P.E.S. COLLEGE OF ENGINEERING, MANDYA - 571401
(An Autonomous & Govt. Aided Institution, Affiliated to VTU, Belagavi)

An Internship Report

on

"IoT-Based Real-Time Monitoring System Using ESP-WROOM-32 with AWS Integration"

Submitted in partial fulfilment for the award of the degree of

BACHELOR OF ENGINEERING

in

ELECTRONICS AND COMMUNICATION ENGINEERING

Submitted by

MANU H P [4PS21EC167]

Internship Carried Out
at

L & T Technology Services Ltd.
9H4V+WW2, KIADB Industrial
Area Hebbal,

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
2024-25

P.E.S. COLLEGE OF ENGINEERING, MANDYA

(An Autonomous & Govt. Aided Institution, Affiliated to VTU, Belagavi)

Department of Electronics and Communication Engineering

CERTIFICATE

This is to certify that MANU H P bearing 4PS21EC167 has successfully completed the Internship work (P21INT802) entitled "IoT-Based Real-Time Monitoring System Using ESP-WROOM-32 with AWS Integration" carried out at L & T Technology Services Ltd. fulfilment for the award of Degree of Bachelor of Engineering in Electronics and Communication Engineering, P.E.S. College of Engineering, Mandya (An Autonomous Institution Affiliated to VTU, Belagavi) during the academic year 2024-2025. It is certified, that all corrections suggested have been incorporated in the report deposited in the library. The Internship has been approved as it satisfies the academic requirements in respect of Internship work prescribed for the Degree in Bachelor of Engineering.

Signature of Co-ordinator	Signature of HOD	Signature of Principal
Niveditha H R	Dr.Punith Kumar M B	Dr.N L Murali Krishna
Assistant Professor	Professor and HOD	Professor and Principal

Details of Internshipreport Viva Voce Examination			
Sl. No.	**Name of the Examiners**	**Signature**	**Date**
1			
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Acknowledgement

I express my gratitude and respect to **Dr. N L Murali Krishna**, Principal, PESCE Mandya, for granting permission to carry out the Internship.

I express my heartfelt gratitude to **Dr. Punith Kumar M B,** Professor and Head, Department of Electronics and Communication Engineering, PESCE Mandya for being supportive throughout the Internship.

I express my deep sense of gratitude to our internship coordinator **Niveditha H R** Asst. Professor, Department of Electronics and Communication Engineering, and External Guides **Mr. Akash Gandhi**, Technical Manager, L & T Technology Services Ltd. for their valuable suggestions and inspiration, motivating guidance and who have been the driving force behind this work and who have constantly dedicated their precious time with timely suggestions and ideas to successfully carry out the Internship.

Last but not the least, I would like to thank my **Parents and Friends** for their moral support.

MANU H P (4PS21EC167)

Abstract

This report outlines my internship experience on the IoT-based embedded systems project, which involved developing and integrating real-time monitoring applications using the ESP-WROOM-32 microcontroller. The internship primarily focused on designing two cloud-connected systems: a temperature-based LED control system using the DHT11 sensor, and a distance measurement system utilizing the HC-SR04 ultrasonic sensor. Both applications were built to publish sensor data to the AWS cloud in real-time using the MQTT protocol and DynamoDB for data storage.

During the internship, I gained hands-on experience in embedded programming using the Arduino IDE, Wi-Fi-based data transmission, and cloud integration through AWS IoT Core. I worked on setting up secure communication using certificates, designing and wiring hardware interfaces, and validating system responses through serial monitoring and cloud dashboards. This practical exposure enhanced my understanding of IoT architecture, sensor interfacing, and secure real-time data communication, laying a solid foundation for a career in embedded systems and Internet of Things (IoT) development.

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List of Abbreviations

AWS	Amazon Web Services
DHT	Digital Humidity and Temperature Sensor
ESP	Espressif
GPIO	General Purpose Input/Output
HC-SR04	High-Current Sonic Ranger 04
IDE	Integrated Development Environment
IoT	Internet of Things
JSON	JavaScript Object Notation
LED	Light Emitting Diode
MQTT	Message Queuing Telemetry Transport
NTP	Network Time Protocol
PWM	Pulse Width Modulation
TLS	Transport Layer Security
VCC	Voltage at the Common Collector
Wi-Fi	Wireless Fidelity

CHAPTER 1

COMPANY PROFILE

L & T TECHNOLOGY SERVICES LIMITED.

