www.idosr.org Nabiryo and Itodo
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International Digital Organization for Scientific Research ISSN: 2579-079X
IDOSR JOURNAL OF SCIENCE AND TECHNOLOGY 7(1):53-66, 2022.

Design and Implementation of Base Station Temperature Monitoring System Using Raspberry Pi

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ABSTRACT

This project describes a telecom base station site temperature monitoring system using Raspberry Pi, utilizing a set of pi boards. It utilizes a raspberry Pi board-central processor and sensor boards. Sensor board is in turn interfaced to the DHT-111 humidity & temperature sensor. It is also linked to a Wi-Fi adapter (802.11 b/g/n) connected to the centralized processor through Internet. A centralized data station is set up and all other sensor pi boards relay their data to this centralized station, which organizes the data and logs them into tables or graphs based on user requirements. This data is also connected to through Ethernet hence this data log can be accessed remotely and the entire data can be controlled from a remote server. The data logged is also uploaded to a cloud server so that it can be accessed anywhere at any time.

Keywords: Design, Implementation, Base Station and Temperature

INTRODUCTION

IoT is used for connecting the electronic devices with the internet. The devices may vary from the temperature measuring equipment and vehicles SOS system to other electronic devices such as sensors, soft wares, and network connectivity facilities, which sanction collecting and exchanging data. The twenty-first century has witnessed a massive paradigm shift to and focusing on global attention onto IoT as a burgeoning discipline with multiple possibilities and diverse opportunities for growth and development [1]. Internet connection facilitates the smooth functioning of the devices that have become indispensable parts of our day-to-day lives and existence. The Internet offers the provision to link and network different kinds of devices like sensors and fitness devices.

All these devices that enable them to upload input as well as output to the Internet using cloud provisioning. The information thus gathered is accessible for monitoring and analysis anywhere in the globe via the internet [3]. In order to cut down on human effort and involvement, of late people increasingly depend on embedded systems to control and monitor the factors affecting the ecosystem. Temperature and humidity are vital in observing and understanding nature. IoT comes into the picture here by significantly enhancing the efficiency of the mechanism and systematically cutting down on human involvement, and thereby overall expenditure [4]. Practically, every part of exercise contains controlled schedules of temperature as well as humidity. However, the exact value of temperature with its significant feature in any field is essential in monitoring [5]. Constant perception in temperature is utilized in various industries like the pharmaceutical industry as the driving force behind these monitoring systems, computerized and straightforward temperature sensors can use [6]. Resistors,semiconductors, thermistors estimate temperatures values. These components are present inside the sensor to retrieve the temperature in consonance with the circumstances. The primary goal of our system is to supervise the live temperature and humidity within a low cost [7]. Raspberry Pi is the observational system or controller which is used for the cloud saving. Python is the programming language which is utilized in Raspberry Pi. HTU 211D sensors is a temperature sensor which is used here for the sensing purpose [8]. This comprises of temperature ascertaining capacity and favourable fundamental position of utilizing HTU 211D sensors, which boasts of less weight and ease of use. The sensor is associated with Raspberry Pi utilizing connecting wires. Temperature sensor HTU 211D sensors is utilizing is perused put away, and shown in the Raspberry Pi unit [9]. IoT based devices in homes and industries are used for controlling all the electrical or electronic devices which are present. Additionally, the saved information of the IoT devices can be controlled from anywhere [10,11,12,]. The sensor analyses the graphical representation of the observed data in every user defined format wherever in the world. In this work, IoT technology and Raspberry Pi microcontroller is used. Humidity and temperature monitoring using IoT technology and Raspberry Pi is an exciting and secure process.

Objective

To design and implement a user friendly, low-cost temperature monitoring equipment to help avoid heat build-up at telecom base station locations, like huts and other network nodes, to continuously monitor the site. A central temperature monitoring system will enable us to keep track of critical temperatures at all telecom base station sites.

Specific Objectives

To interface DHT11 temperature and humidity sensor, LCD, Wi-Fi module with Raspberry Pi Microcontroller unit to read temperature and humidity data from the base station environment and feed data to the Raspberry Pi control unit for processing. To program the Raspberry Pi based temperature monitoring system to continuously transmit/relay the current captured environment and equipment temperature and humidity data to a central Network operation centre location for monitoring purposes

To test and implement the designed Raspberry Pi based base station temperature monitoring system.

METHODOLOGY

System Design and Implementation

System Design

In this project an attempt has been made to develop a base station temperature monitoring system to monitor temperature and humidity at various telecommunication sites, capture the data and relay to a central Network Operation Center.

Figure 1: Telecommunication base station site

Temperature and humidity monitoring of the telecommunication base stations will help avoid heat build-up at telecom locations, like huts and other network nodes, by continuously monitoring the site. A central temperature monitoring system will enable to keep track of critical temperatures at all telecom base stations sites that contain important communication gear. The Central Processing Unit for this system is developed using the Raspberry Pi microcontroller which is a low cost and efficient controller used in many applications. The embedded system technology here is combined with the wireless sensor technology.

