

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

Jan Ypma

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Outline

- 1 Introduction
 - Getting started
- 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

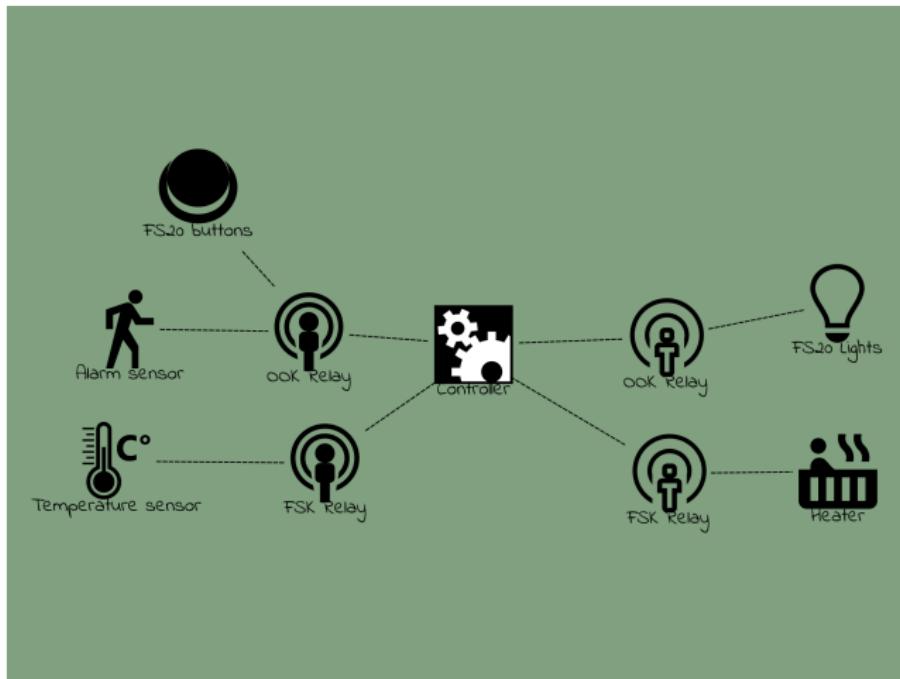
- Controller board failure
- SMPS chip exploded
- System out of production
- Replacement: €5000 (and new thermostats in all rooms)

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

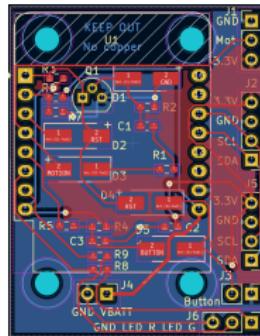
- Purchase some Sonoff switches



- *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

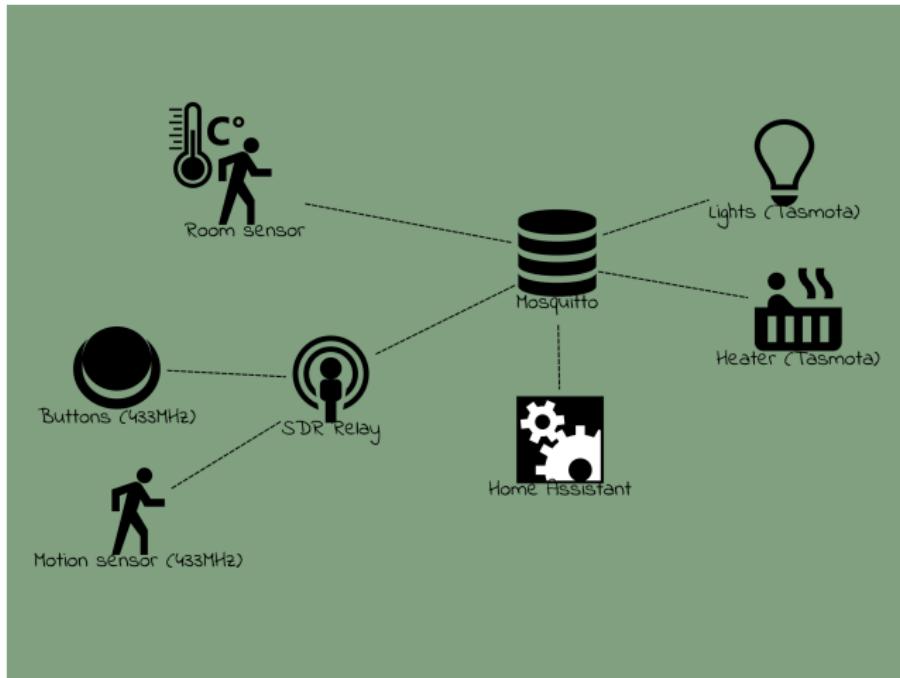
- Let's control our lamps with WiFi instead of FS20
 - Add Sonoff Basic, Sonoff Mini to our fixtures
 - Dimmers with ESP8266 can be found (but less widely supported by Tasmota)
- Let's measure room temperature over WiFi too
 - ESP8266 power management is well-understood
 - The cloned and re-cloned boards 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

