

# Building a Better Thermostat

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<https://github.com/mtreinish/building-a-better-thermostat/tree/lca2018>

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# Poughkeepsie, NY



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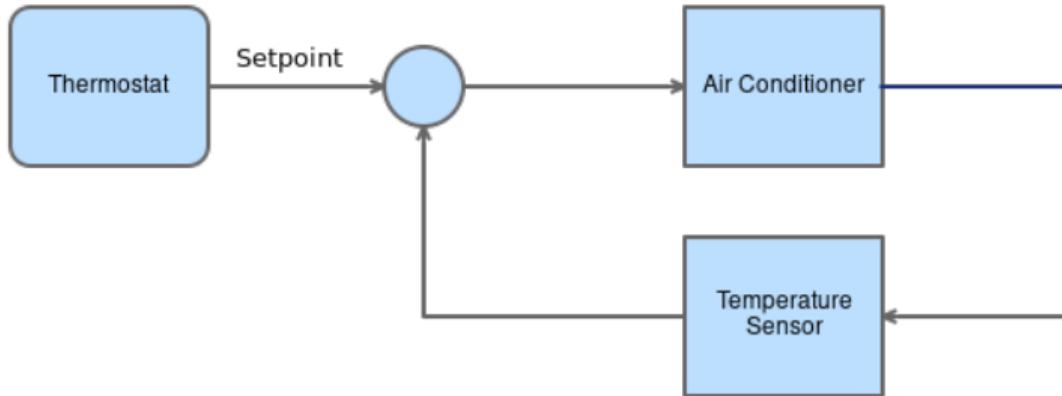
# Room Layout



# Air Conditioner Units



# Thermostat



- ▶ Closed Loop control device
- ▶ 1 input temperature sensor
- ▶ 1 output for controlling heating and/or cooling system

## Constraints for controlling the AC



- ▶ Can't take apart the Air Conditioner (I don't own it)
- ▶ No identifying information for the AC
- ▶ Wireless control is ideal

## Solution for controlling the AC

- ▶ Control via power (use a relay to turn on and off)
- ▶ Measured current draw with clamp meter
- ▶ Purchased a Z-Wave power switch



## What is Z-Wave

- ▶ Low power mesh network for sensors and devices
- ▶ Licensed by Sigma Designs
- ▶ Interoperability tested for all devices by Z-Wave Alliance
- ▶ Software API and protocol docs in the public domain
- ▶ Over 1700 certified devices
- ▶ OpenZwave is an Open Source library to interface with a Z-Wave network



# Sensing the Temperature

- ▶ Wireless sensor
- ▶ Leverage the new Z-Wave network
- ▶ Purchased a Z-Wave multi sensor which included temperature



# Using Z-Wave

- ▶ Setup a Z-Wave network with Aeotec Z-Stick
- ▶ Register each device on the network
- ▶ Leverage OpenZWave to provide an API to interact with devices