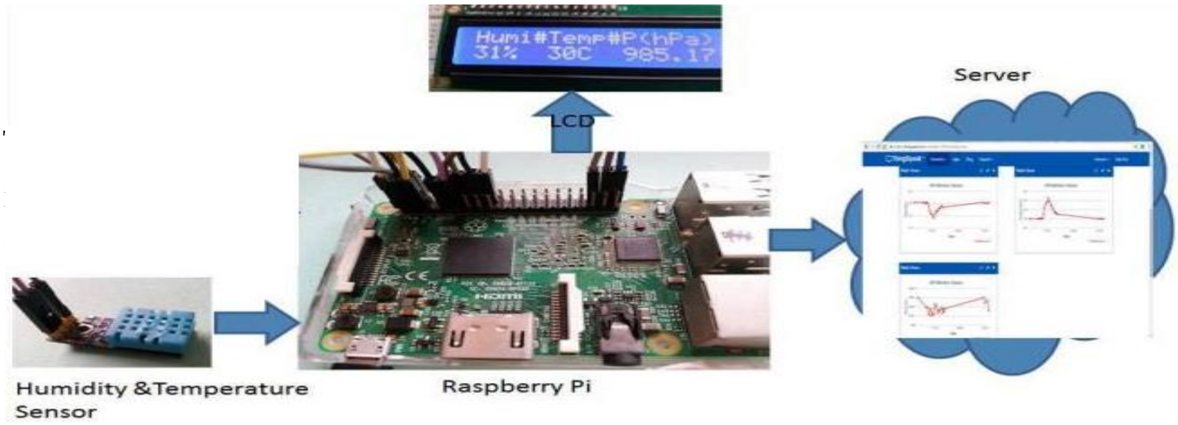


Figure 2: Model diagram

System Setup and Software Design
All the sensors required for the particular base station are set up according to the circuit. A python script is written to initialize the GPIO's of the Raspberry Pi for each sensor.

Devices interfaced

Raspberry pi. The Raspberry Pi is a low cost, credit-card sized computer which plugs into a computer monitor or TV, and requires a standard keyboard and mouse. Raspberry Pi is a dynamic microcontroller and runs with the Python programming language. Raspberry Pi 2 includes a quad-core Cortex A7 processor CPU running at 900 MHz and 1 GB RAM, Integrated Video core 4 Graphics Processing Constituent (GPU) capable of frolicking Maximum 1080p Elevated Meaning Blu-Ray Quality Video,512Mb SDRAM, The free, flexible and exceedingly builder approachable Debian GNU/Linux(RASPBIAN)Operating System, 2 x USB Ports, HDMI Video Output, RCA Video Output,3.5mm Audio Output Jack,10/100Mb Ethernet Port for Internet Access, 5V Micro USB Domination Input Jack, Micro SDHC card, MMC,40 gpio pins. It has capability of a little device that allows people of all ages to explore computing. It's capable of doing everything you would expect a desktop/computer to do, from browsing the internet and playing high-definition video to making spreadsheets, word processing, and playing games. The Raspberry Pi has the ability to interact with the outside world, and has been used in a wide array projects like smart home monitoring system, wireless motion sensor activated light and many more.

