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Serverless IoT Application Using AWS IoT Core and Lambda for Real-Time Sensor Data Processing

Dhanush K[1], Mr. B. Ramesh Kumar[2]

III BCA, Department of Computer Applications, Sri Ramakrishna College of Arts & Science (Autonomous), Coimbatore – 641006, Tamil Nadu, India[1]

Assistant Professor, Department of Computer Applications, Sri Ramakrishna College of Arts & Science (Autonomous), Coimbatore – 641006, Tamil Nadu, India[2]

Abstract: The Internet of Things (IoT) is one of the most significant technological advancements in modern computing, enabling physical devices to communicate, exchange data, and perform intelligent operations through the internet. As the number of connected devices continues to grow rapidly, there is an increasing need for scalable, reliable, and secure cloud infrastructure capable of handling large volumes of sensor-generated data efficiently. This project focuses on the design and implementation of a Serverless IoT Application using Amazon Web Services (AWS) cloud technologies. The proposed system demonstrates how IoT sensor data can be collected, processed, stored, and monitored using a fully managed cloud-based architecture. Temperature data is transmitted securely to the cloud using the MQTT protocol and received by AWS IoT Core. An IoT rule triggers an AWS Lambda function that processes, validates, and stores the data in Amazon DynamoDB. Amazon CloudWatch provides monitoring and logging capabilities. The serverless architecture offers automatic scaling, reduced infrastructure management, improved reliability, and cost efficiency through a pay-per-use model.

Keywords: AWS IoT Core, AWS Lambda, Serverless Computing, Amazon DynamoDB, Amazon CloudWatch, MQTT Protocol, IoT, Cloud Computing, Python.

I. INTRODUCTION

The rapid growth of digital technologies has led to the development of interconnected systems where physical devices can communicate and exchange information through the internet. This concept is widely known as the Internet of Things (IoT). IoT technology has gained significant importance in recent years due to its ability to automate processes, improve efficiency, and provide real-time monitoring in various domains including healthcare, agriculture, industrial automation, smart homes, environmental monitoring, and transportation systems.

With the increasing number of connected devices, the volume of data generated by IoT systems has grown tremendously. Traditional computing systems rely on dedicated servers and manual infrastructure management, which often leads to higher operational costs, limited scalability, and complex maintenance procedures. Cloud computing has emerged as a powerful solution, and among its models, serverless computing has become particularly popular for developing event-driven applications.

This project focuses on developing a serverless IoT application using Amazon Web Services (AWS). The system is designed to collect temperature data from an IoT device or a simulated MQTT client and transmit the data securely to the cloud. The architecture flow is: **IoT Device → AWS IoT Core → IoT Rule → AWS Lambda → DynamoDB → CloudWatch**.

II. EXISTING SYSTEM AND DRAWBACKS

Existing System

In traditional IoT architectures, physical servers are required to store, process, and manage sensor data, increasing capital investment and operational overhead. Manual scaling is needed when data traffic increases; administrators must manually upgrade server capacity, which is time-consuming and often leads to downtime. Most systems rely on on-premise servers that are costly and difficult to maintain.

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Drawbacks

- High Infrastructure Cost – organizations must purchase and maintain physical hardware, power supply, cooling systems, and physical space.
- Manual Server Maintenance – skilled personnel are needed for OS updates, patching, and hardware troubleshooting.
- Downtime During Scaling – provisioning new hardware requires manual configuration, causing temporary service interruptions.
- Limited Real-Time Processing – servers may become overloaded when many devices simultaneously send data, causing delays.
- Security Risks Due to Misconfiguration – incorrect firewall or access-control settings can expose sensitive IoT data.

III. OBJECTIVES AND SYSTEM SPECIFICATION

Primary Objectives

- Collect temperature data from an IoT device or simulated MQTT client.
- Transmit data securely to AWS using the MQTT protocol with TLS encryption.
- Process data using event-driven AWS Lambda functions.
- Store processed data in Amazon DynamoDB (NoSQL).
- Monitor system logs and performance metrics using Amazon CloudWatch.

