

Building a Better Thermostat

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

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Room Layout



Air Conditioner Units



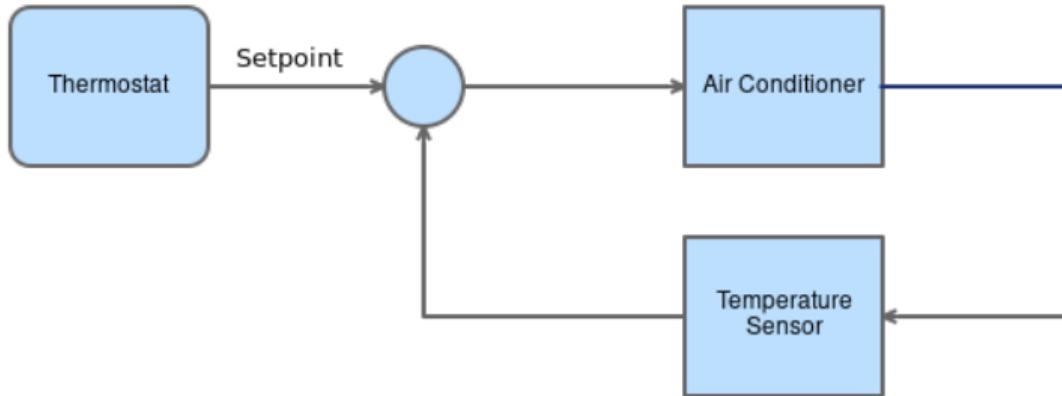
Existing Commercial Solutions



<https://shop.luxproducts.com/products/win100>

<http://centurytimer.com/century-digital-cooling-thermostat-controller-for-cooling-device-40-108-f>