L&T Technology Services Limited (LTTS) is a global leader in Engineering Research and Development (ER&D) services and a subsidiary of the Larsen & Toubro (L&T) Group, one of India's most respected engineering conglomerates. The current CEO and Managing Director of L&T Technology Services (LTTS) is Amit Chadha. The company was established in 2012 and headquartered in Vadodara, Gujarat, LTTS provides innovative engineering solutions to clients across various industries including Automotive, Aerospace, Telecom, Industrial Products, Medical Devices, and Oil & Gas. With a strong global presence, LTTS operates over 20 engineering design centers and R&D facilities worldwide, including locations in North America, Europe, and Asia. LTTS specializes in embedded systems, digital engineering, mechanical design, plant engineering, and product lifecycle management. In the automotive sector, the company is actively involved in developing advanced driver assistance systems (ADAS), connected vehicle technologies, telematics, and electric vehicle systems.

Operating in more than 25 countries with annual revenues exceeding USD 1.26 billion, L&T Technology Services designs, develops, and delivers transformative products and engineering solutions for a diverse global clientele. The company collaborates with some of the world's leading brands across various industries, driving innovation in areas such as mobility, sustainability, and next-generation technologies.

Figure 1.1 Logo of the Company

VISION

Engineering a sustainable tomorrow through technology and innovation

With innovation at our core, we challenge the status quo and continuously leverage technology for scaling the future and inspiring new possibilities for our customers. As we constantly strive for multi-dimensional growth, we hold ourselves accountable for creating a sustainable world and delivering positive outcomes that transcend business boundaries. With the ability to engineer change, and with the effective use of technology, we are committed to achieving environmental stewardship, social development, and economic progress for all our stakeholders.

MISSION

Be the engineering partner of choice by enabling innovation with world-class technologies, processes, and people - delivering inclusive growth for all stakeholders

At LTTS, we are passionate about creating a better and sustainable world for the future of our customers, people, and communities. As a technology led engineering company. we encourage a culture of collaboration and learning. Our innovation DNA and a 'can-do attitude' enable us to engineer the change. With our people as the driving force, integrity, and fairness as our bedrock, we are committed to constantly innovating to strive for the best solution and customer experience. It is this unyielding passion and unfaltering commitment to excellence that ensures inclusive and sustainable growth.

VALUES

Every action of ours, every decision we make, and every future growth area at LTTS, is governed by these core values that we hold.

- ✓ Being Purposeful
- ✓ Ethics & Integrity
- ✓ Caring
- ✓ A Culture of Learning
- ✓ Results with Accountability

CHAPTER 2

INTRODUCTION

The internship project titled "IoT-Based Real-Time Monitoring Using ESP-WROOM-32" focused on designing and implementing embedded systems capable of real-time environmental sensing with cloud connectivity. The internship involved developing two integrated applications: a temperature-based alert system using the DHT11 sensor, and a distance monitoring system using the HC-SR04 ultrasonic sensor. Both systems were built around the ESP-WROOM-32 microcontroller, enabling wireless data transmission to the AWS cloud via MQTT protocol. The collected data—such as temperature, humidity, and distance—was securely stored in AWS DynamoDB, allowing remote access and real-time visualization.

Throughout the project, the system was validated using the Arduino IDE for firmware development and AWS IoT Core for cloud-side configuration. The setup involved configuring secure communication through device certificates and policies, creating IoT rules for data routing, and verifying functionality through serial monitoring and cloud dashboards. Each system triggered LED alerts based on preset thresholds and provided live sensor data to the cloud, simulating a connected smart environment.

As an intern, I was involved in the complete end-to-end development, from sensor integration and coding to cloud connectivity and testing. This hands-on experience strengthened my understanding of embedded IoT architectures, real-time system behavior, and cloud communication protocols, building a strong foundation for future work in embedded and cloud-connected systems.

CHAPTER 3

WEEKLY OVERVIEW OF INTERNSHIP ACTIVITIES

3.1 WEEK 1

INTRODUCTION TO EMBEDDED SYSTEMS AND ESP-WROOM-32 PLATFORM

The first week of my internship was focused on understanding the ESP-WROOM-32 microcontroller, a highly versatile and powerful platform widely used in IoT applications. I began by exploring the architecture and features of the ESP32, including its dual-core processor, built-in Wi-Fi and Bluetooth capabilities, and GPIO configuration for sensor interfacing. This foundational phase involved setting up the Arduino IDE environment, installing the required board packages, and writing simple test programs to familiarize myself with uploading code, serial monitoring, and basic GPIO operations such as LED blinking.

Alongside the hardware setup, I also studied the communication workflow between embedded devices and cloud platforms, which set the stage for future tasks. Particular attention was given to power supply requirements, pin mapping, and understanding how to interface digital sensors like the DHT11. This week laid a strong groundwork for the implementation of sensor-based systems, combining hardware and software elements of real-time embedded applications.