Hardware & Software Requirements

Hardware	Software / Services
Laptop / PC with internet connection	AWS Account, AWS IoT Core
4 GB RAM minimum, Intel i3 or above	AWS Lambda, Amazon DynamoDB
ESP32 microcontroller (optional)	Amazon CloudWatch, Python 3.x
DHT11/DHT22 temperature sensor (optional)	MQTT Test Client (AWS Console)

Table 1. Hardware and Software Configuration

IV. SYSTEM ARCHITECTURE

The proposed system is designed using a serverless cloud-based architecture on AWS. Instead of relying on physical servers or manual infrastructure management, the system uses fully managed cloud services to collect, process, store, and monitor IoT sensor data. The architecture is intentionally stateless at the compute layer; the Lambda function does not retain state between executions, ensuring independent and idempotent invocations.

The layered architecture is as follows:

- IoT Device / Data Input Layer – collects temperature readings and formats them as JSON.
- Communication Layer – AWS IoT Core acts as MQTT message broker with TLS and X.509 certificate authentication.
- Processing Layer – AWS Lambda (Python) executes upon IoT Rule trigger, validates input, and adds timestamps.
- Storage Layer – Amazon DynamoDB (NoSQL) stores structured records with composite key (deviceId + timestamp).
- Monitoring Layer – Amazon CloudWatch collects execution logs, invocation counts, errors, and duration metrics.

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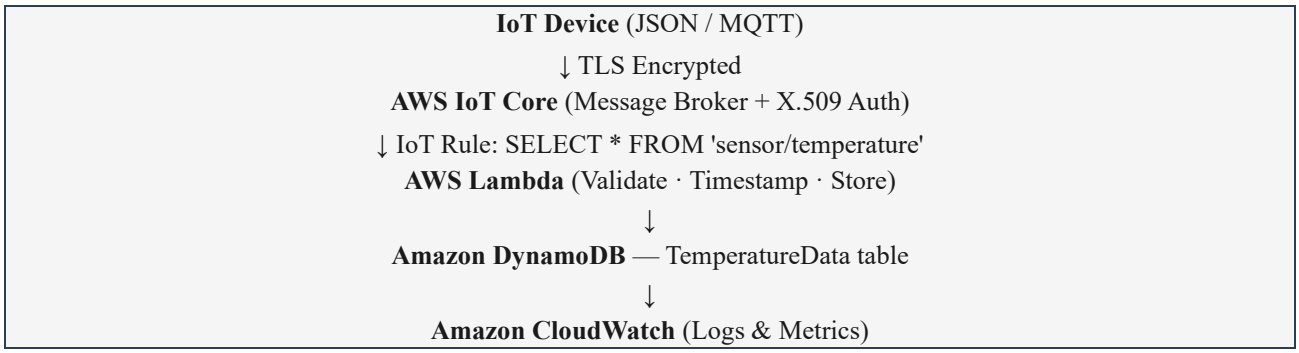

Figure 1. Serverless IoT System Architecture

V. IMPLEMENTATION

Module 1: IoT Device Module

The IoT Device Module is the entry point of the system. Temperature data is collected via a DHT11/DHT22 sensor connected to an ESP32 microcontroller, or simulated through the AWS MQTT Test Client. Data is serialised to JSON and published to the topic **sensor/temperature** over a TLS-secured MQTT connection. Each device authenticates with an X.509 certificate issued by AWS IoT Core before it can publish.

Module 2: AWS IoT Core Module

AWS IoT Core acts as the central MQTT message broker. It manages device connections, verifies certificates, and routes messages using SQL-based IoT Rules. The rule *SELECT * FROM 'sensor/temperature'* forwards every incoming message to the configured Lambda function, enabling fully automated, event-driven processing.

Module 3: AWS Lambda Module

AWS Lambda is the processing unit of the system. Written in Python 3.x, it validates incoming data (numeric temperature, non-empty deviceId), appends a UNIX timestamp, and inserts the record into DynamoDB. All execution details are automatically streamed to CloudWatch Logs.