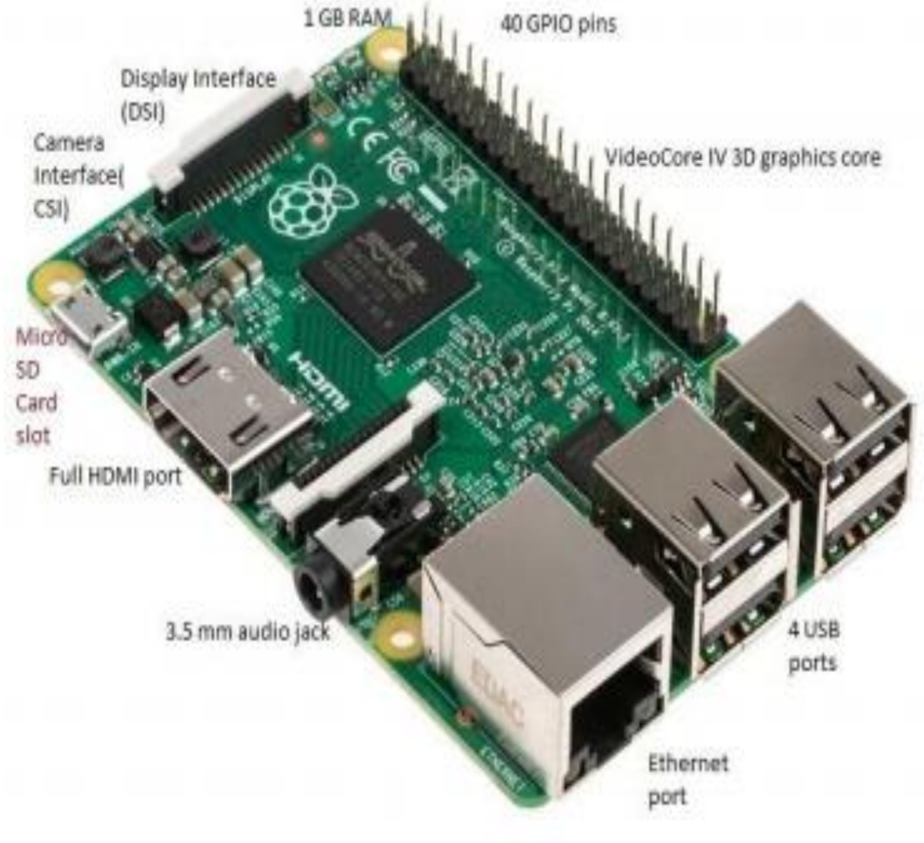


Figure 3: Raspberry pi 2 model b

DHT11 Humidity & temperature sensor for sensing the temperature The Celsius scale Thermometer and percentage scale Humidity meter displays the ambient temperature and humidity through an LCD display