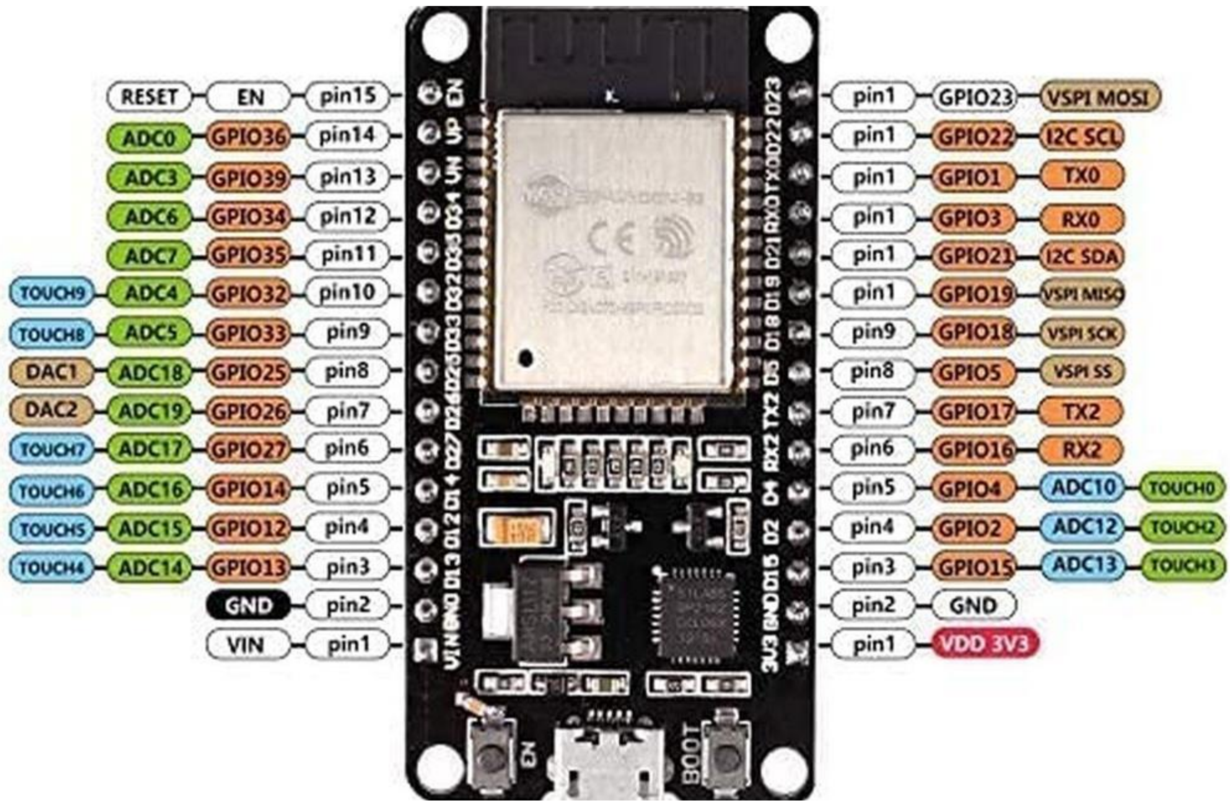


Figure 3.1 ESP32 Architecture

WEEK 2

UNDERSTANDING CLOUD INTEGRATION AND AWS IOT CORE SETUP

The second week of my internship was centered around setting up cloud connectivity using Amazon Web Services (AWS) IoT Core, a platform that enables secure and reliable communication between IoT devices and the cloud. I learned how to register a device (known as a "Thing") within the AWS IoT Console and attach the necessary security certificates and policies for enabling authenticated communication. A key part of the setup involved configuring the MQTT (Message Queuing Telemetry Transport) protocol, which is lightweight and well-suited for publishing sensor data from embedded devices.

In addition to AWS IoT, I was introduced to AWS DynamoDB, which serves as the cloud database for storing real-time sensor data such as temperature, humidity, or distance. I created DynamoDB tables with timestamp-based partition keys and learned how to map incoming MQTT messages to database entries using IoT Rules and SQL queries. This week’s work was essential in establishing the cloud backend infrastructure, laying the groundwork for bi-directional communication between the ESP-WROOM-32 and AWS, a key component in building robust and scalable IoT systems.

