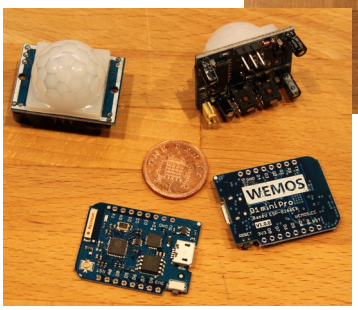
Improve in-home monitoring

- Cameras too intrusive, and cannot give alerts
- Cannot ask mother to carry any devices
- Lots of people need this, so:
  - Open Source / Open Hardware project
  - Design as a product
  - Design for easy installation (wire free)
  - Consider security and privacy from the start
  - Alerting is complex: can we harness AI?
  - Most homes will need a lot of sensors

Room-node

- Temperature
- Movement
- Light level
- Prototype using WiFi
- ESP8266 chip
- WeMOS D1
- Needs mains...
- ZigBee?

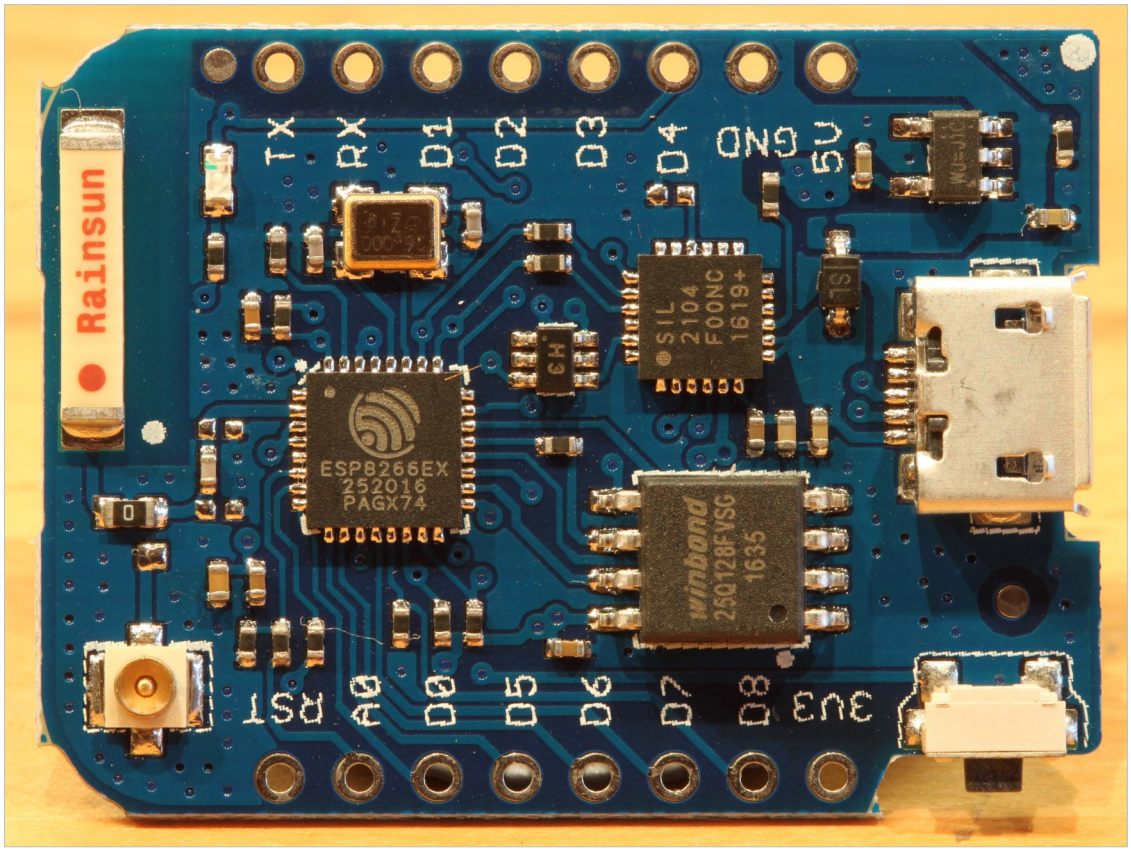




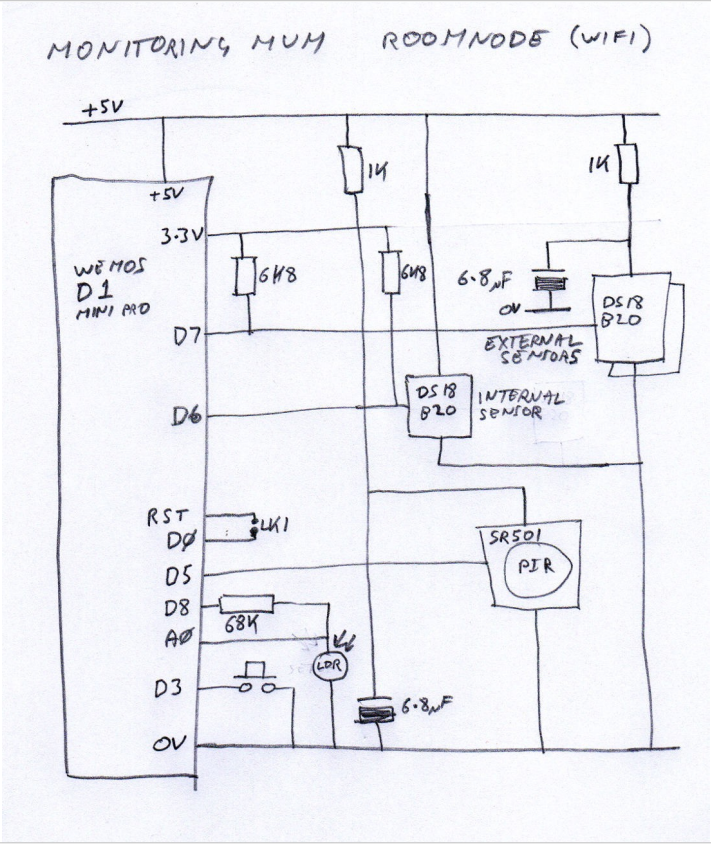
WiFi not ideal – needs power – but easy to prototype

ZigBee or other low-power radio system would allow battery operation – need at least 2 years battery life

Hoping that other projects will produce something useful: Olimex already have demo boards that come close (but use too much power). The MyMultiSensors board from the MySensors universe looks good but is not ready yet.



ESP8266 wonder-chip: 32-bit CPU, 64K instruction RAM, 96K data RAM, WiFi on chip, 16 IO pins
WeMOS D1 modules cost about €5
Adds USB, 16MB Flash, ceramic antenna etc
Modules also made by Olimex and others


MONITORING MUM ROOMNODE (WIFI)
+5V
1K
1K
+5V
3.3V
WEMOS
D1
MINI PRO
6K8
6K8
6.8uF
0V
DS18
B20
D7
EXTERNAL
SENSORS
DS18
B20
INTERNAL
SENSOR
D6
RST
LK1
D0
SR501
PIR
D5
D8
68K
A0
LDR
D3
6.8uF
0V

Homie

- IoT framework using MQTT
- Unconfigured node runs a WiFi access point
- Send messages on event or on timer
- Auto sends housekeeping data
  - Software version
  - Signal level
  - Uptime
- Accepts command messages
- Supports over-the-air software update

