

# Retail Insights Assistant

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## GenAI + Scalable Data Platform

Conversational analytics architecture designed for 100GB+ retail data with guaranteed correctness and zero hallucination



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The Challenge

# Problem & Goal



## Conversational Analytics at Scale

Retail teams need conversational analytics over large, growing sales datasets. The platform must support both **summaries and ad-hoc questions** without predefined schemas or rigid dashboards.



## 100GB+ Data Scalability

The solution must scale beyond 100GB+ of sales data without sacrificing correctness or performance. Traditional BI tools break down at this scale, requiring a **distributed, cloud-native architecture**.



## Zero Hallucination Requirement

LLMs must provide analytics **without hallucination**. Every insight must be grounded in actual data with full traceability and audit capability for regulatory compliance.



## Core Insight

"The problem is not just answering questions, but **answering them correctly at scale.**"

## Success Criteria

- ✓ Sub-second query responses
- ✓ 100% data accuracy guarantee
- ✓ Self-service analytics capability
- ✓ Enterprise-grade security & governance

**100GB+**

Data Scale

**Zero**

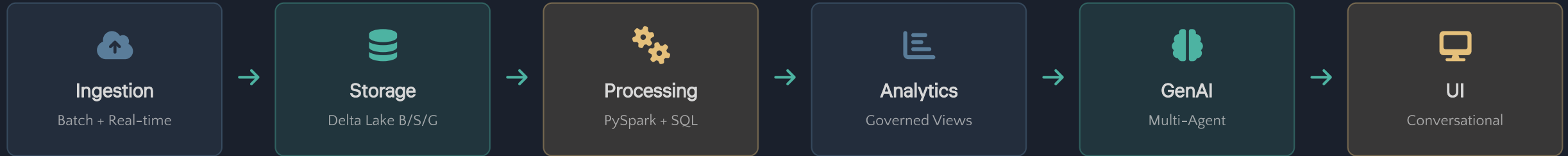
Hallucination

**24/7**

Availability

# High-Level Architecture Overview

End-to-End Architecture (100GB+ Ready)



## Ingestion Layer

- Batch Processing**  
Azure Data Factory + Databricks Jobs
- Real-time Streaming**  
Azure Event Hub for live orders
- Retail Data Sources**  
POS, inventory, customer, e-commerce

## Processing & Analytics

### Processing Engine

PySpark + SQL on Databricks for distributed computing. Handles complex transformations, joins, and aggregations across terabytes of retail data.

### Analytics Layer

Databricks SQL / Azure Synapse with pre-aggregated tables for fast query performance. Materialized views for common patterns.

### Governance Model

Row-level security, column-level masking, data lineage tracking, and automated quality checks ensure trusted data.

## GenAI Layer

- Multi-Agent System**  
Specialized agents for intent, planning, validation, and narration
- No Raw Data Access**  
LLMs only access governed analytics views
- Validation First**  
Results verified before narrative generation

