Automation using the Internet of Things (IoT)

B.Sc. (Honours) in Instrument Engineering

Department of Physical Sciences

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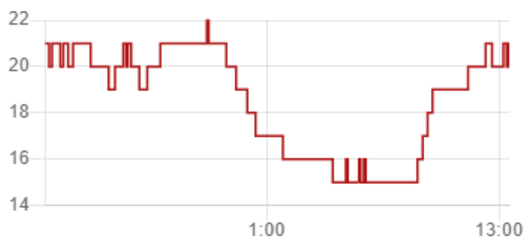
Project Background

- With the recent move to working and studying from home placing even greater emphasis on everyday environmental conditions and power consumption the issues of secure and reliable devices in the home network have been put under sharper focus particularly with smart metering and microgeneration the ability to monitor and ensure safe operating conditions of battery banks and associated switchgear becomes even more critical.
- The project brief was for a temperature control system using commercial off the shelf IoT devices to implement environmental monitoring specifically temperature control loops nested within an existing domestic smart home heating system.
- After researching the rapidly evolving and expanding market for home automation products, protocols and platforms the decision was made to implement a single open source Home Assistant (HA) Operating System given the integrations available to provide adequate control and monitoring.
- This necessitated selecting a temperature controller that would not activate a loud fuel boiler during the night-time trough but also not exceed the warmer afternoon peaks by activating a fan on a smart switch.



Key Achievements

- Adapting the open source OS and 'Lovelace' User Interface and polling devices editing YAML files for converting between JSON and python formats.
- Troubleshooting communication using protocols across MQTT, Ethernet and WiFi.
- Implementing a robust control system with escalating alarms if outer control limits exceeded possible via IFTTT webhook to email or iOS to iPhone app.

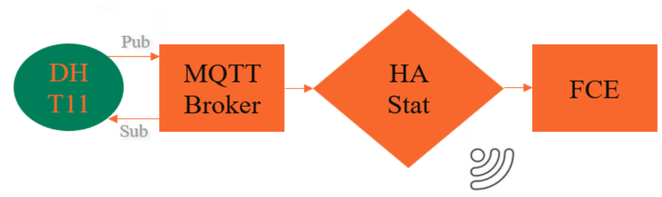
Conclusions

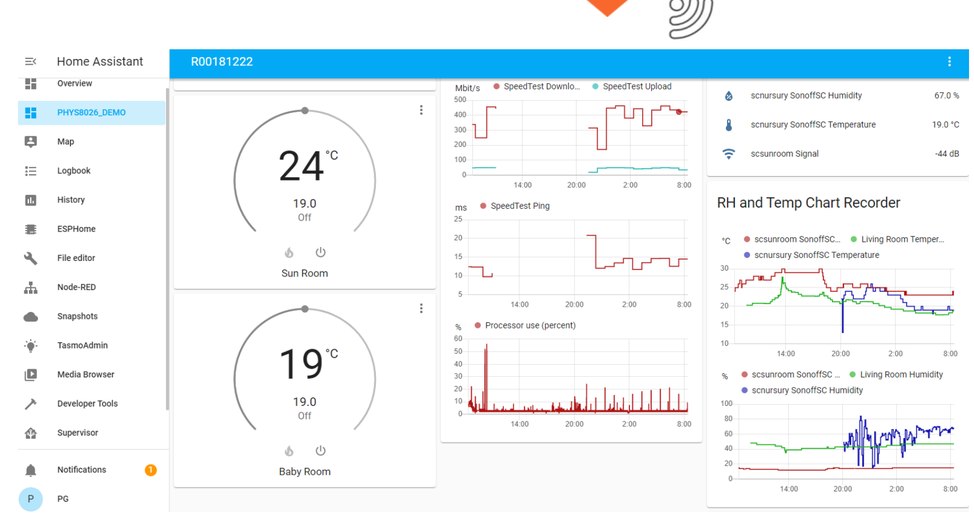
- The plethora of platforms and protocols make home automation a challenge without some level of skill and understanding of their operation while the current trend towards standardisation should allow for greater ease of use, security and reliability.
- Securing the network requires a significant investment in both time and equipment to set-up and maintain via one hub while giving the user greater local control and privacy may explain the popularity of Nest or similar 'plug and play' devices.
- Exploration of technological landscape and future trends with industry applications as part of a wider Digital Transformation[1] throughout this project allowed me to deepen prior knowledge of networking, power quality monitoring and wider Environmental Management and Building Automation Systems in regulated environments such as refrigeration for the biopharmaceutical supply chain[2].