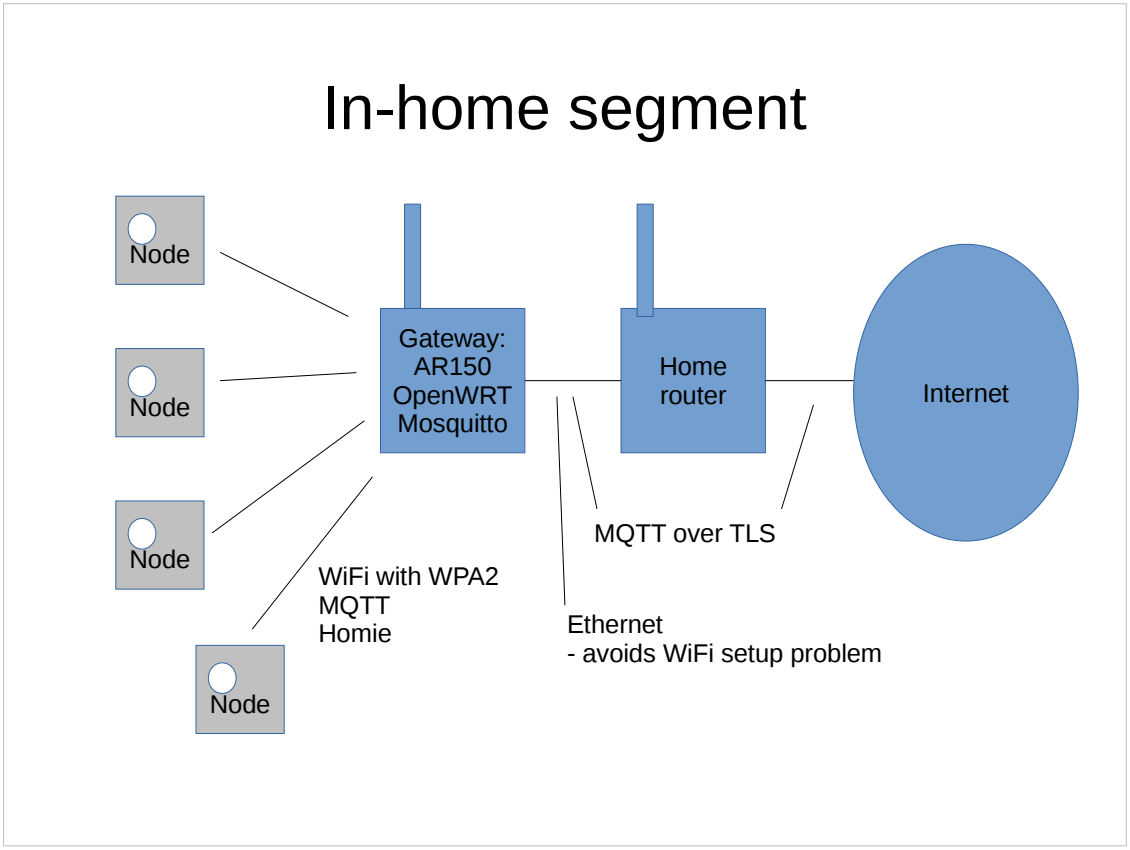
https://github.com/marvinroger/homie

```
void loopHandler() {
  unsigned long now = millis();

  // Start temperature conversion
  if (!thermoConverting && (now - lastTemperatureSent >=
                                          temperatureInterval)) {
      // We need to request a conversion
      internalSensors.requestTemperatures();
      thermoConverting = true;
      // DS18B20 does 12-bit conversion in 750ms so give it 1000ms
      thermoReadyAt = now + 1000UL;
   }

  // Read temperature
  if (thermoConverting && (now > thermoReadyAt)) {
    thermoConverting = false;
    // Read the temperature
