



COLD CHAIN MONITORING GATEWAY

**Mohammad Sahil Shaikh
Nitant Seth
Vinayak Kulkarni
Dolly Rani
Omkar Kadam**

Project Guide: Mr. Rishabh Hardas



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01

INTRODUCTION

SPEAKER:
Mohammad Sahil Shaikh

INTRODUCTION

- Cold chain systems are critical for preserving temperature-sensitive medicines and vaccines in warehouses and storage facilities.
- Maintaining a strict temperature range is essential to prevent spoilage and loss of medical efficacy.
- Traditional monitoring methods are manual and lack real-time visibility and alerting.
- There is a need for an automated, real-time, cloud-connected monitoring solution for warehouse environments.
- This project implements an IoT-based Cold Chain Monitoring Gateway using ESP32 with Zephyr RTOS, BLE/Wi-Fi communication, and AWS IoT for real-time temperature monitoring.



02

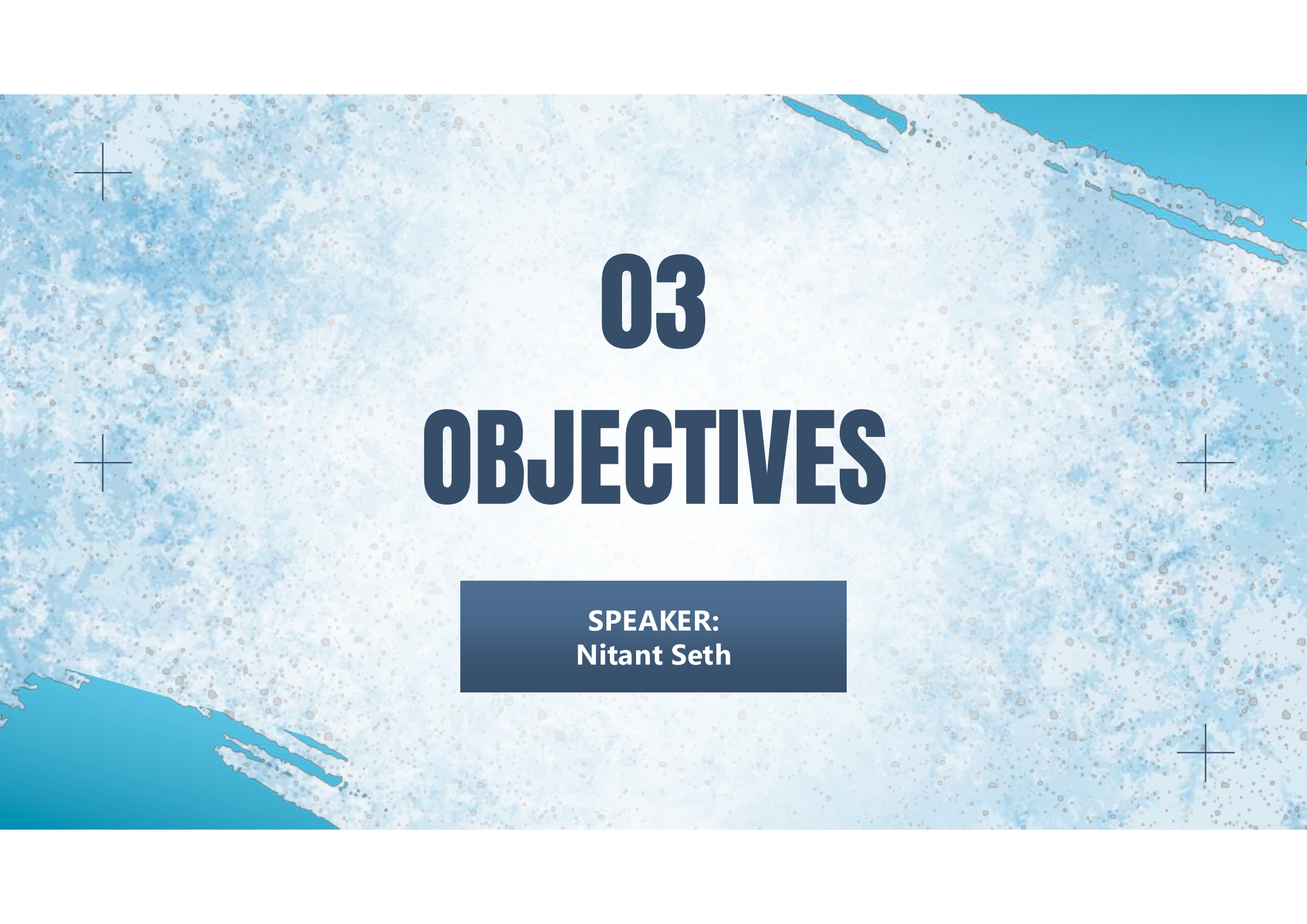
PROBLEM STATEMENT

SPEAKER:
Mohammad Sahil Shaikh



PROBLEM STATEMENT

- Cold chain products (vaccines, food, pharma) require strict temperature control
- Manual monitoring is unreliable and delayed
- Existing systems lack real-time alerts and cloud integration
- Temperature deviations cause product spoilage and financial loss



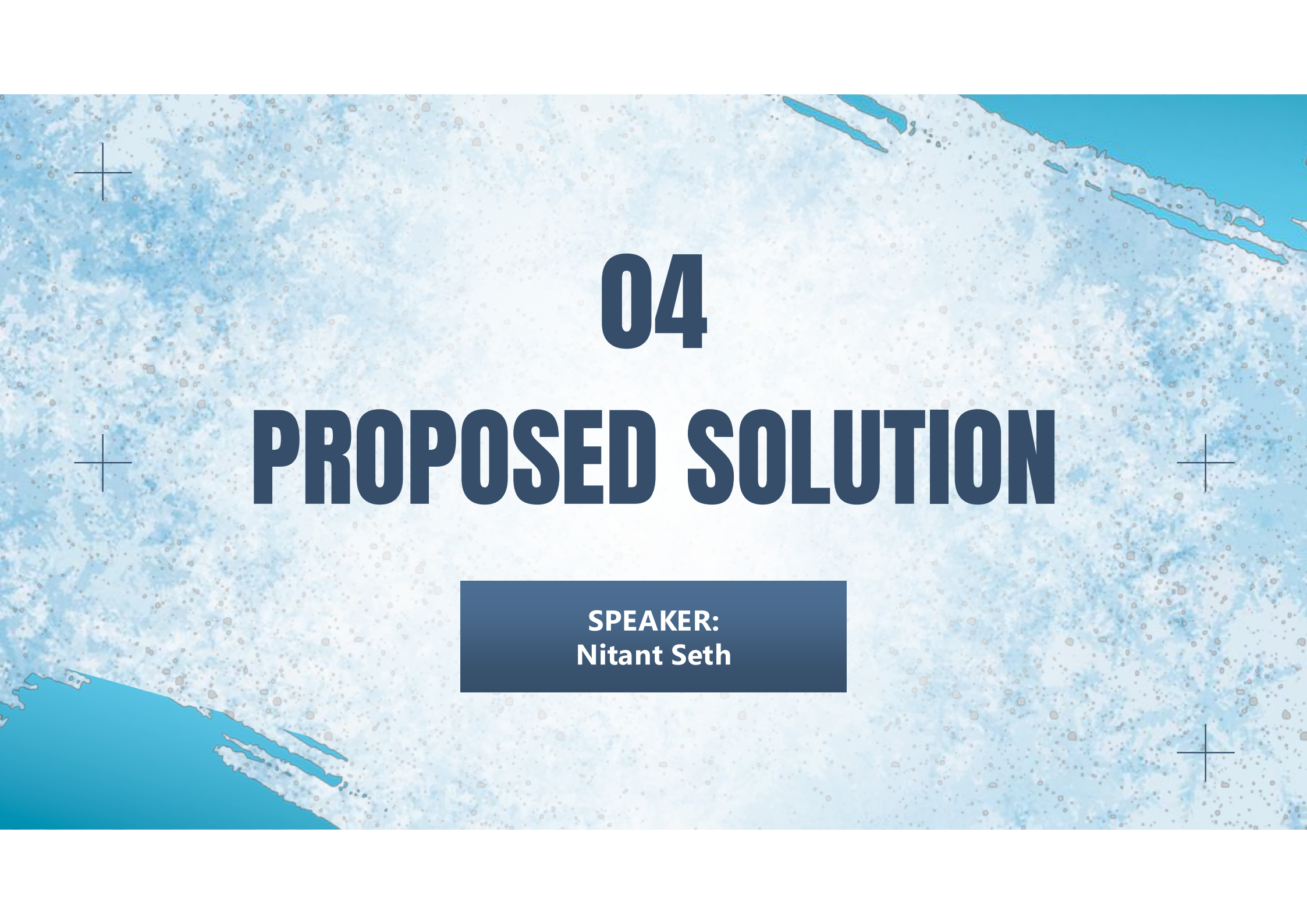
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OBJECTIVES

