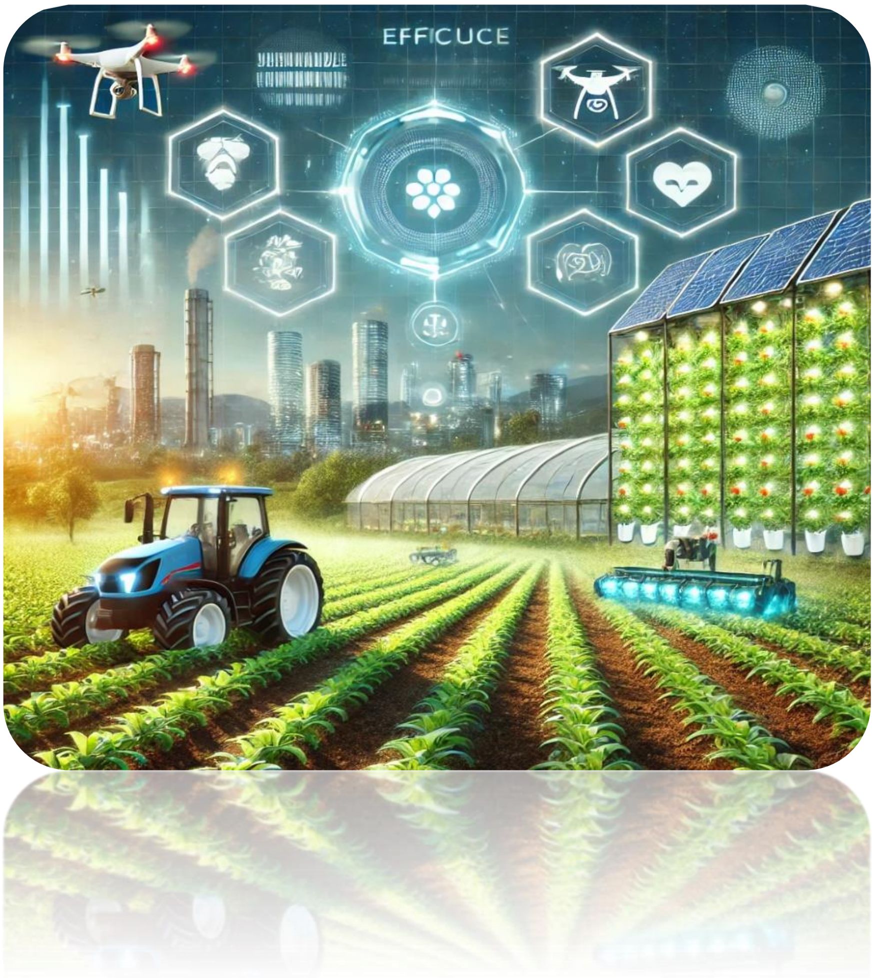
Cloud Architecture For Smart Farm "AgriTech Farms"



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1. Introduction

1.1 Overview of AgriTech Farms

Farming is changing fast, and AgriTech Farms is using new technology to make it better. This project combines IoT devices, cloud computing, and AI to help farmers work smarter. By using these tools, we can provide real-time updates on important things like soil health, weather conditions, and inventory levels. This helps farmers make better decisions and get more from their land.

With IoT sensors, we collect data on soil moisture, temperature, and pH levels. Weather APIs give us forecasts, and inventory data helps track farm supplies. All this information is sent to the cloud using platforms like Azure. The cloud stores and processes the data, making it easy for farmers and managers to see what's happening and plan ahead. The goal is to improve productivity while saving time and resources.

2. Mission & Objectives

2.1 Mission statement

To enhance farming by making it smarter and more efficient through the use of advanced technologies such as IoT sensors, AI, and cloud systems. These tools provide real-time data and predictive insights to help farmers monitor crops, optimize irrigation, manage inventory, and forecast production. The goal is to improve productivity, reduce waste, and support sustainable farming practices.

