

Big Data? We've got Big Data at home!

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# Outline

- 1 Introduction
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- 2 How it all began
  - Back to electronics
  - Putting it together
- 3 A heated period
  - Our heating system
- 4 Two revolutions
  - Home assistant and MQTT
  - Espressif and the ESP8266
  - Cheap SDR
  - Combined
- 5 Integration explosion
  - Connect all the things
- 6 Monitoring and alerting
  - Better historic data
  - Better communication

# About me

Jan Ypma

*By day*

- Freelance software architect & coach
- Distributed systems & microservices
- Domain-driven design
- Open source enthusiast

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These slides: <https://github.com/jypma/home-data/>

# More about me

Jan Ypma

*Also by day*

- Electronics tinkerer
- Type-safe firmware
- Modular synthesizers
- Dungeon Master (DnD)
- Home automation nerd

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These slides: <https://github.com/jypma/home-data/>

# Seeing the light

- 2012: First own home
  - Lot of work to remember to turn off the light
- Introducing our heroes
  - Arduino (ATMega328, ~2010)
    - 32kB ROM, 2kB RAM, 16MHz
    - Old, 8-bit
    - ADC holds up fine to newer ESP and RP2040
  - FS20 (German home automation system, by Conrad and ELV, ~2008)
    - OOK on 868MHz
  - JeeNode (~2012)
    - Combines ATMega328P with HopeRF RF12B on 868MHz
    - Meant for FSK, but can be made to send and receive OOK as well

# Experiment time!

- Ordered some JeeNodes and FS20 products



- Before long, were sending FS20 signals to our lights
- Receiving FS20 from buttons worked fine too
- But, regular "noise bursts" received
- Noise bursts looked a little too regular

# Investigating further

- Falck alarm
  - Central control unit
  - Wireless motion sensors
  - As it turns out: uses OOK on 868MHz
  - Looks like *Visonic* protocol



- No real documentation
- Still good enough quality to receive motion sensor information

# First integrations

- Let's turn the lights off when there's nobody in the room!
- Wanted central control, easily updated rules
  - JeeNode connected to already-on computers as proxies
    - Home server
    - Media center
    - Raspberry pi
  - Java middleware with control DSL
- Some downsides
  - FS20 is control-only (no feedback if lamp received a command)

# Introduction

- Central heating, one valve per room
- Wired thermostats in each room to adjust temperature (analog)
- Single control unit that turns valves on and off

# A bad day

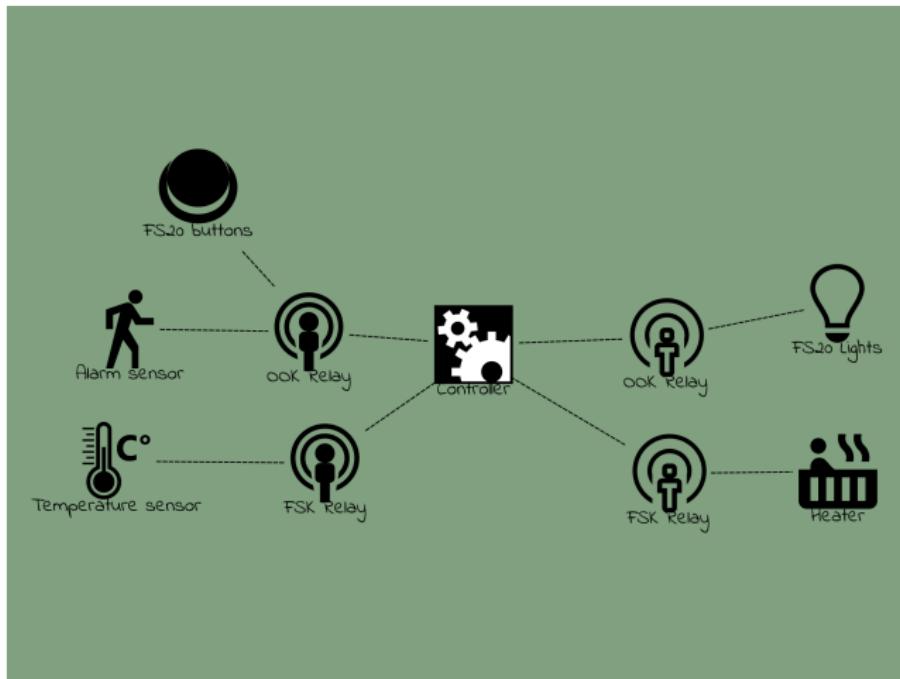
- Controller board failure
- SMPS chip exploded
- System out of production
- Replacement: €5000 (and new thermostats in all rooms)