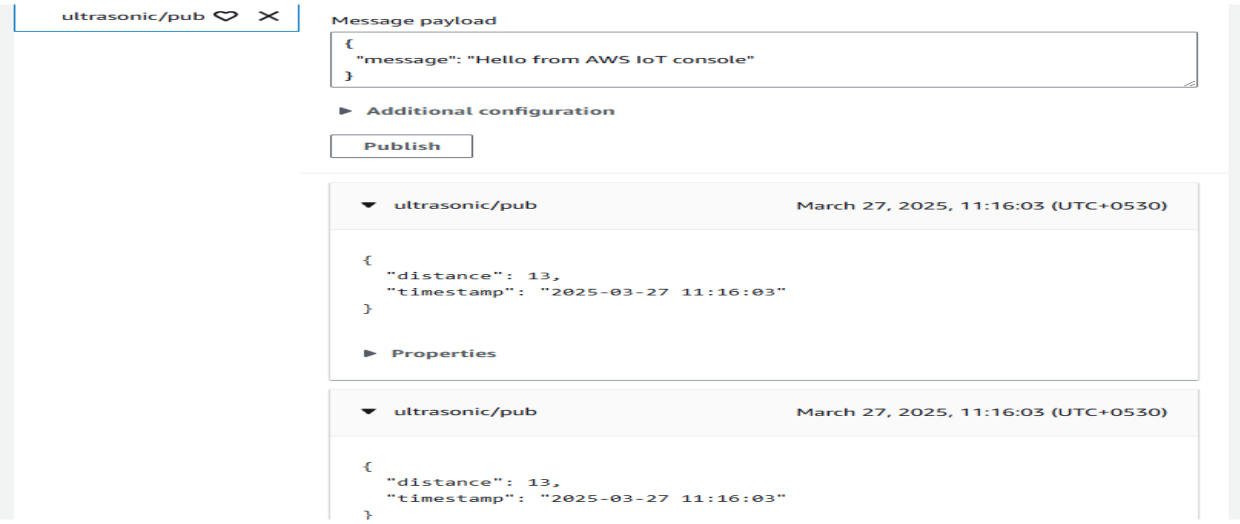


Figure 3.2 MQTT Messages

WEEK 3

Creating DynamoDB Tables and Mapping IoT Data Streams

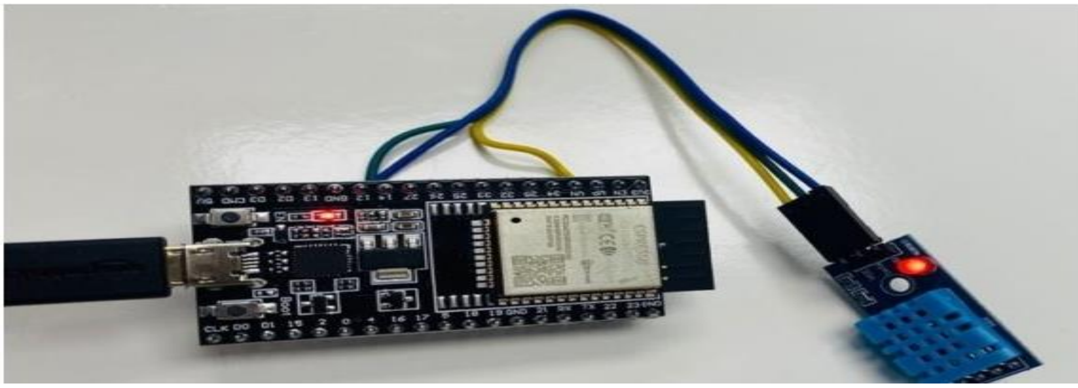
During the third week of my internship, I focused on setting up the data storage infrastructure using AWS DynamoDB, a fully managed NoSQL database service designed for real-time applications. The key task involved creating DynamoDB tables tailored for storing structured data received from the ESP-WROOM-32—such as temperature, humidity, distance, and timestamps. I defined appropriate schema configurations, including partition keys like "timestamp" to efficiently index and query incoming records.

A major learning outcome this week was creating IoT Rules in AWS IoT Core using SQL-like queries that process incoming MQTT messages and route the relevant fields into DynamoDB tables. For instance, I designed a rule to parse messages published on topics like "dht11/pub" or "ultrasonic/pub" and extract specific attributes such as "temperature", "humidity", or "distance". This week's efforts completed the cloud-side setup for structured data logging, enabling seamless integration between sensor data from ESP-WROOM-32 and AWS backend services—thus forming a reliable pipeline for real-time IoT analytics.

WEEK 4

Hardware Interfacing and Sensor Integration with ESP-WROOM-32

In the fourth week, I shifted focus to the hardware side of system development, particularly integrating sensors with the ESP-WROOM-32 microcontroller. This phase involved understanding sensor pin configurations, voltage requirements, and the use of GPIO pins for real-time data acquisition. I began by connecting the DHT11 temperature and humidity sensor, ensuring correct connections for VCC, GND, and the data pin (GPIO 4), and validated its readings through the serial monitor in Arduino IDE.



