

COLD CHAIN MONITORING GATEWAY

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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.**

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PROBLEM STATEMENT

SPEAKER:
Mohammad Sahil Shaikh

PROBLEM STATEMENT

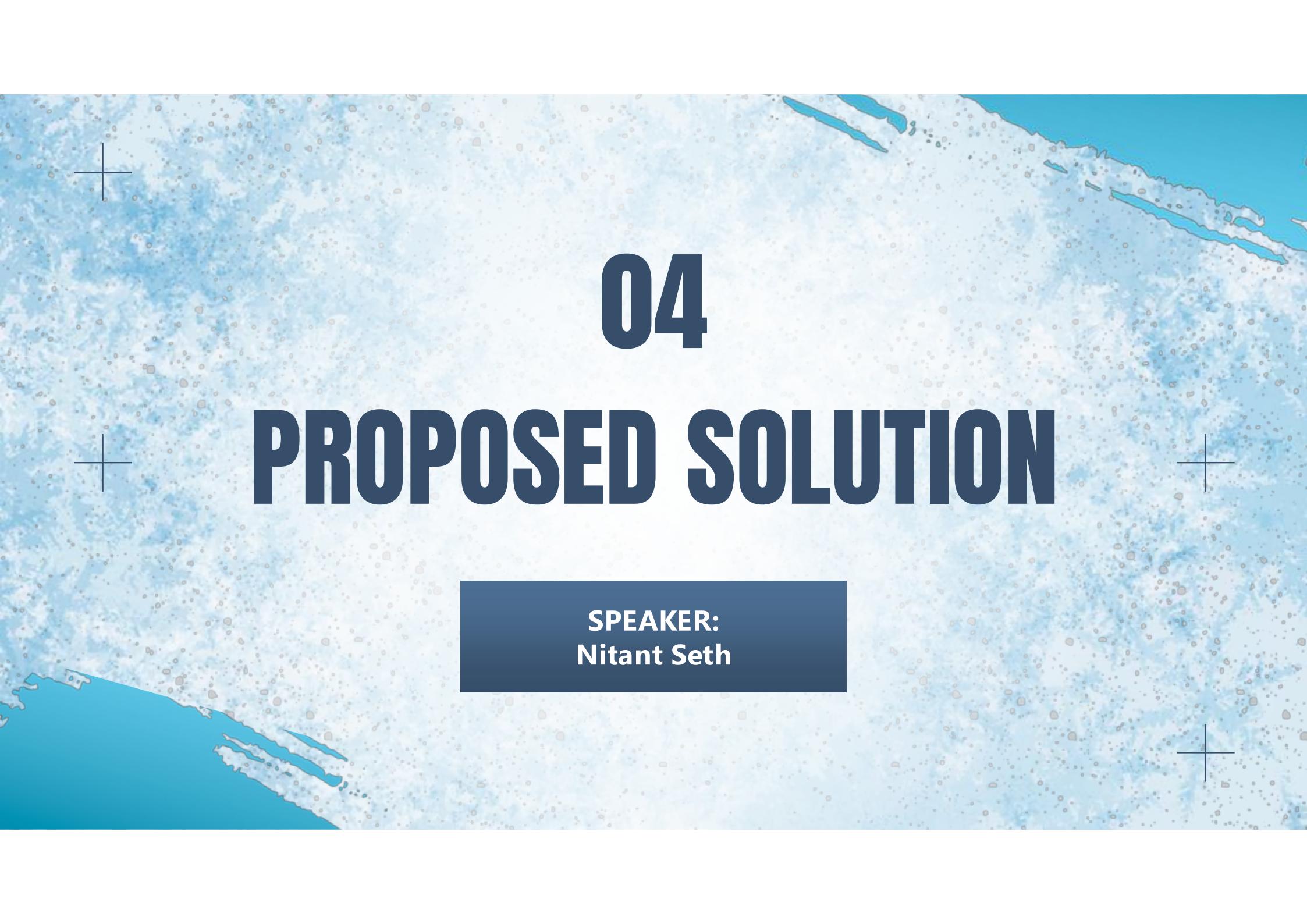
- Cold chain products (vaccines, food, pharma) require strict temperature control
- Manual monitoring is unreliable and delayed
- Existing systems lack real-time alerts and cloud integration
- Temperature deviations cause product spoilage and financial loss

03 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



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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  
  
 Autoscroll  Show timestamp  Newline
```

2.Arduino Serial Monitor Screenshot

```
▼ coldchain/data  
January 24, 2026, 15:50:05  
(UTC+0530)  
  
{  
  "warehouse_id": "WH-PUN  
E-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-PUN  
E-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**