Building a Better Thermostat

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https://github.com/mtreinish/building-a-better-thermostat/tree/seagl2017

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$$T_{(^\circ F)} = T_{(^\circ C)} \times 1.8 + 32$$

Poughkeepsie, NY

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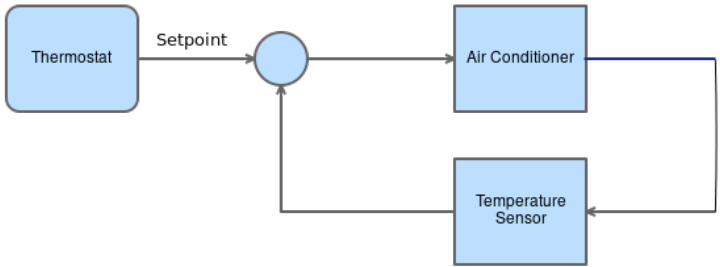
Room Layout


Balcony
Bathroom
11ft x 8ft
Kitchen
11ft x 11ft
Closet
Dining Room
10ft x 9ft
Walk in
Closet
Closet
Living Room
17ft x 13ft
Bedroom
14ft x 11ft

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

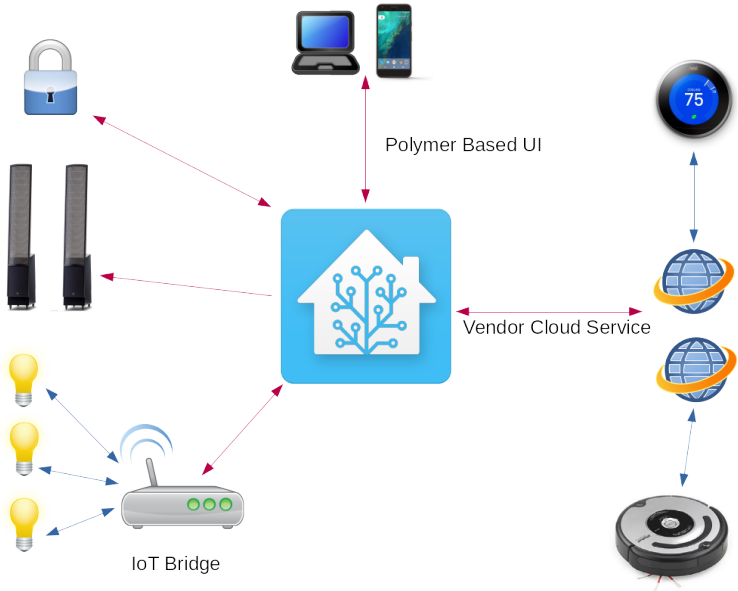
Using Z-Wave

- 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

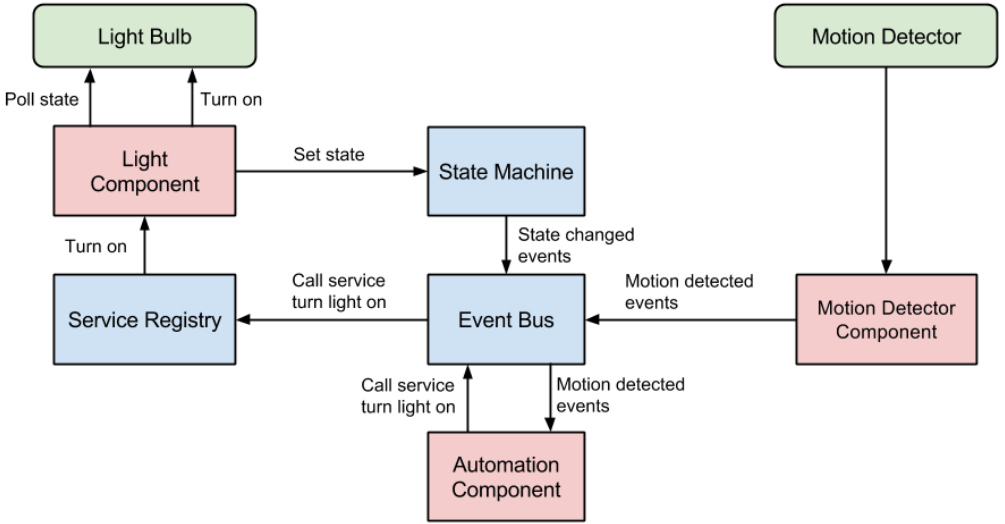
Home Assistant

- Open Source Home Automation Platform
- Written in Python 3
- Has over 800 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

