High altitude Real-time Weather Monitoring Mesh Network

Vishal Patra[1], Vaishnavi Shinde[2], Sakshi Karnik[3], Nitish Singh[4]

[1,2,3,4]*Student, Dept. of Information Technology, PGMCOE, Pune, Maharashtra, India*

Abstract - *In our project, we create a network of data collecting and transporting nodes to collect & diffuse data to all the nodes of the network. This network will be made to be tolerant of extreme weather conditions and allows numerous nodes connected in a mesh network topology while being a self-healing network. The implemented system is developed in a combination of hardware and software. It's a unique data- collecting network working on an open-source ESP32 board powered by a 18650 3.5v DC Battery for easy & universal implementation and deployment. The system empowers the user to collect data without the need for a router to long distances through inaccessible and rough terrains.*

Key Words: Mesh Network, IoT, Mountaineering, ESP-32, ESPnow, Data Collection Network.

1. INTRODUCTION

This experimental system provides a valuable application of IoTs to save lives and cater to users in extreme environments where data is essential for life and death circumstances. The research area of the IoT in recent years has experienced growth and development in a multidisciplinary manner. IoT is the interconnection of physical devices, vehicles, buildings and other items embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data. The traditional fields of embedded system, wireless sensor networks, control system, automation systems are together interconnected to form the Internet of Things. That means the internet of things builds over the revolutionary success of mobile and internet Networks. We propose a system of interconnected ESP32 boards in an autonomous network of nodes which pass realtime data to a long distance. For this we use an open-source board ESP 32 to create a seamless Mesh network which send, receive and propagate data collected from various sensors to all its node.

This network can handle multiples relays and can work in real-time data mode (More energy consuming) or Deep sleep mode (Energy conserving mode) where it relays its data once a day. It can cover more than 1 km in L.O.S. (with a pair of device) and deploy the data to a web server at any end of the node. With sensors like DHT11, BMP180 & LDR we can create a real-time alert system which can alert our users of incoming danger and help them make safer choices.

1.1 OBJECTIVES

To examine the viability of our project we create a minimum functional product, this prototype should be able to perform following functions:

1. Seamless Integration of a node in the network.
2. Collect and push the data in the network via its mesh network.
3. Sync time and verify timestamp in between nodes.
4. Continuous search for other nodes in vicinity of the network.
5. Work autonomously and independent of an external power source.

1.2 BACKGROUND

Isolated & Extreme places like Mountains are toughest terrains to gather data from, Present solutions include Weather Proof Weather Station which are bulky and hard to install or Weather Satellites which are extremely expensive and real-time. To solve this issue, we created a IOT project which is easy to use and can work in extreme conditions without the need for regular maintenance.

2. REQUIREMENTS

2.1 HARDWARE REQUIREMENTS

The system requires multiple numbers of ESP32 boards to experiment with the mesh network powered through 18650 3.3v batteries. The collector node will be connected to DHT11 sensor and the display node will be connected to a computer for data visualization purpose in our experiment. Hardware required are listed below in table-1 given below.

ESP32 is a series of low-cost, low-power system on chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth. The ESP32 series employs either a Tensilica Xtensa LX6 microprocessor in both dual-core and single- core RISC-V variations or a single-core RISC-V microprocessor and includes built-in antenna switches, RF balun, low-noise receive amplifier, filters, and power management modules. The 18650 is a rechargeable lithium-ion battery. They offer the performance of a lithium-ion cell the capacity and the range of 1800mAh to around 3500mAh, and an output of 3.7 volts. They're used in a large range of devices from laptops to laser pointers, and camera accessories like gimbals and sliders.

The DHT22 is a basic, low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed).

Hardware Requirements			
S no.	Name	Quantity	Usage
1	ESP 32	2	Development board
2	18650	2	Power
3	DHT11	1	Data Sensor
4	Breadboard	1	Prototyping
5	Connecting Wires	10	Connection to GPIO

Table -1: Hardware Requirements

The developed system consists of multiple components hardwired as per the circuit design demonstrated in figure 3.1. Here in this design the connections were made using multi-colored wires with proper signal flow directions so that it could be tracked easily that which wire belongs to which component. The signal flow exemplify here segregates the input signal and output signal. All the components were interfaced to the GPIOs of ESP32 board as per the table-2 given below.