Project Implementation

Hardware selected – Sonoff SC Multisensor by Itead

- This platform utilised ESP8266 and ATMega328 allowed for regularly polling temperature, humidity values over home WiFi network using Tasmota and an Message Queuing Telemetry Transport (MQTT) broker could be battery powered or from a DC driver for locations not easily accessed with 230 VAC mains. Th measured value was checked against set point and upper or lower deviations triggered a corrective action around a dead band to prevent cycling either by powering on heating element or cooling fan.

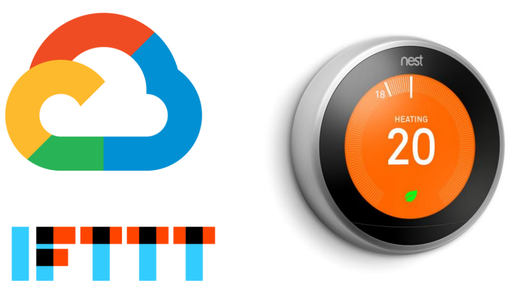




Added Value Work Completed and Future Work

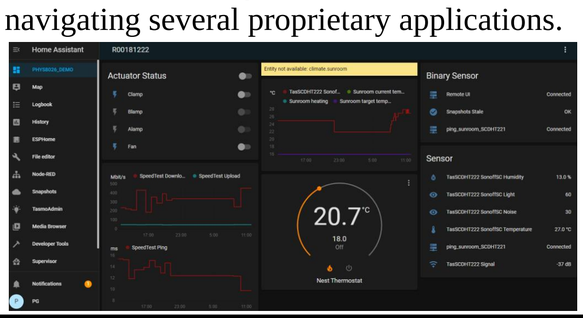
Integrate Nest on HA using Google Cloud Platform

As IFTTT webhooks are no longer supported with the Nest Learning Thermostat[3] we integrated the whole home heating capabilities with additional zones; sunroom and baby's room thus allowing for data acquisition for further characterisation, control loop tuning and optimisation.



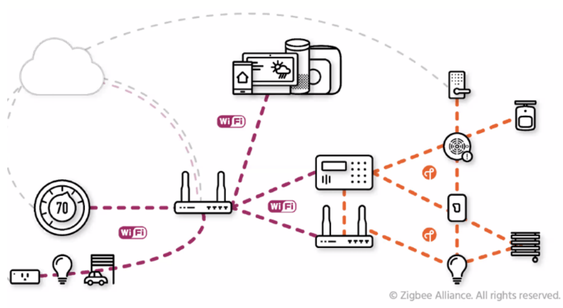
Developing an accessible and interactive User Interface

A key benefit of using HA was the ease of use in building and modifying the 'Lovelace' UI for continuously displaying measured values and user intervention either on desktop terminal, a dedicated touchscreen home hub or even on mobile devices while away from the home without navigating several proprietary applications.



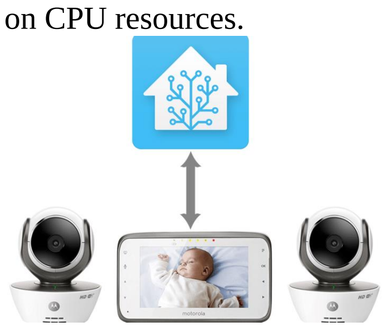
Securing the Home Network

While HA has a number of encryption features a security by design and defence-in depth approach to physically isolate and firewall IoT devices to a locally controlled 'Network of Things' on sub-netted Virtual LAN with the immanent adoption of a standardised Project CHIP[4] WiFi 6, 5G and Fibre Optic High Speed Broadband.



Expanding the WSN

After initial set-up to scale-up this system firstly the HVAC from the spring/ summer months when the emphasis was on cooling and ventilation to the winter months using Zigbee controlled actuators on radiators based on climatological data and presence detection and internal CCTV for secure baby monitoring[5] with a much larger commit on CPU resources.



References and Further Reading

1) Bernherd, A *et al* (2021) 'Leveraging Industrial IoT and advanced technologies for digital transformation' McKinsey https://www.mckinsey.com/~/media/mckinsey/business%20functions/mckinsey%20digital/our%20insights/a%20manufacturers%20guide%20to%20generating%20value%20at%20scale%20with%20iiot/leveraging-industrial-iot-and-advanced-technologies-for-digital-transformation.pdf Peraval, 2) S.P., (2017) https://www.ns-healthcare.com/analysis/prevention-of-temperature-deviation-in-the-pharma-supply-process-5963580/
Home Assistant, Nest Integration https://www.home-assistant.io/integrations/nest/ 3) Higginbotham, S. (2021) Project CHIP embraces a timeline and the blockchain https://staceyoniot.com/project-chip-embraces-a-timeline-and-the-blockchain/
5) Josh McCarty (2018) 'Incorporate a Motorola WiFi Baby Monitor into Home Assistant' https://joshmccarty.com/incorporate-motorola-wifi-baby-monitor-home-assistant/