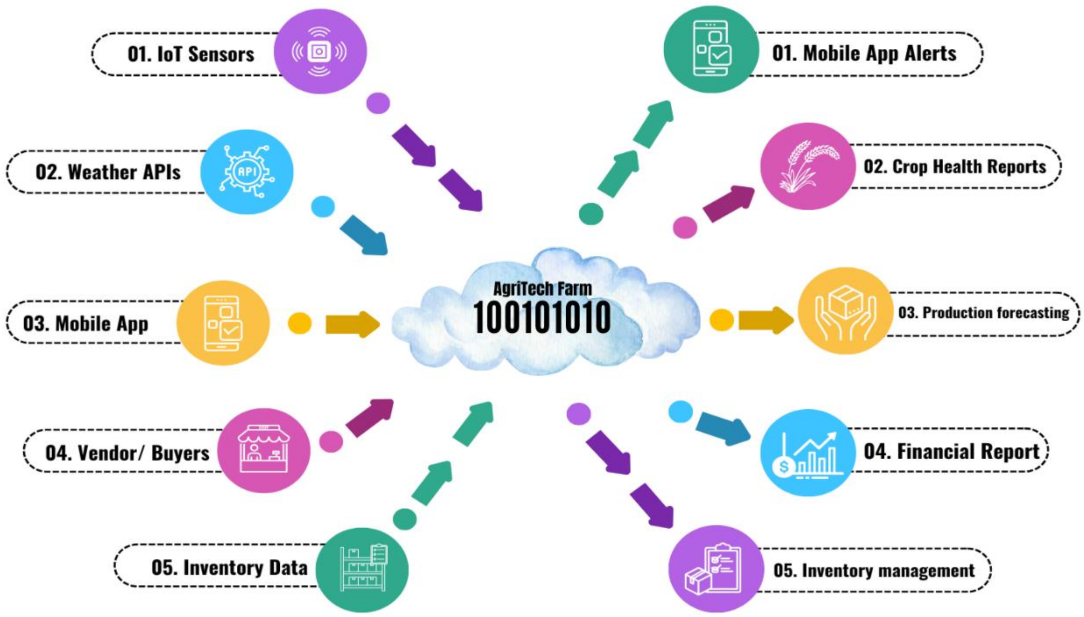
2.2 Objective

Help farmers grow better crops, save resources, and earn more with easy-to-use tools.

1. Use technology to monitor and improve farming.
2. Save water, fertilizer, and energy.
3. Give farmers real-time updates on their crops.
4. Reduce crop losses and protect the environment.

3. Design and Discovery Phase

3.1 Understanding farm requirements



3.2 Identifying key challenges and opportunities

This phase focused on understanding the needs of AgriTech Farms:

- **Challenges**: Farmers face issues like unpredictable weather, uneven crop health, and inefficient use of resources.
- **Opportunities**: Using real-time data can help solve these problems and improve farm operations, leading to better crop management and higher yields.

4. Data Sources Overview

4.1 IoT Sensors (Soil Monitoring)

- **Type of Data**: Numeric
- **Examples**: Soil moisture (%) , pH levels, Nutrient levels (NPK values in %).
- **Data Flow**: Streaming (real-time updates).
- **Source**: IoT sensors installed on the farm.
- **Access Method**: On-premises devices connected via IoT Hub
- **Kind of Data**: Structured (time-series data with timestamps).

4.2 Weather APIs

- **Type of Data**: Numeric and Text
- **Examples**: Temperature (°C/°F), Rainfall probability (%),Wind speed (km/h),Weather descriptions (e.g., "cloudy", "sunny").
- **Data Flow**: Batch (data pulled periodically).
- **Source**: Third-party APIs
- **Access Method:** Web API
- **Kind of Data**: Structured (JSON or XML format).

4.3 Mobile App Data

- **Type of Data**: Numeric and Categorical
- **Examples**: Crop health scores (1-10),Irrigation logs (e.g., "Irrigation started at 10:00 AM"), Pest reports (e.g., "Aphids detected"), Task updates (e.g., "Fertilizer applied on 5 acres").
- **Data Flow**: Streaming or Batch (depends on user activity).
- **Source**: Mobile devices used by farmers and workers
- **Access Method**: Cloud sync via app backend
- **Kind of Data**: Semi-structured (JSON or relational database entries).