ESP32 Pin Interfacing			
S no.	Pin Connected	Interfaced with	Action
1	GPIO14	DHT11	Data input
2	3.3v	DHT11	Power Supply +ve
3	And	DHT11	Power Supply -ve
4	Vin	18650 Batteries	Power Supply +ve
5	And	18650 Batteries	Power Supply -ve

Table -2: ESP32 Pin Interfacing

2.2 SOFTWARE REQUIREMENTS

For our system Arduino IDE is used to write and upload programs to our development board. The Arduino IDE is a cross-platform application that is written in functions from C and C++.

3. DESIGN

3.1 ARCHITECTURE

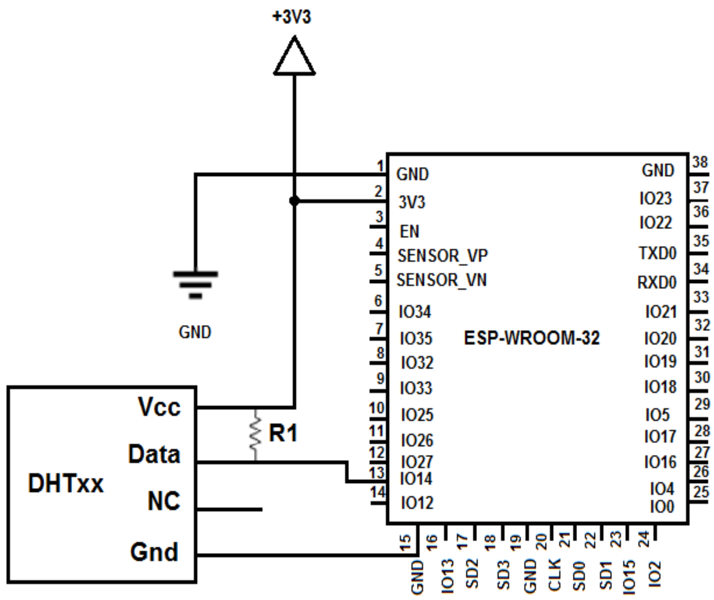

Fig1 : Architecture ESP32 Data node

3.2 DATA FLOW DIAGRAM

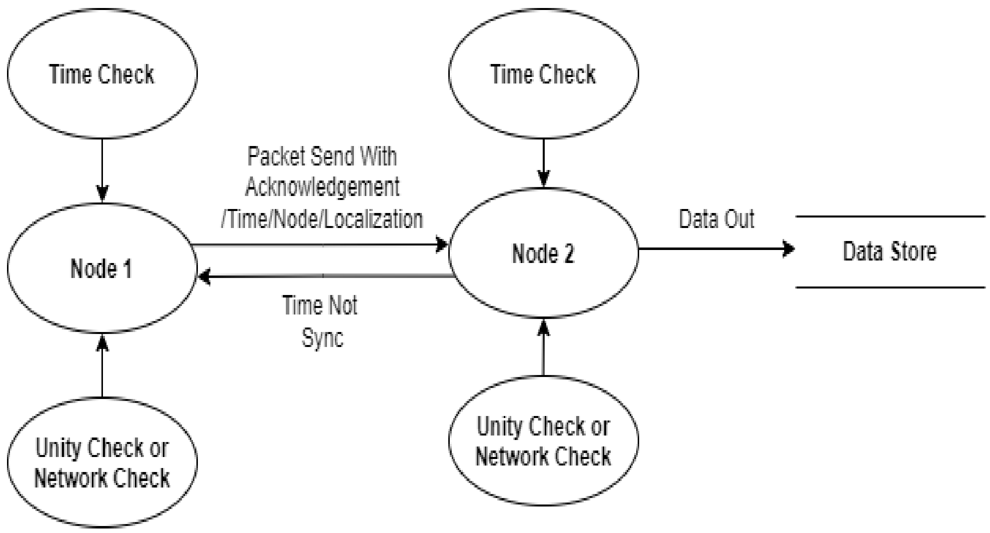

Fig2 : DFD

4. TESTING METHODOLOGY AND SETUP

4.1 TESTING SETUP

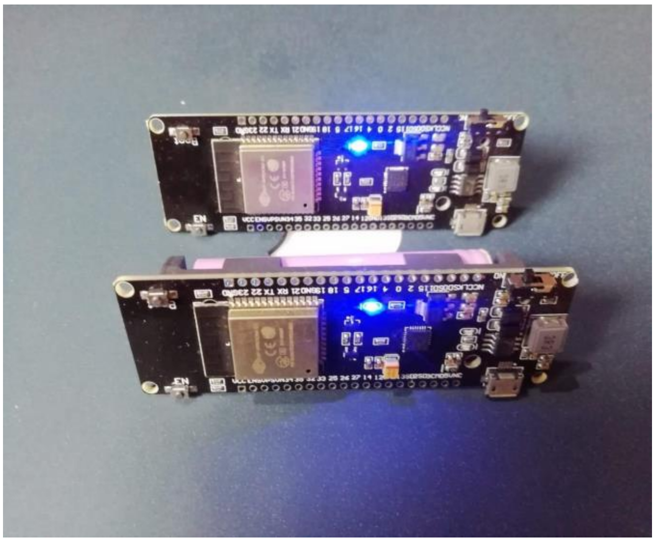

Fig3 : ESP32 nodes in sync

For our testing purposes we take two ESP32 board and compile and push our code to our boards via Arduino IDE.

One node of our setup is connected to DHT11 to collect data through and kept in a distance of 1m from other node is connected to a computer to visualise the data and check status of the network. Our boards are programmed to sync time and data at interval of 1000ms.

4.2 TESTING METHODOLOGY

Functional Test

To test the MFP we check the data and timestamp to verify the data integrity we check the readiness and quickness of the system by turning the nodes on / off at intervals. Our software ping device and blink no. of nodes connected in the network to reflect the no.s of nodes in the mesh network.

5. CONCLUSION

After the successful testing of this system it was concluded that through our Mesh Network we can connect multiple nodes, multiple sensors and power sources in a network so that they can talk to each other, data acquired from these things can be used to keep a log & monitor isolated & extreme environments without any human intervention. Thus, IoT is like global networks which give the transmission between things to things, human to things and human to human. IoT is the development of existing internet space to manage everything which exists