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

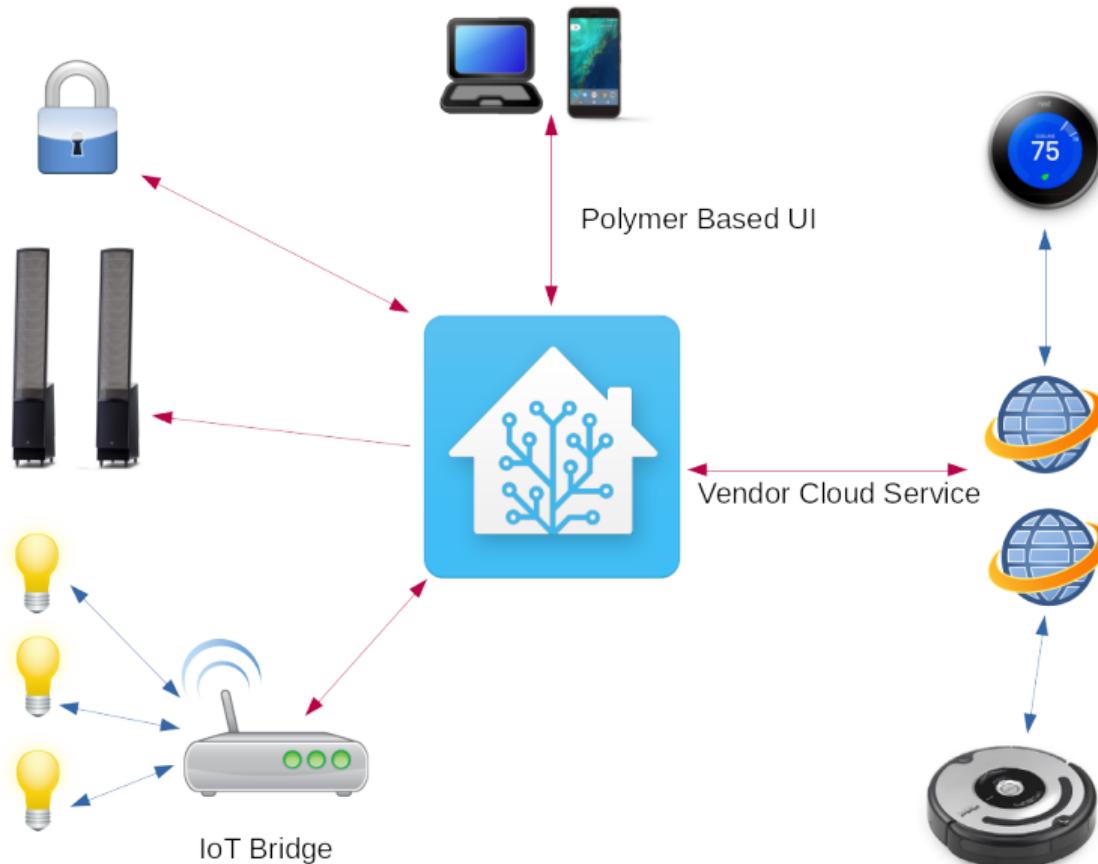


Home Assistant

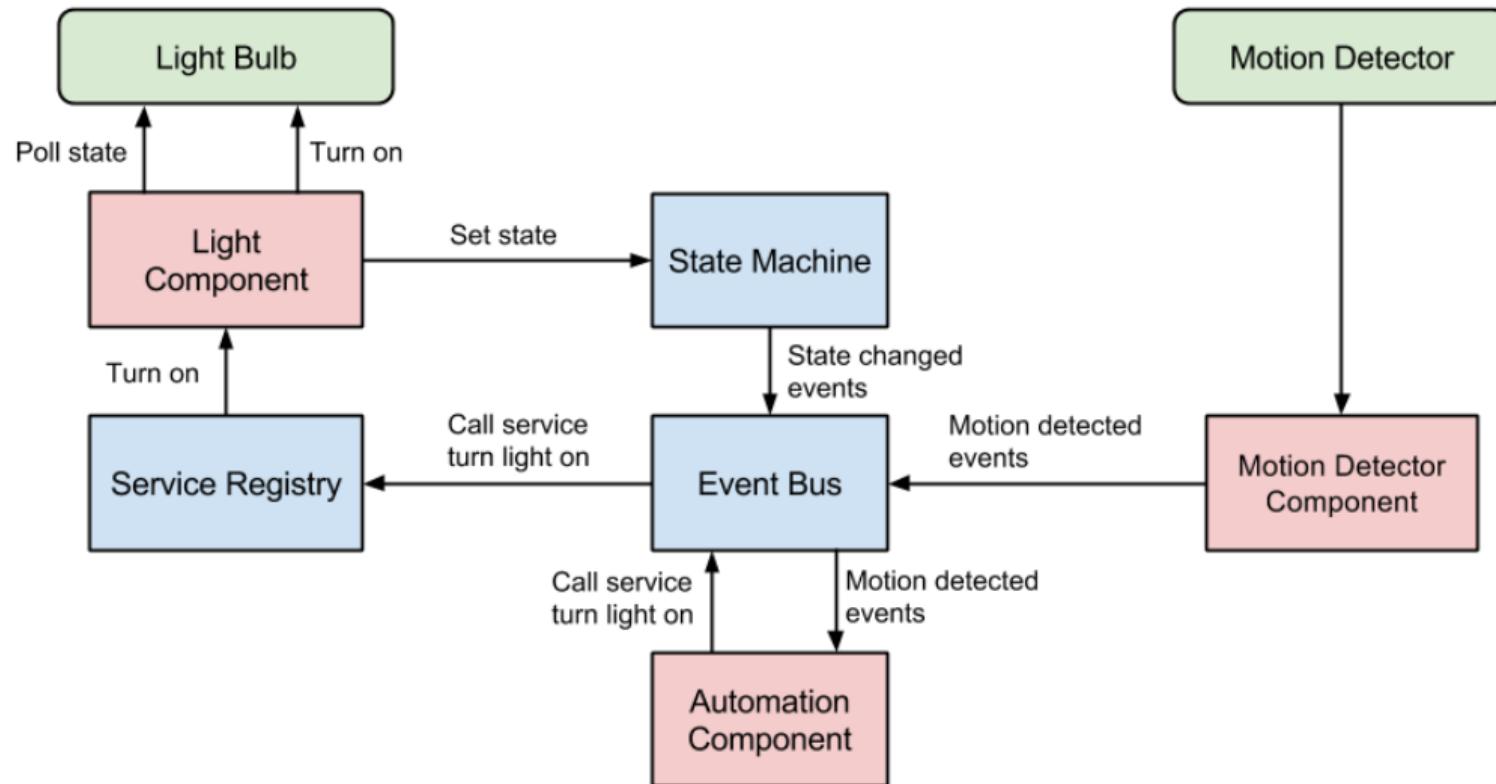
- ▶ Open Source Home Automation Platform
- ▶ Written in Python 3
- ▶ Has over 900 different components
- ▶ Runs locally (with all data stored locally)
- ▶ Design point that it will always run on Raspberry Pi 3



