AI & Data Science-Powered SCM System Design

EURON

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Use Case: AI-driven demand forecasting, anomaly detection, real-time inventory optimization, and predictive logistics.

1️⃣ Functional Components & Details

Component	Functionality
AI-Powered Demand Forecasting	Predict future demand based on historical data, trends, seasonality, and market factors.
Inventory Optimization	AI-based recommendations for stock levels, reducing overstock and shortages.
Real-time Anomaly Detection	Detect supply chain disruptions (delays, fraud, failures) using ML models.
Route Optimization	AI-driven logistics routing for minimizing delivery time and cost.
Chatbot & Voice Assistants	AI-powered support agents for warehouse staff and customers.
AI-Powered Supplier Risk Analysis	Machine learning models assess risks associated with vendors/suppliers.
Automated Reordering & Procurement	AI models trigger restocking based on consumption trends.
Computer Vision in Warehouses	AI-based visual recognition for automated warehouse management (defect detection, stock audits).
Sentiment Analysis on Customer Feedback	AI analyzes customer reviews and social media for brand perception and demand insights.

2️⃣ AI & Data Science Technical Architecture

This architecture integrates **data ingestion, AI/ML model training, real-time inferencing, and automated decision-making**.

🛠 Key Technical Components

1. Data Ingestion Layer

- **Sources**:

    - IoT Sensors (RFID, Barcode Scanners, GPS)
    - Enterprise Systems (ERP, CRM, WMS)
    - Third-Party APIs (Weather, Market Trends, Supplier Ratings)
    - User Data (Customer Orders, Feedback, Returns)
- **Technologies**:
    - Apache Kafka / RabbitMQ (Real-time event streaming)
    - AWS Kinesis / Google PubSub (Cloud event processing)
    - Airflow / Luigi (Batch data pipelines)
    - IoT Protocols (MQTT for sensor data)

2. Data Processing & Storage Layer

- **Data Lake** (Raw Data Storage)
    - Amazon S3 / Google Cloud Storage / Azure Data Lake
- **Data Warehouse** (Structured Data)
    - Snowflake / BigQuery / Amazon Redshift
- **Time-Series Data Store** (For real-time tracking)
    - InfluxDB / TimescaleDB
- **NoSQL for Semi-Structured Data** (Logs, Unstructured data)
    - MongoDB / Cassandra

3. AI & Machine Learning Layer

- **Model Development**:
    - Demand Forecasting (LSTMs, Prophet, XGBoost)
    - Route Optimization (Reinforcement Learning, Genetic Algorithms)
    - Fraud Detection (Anomaly Detection via Isolation Forests, Autoencoders)
    - Image Processing (YOLO, OpenCV for warehouse automation)
    - NLP (BERT, GPT-based chatbot)
- **ML Frameworks**:
    - TensorFlow, PyTorch, Scikit-Learn, XGBoost
- **Feature Engineering & Pipelines**:
    - Databricks, Apache Spark ML, Kubeflow

4. Real-Time AI Inference & Decision Making

- **Model Serving**:
    - TensorFlow Serving / TorchServe
    - FastAPI / Flask for REST APIs
    - Triton Inference Server for multi-model serving
- **Event-Driven AI Decisioning**:
    - Apache Flink / Kafka Streams for AI event processing
    - Serverless AI Functions (AWS Lambda, Google Cloud Functions)

5. Monitoring & Governance

- **Model Monitoring**:
  - MLflow, Prometheus, Grafana (Model drift detection)
- **Explainability & Bias Detection**:
  - SHAP, LIME (AI interpretability)
- **Logging & Observability**:
  - ELK Stack (Elasticsearch, Logstash, Kibana)
- **Security & Compliance**:
  - Role-Based Access Control (RBAC)
  - GDPR & AI Ethics Compliance Tools

6. User Interaction Layer

- **Dashboards & Analytics**
  - Streamlit, Power BI, Tableau, Looker
- **Chatbot / AI Assistants**
  - Rasa / Dialogflow / GPT-based conversational AI
- **API Gateway**
  - GraphQL / REST API for external access

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3 Workflow & Data Flow

1. **Data Collection** → Sensors, ERP, Customer Interactions send data to Kafka.
2. **Data Processing** → Raw data stored in **Data Lake**, structured data in **Data Warehouse**.
3. **Feature Engineering & Model Training** → AI models trained in Spark/Kubeflow.
4. **AI Inference & Decisioning** → Real-time models predict demand, detect anomalies.
5. **Action & Automation** → Inventory restocking, shipment rerouting, chatbot assistance.
6. **Continuous Monitoring** → Model accuracy tracked; retraining triggered if drift detected.

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4 Technology Stack

Layer	Technologies
Data Ingestion	Kafka, Airflow, MQTT, APIs
Storage	S3, BigQuery, MongoDB, InfluxDB
Processing & AI	TensorFlow, PyTorch, Spark ML, XGBoost
Serving & Decisioning	FastAPI, TensorFlow Serving, Flink

Layer	Technologies
Monitoring & Logging	MLflow, Prometheus, Grafana, ELK
Deployment & Cloud	Kubernetes, AWS Lambda, Docker

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5 Summary & Benefits

- 🚀 **AI-Powered Optimization** → Reduces costs, improves efficiency.
- 📡 **Real-Time Tracking & Alerts** → Prevents supply chain disruptions.
- 🔍 **Predictive Analytics** → Anticipates demand, avoids stock issues.
- □ **ML-Driven Automation** → Minimizes manual intervention.
- 📈 **Continuous Learning & Adaptation** → Self-improving AI models.