4.4 Vendor/Buyer Data

- **Type of Data**: Text and Numeric
- **Examples**: Buyer names and contact info, Crop orders, Transaction amounts Preferred delivery schedules (e.g., "Weekly on Mondays").
- **Data Flow**: Batch (uploaded after transactions).
- **Source**: Sales records from farmer systems or point-of-sale software.
- **Access Method**: Web portal or database.
- **Kind of Data**: Structured (relational database or spreadsheets)

4.5 Inventory Data

- **Type of Data**: Numeric and Categorical
- **Examples**: Fertilizer stock levels, Seed stock levels, Usage logs, Restocking dates.
- **Data Flow**: Batch (periodic updates).
- **Source**: Farm management systems or manual input.
- **Access Method**: On-premises or cloud-based inventory tools (e.g., Excel, SAP).
- **Kind of Data**: Structured (relational database, CSV).

5. Key Deliverables

5.1 Mobile App Alerts

- **Delivery Method**: Mobile app (Push Notifications/SMS).
- **What We Deliver**: Irrigation alerts, Pest control alerts, Weather updates.

5.2 Crop Health Reports

- **Delivery Method**: Power BI/Tableau dashboards, PDF reports.
- **What We Deliver**: Weekly crop health insights, Soil quality trends.

5.3 Production Forecasting

- **Delivery Method**: Power BI/Tableau dashboards, forecast reports.
- **What We Deliver**: Predicted crop yield, Optimal planting/harvesting periods, Scenario-based forecasts.

5.4 Financial Reports

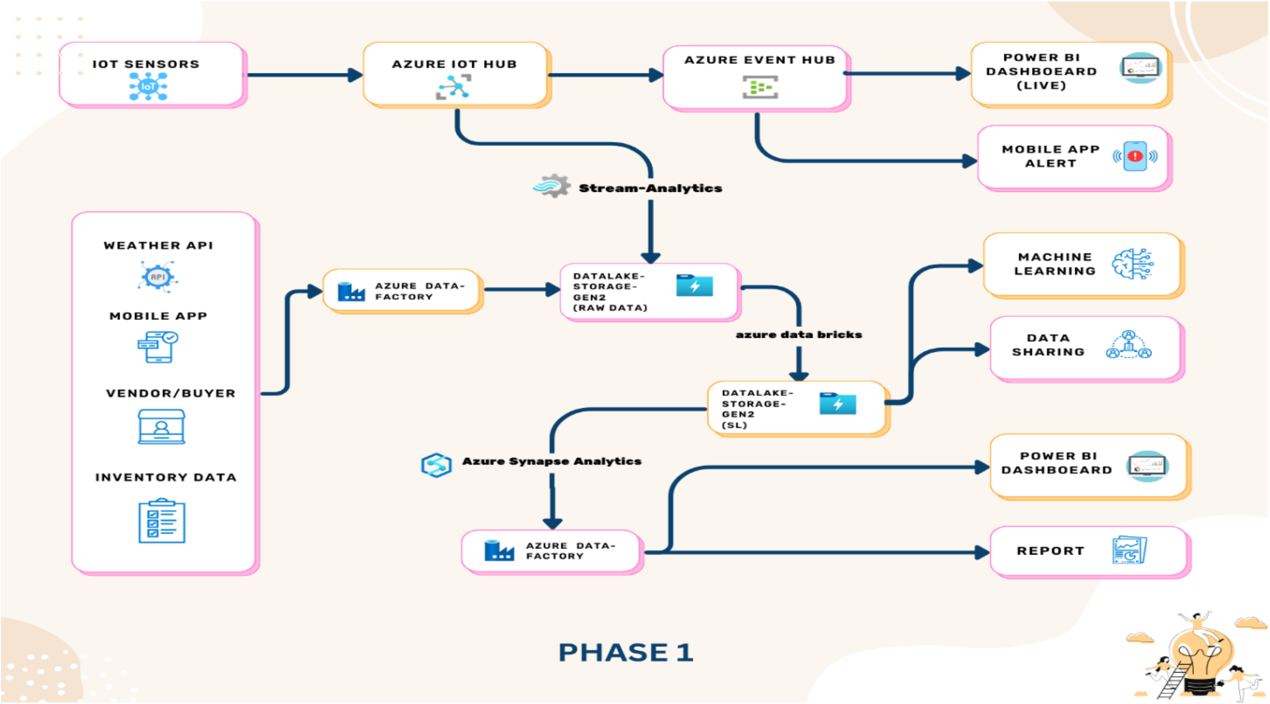
- **Delivery Method**: Power BI dashboards, monthly email reports.
- **What We Deliver**: Cost analysis of operations, Revenue from crop sales, Profit/loss summaries.