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>

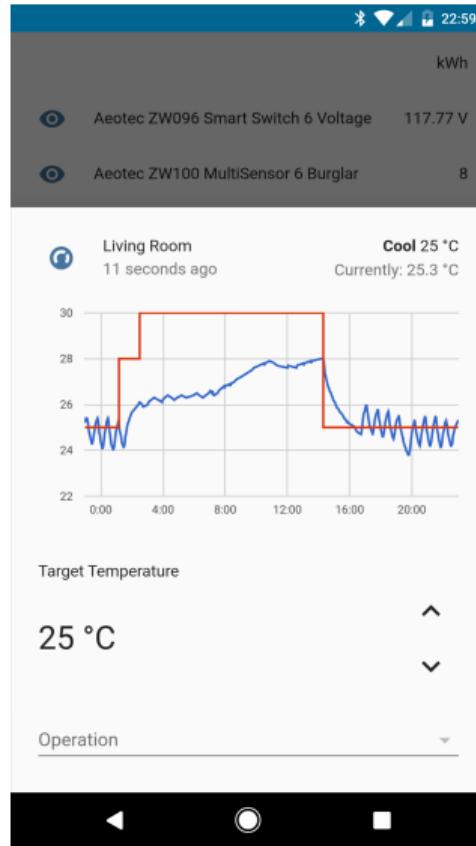
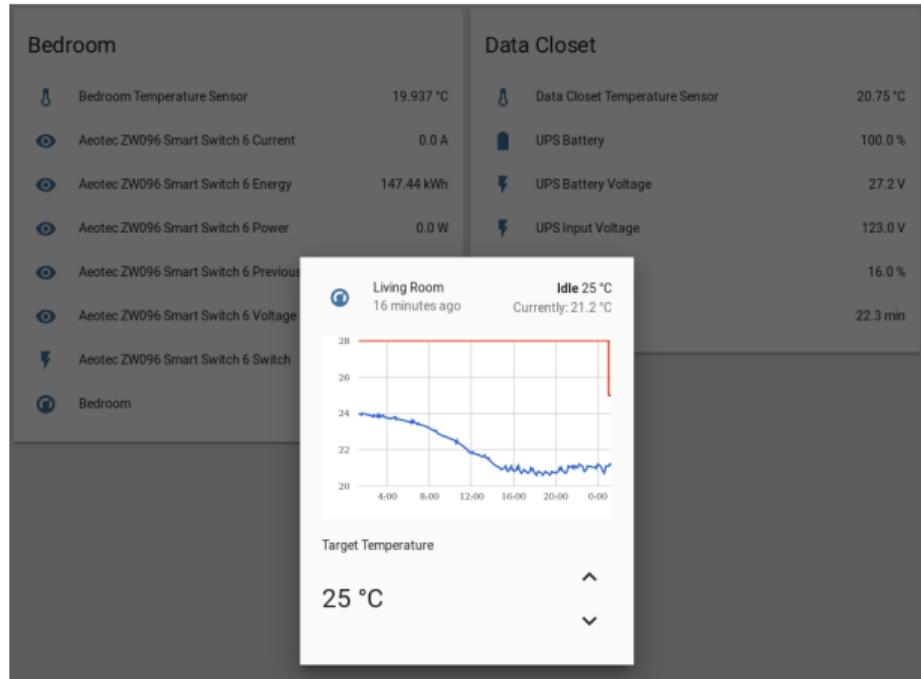
 Ecobee Thermostat climate	 eQ-3 MAX! Cube climate	 eQ-3 MAX! Cube binary sensors climate	 eQ-3 MAX! Cube binary sensors climate
 eQ3 Bluetooth Smart Thermostats climate	 Generic Thermostat climate	 heatmiser Heatmiser Thermostat climate	 HomeMatic Homematic Thermostats climate
 Honeywell Thermostat climate	 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...