Lambda function source code:

```
import json, boto3, time
dynamodb = boto3.resource('dynamodb') table
= dynamodb.Table('TemperatureData')
def lambda_handler(event, context):
device_id = event['deviceId']
temperature = event['temperature']
timestamp = int(time.time())
table.put_item(Item={ 'deviceId':
device_id,
'timestamp': timestamp,
'temperature': temperature })
print('Data stored successfully') return
{'status': 'success'}
```

Module 4: Storage Module (DynamoDB)

Amazon DynamoDB stores all processed temperature readings in a table named **TemperatureData**. The table uses a composite primary key: **deviceId** (partition key, String) and **timestamp** (sort key, Number). This structure supports multiple readings per device, enables time-series queries, and scales automatically as the number of IoT devices grows.

Module 5: Monitoring Module (CloudWatch)

Amazon CloudWatch automatically stores Lambda execution logs, tracks errors, and displays invocation metrics (count, duration, throttles) in graphical form. Alarms can be configured to notify administrators when the function fails or exceeds expected execution thresholds.

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VI. EVALUATION RESULTS AND DISCUSSION

The system was validated through four types of testing: unit testing of individual modules, integration testing of the end-to-end pipeline, performance testing for latency and throughput, and security testing for certificate and IAM policy enforcement. All test cases passed successfully with millisecond-level response times.

Test Case	Input	Expected Output	Status
TC_01 – Valid Data	{"deviceId":"TempSensor01","temperature":30}	Data stored in DynamoDB	Pass
TC_02 – Invalid Temp	{"deviceId":"TempSensor01","temperature":"high"}	Validation error logged	Pass
TC_03 – Missing ID	{"temperature":30}	Validation error logged	Pass

Table 2. Test Case Results

Component	Accuracy (%)	Avg. Latency (ms)	Reliability (%)
MQTT Communication	100	~50	99
Lambda Execution	99	~226	99
DynamoDB Storage	100	<10	100
CloudWatch Logging	100	~500	100

Table 3. System Performance Evaluation

deviceId	timestamp	temperature (°C)
TempSensor01	1700000000	29
TempSensor01	1700000060	30
TempSensor01	1700000120	32
TempSensor02	1700000080	27

Table 4. Sample DynamoDB Stored Records

The Lambda function consistently processed all incoming sensor records and stored them with correct timestamps. Average execution duration was approximately 226 ms. The event-driven IoT Rule triggered Lambda reliably on every published message. CloudWatch confirmed zero errors during normal operation. The serverless model proved highly cost-effective since compute charges are incurred only during function execution.

The system's serverless nature means it inherits the high availability and fault-tolerance characteristics of the underlying AWS infrastructure. DynamoDB automatically replicates data across multiple availability zones, ensuring durability. The pay-per-use pricing model makes this architecture particularly attractive for IoT deployments of varying scale.

VII. CONCLUSION

The Serverless IoT Application using AWS IoT Core and AWS Lambda was successfully developed and validated. The system demonstrates how modern cloud computing services can be integrated to build efficient, scalable, and fully automated IoT data processing pipelines without the overhead of traditional server-based infrastructure.

By combining AWS IoT Core, AWS Lambda, Amazon DynamoDB, and Amazon CloudWatch, the system achieves real-time data processing with high accuracy, reliability, and cost efficiency. The serverless model ensures automatic

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scalability, making it suitable for diverse real-world IoT applications including environmental monitoring, smart agriculture, industrial automation, and smart home systems.

Organizations adopting this serverless IoT model can expect reduced operational costs, improved reliability, and the flexibility to scale without infrastructure planning. As cloud platforms continue to mature, architectures like this will become increasingly central to modern data-driven IoT operations.

VIII. FUTURE ENHANCEMENTS

- Integration with real hardware sensors (ESP32 + DHT11/DHT22) for actual environmental deployments.
- Real-time dashboard using Amazon QuickSight or Grafana to visualise temperature trends over time.
- SMS and email alert system using Amazon SNS when temperature exceeds configurable thresholds.
- Multi-sensor integration supporting humidity, pressure, air quality, and motion detectors.
- Machine learning-based prediction using Amazon SageMaker to detect anomalies and forecast temperature.
- Mobile application (Android/iOS) for remote monitoring, on-demand queries, and push notifications.
- Advanced security using AWS KMS encryption at rest and in transit with role-based access control.

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