Case Study

"Bharat-Krishi Connect": National Precision Agriculture & Unified Data Platform

1. Detailed Business Scenario

The Organization: The **National Agricultural Research & Development Board (NARDB)**.

The Mission: To modernize India's agricultural backbone by launching "Bharat-Krishi Connect." This platform aims to provide **Real-time Crop Advisory** and **Automated Resource Management** (*water/pesticides*) to **100 million farmers across the country**.

The Mission: Build a unified, multi-tenant platform that serves **140 million landholdings**.

The Phased Roadmap:

The platform is designed to scale horizontally as more states and landholdings are onboarded.

- **Phase 1 (Pilot):** **Implementation** across **4 Southern States** (***Tamil Nadu, Kerala, Karnataka, and Telangana***).
    - **Target:** **25 million Farmers** and **30 million Landholdings**.
    - **Focus:** Managing **diverse topography** from **coastal belts** to the **Deccan Plateau**.
- **Phase 2 (Scale):** Expansion to **100 Million Farmers** (*reaching approximately **50% of the national footprint***).
- **Phase 3 (Full Rollout):** Final **unified nation**.

The **platform** must move from **"Manual Monitoring"** to **"Autonomous Farming".**

Business Goals & Key Results (KRs):

- **Yield Increase:** **Improve national crop productivity** by **18%** through AI-driven **sowing recommendations**.
- **Water Conservation:** **Reduce** agricultural **water consumption** by **25%** using **automated** IoT-gated **irrigation**. **Success** requires a **<500ms end-to-end "Sensor-to-Valve"** control loop.
    - ***Core Mechanism**:* **Rain-Preemption Logic.** The **system** must **automatically issue** a **"SKIP_IRRIGATION" command** to all relevant **farm gateways** if the **localized IMD** (*India Meteorological Department*) **rain probability exceeds 70%.**

- **Market Access:** Provide **real-time "Mandi" price** transparency to farmers within **2 seconds** of **price updates**.
- **Disaster Mitigation:** **Reduce crop loss** from **pests/weather** by **sending alerts** to **2.5 million+ concurrent users** within **60 seconds** of an event detection.

The Technical Challenge: Extreme Scale & Resilience

- **Astronomical Scale:** **Managing 150+ million hectares** requires a system that can **ingest 2 million+ messages per second** at **peak** national rollout. The **storage** layer must **handle petabytes** of **time-series data** while remaining searchable for historical yield trends.
- **Rural Connectivity Gaps:** **Despite 5G growth**, the **last mile** in **rural India** remains **unstable**. The **architecture** must **solve** the **Intermittent Connectivity**.
- **Real-Time Performance:** **"Actionable Insights"** *(e.g., detecting a locust swarm or a pump failure*) **lose value** if **delayed**.
- **Data Integrity (The RPO Challenge):** The system must survive regional disasters without losing critical "State" data. An **RPO of < 5 seconds** is **mandatory** to ensure that the **"Last Known State" of 30M+** valves is **consistent** across **primary** and **backup sites**.

2. Operational & Technical Constraints

A. Data Residency (The Legal Constraint)

- **Sovereign Boundary:** All **data** must be **hosted** on **servers** physically located **within India**. No data or metadata can be processed in overseas regions (*e.g., US-East or EU-West*).
- **Placement Flexibility: Data can** be **moved freely** between any Indian data centers (*e.g., Mumbai, Chennai, Delhi, or Hyderabad*) for load balancing or disaster recovery.

B. High Availability & Disaster Recovery

- **99.99% Uptime: Agriculture** is **time-sensitive**. A **system outage** during the **sowing season** could lead to **national food shortages**.
- **15-Minute RTO (Recovery Time Objective): Maximum time allowed** to **switch operations** from the Primary Hub to the DR site during a total outage.
- **< 5-Second RPO (Recovery Point Objective):** The system must guarantee that **no more than 5 seconds of sensor data or command logs are lost** during a failover. This prevents "Ghost Watering" (double-irrigation) caused by data gaps during a site switch.

- **Active-Active/Passive:** The system **must survive** a **total outage** of a **primary region** (*e.g., Mumbai*) by **failing over** to a **secondary region** (*e.g., Hyderabad*) within **15 minutes**.

C. Technical Friction Points

- **Legacy Integration:** The **platform** must **pull data** from **existing state-level weather stations** that use older SOAP APIs.
- **Peak Loads: During monsoon** or **harvest periods**, **traffic spikes 20x compared** to the **off-season**.

3. The Assignment: 12 Detailed Tasks

Students must act as the Lead Solution Architect to complete the following:

Section 1: Strategic Mapping

- **Assignment 1: Business Vision to Technical Vision.**
- **Assignment 2: Functional & Non-Functional Requirements.**

Section 2: Architectural Selection

- **Assignment 3: Select Paradigm.**
- **Assignment 4: Select Model.**
- **Assignment 5: Select Architecture Style.**
- **Assignment 6: Select Architecture Pattern.**

Section 3: Technical Design & Flow

- **Assignment 7: High-Level Design (HLD).**
- **Assignment 8: Low-Level Design (LLD).**
- **Assignment 9: Component & Service Selection.**
- **Assignment 10: Create 3 ADRs (Architectural Decision Records).**

Section 4: Visualizing the Flow

- **Assignment 11: Create System Flow.**
- **Assignment 12: Final Architecture Picture.**