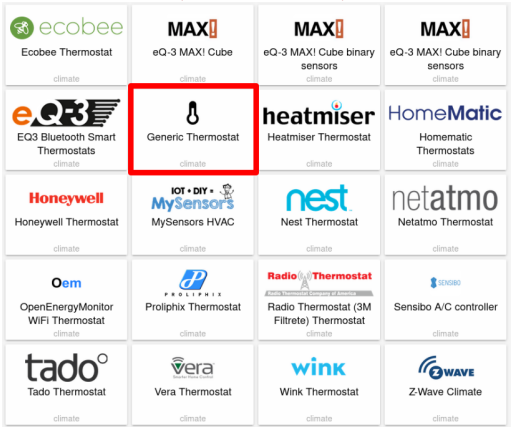
```yaml
alias: Turn off Living Room AC when below 25 C
trigger:
  platform: numeric_state
  entity_id: sensor.aeotec_zw100_multisensor_6_temperature_4
  below: 25
condition:
  - condition: state
    entity_id: switch.aeotec_zw096_smart_switch_6_switch_2
    state: 'on'
    for:
      minutes: 20
action:
  service: switch.turn_off
  entity_id: switch.aeotec_zw096_smart_switch_6_switch_2
```

Issues with this approach

- Requires writing a separate rule for ever 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

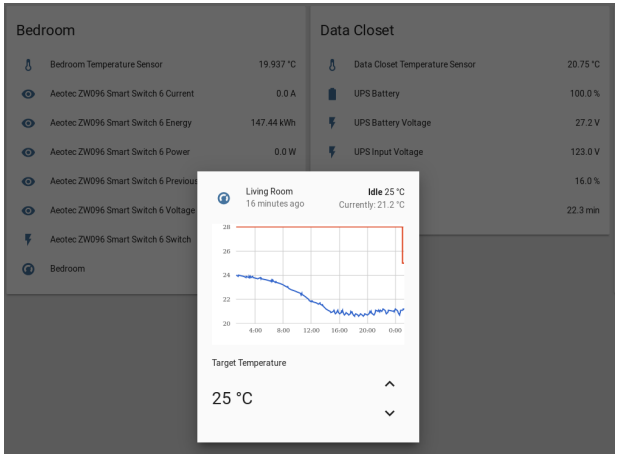


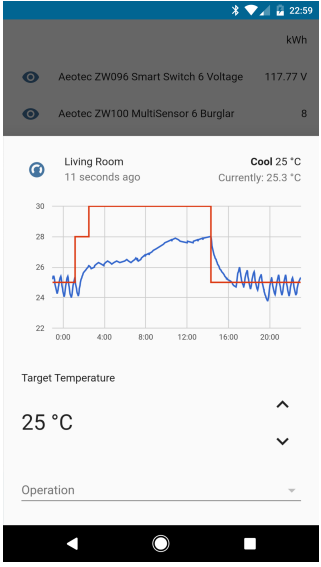
- Many thermostat modules depending on hardware
- The generic thermostat component exists to run it in software
- In the component configuration define a generic thermostat devices with a temperature sensor and switch

Configuring a software thermostat in Home Assistant

```
climate:
  - name: Living Room
    platform: generic_thermostat
    heater: switch.aeotec_smart_switch_6_switch_5_0
    target_sensor: sensor.aeotec_zw100_multisensor_6_temperature_4_1
    min_temp: 20
    max_temp: 35
    target_temp: 25
    ac_mode: True
```

Home Assistant Web Dashboard

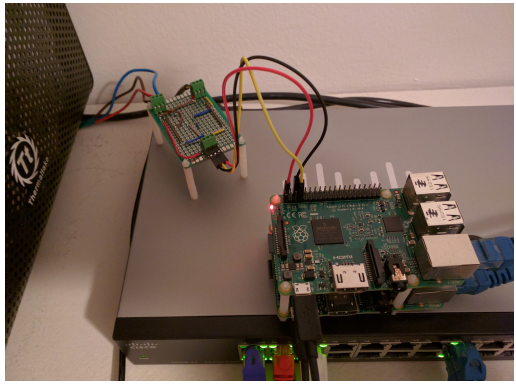




Problems with this. . .