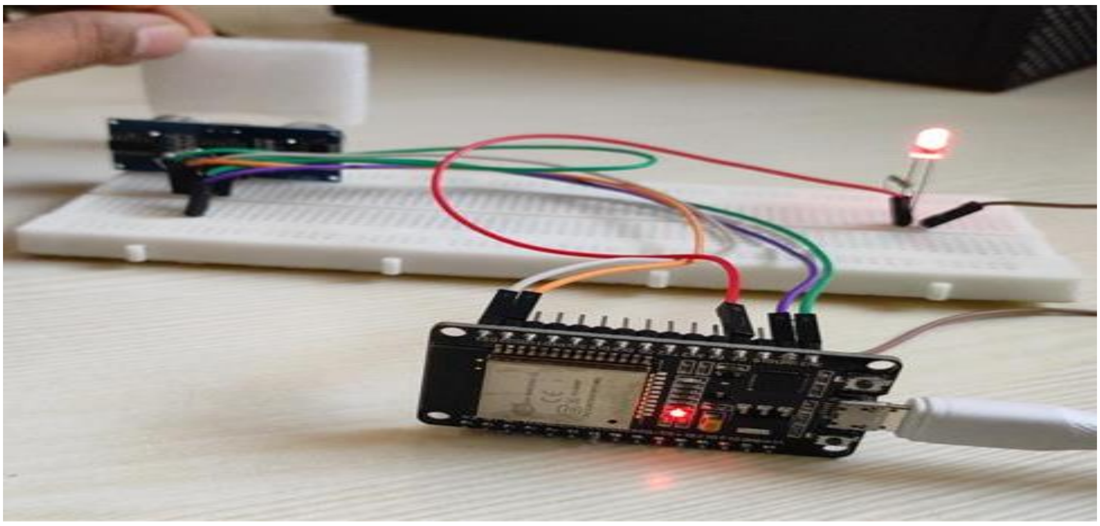


Figure 3.3 Connections of DHT11 and HC-SR04 to ESP32

Parallelly, I worked on integrating the HC-SR04 ultrasonic sensor for distance measurement, which required precise timing logic using TRIG and ECHO pins. Since the ECHO pin outputs a 5V signal and the ESP-WROOM-32 operates at 3.3V logic, I designed a voltage divider circuit using 2.2kΩ and 1kΩ resistors to safely interface the sensor. Additionally, I configured an LED output on GPIO 2, allowing visual alerts based on specific sensor thresholds. This week marked the completion of physical hardware assembly and set the stage for implementing logic to drive automated sensor-based control and cloud data transmission.

WEEK 5

FIRMWARE DEVELOPMENT FOR SENSOR-BASED MONITORING AND LED CONTROL

In the fifth week, my focus shifted towards developing the embedded firmware that would control sensor readings and trigger corresponding actions based on threshold conditions. Using the Arduino IDE, I began writing code to interface the DHT11 sensor, enabling the ESP-WROOM-32 to continuously read temperature and humidity data from GPIO 4. Logic was added to compare the measured temperature with a defined threshold (25°C), and if exceeded, an LED connected to GPIO 2 was programmed to blink as a warning indicator.

In parallel, I developed a similar logic structure for the HC-SR04 ultrasonic sensor, measuring the distance to nearby objects and activating the LED if the distance fell below 5 cm. To ensure non-blocking operation and real-time responsiveness, sensor readings and LED control were organized within a structured loop. The code also included error-checking mechanisms to handle failed sensor readings gracefully. This week marked a critical step in achieving real-time sensor monitoring and autonomous LED control—essential building blocks of the IoT-based system I was developing.

WEEK 6

IMPLEMENTING CLOUD COMMUNICATION AND MQTT-BASED DATA PUBLISHING

In the sixth week, I focused on implementing cloud communication capabilities for the ESP-WROOM-32 by using the MQTT protocol to publish sensor data to AWS IoT Core. This involved writing firmware that formatted the sensor readings—temperature, humidity, and distance into JSON payloads, which were then published to dedicated MQTT topics like "dht11/pub" and "ultrasonic/pub". A timestamp was generated using network time protocol (NTP) to ensure accurate data logging.

To enable secure communication with AWS, I configured the device to use TLS encryption along with the previously downloaded device certificate, private key, and root CA. The MQTT client setup was carefully integrated within the firmware to ensure reliable connection and reconnection logic during runtime. Testing was conducted via the AWS MQTT Test Client, which allowed me to verify if the published data matched the real-time values captured from the sensors. This week marked the successful completion of real-time data publishing from the edge device to the cloud, forming the core of the system's IoT functionality.

WEEK 7

TESTING AND VALIDATING END-TO-END IOT WORKFLOW WITH CLOUD INTEGRATION

In the seventh week, I concentrated on testing and validating the complete end-to-end IoT system, ensuring that all integrated components—hardware, firmware, and cloud infrastructure functioned cohesively. ESP-WROOM-32 was programmed to perform periodic sensor readings and publish the results to AWS IoT Core, where the data was routed to DynamoDB. I used the Serial Monitor in Arduino IDE to track sensor activity and confirm that temperature and distance thresholds triggered the LED as expected.

To evaluate the reliability of communication, I monitored message flow using the AWS MQTT Test Client, observing whether the sensor data matched live environmental changes. I also tested edge cases, such as temporary Wi-Fi loss or cloud disconnection, to confirm that the firmware could recover and resume publishing once reconnected. This phase emphasized the importance of data integrity, timing synchronization, and seamless interaction between the physical and cloud layers, ensuring that the system could operate robustly in real-time IoT scenarios.