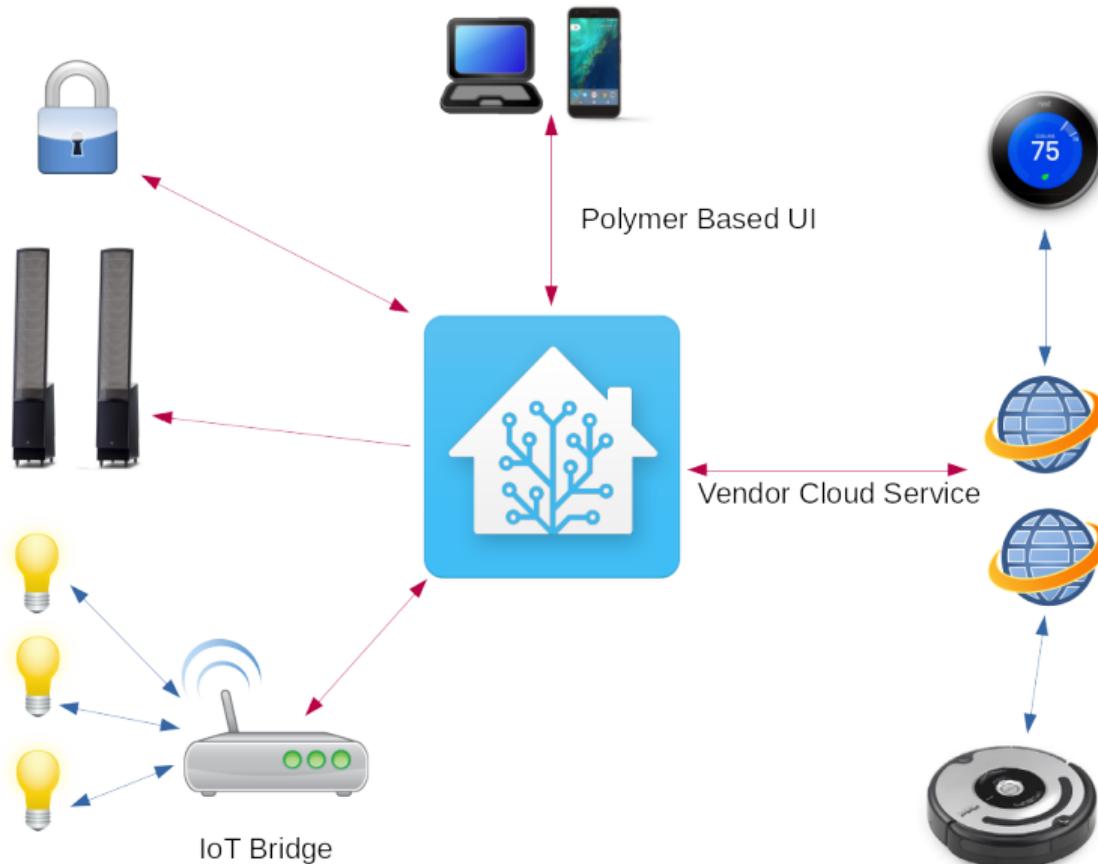


# Home Assistant

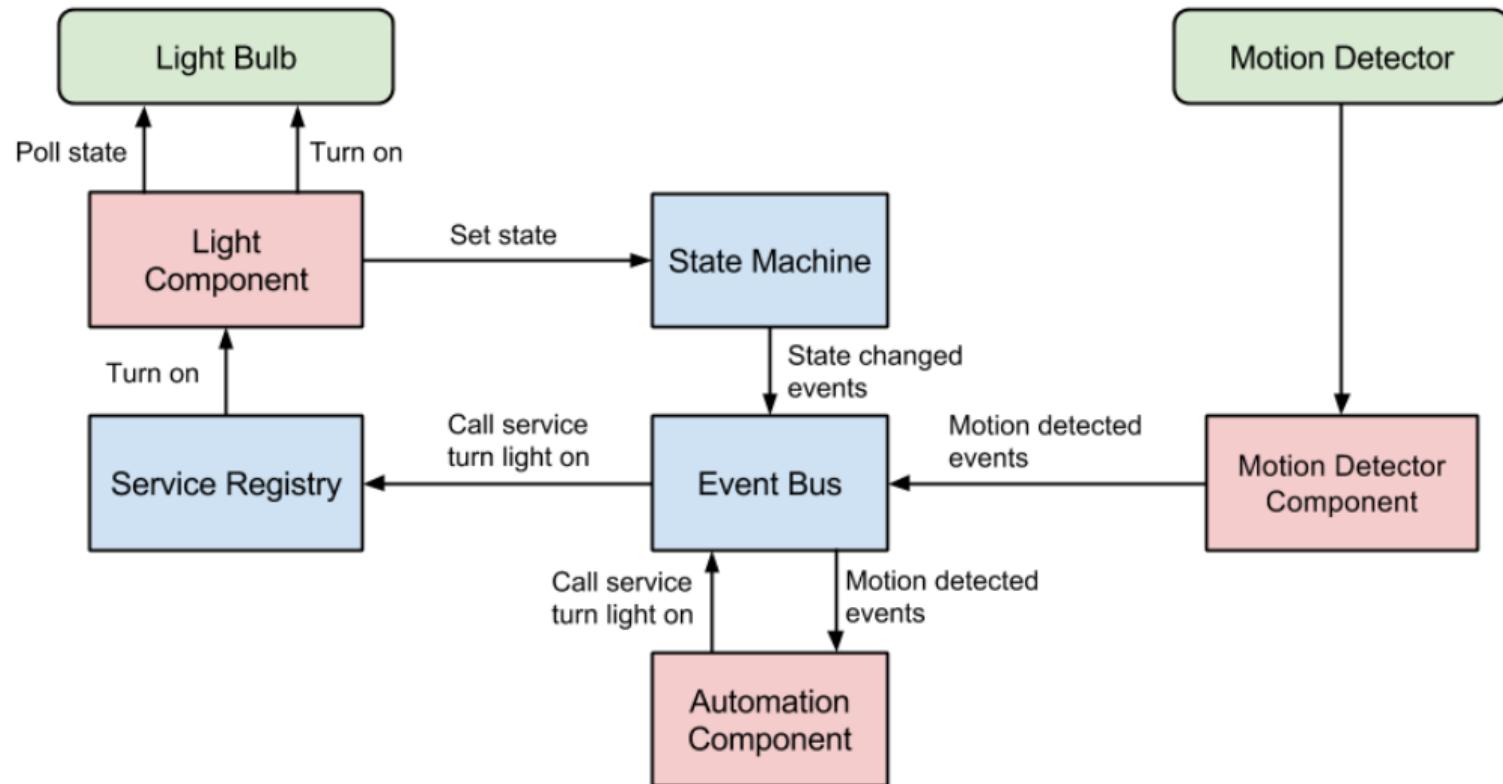
- ▶ Open Source Home Automation Platform
- ▶ Written in Python 3
- ▶ Has over 900 different components
- ▶ Runs locally (with all data stored locally)
- ▶ Design point that it will always run on Raspberry Pi 3