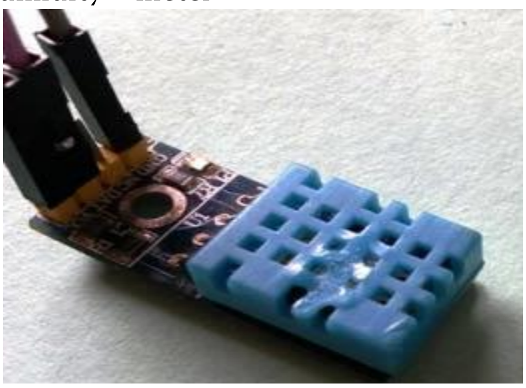


Figure 4: DHT11 Humidity & temperature sensor

Circuit diagram

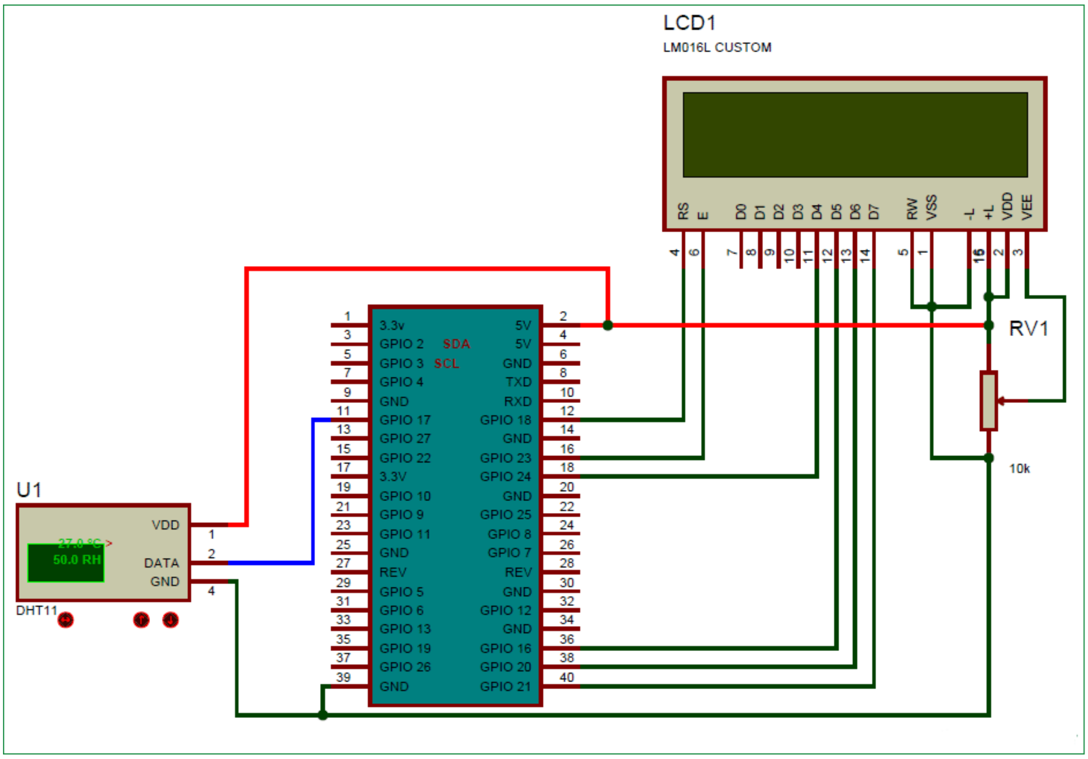


Figure 5: Circuit diagram

Flow chart of Circuit system

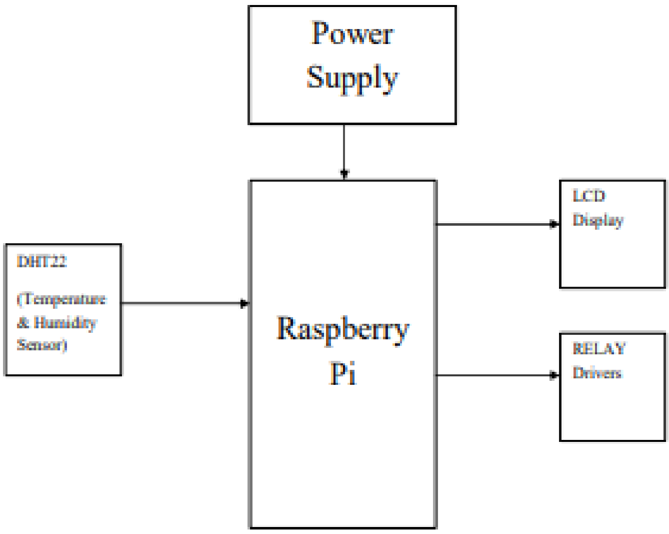


Figure 6: Flow chart of system diagram

Working and Thing Speak setup

- Firstly, DHT11 sensor senses the Humidity & Temperature Data.
- Secondly, Raspberry Pi reads the DHT11 sensor module's output by using single wire protocol and extracts sensor values into a suitable number in percentage (humidity), and Celsius scale (temperature).
- Thirdly, these values are sent to Thing Speak server by using inbuilt Wi-Fi of Raspberry Pi for live monitoring from anywhere in the world over internet.