    float internalTemperature = internalSensors.getTempCByIndex(0);
    // Send the temperature
    temperatureNode.setProperty("internal").send(
                                      String(internalTemperature) );
    // Record the time
    lastTemperatureSent = now;
  }
}
```

Part of the event loop for the roomnode



We don't use the home WiFi: need to shield the roomnodes from malicious devices

Gateway runs OpenWRT router code but does not forward IP packets.

Homie does not yet support TLS, so we add that in the gateway

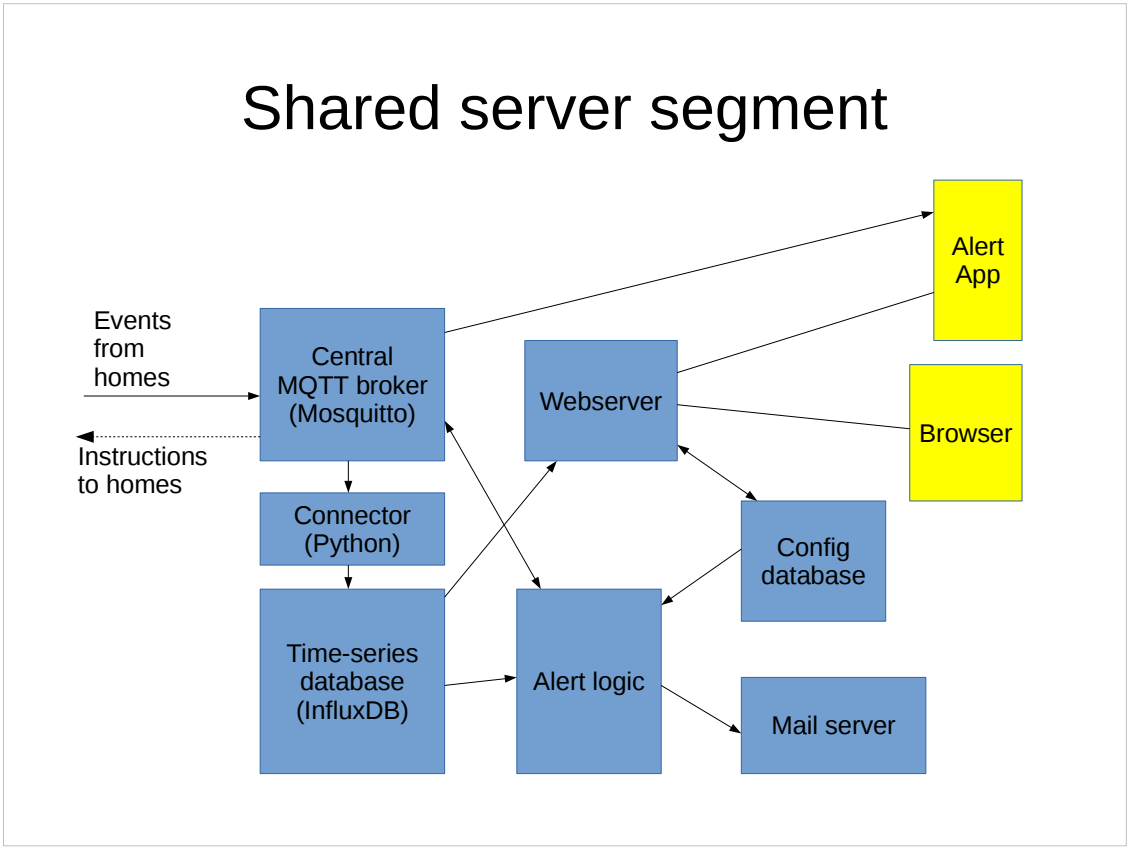
GL-Inet AR150 routers: OpenWRT, £20, can add Mosquitto etc.