# Home Assistant in Practice



# Internal Architecture



## First Attempt at a thermostat

```
1 alias: Turn off Living Room AC when below 25 C
2 trigger:
3     platform: numeric_state
4     entity_id: sensor.aeotec_zw100_multisensor_6_temperature_4
5     below: 25
6 condition:
7     - condition: state
8         entity_id: switch.aeotec_zw096_smart_switch_6_switch_2
9         state: 'on'
10    for:
11        minutes: 20
12 action:
13     service: switch.turn_off
14     entity_id: switch.aeotec_zw096_smart_switch_6_switch_2
```

## Issues with this approach

- ▶ Requires writing a separate rule for every possible condition
- ▶ Rules only triggered on state updates
- ▶ Switching became unreliable
- ▶ Adjusting the set point required a configuration update

# Setting up a thermostat device in Home Assistant

<https://home-assistant.io/components/#climate>

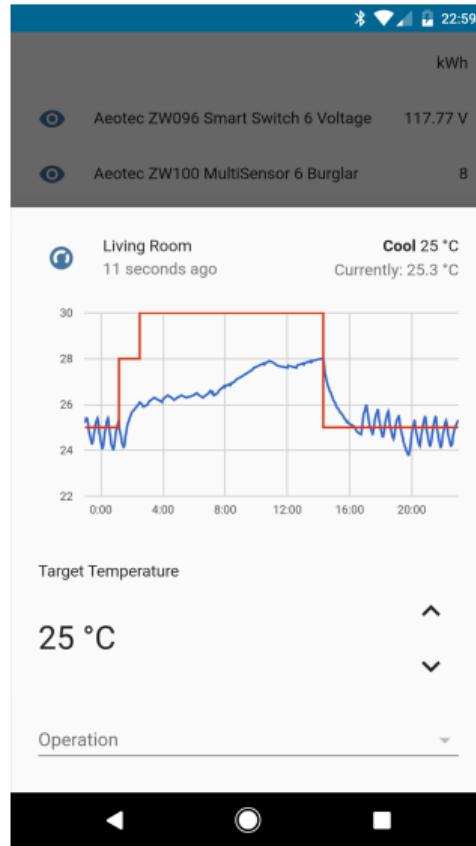
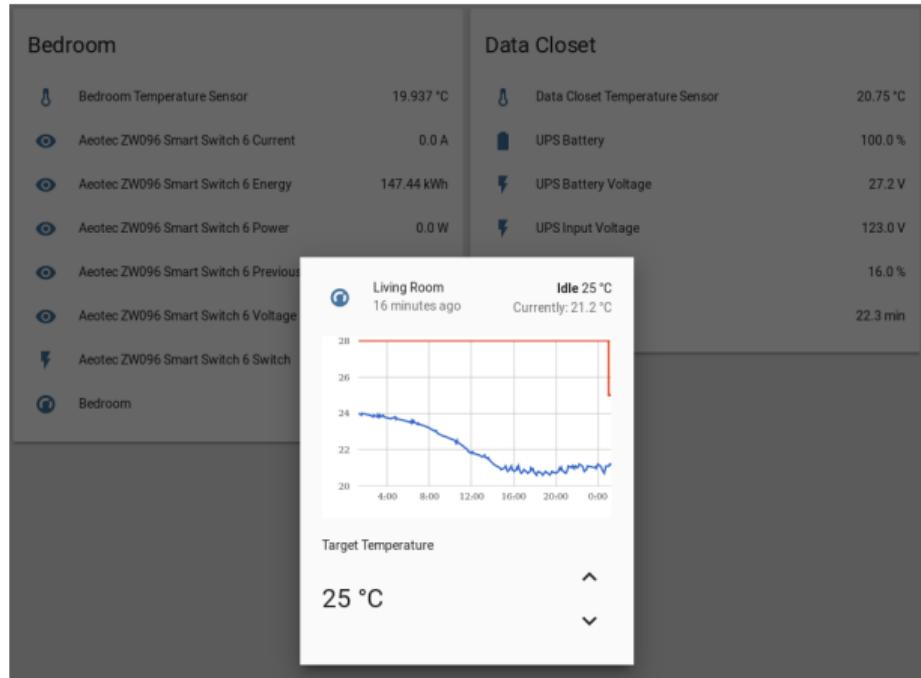
 Ecobee Thermostat climate	 eQ-3 MAX! Cube climate	 eQ-3 MAX! Cube binary sensors climate	 eQ-3 MAX! Cube binary sensors climate
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 Honeywell Thermostat climate	 MySensors HVAC climate	 Nest Thermostat climate	 Netatmo Thermostat climate
 OpenEnergyMonitor WiFi Thermostat climate	 Proliphix Thermostat climate	 Radio Thermostat (3M Filtrate) Thermostat climate	 Sensibo A/C controller climate
 Tado Thermostat climate	 Vera Thermostat climate	 Wink Thermostat climate	 Z-Wave Climate climate

- ▶ Many thermostat modules depending on hardware
- ▶ The generic thermostat component exists to run it in software
- ▶ In the component configuration define a generic thermostat devices with a temperature sensor and switch

# Configuring a software thermostat in Home Assistant

```
1 climate:  
2   - name: Living Room  
3     platform: generic_thermostat  
4     heater: switch.aeotec_smart_switch_6_switch_5_0  
5     target_sensor: sensor.aeotec_zw100_multisensor_6_temperature_4_1  
6     min_temp: 20  
7     max_temp: 35  
8     target_temp: 25  
9     ac_mode: True
```