5.5 Inventory Management

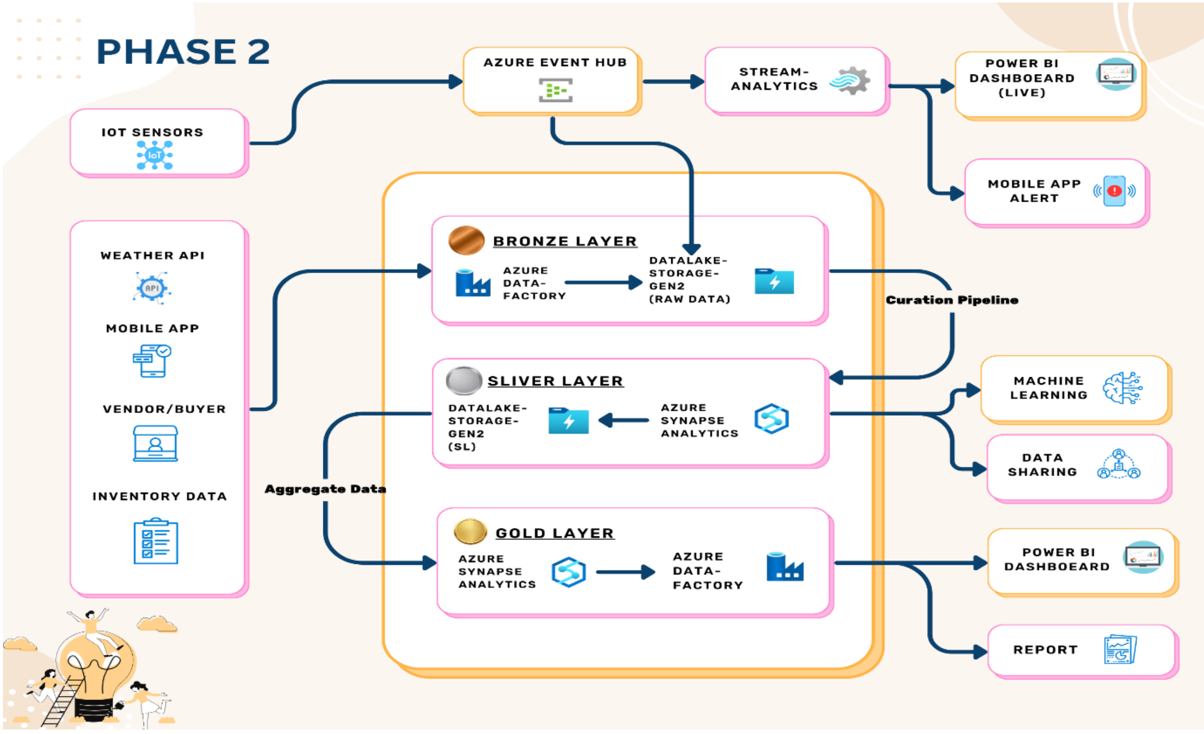
- **Delivery Method**: Power BI dashboards, inventory reports.
- **What We Deliver**: Current stock levels, Usage and restocking logs, Alerts for low inventory.