Gateway can also support GSM modem for non-Internet households

Messages from Room-nodes

- Topic names: mm/<location>/<node-ID>/<item>

mm/granny90/2c19e0ef/$stats/signal	16
mm/granny90/2c19e0ef/$stats/uptime	176409
mm/granny90/2c19e0ef/movement/recent	false
mm/granny90/2c19e0ef/temperature/internal	17.12
mm/granny90/1925b6ef/light/level	19
mm/granny90/2c198eef/$fw/checksum	87317735484734f90d14f2f208e8d1a0



Message Broker makes lots of things possible:

Alerting app on smartphone

Remote software updates (a new binary is just a message...)

It gets around the NAT problem as the home gateway opens the TCP session

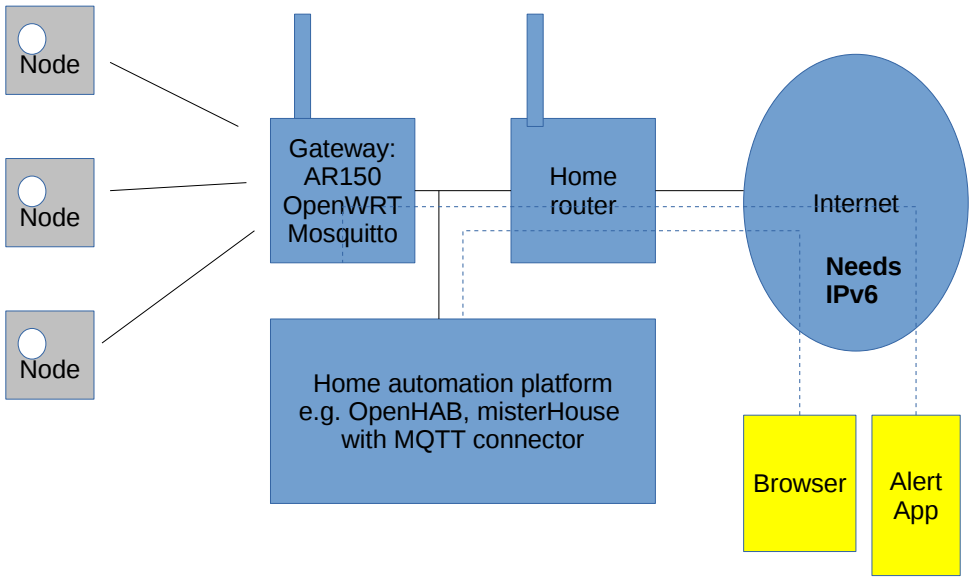
Can potentially allow third-party alerting services to receive messages for particular homes

Buy it in a shop?