- Finally, ThingSpeak analyses the data and shows it in a Graph form. A LCD is also used to display these values locally.

Raspberry Pi Configuration and Python Program:

The GPS system is set up so as to obtain the coordinates of the system. The board is further programmed to log the data and store it locally in a file at low sample rate to avoid excessive usage of system memory. This file is transmitted at the end of each day to the central server. It should be noted that the central server still has complete access to the base station at any given time provided it is within the Wi-Fi network.

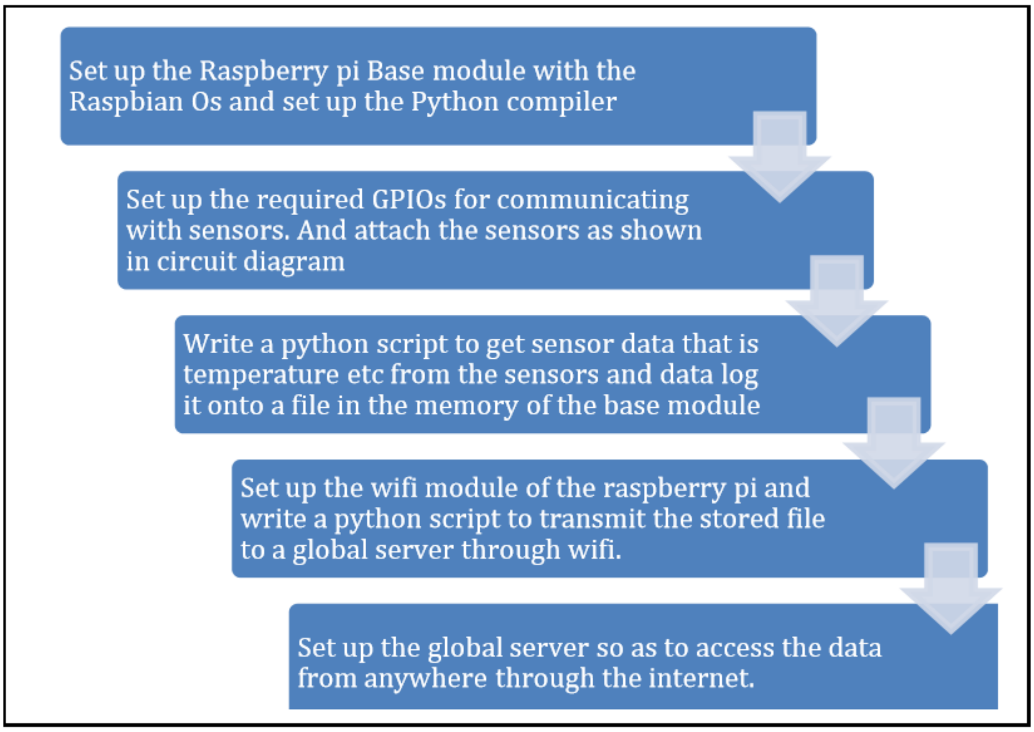
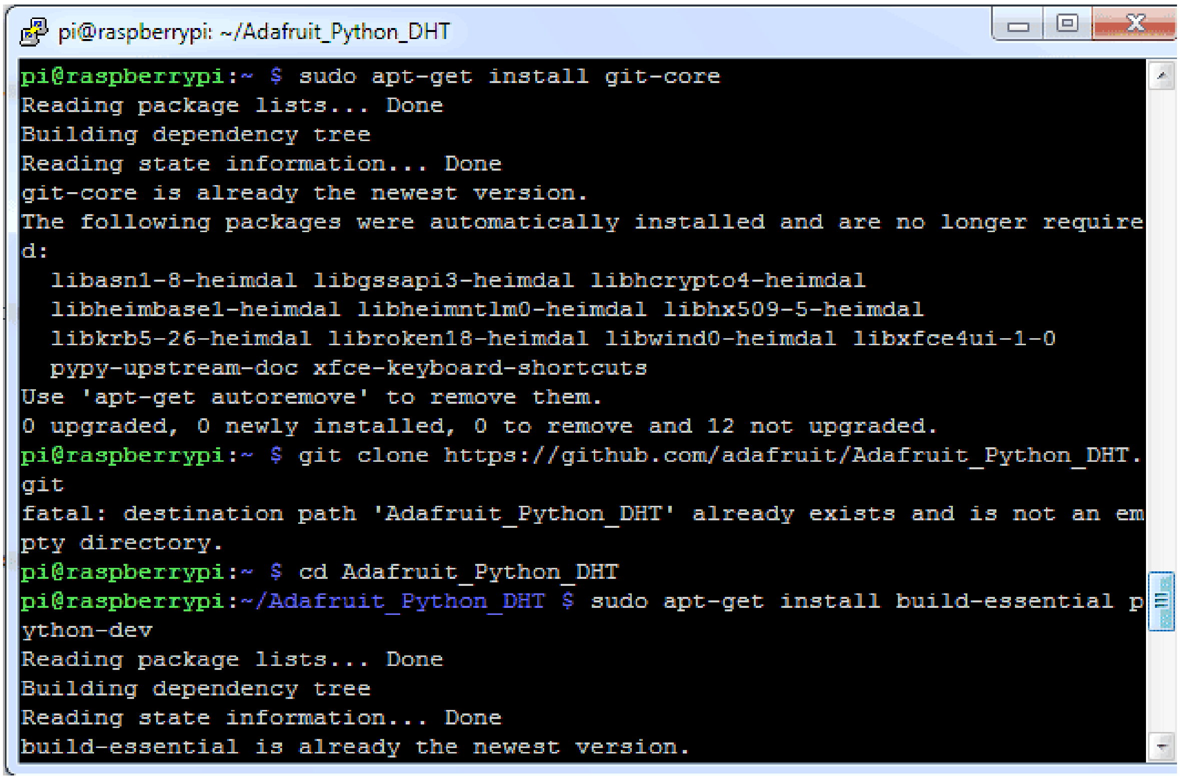