# Home Assistant Web Dashboard

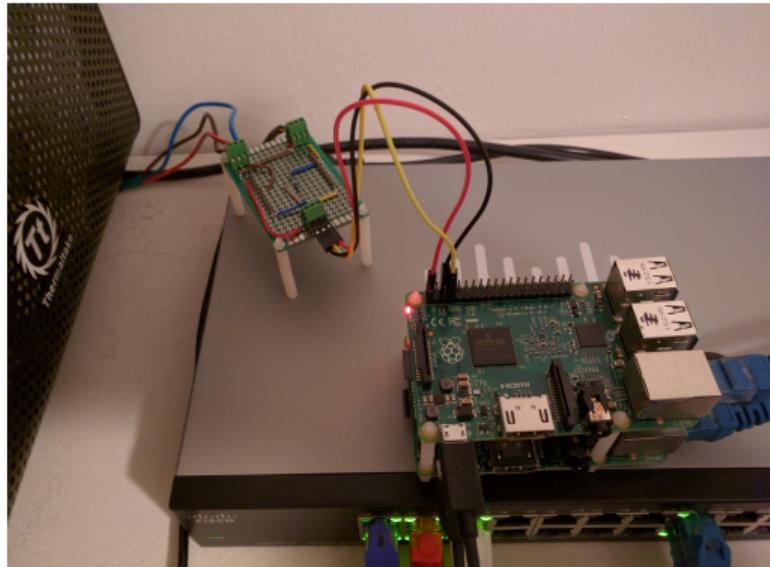


## Problems with this...



# Bedroom Temperature Sensing

- ▶ Track both bedroom and “data” closet temperatures
- ▶ Leverage spare Raspberry Pi sitting in “data” closet
- ▶ 2x DS18B20 Dallas 1 wire temperature sensors used



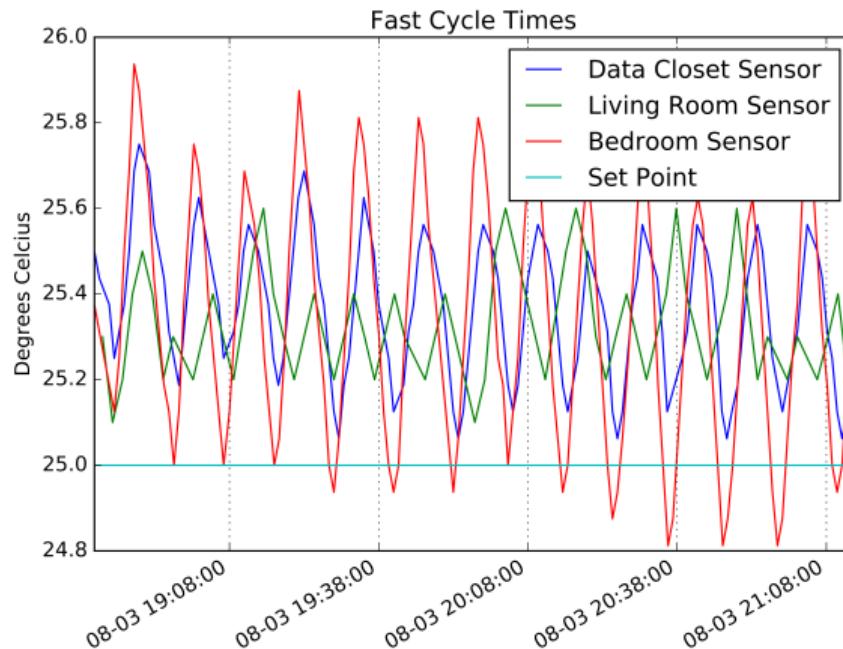
# Data Closet



## DallasMQTT

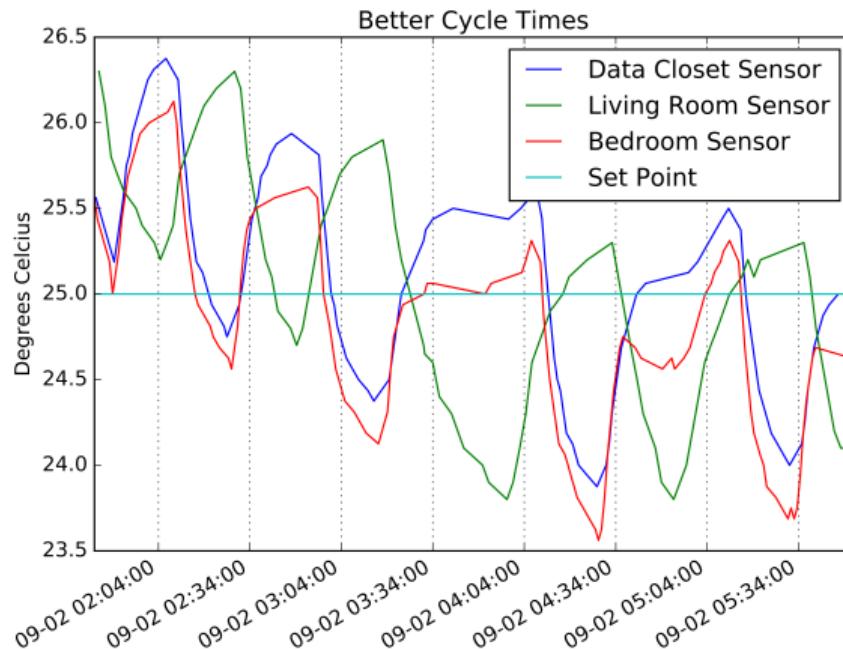
- ▶ Framework for polling sensors and pushing results on MQTT
- ▶ Handles an arbitrary number of sensors
- ▶ Currently only supports Dallas 1 wire temperature sensors from w1\_therm linux driver
- ▶ Written in python