# What's needed for controlling a heating system?



- 24V to valves
  - JeeNode with MOSFET
- A temperature sensor
  - JeeNode with DHT22 (AliExpress)
- Controller software
  - Let's extend our Java software with heater control

# Complexity is growing



- FS20 lack of confirmation required a custom ACK protocol
- Potential 4G LTE interference on 868MHz is reducing reliability

# Introduction

- MQTT

- *Message Queue Telemetry Transport*
- Lightweight binary protocol for broadcasting messages to topics
- Not actually a message queue
- Open source implementation `mosquitto`

- Home assistant

- Python-based web interface for home automation modules
- 10+ years of history
- Configurable through YAML

# Hooking it up

- Let's see if we can replace our own Java middleware
  - Reduce Java part to make all JeeNode modules available over MQTT
  - Register sensors in Home Assistant for MQTT
  - All logic now in Home Assistant *automations*

# Introduction

- Chip originally from a family of USB WiFi products
- "*Let's make this into a cheap dev board!*"



- "*Let's build these cheap dev boards into our WiFi switch or lamp!*"
  - Sonoff switches
  - Tasmota firmware

# Experiment time

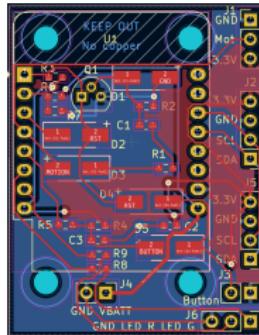
- Purchase some Sonoff switches



- *Sonoff Basic*: 240V in, 240V out
- *Sonoff Mini*: 240V in, switch in, 240V out
- Flash Tasmota on them
  - Typically TX, RX, 3V3 and GND are available on the PCB as pads
  - Often even labelled
  - Autodiscovery in Home Assistant

# Rethinking our setup

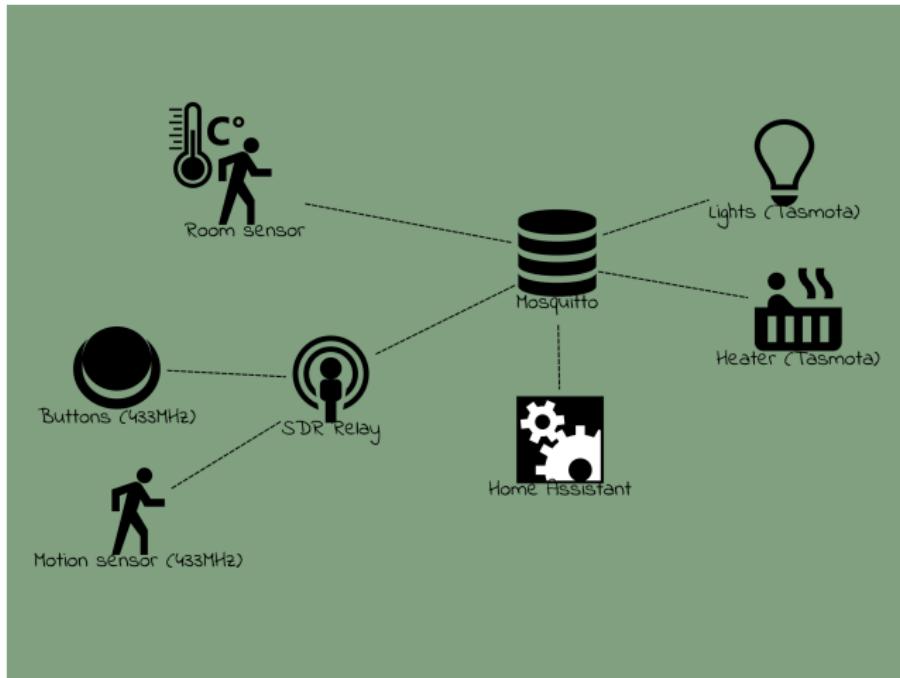
- Let's control our lamps with WiFi instead of FS20
  - Add Sonoff Basic, Sonoff Mini to our fixtures
  - Dimmers with ESP8266 can be found (but less widely supported by Tasmota)
- Let's measure room temperature over WiFi too
  - ESP8266 power management is well-understood
  - The cloned and re-cloned boards are not
  - Official Wemos D1 mini can sleep on low power
  - Add Lithium battery charge module