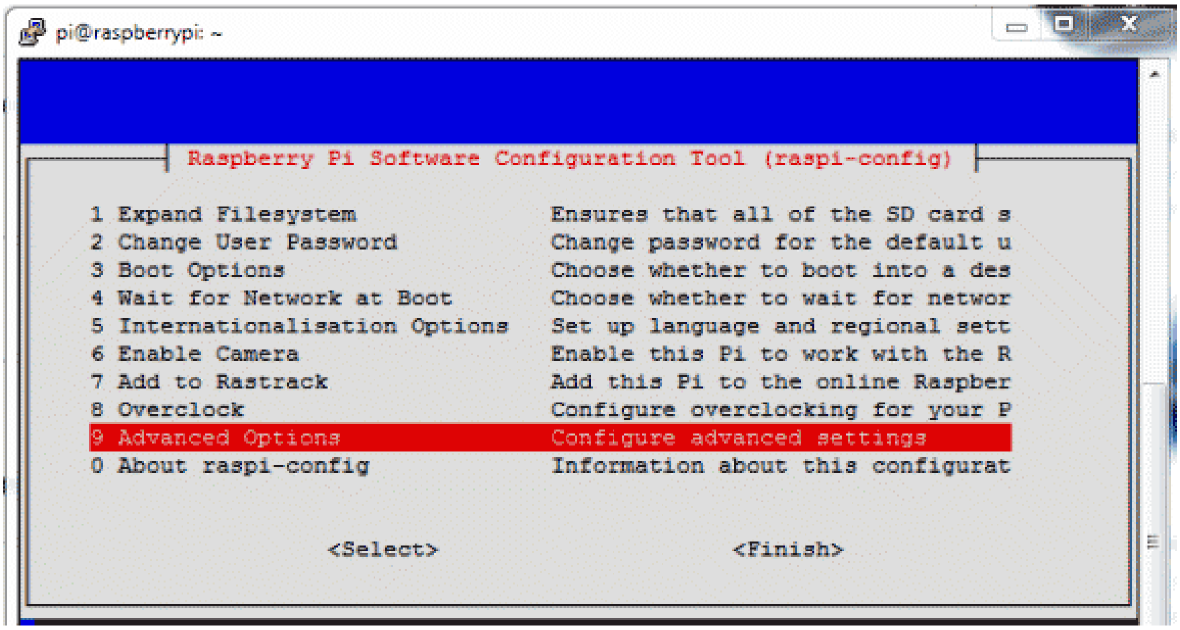
Figure 7: Workflow for System Design

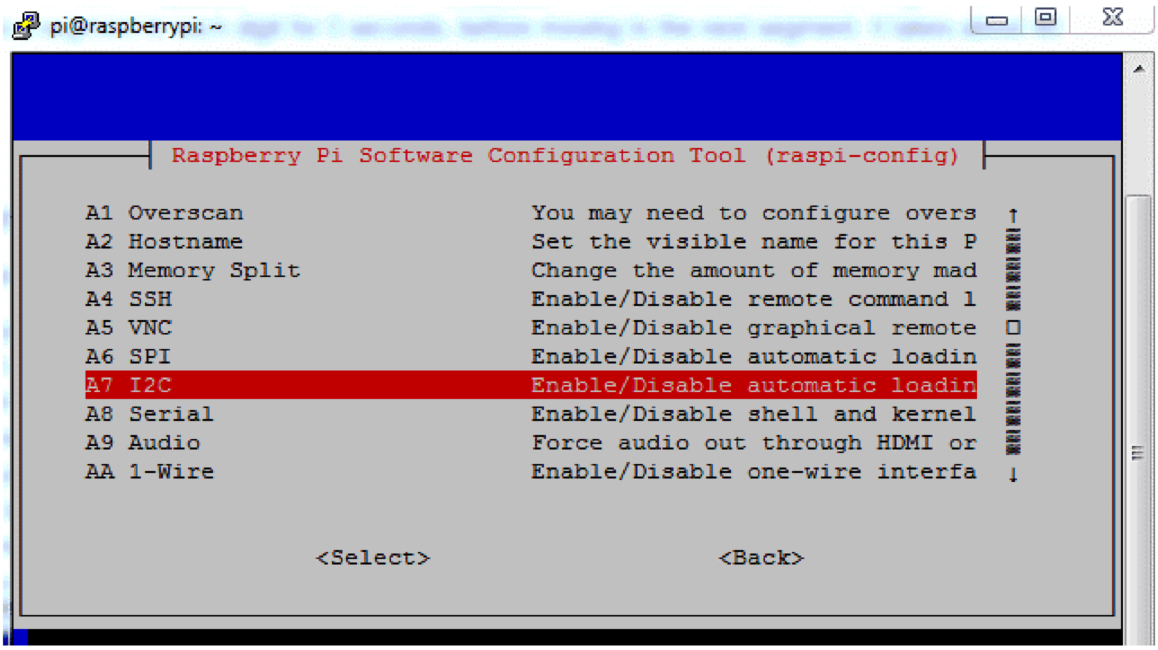
- Adafruit Python DHT Sensor Library is installed to run this project on Raspberry Pi using the below commands

```
sudo apt-get install git-core
sudo apt-get update
git clone https://github.com/adafruit/Adafruit_Python_DHT.git
cd Adafruit_Python_DHT
sudo apt-get install build-essential python-dev
sudo python setup.py install
```


pi@raspberrypi: ~/Adafruit_Python_DHT
pi@raspberrypi:~ $ sudo apt-get install git-core
Reading package lists... Done
Building dependency tree
Reading state information... Done
git-core is already the newest version.
The following packages were automatically installed and are no longer require
d:
libasn1-8-heimdal libgssapi3-heimdal libhcrypto4-heimdal
libheimbase1-heimdal libheimntlm0-heimdal libhx509-5-heimdal
libkrb5-26-heimdal libroken18-heimdal libwind0-heimdal libxfce4ui-1-0
pypy-upstream-doc xfce-keyboard-shortcuts
Use 'apt-get autoremove' to remove them.
0 upgraded, 0 newly installed, 0 to remove and 12 not upgraded.
pi@raspberrypi:~ $ git clone https://github.com/adafruit/Adafruit_Python_DHT.
git
fatal: destination path 'Adafruit_Python_DHT' already exists and is not an em
pty directory.
pi@raspberrypi:~ $ cd Adafruit_Python_DHT
pi@raspberrypi:~/Adafruit_Python_DHT $ sudo apt-get install build-essential p
ython-dev
Reading package lists... Done
Building dependency tree
Reading state information... Done
build-essential is already the newest version.