SPEAKER:
Nitant Seth

OBJECTIVES

- **Continuous temperature monitoring for multiple cold boxes/freezers.**
- **Local control at node level for safety even during network failure.**
- **Transmit sensor data from nodes to gateway using BLE.**
- **Publish aggregated data to cloud/server using Wi-Fi.**
- **Generate alerts on temperature threshold violations.**



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PROPOSED SOLUTION

**SPEAKER:
Nitant Seth**

PROPOSED SOLUTION

- **ESP32 sensor nodes running Zephyr RTOS collect temperature data**
- **BLE used for Sensor Node → Gateway communication**
- **Gateway aggregates sensor data and forwards it to cloud**
- **Gateway publishes telemetry data to AWS IoT using MQTT over Wi-Fi**
- **Cloud dashboard displays real-time warehouse temperature readings**
- **Alerts are generated when predefined temperature thresholds are crossed**



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HARDWARE OVERVIEW

**SPEAKER:
Dolly Rani**

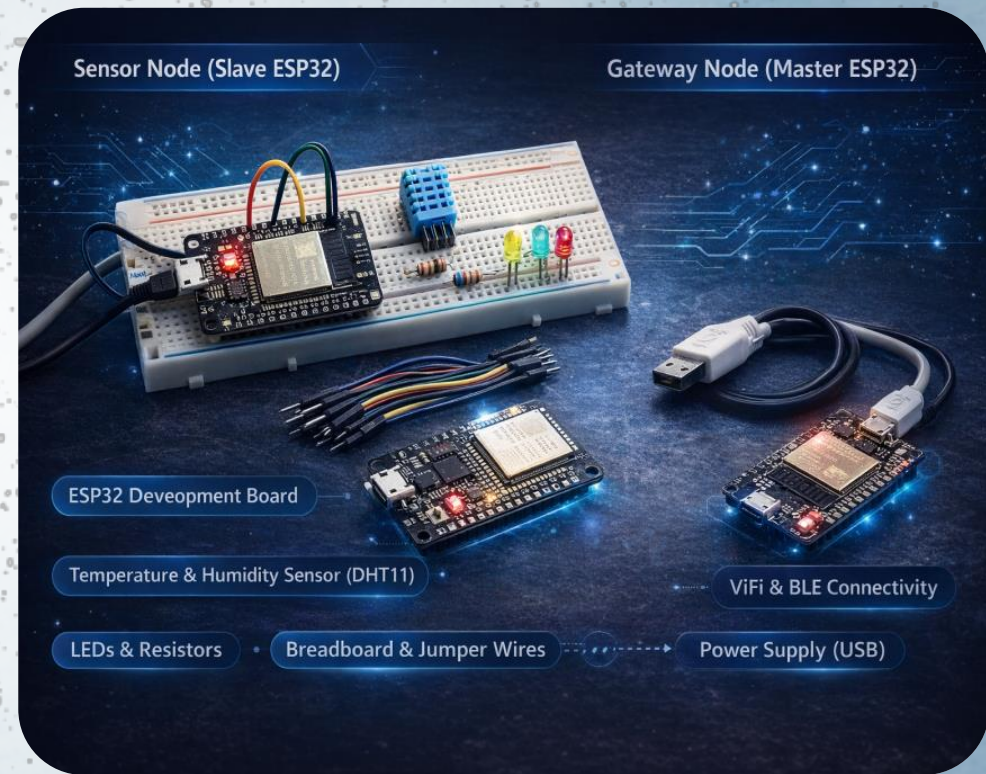
HARDWARE OVERVIEW

❑ Sensor Node (Slave ESP32)

- ESP32 Development Board
- Temperature & Humidity Sensor (DHT11)
- LEDs & Resistors
- Breadboard & Jumper Wires
- Power Supply (USB)

❑ Gateway Node (Master ESP32)

- ESP32 Development Board
- WiFi Connectivity (on-board ESP32)
- BLE Connectivity (on-board ESP32)
- USB Power Supply