Even more zones

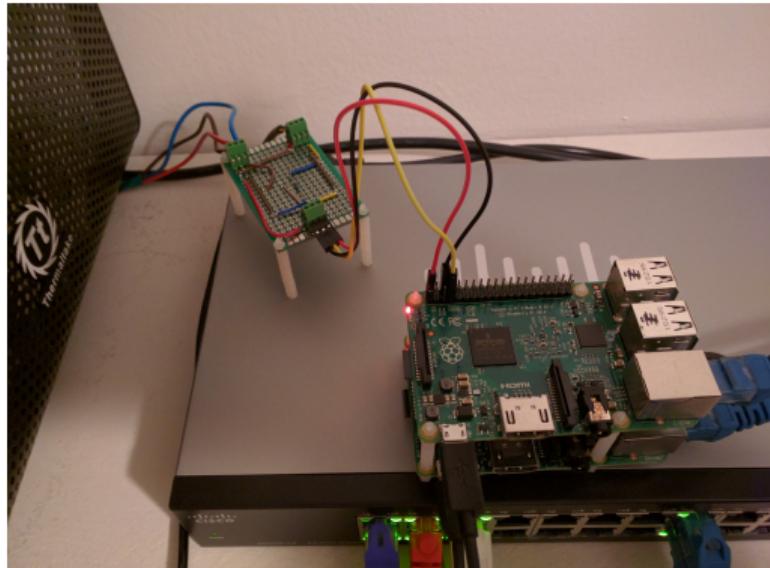


Data Closet



Bedroom Temperature Sensing

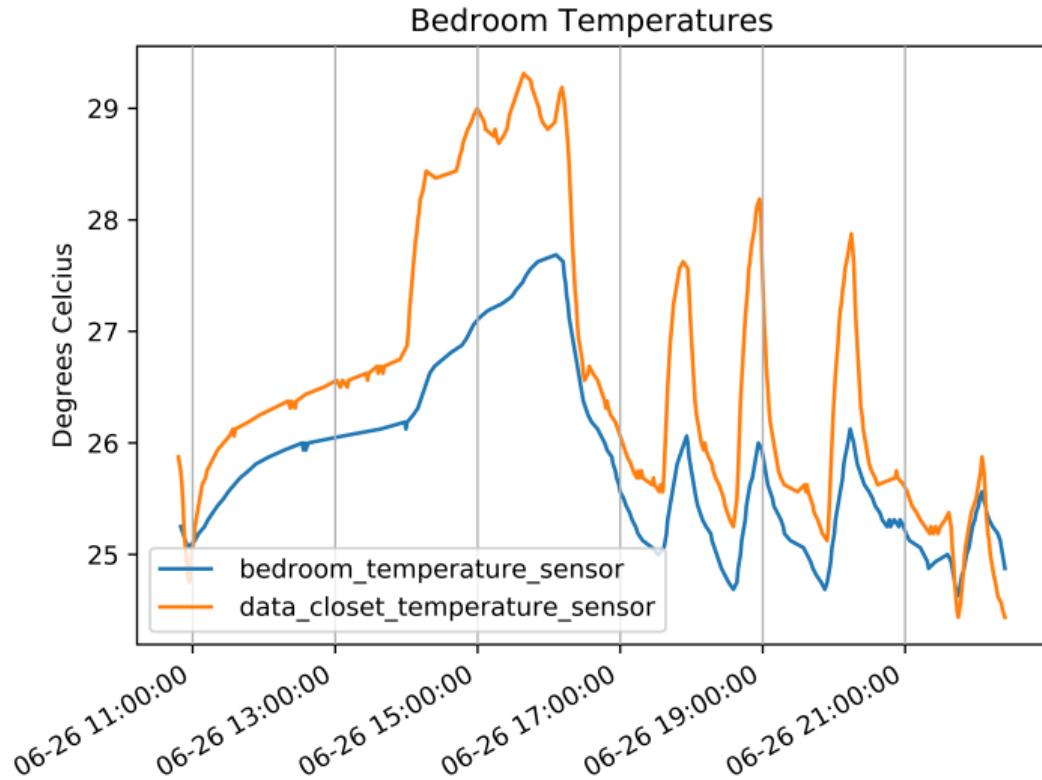
- ▶ Track both bedroom and “data” closet temperatures
- ▶ Leverage spare Raspberry Pi sitting in “data” closet
- ▶ 2x DS18B20 Dallas 1 wire temperature sensors used