- Enable Raspberry Pi I2C in RPi Software Configuration:





Programming

All required libraries are included, initiaze variables and define pins for LCD and DHT11.

```
import sys
import RPi.GPIO as GPIO
import os
import Adafruit_DHT
import urllib2
import smbus
import time
from ctypes import c_short

#Register Address
regCall   = 0xAA
... ......
 ..... ...
```

def main(): function, below code is being used for sending the data to the server and display it over the LCD, continuously in while loop.

```
def main():

    print 'System Ready...'
    URL = 'https://api.thingspeak.com/update?api_key=%s' % key
    print "Wait...."
    while True:
            (humi, temp)= readDHT()
            (pressure) =readBmp180()

            lcdcmd(0x01)
            lcdstring("Humi#Temp#P(hPa)")
            lcdstring(humi+'%'+"  %sC  %s" %(temp, pressure))
            finalURL = URL +"&field1=%s&field2=%s"%(humi, temp)+"&field3=%s" %(pressure)
            print finalURL
            s=urllib2.urlopen(finalURL);
            print  humi+ " " + temp + " " + pressure
            s.close()
            time.sleep(10)
```

For LCD, def lcd_init() function is used to initialize LCD in four bit mode, def lcdcmd(ch) function is used for sending command to LCD, def lcddata(ch) function is used for sending data to LCD and def lcdstring(Str) function is used to send data string to LCD. You can check all these functions in Code given afterwards. Given def readDHT() function is used for reading DHT11 Sensor:

```
def readDHT():
    humi, temp = Adafruit_DHT.read_retry(Adafruit_DHT.DHT11, DHTpin)
    return (str(int(humi)), str(int(temp)))
```

Network Setup

For communication between base station and the central station, SSH server client protocol is set up on the Raspberry Pi. For an SSH connection to be initiated, 4 pieces of data are needed:

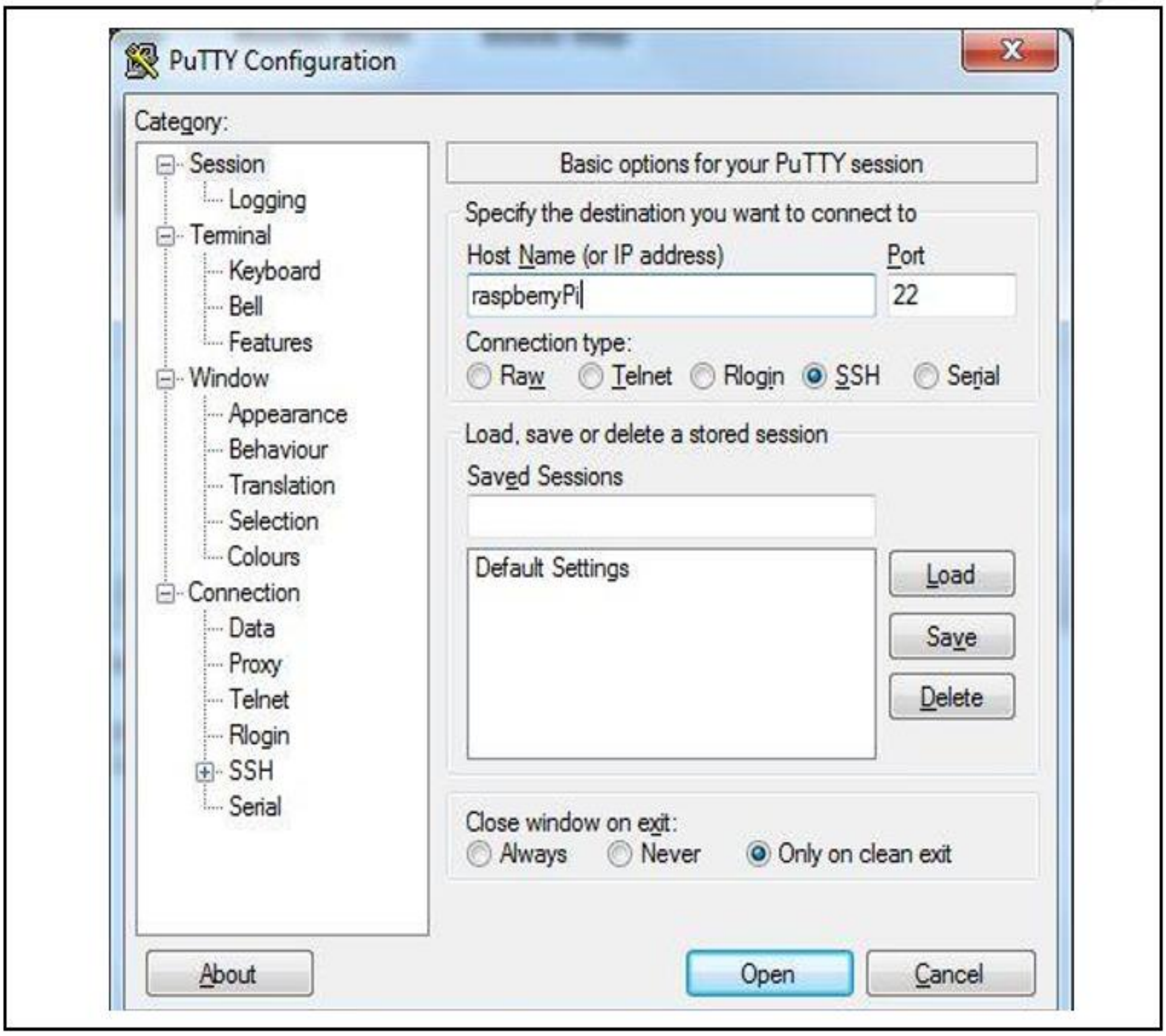
The address (IP address or domain name) of the target machine.