6. Cloud Architecture Phases

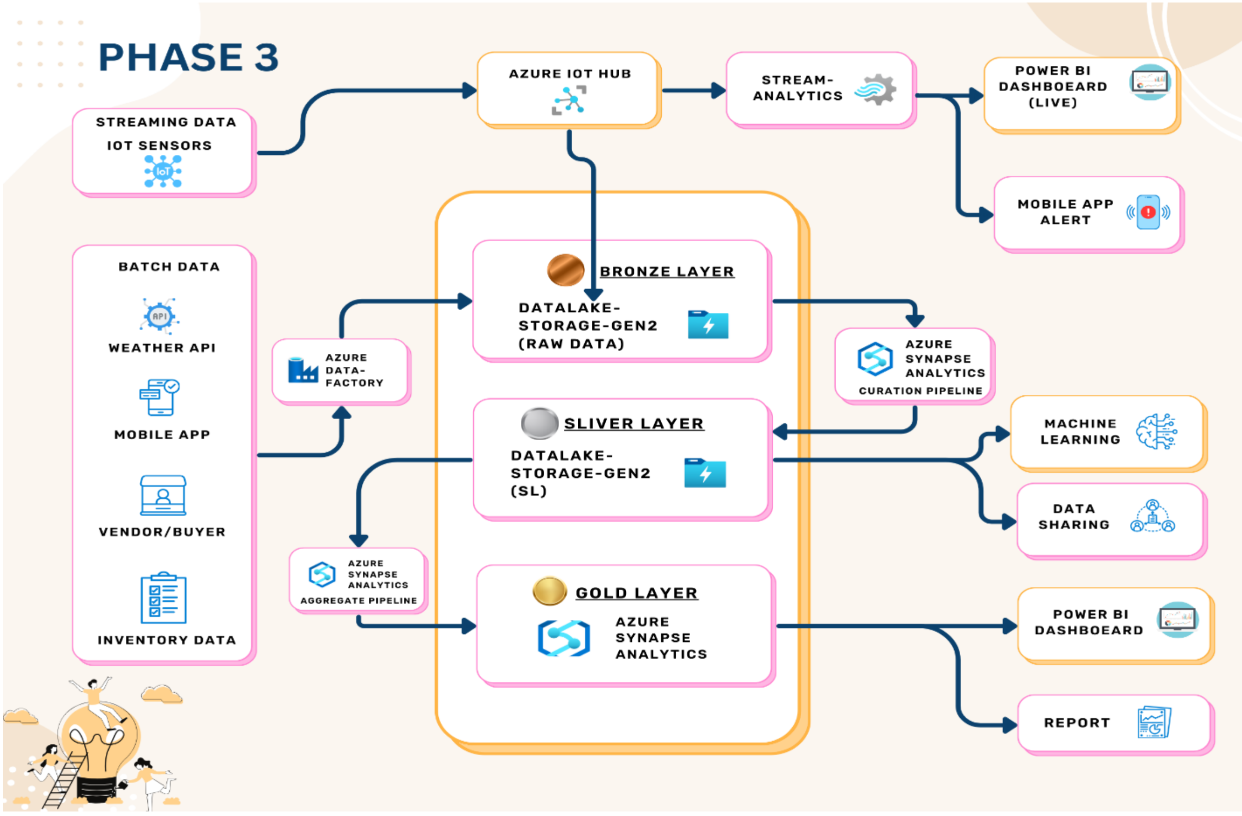
6.1 Phase 1: Initial Design



6.2 Phase 2: Refinement



6.3 Phase 3: Final Architecture



7. <u>Process of Creating Pipeline</u>

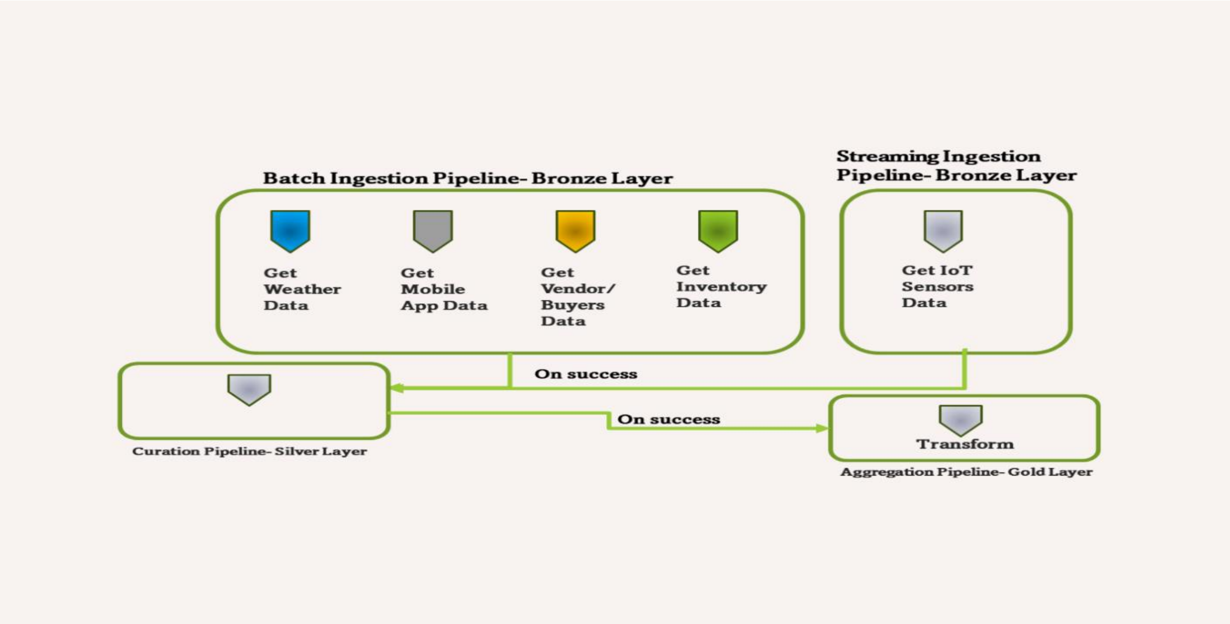
7.1 Bronze Layer(Ingest Data)

In this project, we set up two types of data pipelines: **batch ingestion** and **streaming ingestion**.

For **batch ingestion**, we used **Azure Data Factory** to collect and process data at specific times. This is useful for working with large sets of data and creating reports.

For **streaming ingestion**, we used **Azure IoT Hub** to handle live data from sensors in real time. This helps us get instant updates, like checking the current condition of crops or equipment.