## Short Cycle Time



- ▶ Bedroom on for 8 min. and off for 4 min.
- ▶ Living Room on for 4 min. off for 2 min.

# Corrected Cycle Time



- ▶ Bedroom on for 20 min. and off for 21 min.
- ▶ Living Room on for 17 min. off for 29 min.

## Starting to Automate

```
1 alias: Set Living Room AC to 30 C when asleep
2 trigger:
3     platform: time
4     after: '12:30:00'
5 condition:
6     - condition: time
7     before: '09:30:00'
8 action:
9     service: thermostat.set_temperature
10    entity_id: thermostat.living_room
11    data:
12        temperature: 30
```

## Location Tracking

- ▶ Start writing rules based on my location
- ▶ Set temperature higher when I'm not home
- ▶ Pre-cool apartment when I'm heading home

# Owntracks

- ▶ Open Source iOS and Android app for reporting location over MQTT
- ▶ Enables you to use either a private MQTT broker or public service
- ▶ Home Assistant component available



## Location Based Automation Rules

```
1 alias: Set Living Room AC to 26 C when leaving starbucks route 9
2 trigger:
3     platform: state
4     entity_id: device_tracker.myphone
5     from: 'Starbucks Route 9'
6 action:
7     - delay:
8         minutes: 5
9     - service: climate.set_temperature
10    entity_id: climate.living_room
11    data:
12        temperature: 26
```

## Turn the Air Conditioning off Based on the Outside Temperature

```
1 alias: Turn off AC when it's cold outside
2 trigger:
3     platform: numeric_state
4     entity_id: sensor.pws_temp_c
5     below: 22.0
6 action:
7     service: thermostat.set_operation_mode
8     entity_id: thermostat.living_room
9     data:
10        operation_mode: off
```

## Increase TV volume when the AC turns on

```
1 alias: Raise volume when AC turns on
2 trigger:
3     platform: state
4     entity_id: switch.aeotec_zw096_smart_switch_6_switch_2_0
5     to: 'on'
6 conditions:
7     - condition: state
8         entity_id: media_player.living_room_av_reciever
9         state: 'on'
10    - condition: template
11        value_template: '{{ states.media_player.reciever.volume_level < 0.7
12 action:
13     service: media_player.volume_up
14     entity_id: media_player.living_room_av_reciever
```

## Turn AC on when Closet Cloud starts

```
1 alias: Turn AC on when altocumulus starts
2 trigger:
3     platform: state
4     entity_id: switch.altocumulus01
5     from: 'off'
6     to: 'on'
7     for:
8         minutes: 2
9 action:
10    service: climate.set_operation_mode
11    entity_id: climate.bedroom
12    data:
13        operation_mode: on
```

## Future Work

- ▶ More Sensors
- ▶ More automation
- ▶ Additional Power monitoring
- ▶ Adjust/tune switching parameters

## Where to get more information

- ▶ Blog Post <http://blog.kortar.org/?p=319>
- ▶ <https://home-assistant.io/>
- ▶ <https://github.com/mtreinisch/dallasMQTT>
- ▶ <http://zwavepublic.com/>
- ▶ <http://owntracks.org/>
- ▶ <https://github.com/openzwave/>
- ▶ W.J. Mulroy, "The Effect of Short Cycling and Fan Delay on the Efficiency of a Modified Residential Heat Pump", *ASHRAE Transactions*, Vol. 92, No. Part 1, pp. 813-816, January 1986
- ▶ Slides: <https://github.com/mtreinisch/building-a-better-thermostat/tree/lca2018>