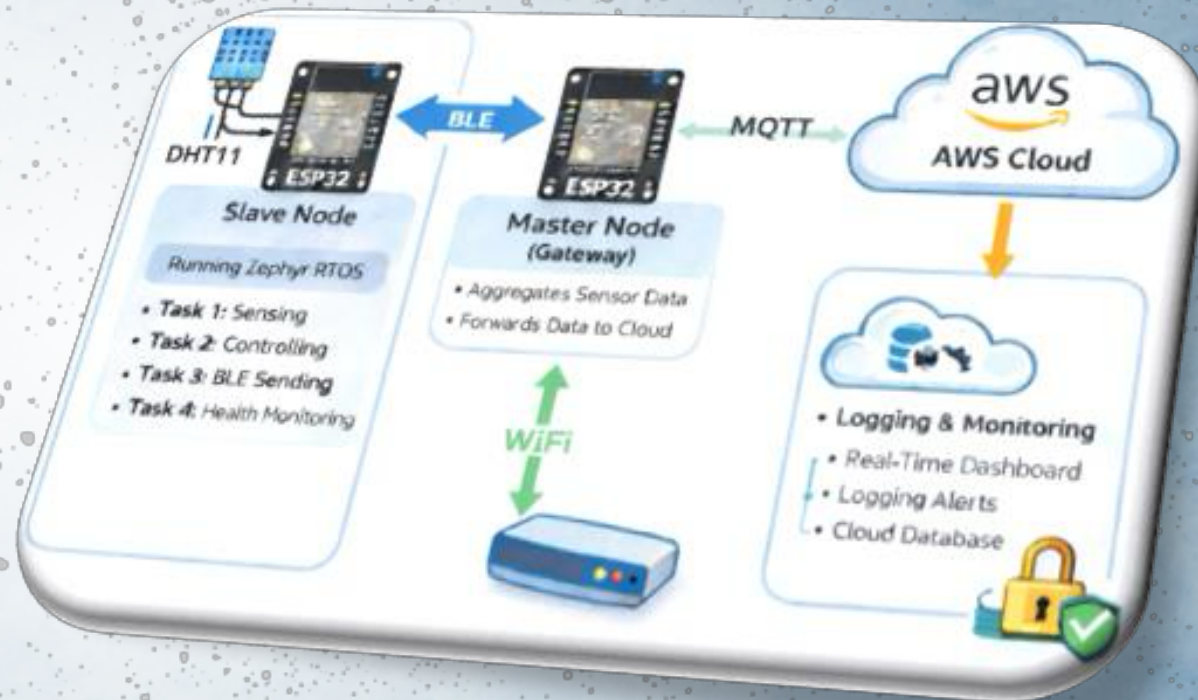
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SYSTEM ARCHITECTURE & WORKING

SPEAKER:
Mohammad Sahil Shaikh

SYSTEM ARCHITECTURE & WORKING

- Sensor node reads temperature
- Data transmitted via BLE
- Gateway receives sensor data
- Gateway connects to Wi-Fi
- MQTT publishes to AWS IoT
- Cloud dashboard displays readings
- Alert generated on threshold violation





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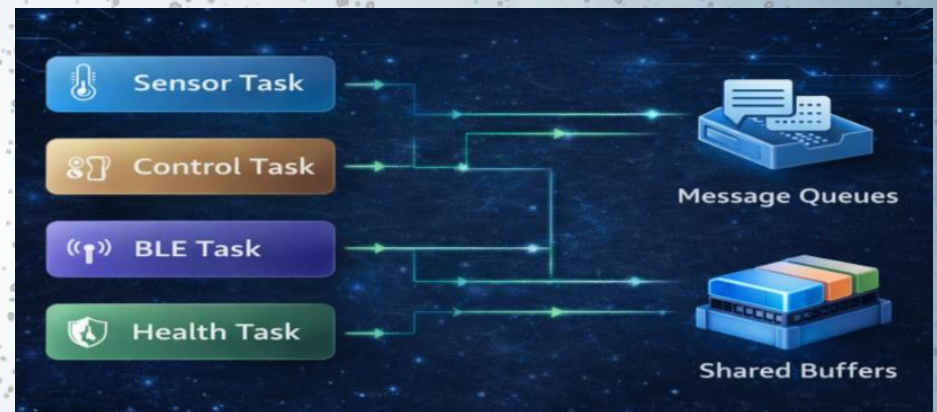
SOFTWARE & RTOS DESIGN