These pipelines make it easy to manage both real-time data and data collected over time.



7.2 Sliver Layer(Curate Data)

Data Curation Process

The process starts by looking at sample data to check its quality.

First, they visually check the data from different sources.

Sometimes, they need to use simple programs to find and fix problems like:

- Data that doesn’t follow a standard format.
- Incorrect or repeated information.
- Data that’s not secure or consistent.

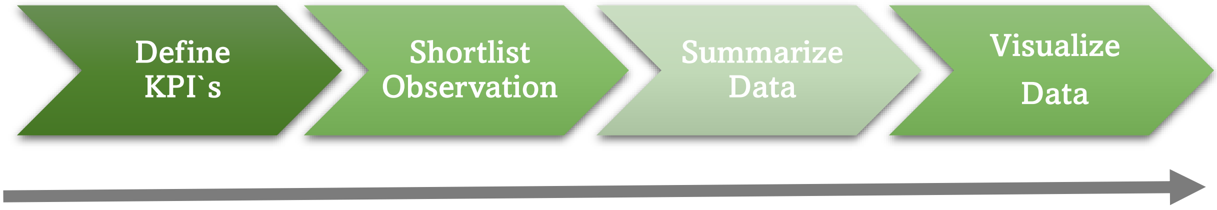
Data Curation Process

7.3 Gold Layer(Aggregate Data)

The gold layer is used to combine and summarize data to make it easier to understand.

It helps find patterns by looking at a group of data with certain details.

