

Temperature Monitoring System

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Overview

An internet connected system to monitor the temperature with logging, reporting and alert capabilities. Built using a Raspberry Pi Zero Wireless device, DHT22 temperature-humidity sensor, SQL database and Python 3 scripts.

Introduction

Business's that have temperature critical stock need to ensure that their storage facilities remain below a certain temperature. They are also likely to be required to keep historical records of the temperature of their storage facility.

The internet enabled temperature monitoring system can manage these tasks allowing businesses to concentrate on other issues, the temperature monitoring system has the following features:

- Temperature logging
- Sends a weekly report detailing the temperature of the facilities for each of the last 7 days
- Sends email alerts if the temperature exceeds a pre-defined limit
- Verifies itself when the system is initially set up to ensure it is working correctly

Hardware

The hardware used in this system is:

- Raspberry Pi Zero Wireless Device
- A DHT sensor (<https://www.adafruit.com/product/385>)
- A custom made cable linking the Raspberry Pi Zero Wireless GPIO pins to the DHT sensor
- A USB Charger
- A USB Cable

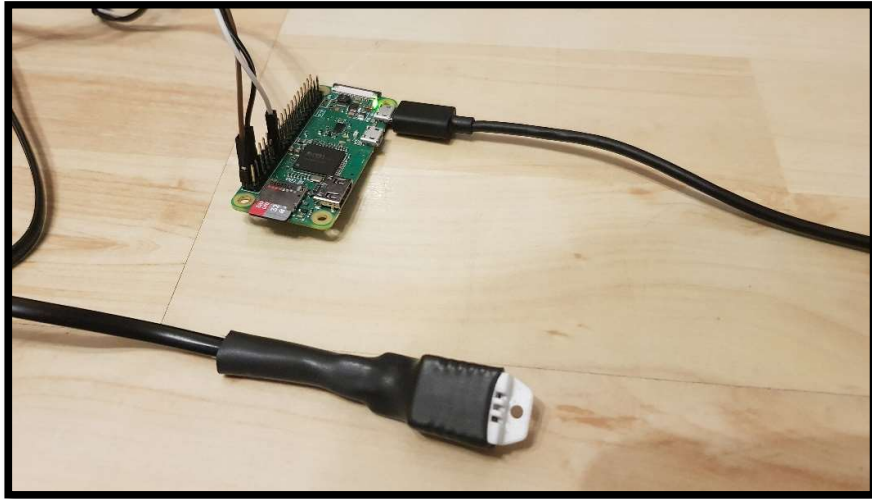


Figure 1 Image showing the Raspberry Pi Zero Wireless connected to the custom-made cable with the DHT sensor and a USB cable powering the device

Software

The temperature monitoring system includes a SQL database (using sqlite3) and a collection of Python 3 scripts that run on a headless Raspberry Pi Zero Wireless using the operating system Raspbian OS.

When the system is powered up multiple Python scripts are auto started using bash commands written in the `/etc/rc.local` file.

The following sections give a functional description of how the software works.

System Set Up

When the system is first installed or when the system needs to be reconfigured the following parameters need to be defined:

- Geographical location of the storage facility
- A unique ID for the storage facility
- The temperature limit, which when past, an alert will be sent
- The email address that will receive the alerts and the weekly reports

When the system is first installed, the installer will have to set up the wireless internet connection. After that they will need to run the `userInput` script which is used to configure the system. This script:

- Allows the installer to view settings if they have already been set up and will give an option to delete them and enter new settings
- Includes basic data validation rules to ensure all settings are entered and that the email is correctly entered by asking for it twice
- Saves the settings in a json format
- Verifies that the database, temperature sensor and email are all working and then sends an email to confirm this

The system will need to be power cycled in order for new settings to take effect.

Logging Temperature

The temperature monitor system has two SQL tables using sqlite3 to store temperature data.

1. A daily temperature table which stores the temperature, time and date at 13:00 each day. This data will be used for the weekly temperature report
2. A temperature data table that stores temperature, time and date every minute

The system measures the temperature data using the DHT sensor that is connected to the Raspberry Pi through the GPIO pins.

Database Management

The temperature data table which records data every minute is limited to store 100 days of data or 144000 data entries. Although the device has enough space for 10's of years of data, the database is kept to a small size to ensure the performance of the system is not affected.

In order to achieve this the system will start to delete the oldest days worth of data after 100 days, and thereafter delete the oldest days data each day.

Due to the small amount of data recorded in the daily temperature table, the size of this table is not managed.

Weekly Report

One of the key features of the temperature monitoring system is to send weekly reports detailing the recorded daily temperature for the last 7 days. The temperature, time and date data from the last 7 days are retrieved from

the daily temperature table in the database and inserted into a html template that can be customised to the users specifications. This is then converted into a PDF and attached to an email to be sent. This feature will only work if the settings have been configured. Figure 2 shows an example of the weekly temperature reports.

