# Chapter 6: IoT Data Management and Cloud Integration

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## 📘 Description

This chapter explores how data from IoT devices is collected, stored, processed, and visualized using cloud platforms. You'll learn about real-time data handling, integration with cloud services like AWS IoT, Firebase, and how dashboards help in monitoring and control.

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## 🎯 Learning Objectives

By the end of this chapter, you will be able to:

- Understand how IoT data is collected and processed.
- Explore cloud platforms and their IoT services.
- Learn how to connect devices to the cloud.
- Visualize IoT data in real-time using dashboards.

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## 📥 Section 1: Data Flow in IoT Systems

**Flow**:

1. Sensors generate data →
2. Microcontroller collects and preprocesses it →
3. Data transmitted to cloud via communication protocols →
4. Cloud stores and analyzes →

5. User accesses insights via dashboards or apps

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## ☁️ Section 2: Popular Cloud Platforms for IoT

| Platform | Features |
|---|---|
| **AWS IoT Core** | Device management, rules engine, analytics, MQTT/HTTP support |
| **Google Cloud IoT** | Real-time telemetry, device registry, BigQuery integration |
| **Microsoft Azure IoT Hub** | Scalable messaging, device twin model |
| **Firebase (Google)** | Realtime database, authentication, used with ESP32/ESP8266 |
| **ThingsBoard** | Open-source dashboard and device management platform |

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## 🔗 Section 3: Device-to-Cloud Communication

- **MQTT over TLS**: Secure and lightweight for telemetry
- **HTTP POST**: For sending REST data to cloud APIs
- **Firebase Realtime Database**: ESP32 writes/reads directly to/from cloud

### Example: Sending Temperature Data to Firebase (ESP32)

cpp
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```
Firebase.setFloat("/sensor/temp", 28.5);
```

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## 📊 Section 4: Data Storage and Analytics

- **Time-series databases**: Store data with timestamps (InfluxDB)

- **Cloud databases**: Firebase, DynamoDB, BigQuery
- **Data visualization**: Dashboards (ThingsBoard, Grafana) for trends and alerts
- **Edge analytics**: Basic processing near the device for low-latency decisions

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## 📈 Section 5: Real-Time Dashboards and Alerts

Dashboards help users:

- View sensor data in real time
- Trigger alerts (e.g., SMS/email when temperature crosses a limit)
- Control devices remotely via buttons or switches

Example: Turning a fan ON from a dashboard when temperature > 30°C

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## ✅ Chapter Summary

- IoT data flows from devices to cloud platforms for storage and analysis.
- Popular platforms like AWS IoT, Firebase, and ThingsBoard offer full-stack solutions.
- Real-time dashboards help users monitor and interact with their systems.
- Data management is crucial for automation, reporting, and analytics in IoT.