WEEK 8

TESTING DATA STORAGE AND VALIDATION USING AWS DynamoDB AND MQTT Client

In the eighth week, I focused on validating the cloud-side data storage by thoroughly testing AWS DynamoDB integration and ensuring that the published sensor data was reliably captured and stored. Using the AWS DynamoDB Console, I monitored entries being populated in real time, checking whether values such as temperature, humidity, distance, and timestamps were correctly mapped to their respective attributes in the DynamoDB tables (temptable1 and UltrasonicReadings). This helped confirm that the IoT rules and SQL-based filters applied in AWS IoT Core were functioning as intended.

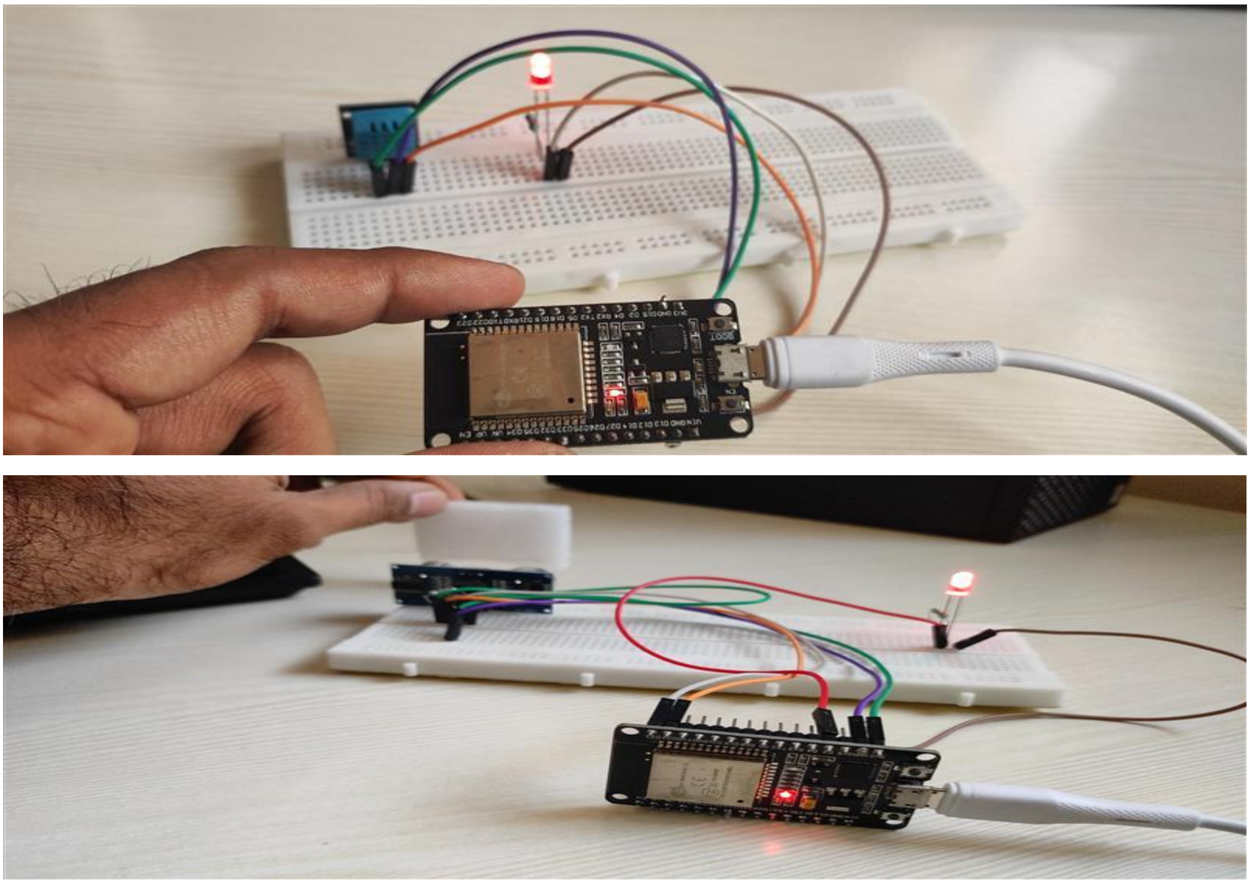


Figure 3.4 Testing DHT11 and HC-SR04 to ESP32

Simultaneously, I used the MQTT Test Client provided by AWS to simulate data publishing and verify message formats, ensuring seamless decoding and storage in the backend. I also cross-verified the received data with the actual sensor readings observed through the serial monitor, validating the accuracy of both transmission and logging. This week highlighted the importance of real-time data validation, backend consistency, and payload structure, strengthening my understanding of how embedded devices interact with cloud databases in a typical IoT architecture.