- Box containing gateway and a few sensors
  - Radios and security already configured
  - All open-source so can be re-flashed if desired
- Subscribe to a monitoring service (or build one)
  - Establish connection and trust with gateway
- Securely introduce more sensors if needed
- Securely exclude suspect nodes

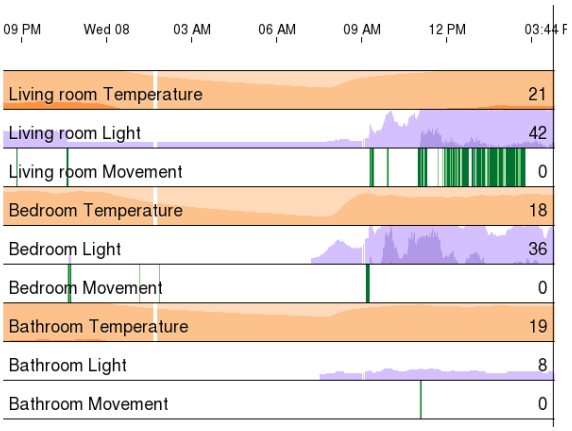
Not such a bad idea, whatever Michael Flanders might have thought...

Completely in-home variant



External access depends on making inbound TCP connections. Many domestic ISPs make this very hard. A clean IPv6 connection is the best long-term solution.

Display: horizon graphs



- Compress Y axis by using colour to indicate wraparound
- Scan cursor with mouse to read values

Display: OpenHab

Message queue allows many data consumers so we can try out new ideas easily

OpenHAB panel looks good, but has issues with intermittent data sources

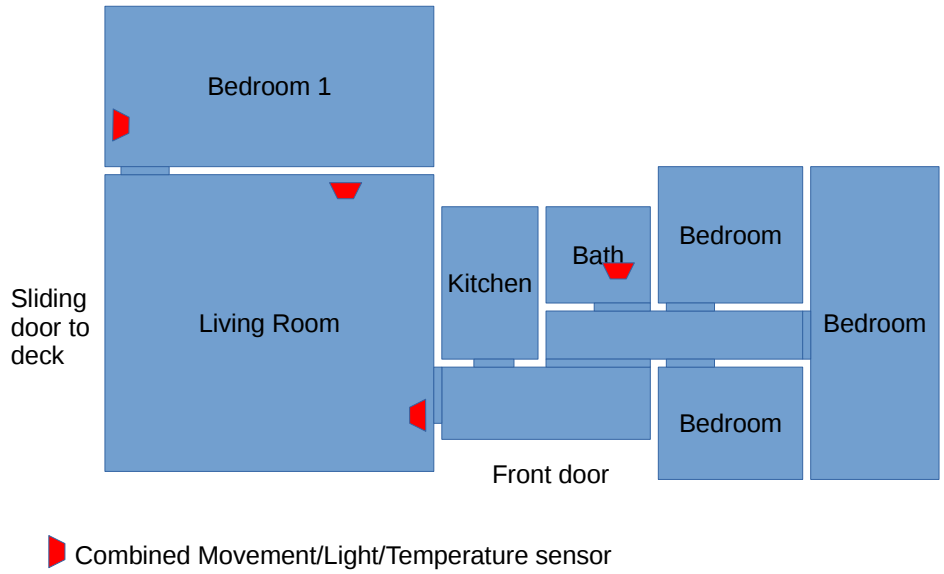
What can we learn?

This is a 'normal' day:
Got up at about 9am
Moved around living room
Visited bathroom twice
Went to bed about 10:30pm and got up at 9:30am the next day
Some lost data on the second morning – maybe Internet connectivity problem?

Alerting Rules

- House too cold or too hot
- Stuck in one room
- Did not go to bed overnight
- Did not get up in the morning
- Has not visited kitchen in <x> hours
- Has not visited bathroom in <x> hours
- Went outside and has not come back
- Has not taken medicines on time