in the world or exists in the future. The system is working well in the local environment and responded well as pethe expectations. The software is super easy to use. It's compatible with Arduino, Raspberry Pi, NodeMCU, and other microcontrollers. Very little coding is required and one can get a system up and running in no time.

6. FUTURE SCOPE

In the future iteration of our system we will conduct our test with >5 nodes and multiple inputs, performance test our system for longer distances and create a weather proof enclosure. A low energy consuming mode will be developed for the non- real time scenarios.

7. REFERENCES

1.Espressif Announces the Launch of ESP32 Cloud on Chip and Funding by Fosun Group". Espressif Systems. 2016-09-07.

2.Emanuele Di Pascale; Irene Macaluso; Avishek Nag; Mark Kelly; Linda Doyle, “The Network as a Computer: A Framework for Distributed Computing Over IoT Mesh Networks”, IEEE Internet of Things Journal, 2018, Volume: 5, Issue: 3, Journal Article, Publisher: IEEE

3.Xiaofan Jiang; Heng Zhang; Edgardo Alberto Barsallo Yi; Nithin Raghunathan; Charilaos Mousoulis; Somali Chaterji; Dimitrios Peroulis; Ali Shakouri; Saurabh Bagchi, “Hybrid Low-Power Wide-Area Mesh Network for IoT Applications”, IEEE Internet of Things Journal, 2020, Early Access Article, Publisher: IEEE

4.Rajiv Kashyap; Mohamed Azma ; Jithu G. Panicker, “Ubiquitous Mesh: A Wireless Mesh Network for IoT Systems in Smart Homes and Smart Cities”, IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT), 2019, Publisher: IEEE

5.S. Sujin Issac Samuel, “A review of connectivity challenges in IoT-smart home”, 3rd MEC International Conference on Big Data and Smart City (ICBDSC), 2016, Publisher: IEEE

6.Heon Huh ; Jeong Yeol Kim, “LoRa-based Mesh Network for IoT Applications”, IEEE 5th World Forum on Internet of Things (WF-IoT), 2019, Publisher: IEEE

7.Hamid Al-Hamadi; Mohammad Saoud; Ing-Ray Chen; Jin- Hee Cho, “Optimizing the Lifetime of IoT- Based Star and Mesh Networks”, IEEE Access, 2020, Volume: 8, Journal Article, Publisher: IEEE