# RF Motion sensors and buttons

- Not quite 433 MHz
- RTL-SDR
  - RTL2832 chip (*originally for DVB-T reception*)
  - \$10 USB receiver
  - 48.25 MHz to 1.7 GHz (*up to about 2Mhz bandwidth, actual maximum frequency varies*)
- rtl\_433 decoding software
  - Decode detected pulses into JSON
  - Send this to MQTT

# Our new setup



# Kodi

- Media center software
- REST API
- Home assistant integration queries the API
  - Can now react to videos started and stopped
  - Automatic dimming of lights
- Let's have a look

# TV LED strip

- (around) 2002: Philips AmbiLight
- With cheaper addressable LED strips, clones soon followed
- Modern implementation: Luficerin
  - ESP8266 runs firmware that controls the LEDs
  - Input over UDP or MQTT
  - Screen grabber software runs with Kodi and sends LED data
  - Very low latency
  - MQTT integration to home assistant

# Solar inverter and battery

- High electricity tax in Denmark
- Large price difference between night, day and evening
- Solution: solar cells with battery
- Huawei "Sun 2000" inverter and battery
  - Well-documented modbus protocol (over TCP, WiFi)
  - Existing integration into Home Assistant
  - All sensor values available (but needs custom processing)

# Energy prices

- Prices of the Danish market are available online from Nordpool
- Hence, they're also available in Home Assistant
- Let's make sure we always have enough charged battery
  - Use a web service to guess solar output for rest of the day (and tomorrow)
  - Know estimated house usage from hour to hour
  - Charge battery if electricity now is cheaper than when we'd need it

# Car charger (e-go)

- Time for a new car
  - May as well be electric
  - Integrate the car itself? No... \*
- Let's get a charger with an open API
  - Go-e car charger with API on Github
- Let's charge with surplus solar energy
  - New API feature, (still) not documented

```
{"pPv": 116, "pGrid": 1491, "pAkku": 0}
```

- So, pPv must be the solar power, pGrid is what we're sending to the grid, and pAkku battery... right?

# 3D Printer

- Prusa MK3S with Octoprint on an Orange Pi
- Want to turn off printer after printing
  - Octoprint can publish status to MQTT
  - Integrated to Home Assistant
  - Turn off printer (through a Sonoff switch) once idle a certain time

# Nilan

- Denmark
  - Cold during the winter
  - Well-isolated houses
  - Need extra active ventilation
- Nilan
  - Heat exchanger with heat pump
  - Can cool (a little) during summer, but energy-intensive
  - Well-documented modbus protocol (over RS485), with several Home Assistant integrations
  - Let's cool the house down if extra solar power is available

# Security cameras

- Motion-sensing IP cameras
- Send an MQTT message whenever motion is detected
- Available in Home Assistant as a binary sensor

# Doorbell

- Wemos D1 mini (ESP8266)
- Same firmware as room sensor (adding button support)
- Home Assistant automation
  - Play doorbell sound
  - Send e-mail if nobody is home

# Grafana

- All these sensors and their data
- Home assistant's history features are rather limited
- Let's put our metrics somewhere else