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

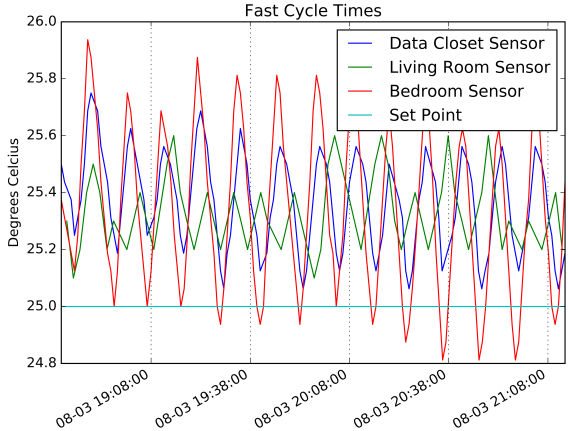


Data Closet

DallasMQTT

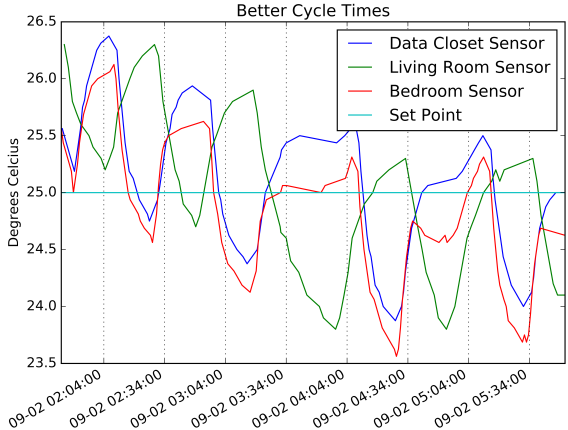
- Framework for polling sensors and pushing results on MQTT
- Handles an arbitrary number of sensors
- Currently only supports Dallas 1 wire temperature sensors from w1_therm linux driver
- Written in python

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

```
alias: Set Living Room AC to 26 C when leaving starbucks route 9
trigger:
  platform: state
  entity_id: device_tracker.myphone
  from: 'Starbucks Route 9'
action:
  - delay:
      minutes: 5
  - service: climate.set_temperature
    entity_id: climate.living_room
    data:
      temperature: 26
```

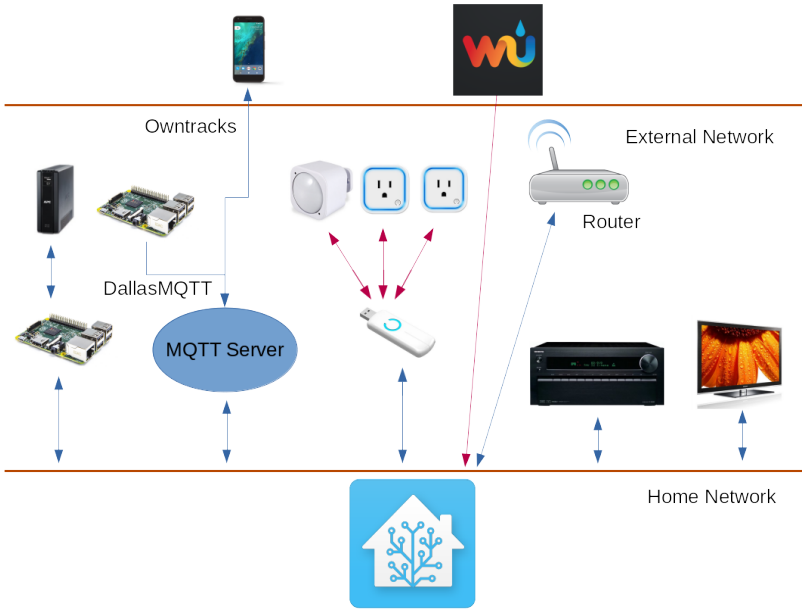
Turn the Air Conditioning off Based on the Outside Temperature

```
alias: Turn off AC when it's cold outside
trigger:
  platform: numeric_state
  entity_id: sensor.pws_temp_c
  below: 22.0
action:
  service: thermostat.set_operation_mode
  entity_id: thermostat.living_room
  data:
    operation_mode: off
```

Increase TV volume when the AC turns on

```
alias: Raise volume when AC turns on
trigger:
  platform: state
  entity_id: switch.aeotec_zw096_smart_switch_6_switch_2_0
  to: 'on'
conditions:
  - condition: state
    entity_id: media_player.living_room_av_reciever
    state: 'on'
  - condition: template
    value_template: '{{ states.media_player.reciever.volume_level < 0.7
action:
  service: media_player.volume_up
  entity_id: media_player.living_room_av_reciever
```

State of Apartment Automation



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/mtreinish/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/mtreinish/building-a-better-thermostat/tree/seagl2017