- **Total Crop Yield per Season**: Total production in a season.
- **Total Revenue from Crop Sales per Quarter**: Quarterly sales revenue.
- **Average Fertilizer Usage per Field**: Average fertilizer used across fields

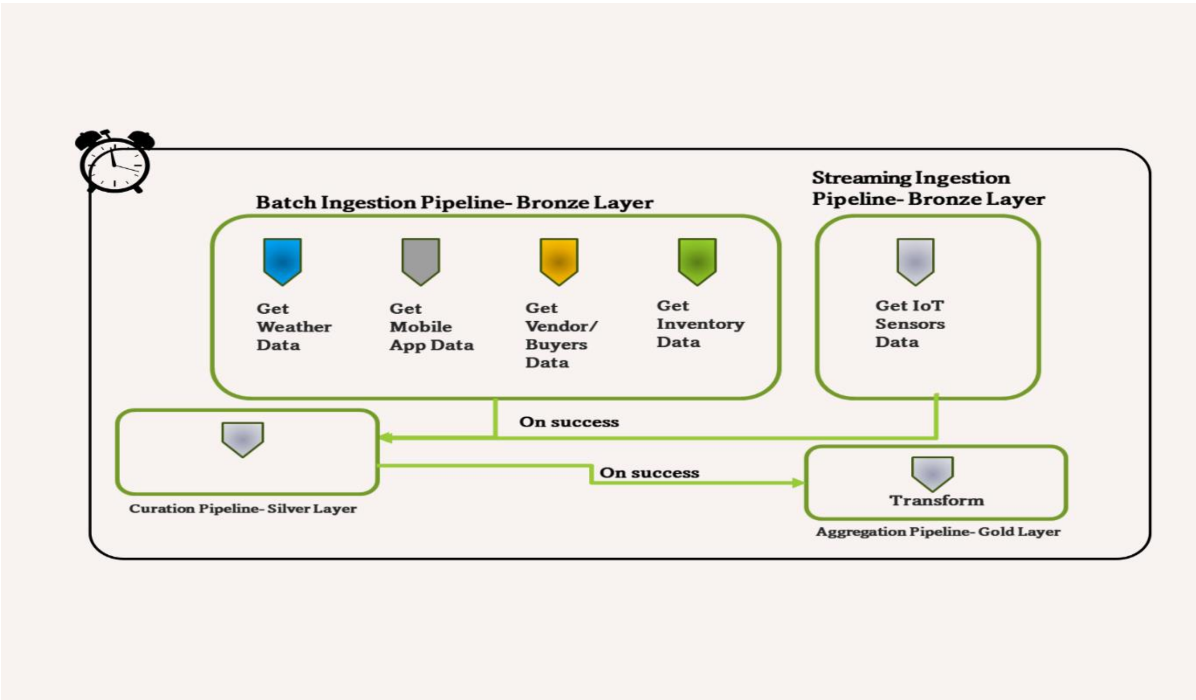


Data Aggregation Process

7.4 Pipeline Approach

We set up our data pipelines using an **event-based approach** to ensure smooth and efficient data processing.

A **master pipeline** was created to oversee the execution of all other pipelines. It triggers each pipeline based on specific events, such as whether the previous pipeline ran successfully or encountered a failure.



To keep the system running regularly, the master pipeline is scheduled to run every 24 hours, starting at **12:05 AM**. This setup ensures that all data processes are automated and completed on time, reducing manual effort and minimizing delays in data processing.

7.5 Pipeline Failure

Pipeline Failure

A pipeline failure occurs when a data pipeline cannot process, transfer, or load data as expected. This can happen due to various reasons, like network issues, incorrect data formats, or system errors.

- **Retry Attempts**: If a failure occurs, the system will automatically retry up to **3 times** to fix the issue.
- **Retry Interval**: Each retry will happen **after a 1-hour gap** to allow time for the system to stabilize or resolve temporary problems.

This process ensures that minor issues don’t stop the pipeline and gives it a chance to recover before requiring manual intervention.

8. Conclusion

8.1 Summary of project outcomes

The AgriTech Farms project demonstrates how technology can simplify and improve farming. By using real-time data from IoT sensors and weather updates, farmers can make smarter decisions about their crops and resources. Predictive tools help them plan ahead for issues like pests or running low on supplies, while dashboards and alerts keep them informed with quick updates.

This project not only helps farmers with their daily tasks but also supports bigger goals like sustainable farming and increased food production. AgriTech Farms shows that smart farming is the way forward, making farming more efficient, productive, and environmentally friendly. With these tools, farmers can grow more with less effort, reduce waste, and protect natural resources for future generations.