SPEAKER:
Dolly Rani

SOFTWARE & RTOS DESIGN

System divided into Sensor Node (ESP32 + Zephyr RTOS) and Gateway ESP32

- Sensor node runs multiple RTOS tasks:
 - Sensor Task – reads temperature
 - Control Task – fan/heater logic
 - BLE Task – sends data to gateway
 - Health Task – fault monitoring
- Inter-task communication using Zephyr message queues / shared buffers
- Tasks assigned priorities to satisfy real-time constraints
- Zephyr RTOS enables concurrent scheduling with deterministic behavior
- Gateway forwards BLE data to AWS over Wi-Fi





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CLOUD INTEGRATION

SPEAKER:
Omkar Kadam

CLOUD INTEGRATION

- ❑ **AWS IoT Core platform**
 - MQTT publish-subscribe protocol
- ❑ **Security:**
 - TLS encryption
 - X.509 certificates
 - Private key + Root CA
- ❑ **Features:**
 - Real-time dashboard
 - Secure device authentication
 - Threshold alerts



AWS IoT Core



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RESULTS & PERFORMANCE

SPEAKER:
Omkar Kadam

RESULTS

```
=====
❄ COLD CHAIN MONITORING GATEWAY ❄
=====
Warehouse ID : WH-PUNE-01
Box ID       : BOX-CC-007
=====
Temperature  : 6.50 °C
Humidity     : 60.00 %
=====
Fan Status   : OFF
Heater Status: OFF
Alert Status  : OFF
=====
BLE Adv      : ACTIVE
BLE TX       : DATA SENT
Sensor Health: OK ✅
=====
```

1. Ubuntu Terminal Screenshot

```
/dev/ttyUSB1

line synced
Connecting to AWS IoT... Connected to AWS IoT
BLE Slave Connected
Temp: 4.00 | Hum: 60.00
Published to AWS
Temp: 4.50 | Hum: 60.00
Published to AWS
Temp: 5.00 | Hum: 60.00
Published to AWS
Temp: 5.50 | Hum: 60.00
Published to AWS
Temp: 6.00 | Hum: 60.00
Published to AWS
Temp: 6.50 | Hum: 60.00
Published to AWS
```

2. Arduino Serial Monitor Screenshot

```
▼ coldchain/data
January 24, 2026, 15:50:05
(UTC+0530)

{
  "warehouse_id": "WH-PUNE-01",
  "box_id": "BOX-CC-007",
  "temperature": 6.5,
  "humidity": 60
}
```

► Properties

```
▼ coldchain/data
January 24, 2026, 15:50:00
(UTC+0530)

{
  "warehouse_id": "WH-PUNE-01",
  "box_id": "BOX-CC-007",
  "temperature": 6,
  "humidity": 60
}
```

► Properties

3. AWS IoT Core Dashboard Screenshot

PERFORMANCE



METRICS	VALUE
End-to-End Latency	~1.5 sec
BLE Delay	~100 ms
Packet Success Rate	95-98%
Uptime	3+ hrs



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REAL WORLD APPLICATIONS

SPEAKER:
Vinayak Kulkarni

REAL WORLD APPLICATIONS

- Vaccine cold chain monitoring
- Pharmaceutical storage
- Food supply chain logistics
- Cold storage warehouses
- Hospital refrigeration systems
- Blood bank monitoring
- Smart logistics tracking
- Temperature-sensitive shipment monitoring



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CONCLUSION

SPEAKER:
Vinayak Kulkarni

CONCLUSION

- **Successfully designed and implemented an ESP32 based cold chain monitoring system.**
- **Zephyr RTOS on sensor nodes enabled reliable real-time temperature acquisition.**
- **BLE communication ensured efficient data transfer to the gateway.**
- **Secure cloud integration was achieved using AWS IoT with MQTT and TLS.**
- **The system provides real-time monitoring and alert capability for temperature-sensitive applications.**
- **The developed solution demonstrates a scalable, modular, and cost-effective architecture for smart cold chain management.**



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FUTURE SCOPE

SPEAKER:
Vinayak Kulkarni

FUTURE SCOPE

- **Integration of humidity and gas sensors for enhanced environmental monitoring.**
- **Development of a mobile application for remote access and alerts.**
- **Implementation of Edge AI for predictive anomaly detection.**
- **Optimization of power consumption for battery-operated nodes.**
- **Expansion to large-scale multi-node industrial deployment**