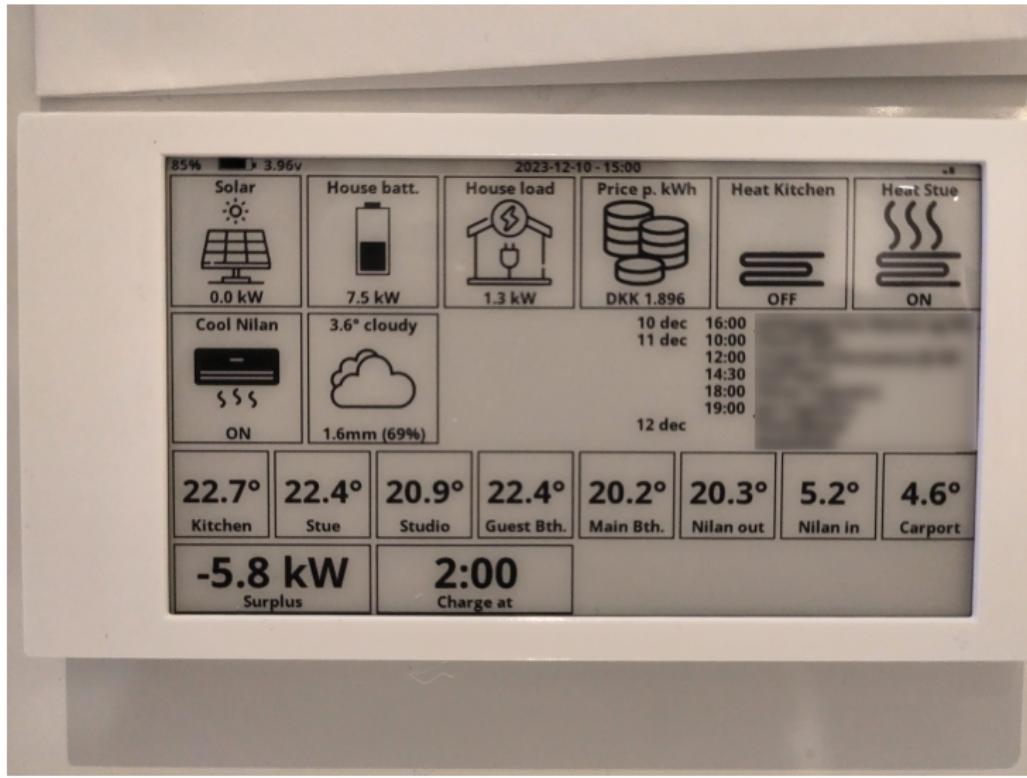
Alerts

- 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...)
 - Light bulb conspiracies?
- Why should the internet participate in me turning on a light bulb, or my doorbell ringing?

Thank you! jan@ypmania.net