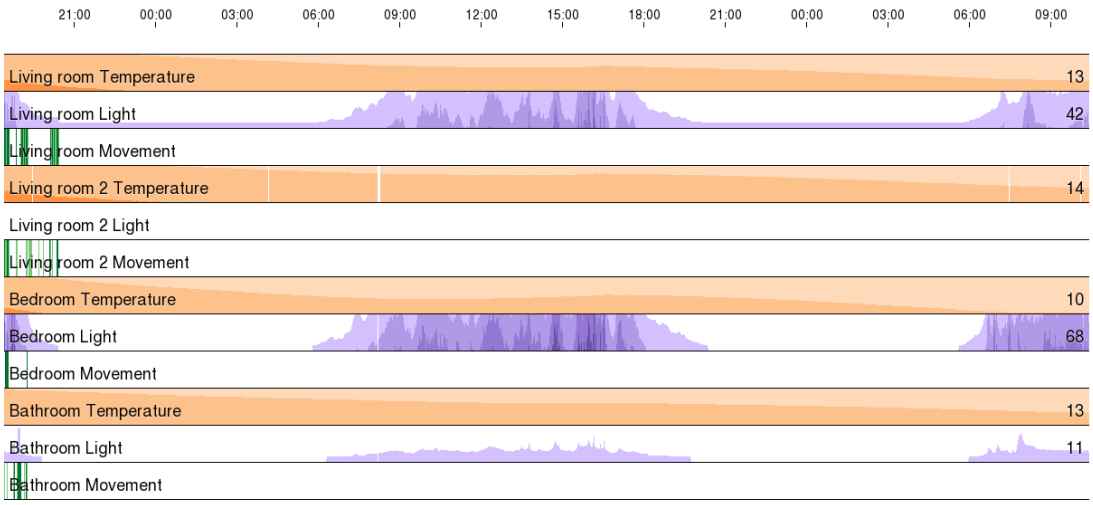
Sensor placement and rules



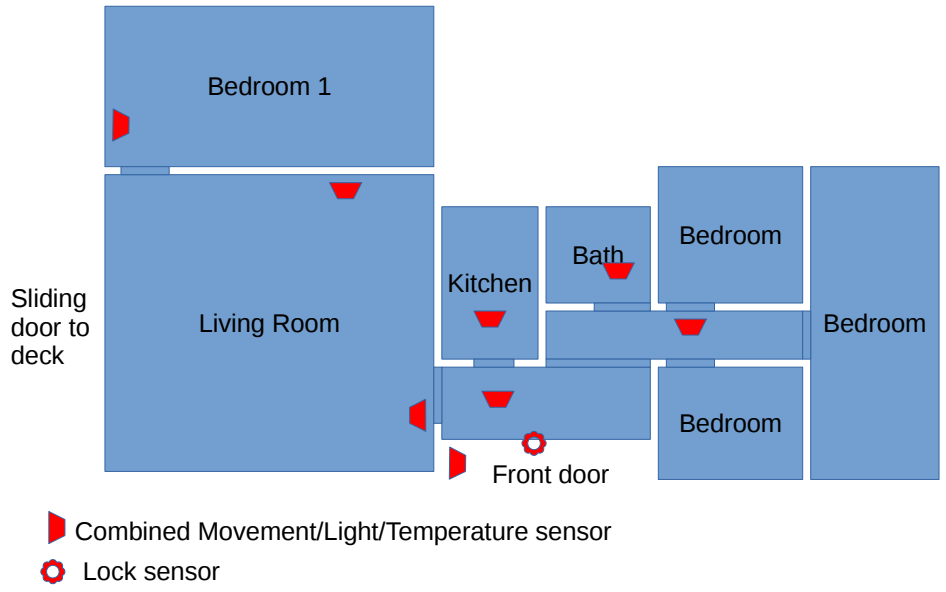
Can we now write some useful alerting rules?
Try these:
1) Fallen over and stuck in the bathroom
2) Did not go to bed
3) Did not get up in the morning

How do we cope with visiting carers and family?
How do we cope with going to stay with family for a few days?
Do we need more sensors?
Can we sense the front-door deadlock?

Where is Mum?


21:00
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
03:00
06:00
09:00
Living room Temperature
13
Living room Light
42
Living room Movement
Living room 2 Temperature
14
Living room 2 Light
Living room 2 Movement
Bedroom Temperature
10
Bedroom Light
68
Bedroom Movement
Bathroom Temperature
13
Bathroom Light
11
Bathroom Movement

More sensors



Now up to 8 movement sensors
Assuming smaller bedrooms seldom visited
Should be enough to work out which room a single person is in at any time
Might be able to detect cooker-left-on incidents from kitchen temp, or could add more temp sensors there

Behaviour changes

- Older people may not keep regular hours
- They become dependent on others
  - Stop going shopping
  - Stop gardening
- They lose motivation for basic routine
  - Cooking
  - Cleaning
  - Bathing
- Each change will need adapted rules

Andy's gran and the dog...

A challenging problem

- Writing good alert rules is hard
  - How can we make it possible for carers to adapt rules to requirements?
- Are we doing this for the client or for the carer?
  - Maybe a few robust rules and a good display system would work better
  - Carers must accept that it could take hours to generate an alert
- Issues of privacy and consent

Monitoring Mum

Now on GitHub:
https://github.com/afindlay/monmum

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27th April 2017