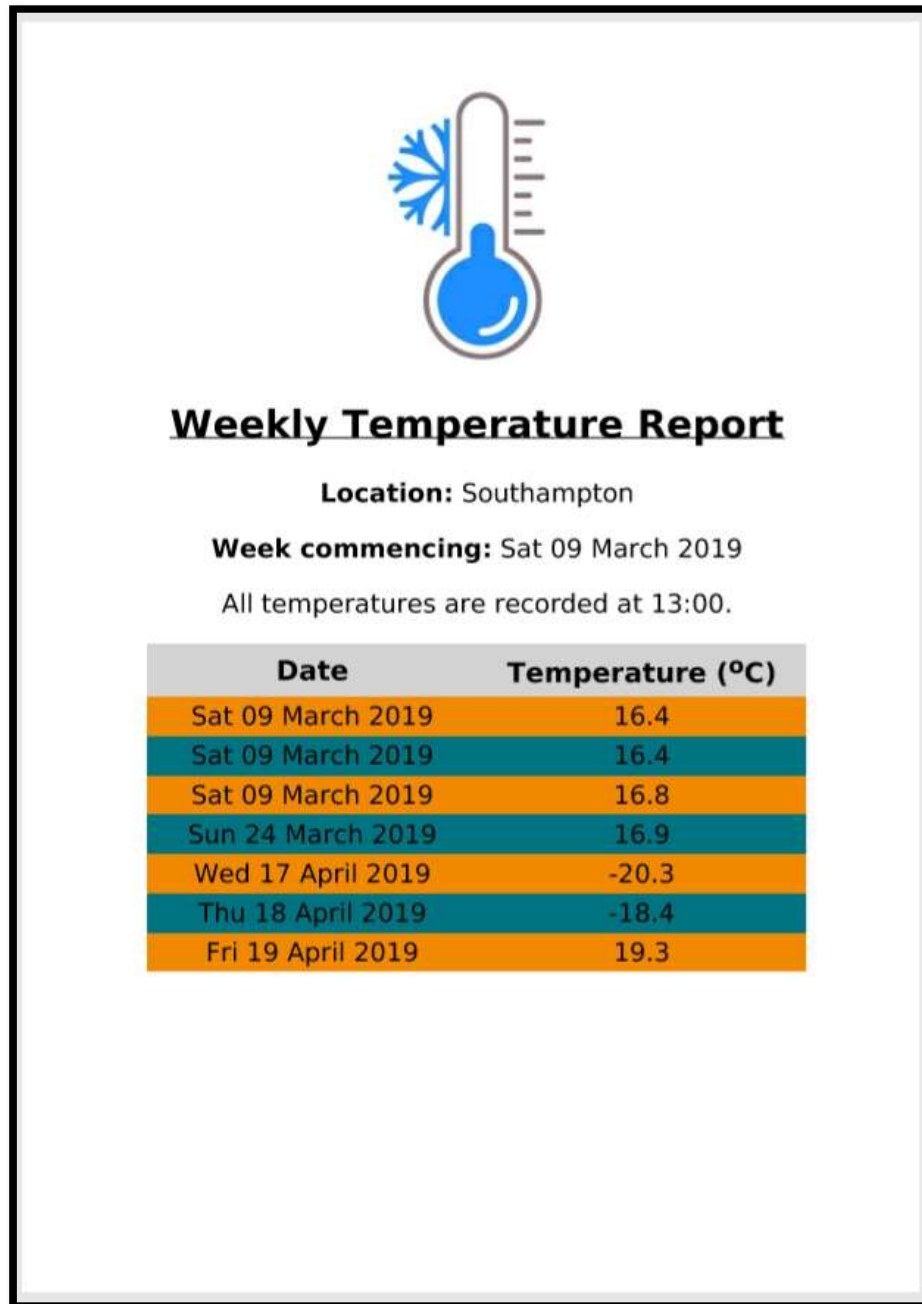


Figure 2 An example of a weekly temperature report

Alert System

The main feature of the temperature monitoring system is to alert the business when the temperature of the monitored facility is approaching unsafe limits. This will allow the business to take immediate action and maybe prevent the loss of stock due to rising temperatures.

The system will constantly check the current temperature of the monitored facility by reading the DHT sensor every second. The measurement is compared to a temperature limit, which is defined in system set up. If the current temperature goes over the limit and stays over the limit for 2 minutes then an email alert is sent. The two minute period is used to ensure that the temperature measurement is not an anomaly or the temperature is not fluctuating above and below the limit.

The email alert sent will include the location of the monitoring system in the subject line and in the email. It will also include a table showing the temperature of the facility for the last 10 minutes to give the user useful additional information.

Once an email alert has been sent the system will not be able to send another alert email for 60 minutes, this is to prevent the temperature monitor spamming the user's email if the facility remains over the temperature limit for an extended period of time.

Note that the alert feature will not work until the settings have been configured. Figure 3, on the next page, shows an example of the email alerts.



Temperature Alert

Location: Southampton

Temperature Limit: -12

Current Temperature: 19.7

You will not receive another alert for 60 minutes even if the temperature remains over its limit. Below shows a table of the temperature data for the last twenty minutes.

Time	Temperature (°C)
15:23:13	19.6
15:24:14	19.6
15:25:15	19.6
15:26:15	19.6
15:27:16	19.6
15:28:16	19.6
15:29:17	19.6
15:30:18	19.6
15:31:28	19.7

Figure 3 An example of the email alerts