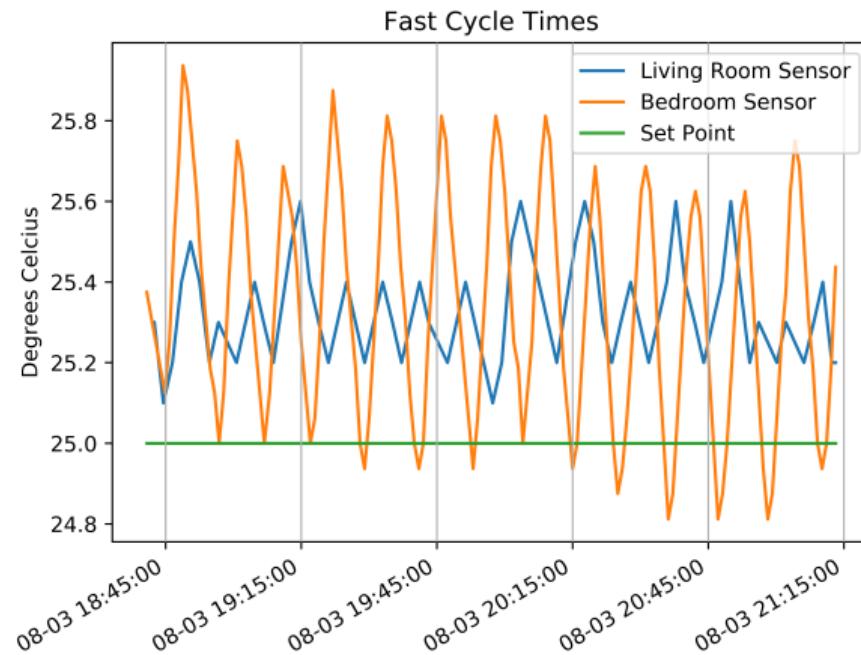
DallasMQTT

- ▶ 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

The ΔT

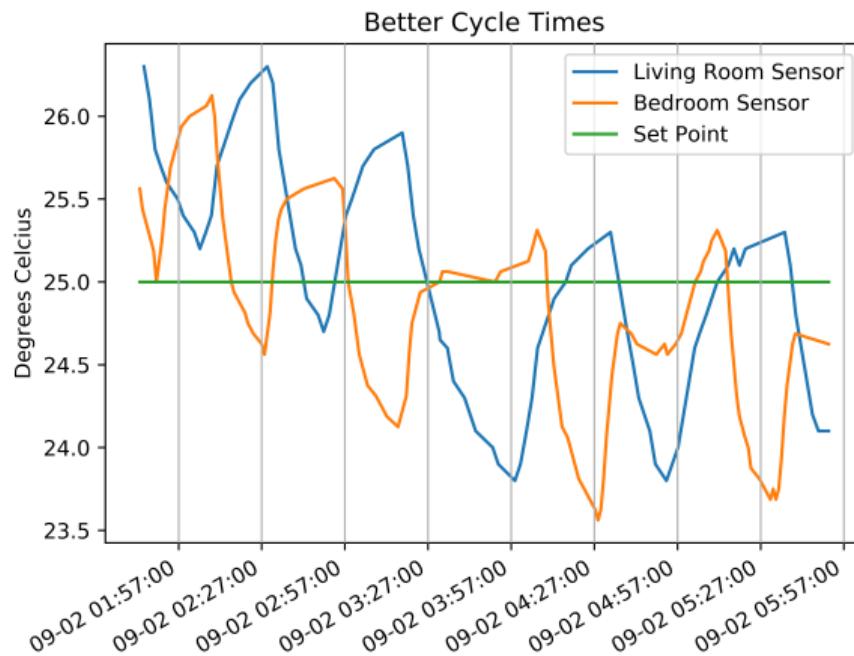


Short Cycle Time



- ▶ 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

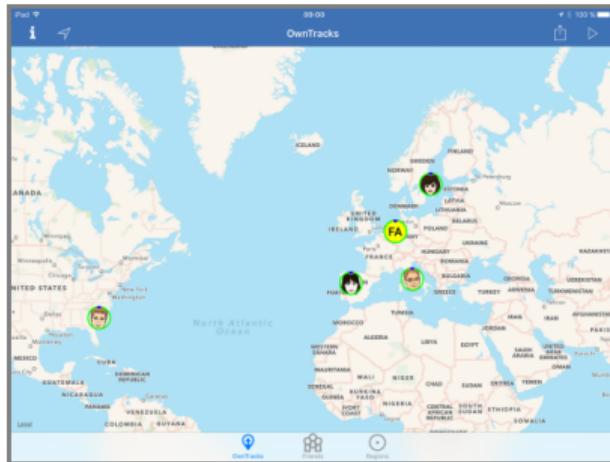
```
1 alias: Set Living Room AC to 30 C when asleep
2 trigger:
3     platform: time
4     after: '12:30:00'
5 condition:
6     - condition: time
7     before: '09:30:00'
8 action:
9     service: thermostat.set_temperature
10    entity_id: thermostat.living_room
11    data:
12        temperature: 30
```

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>