`statsd:`

`host: statsd.lan`

- Grafana for gorgeous dashboards and precision

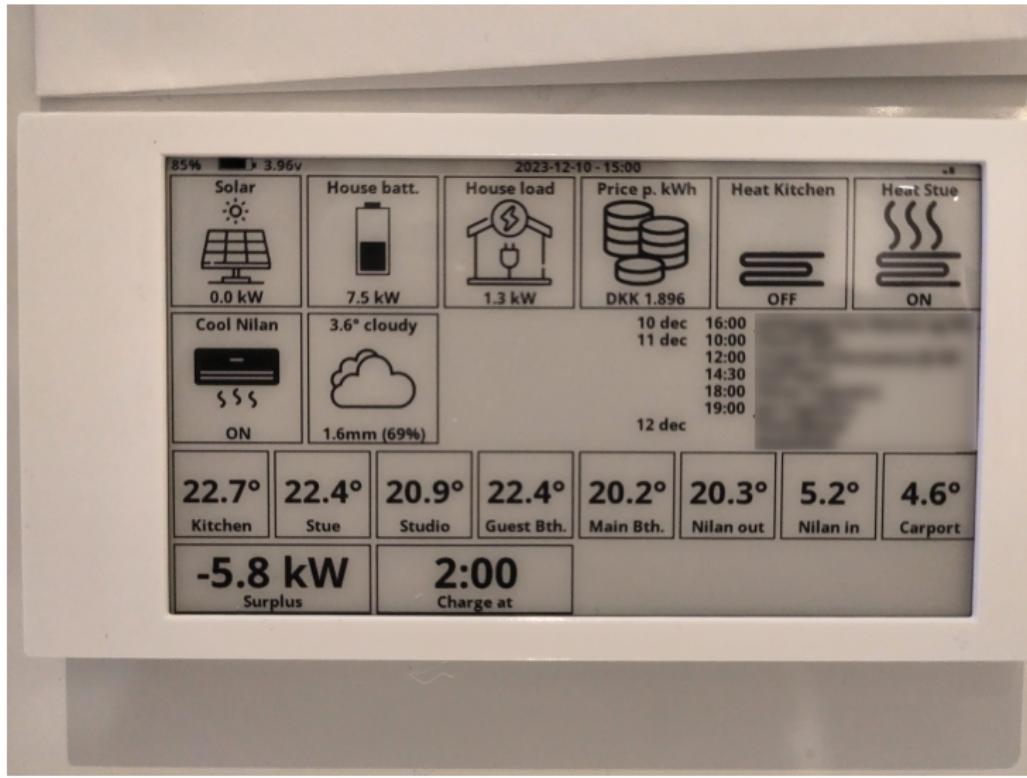
# Alerts

- Dashboard are pretty to look at, but we have better things to do with our time
- Anything worth graphing, is probably worth alerting about
- Send e-mail when
  - Battery of any of the temperature sensors is getting low
  - Outside motion sensors haven't seen motion for a while
  - Any of the raspberry pis can't be pinged
  - Doorbell is pressed while we're on vacation
  - Server is about to go out of disk space

# General status overview

- Still nice to have a quick overview of things
  - Grabbing a phone or computer, opening it, navigating, takes way too much time
  - Always-on solution
- E-paper to the rescue
  - Has gotten more affordable
  - Development kits exist with out favorite microcontrollers
  - *LilyGo T5 4.7"*: E-paper display with ESP32

# At a glance



# It's all about data

- Prefer devices where you can control the data coming *IN* and *OUT*
- Open standards are preferred, but reverse-engineered protocols work fine too
- Open source software is crucial
  - Quality varies, but you can always participate
- It's not easy (yet...)
  - *Home assistant*: Large python code base, many developers, well-intentioned refactors
  - *Tasmota*: Multiple embedded platforms, challenges in unit testing
  - Light bulb conspiracies?
- Why should the internet participate in me turning on a light bulb, or my doorbell ringing?

Thank you! [jan@ypmania.net](mailto:jan@ypmania.net)