The port number of the target machine on which the SSH server is listening.

The user name of the user who is logging in.

The password of the user who is logging in.

Logging into the super user mode, the hostname and password of the Raspberry Pi can be set up by modifying the configuration file by the following command in terminal – "nano /etc/dhcp/dhclient.conf"



PuTTY Configuration Window on PC

The base station can be accessed by calling the Linux SSH client from command line using the 4 pieces of data previously set up, or can be accessed through SSH client application such as PuTTY for large file transfers.

RESULTS

Tests

The base station temperature monitoring system was designed and tested to evaluate its functionality and efficiency. The system is installed at multiple telecom base station sites to capture temperature and humidity readings of the site environment with the help of DHT11 Temperature & Humidity Sensor and the captured data is fed to Raspberry Pi microcontroller for further processing. The processed data is displayed on an LCD screen and relayed to a central server Network operation centre for monitoring.

Tests were carried out at 3 multiple telecommunication base stations to evaluate the working of the system.

The results of the 3 tests carried out were as discussed below

1. Base Station Site A

Figure 8: Working system design

At base station A, the system relayed temperature reading of 34 degrees Celsius and humidity 40%

2. Base Station Site B

Figure 9: Test at Base station A

At base station B, the system relayed temperature reading of 30 degrees Celsius and humidity 51%

Figure 10: Test at Base station B

Base Station Site C

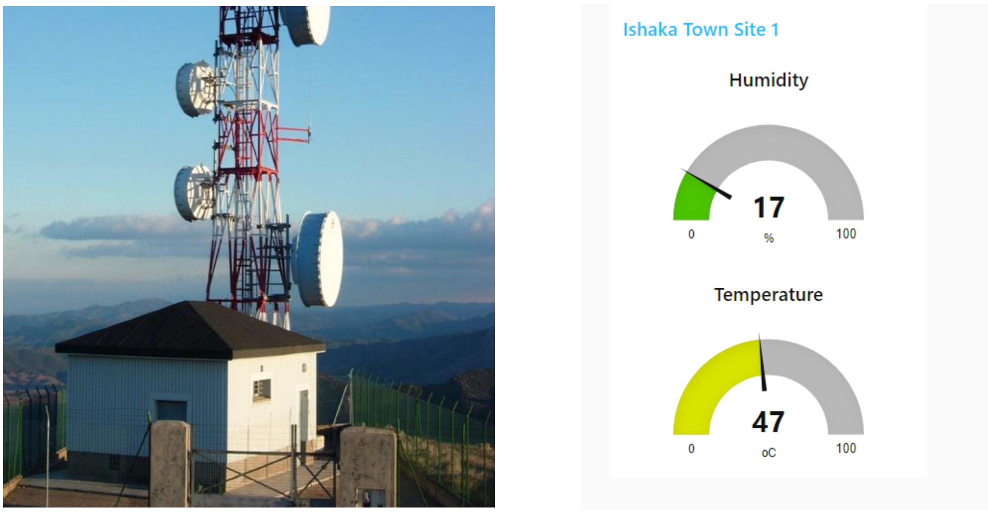


Figure11: Test at base station C

At base station C, the system relayed temperature reading of 47 degrees Celsius and humidity 17%

CONCLUSION

Temperature and humidity monitoring of the telecommunication base stations helps avoid heat build-up at telecom locations, like hubs and other network nodes, by continuously monitoring the site from a central Network operation centre making it possible to keep track of critical temperatures at telecom base stations sites that contain important communication gear. This prevents sites from going down due to very high critical temperatures. The system design in this project proved to be effective in the monitoring of temperatures and humidity at remote telecommunication base station sites.

Limitation

The system design has some limitations which include: The first consideration in evaluating temperature monitoring systems is the type of sensor to use to track room temperature. An analog sensor is superior to digital sensors because it tracks temperature in real-time across a continuous range. Digital temperature monitoring systems, by contrast, will only tell you if the temperature is above or below a predetermined value. There's no way to know how much the temperature has risen (or fallen) beyond the temperature you specify. Analog sensors are recommended in most cases when you're setting up an environmental monitoring system. Analog sensors offer the ability to check the precise temperature at any time. The only real value of a digital sensor is the ability to send alerts when a specific threshold is crossed. If cost is a big factor in your decision, however, a digital temperature sensor is 100% more useful than nothing at all. To get the threshold temp alert capability, you need to select the right alarm remote to link your sensors from your remote site to your central office. Network-based temperature monitoring bridges the gap between your sensors, which communicate with analog or discrete contact closures, and your central office.

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