WEEK 9

SYSTEM TESTING, DEBUGGING, AND FINAL INTEGRATION CHECKS

In the ninth week, I concentrated on performing comprehensive testing and debugging of the complete IoT system to ensure seamless operation across all modules. This phase involved validating the interaction between hardware components, firmware logic, and cloud services as a single integrated unit. By observing the data flow from sensors through the ESP-WROOM-32 to AWS DynamoDB via MQTT, I ensured the system behaved reliably under various real-world conditions.

Using serial debugging and live monitoring tools, I tested how the firmware responded to rapid sensor input changes, Wi-Fi instability, and power resets. Emphasis was placed on data accuracy, response timing, and the system's ability to reconnect to the cloud automatically after network interruptions. Any inconsistencies in data formatting, publishing frequency, or LED triggering were identified and corrected through iterative code updates. This phase resembled software integration testing, where individual subsystems—sensor input, control logic, and cloud communication—were validated together, ensuring the project was robust, synchronized, and ready for final demonstration.

WEEK 10 – WEEK 12

FINAL TESTING, PERFORMANCE VALIDATION, AND REPORT DOCUMENTATION

During the final three weeks of the internship, I focused on thoroughly validating system performance, refining the codebase, and preparing detailed documentation for the entire project. Multiple testing iterations were conducted to ensure that both sensor systems—the temperature-based LED control and distance monitoring setup—functioned reliably under different conditions. I verified that the ESP-WROOM-32 could consistently read sensor values, trigger alerts, and publish structured data to AWS IoT Core, with accurate timestamps and minimal latency.

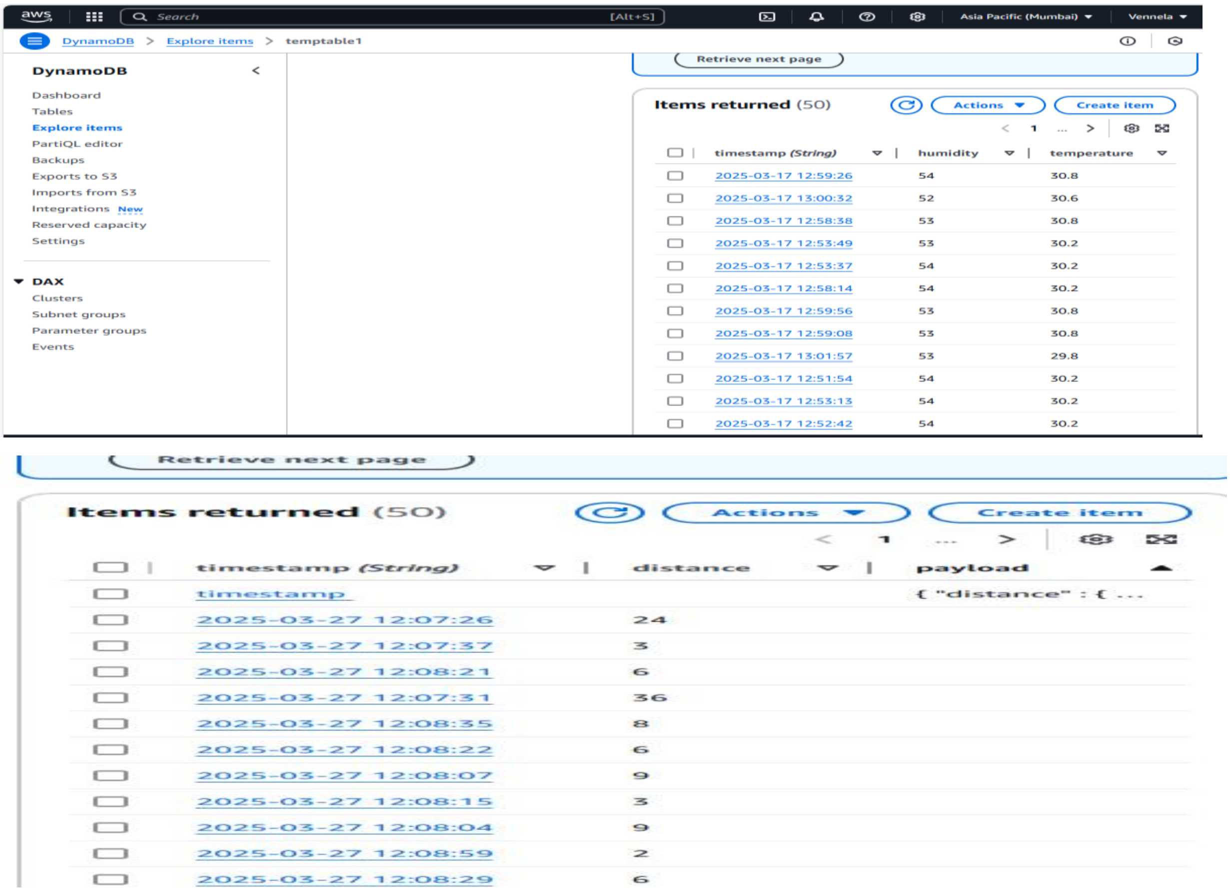


Figure 3.5 Technical Validation

I also worked on optimizing the firmware, ensuring efficient memory usage and smoother task execution within the loop() function. Special attention was given to edge case handling like sensor disconnection or delayed Wi-Fi responses, to build robustness into the system. Once satisfied with system stability, I captured screenshots of MQTT client outputs, serial logs, and DynamoDB tables as proof of correct cloud-side data logging.

Alongside the technical validation, I began preparing the internship report, consolidating all aspects from initial setup to final testing into a structured format. This included writing technical descriptions, compiling wiring diagrams, and reviewing code snippets. These final weeks not only helped solidify my understanding of the project but also improved my ability to document engineering work professionally, rounding off the internship with a well-functioning IoT solution and a detailed technical report.

CHAPTER 4

CONCLUSION

4.1 My Experience in the Organization

The 12-week internship at L&T Technology Services Ltd., Mysuru, was a highly enriching experience that provided me with practical exposure to IoT-based embedded system development. Working on real-time projects involving ESP-WROOM-32, AWS IoT Core, and sensor-based automation, I gained hands-on experience in developing, testing, and deploying cloud-connected embedded solutions. The internship allowed me to explore the end-to-end workflow of building reliable IoT systems, from hardware integration and firmware development to cloud communication and data validation. This opportunity helped me improve my problem-solving skills, develop structured thinking, and understand how theoretical concepts are applied in real-world projects within a professional environment.

4.2 My contribution to the Organization

During the internship, I contributed actively to the development of two major IoT-based prototypes: Temperature-Based LED Control using DHT11 and Distance Monitoring using HC-SR04, both powered by ESP-WROOM-32. I was responsible for writing and debugging embedded code using the Arduino IDE, configuring AWS IoT services, and implementing secure MQTT-based data transmission. I also designed and tested hardware circuits, created voltage dividers, and validated sensor outputs against cloud-stored values in DynamoDB. My role involved ensuring consistent data publishing, handling edge cases such as Wi-Fi dropouts, and verifying end-to-end functionality through MQTT test clients and serial monitoring.

Key contributions include:

- Writing embedded firmware for sensor-based data collection and threshold-based LED alerts.
- Setting up AWS IoT Things, policies, certificates, and DynamoDB tables.
- Implementing MQTT-based secure communication between ESP32 and AWS IoT Core.
- Designing and testing real-time data validation workflows.
- Debugging hardware and software integration issues to ensure stable performance.

4.3 Outcomes of the Internship

This internship significantly boosted my technical capabilities and confidence in working with embedded IoT systems. I learned how to design and implement complete IoT solutions using industry-standard tools and platforms. The hands-on exposure enabled me to move beyond theoretical understanding to real-world applications, especially in areas like sensor interfacing, cloud integration, and secure data handling.

Key outcomes include:

- Strong understanding of ESP-WROOM-32 architecture and Arduino-based firmware development.
- Ability to interface and control real-world sensors such as DHT11 and HC-SR04.
- Practical knowledge of MQTT protocol and cloud services like AWS IoT Core and DynamoDB.
- Skill in designing robust systems with secure communication and real-time responsiveness.
- Improved documentation, testing, and debugging skills applicable in embedded and IoT domains.

Overall, the internship strengthened my technical skills and provided valuable insights into IoT-based embedded system design and cloud integration, which will be highly beneficial for future roles in embedded systems, smart automation, and connected technologies.

4.4 Conclusion

The 12-week internship at L&T Technology Services Ltd. served as a valuable bridge between academic learning and industry practices. Working on real-time sensor-based projects helped me develop a comprehensive understanding of embedded IoT architectures and cloud-based communication models. It enhanced my ability to handle both hardware and software components of a system and strengthened my interest in building smart, connected solutions for real-world problems.

Overall, this experience laid a strong foundation for a career in Embedded Systems and IoT, while also helping me cultivate a professional mindset, teamwork ethic, and confidence to take on future challenges in the tech industry.

INTERNSHIP CERTIFICATE

L&T Technology Services

L&T-TS HR/99014684 19 May 2025

Mr. Manu H P

INTERNSHIP CERTIFICATE

This has reference to your Completion of Internship in L&T Technology Services Limited (LTTS).

Relevant details of internship during the tenure with LTTS are as under.

INTERNSHIP ID	:	99014684
INTERNSHIP START DATE	:	17th February 2025
INTERNSHIP END DATE		16th May 2025
LOCATION	:	Mysore

We wish you success in your future endeavours.

Yours Sincerely,

For L&T Technology Services Limited,

Ashwin J
Group Manager
Employee Relations & Compliance -HR

Registered Office: L&T House, N. M. Marg, Ballard Estate, Mumbai - 400 001. INDIA

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