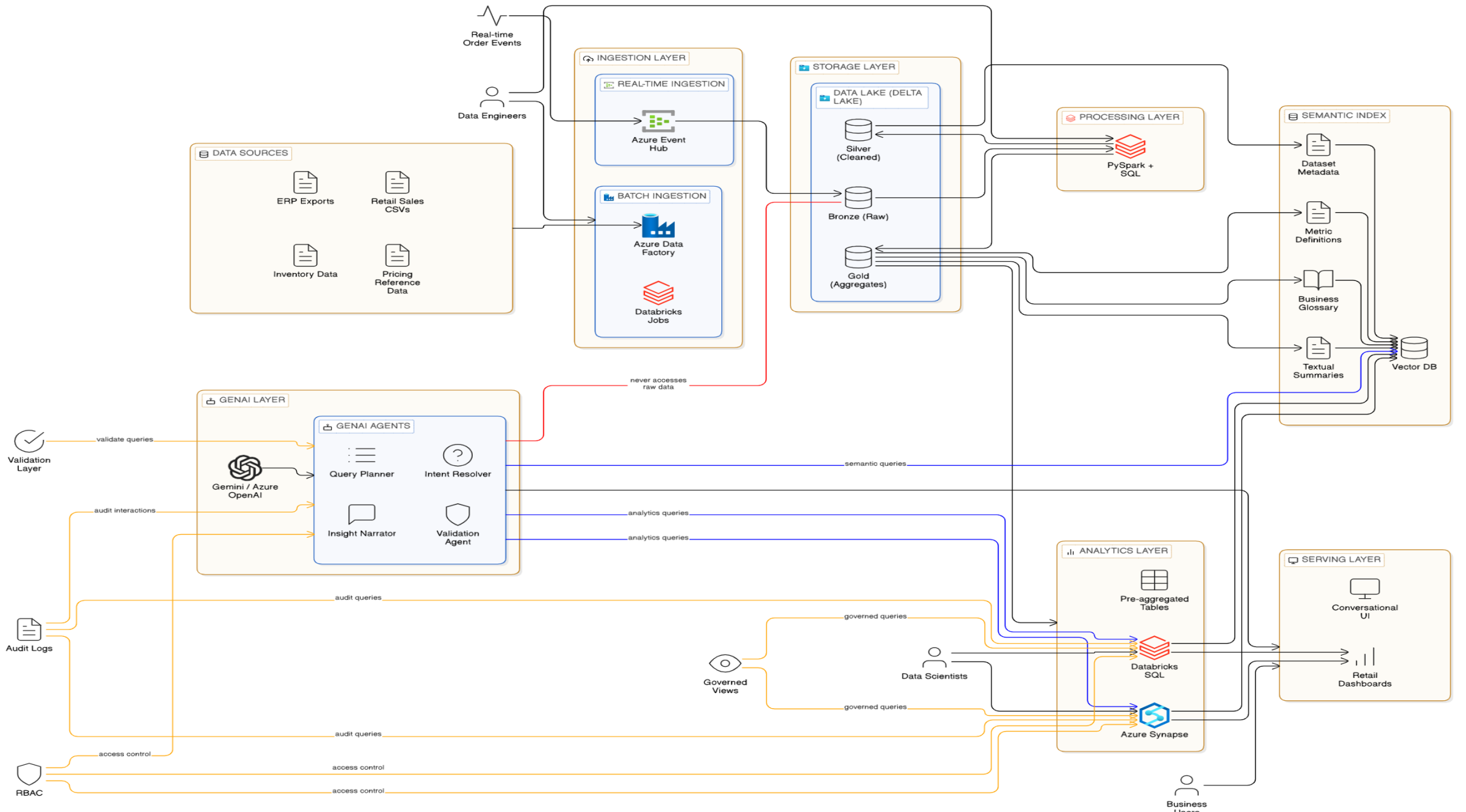
## Storage Pattern

**Bronze** Raw  
Unprocessed source data

**Silver** Cleaned  
Filtered, enriched datasets

## UI Layer

- Conversational Interface**  
Natural language queries and follow-ups
- Rich Visualizations**  
Auto-generated charts and dashboards
- Multi-Channel**  
Web, mobile, Teams integration



# Scalable Data Engineering Design



## Batch Ingestion

### Azure Data Factory

Orchestrates data movement from source systems

### Databricks Jobs

Scheduled ETL pipelines with Spark



## Storage

### Azure Data Lake

Cheap, durable cloud storage

### Delta Lake

ACID, time travel, indexing



## Processing Engine

### PySpark

Distributed data processing

### SQL

Declarative transformations

### Databricks

Unified analytics platform



## Analytics Layer

### Databricks SQL

Serverless SQL warehouse

### Azure Synapse

Enterprise analytics



## Streaming Ingestion

### Azure Event Hub

Ingests real-time order events

**Low Latency:** Sub-second ingestion for thousands of orders/sec. Auto-scales during peak retail hours (Black Friday, holiday seasons). Event Hub processes 1M+ events/sec with 99.9% availability SLA.

## ✓ Design Achievements

- ✓ **Retail Velocity:** Handles batch loads and real-time streams
- ✓ **Performance:** Pre-aggregations + indexing for speed
- ✓ **Cost Efficiency:** Auto-scaling + storage-compute separation

10TB+

Daily Ingestion

<1s

Query Response

99.9%

Availability SLA

50%

Cost Reduction

## 04 AI Architecture GenAI with Guardrails (No Hallucinations)

### Multi-Agent GenAI

#### 1 Intent Resolver

Analyzes user questions to determine required data, metrics, and time period

#### 2 Query Planner

Generates optimized SQL queries using metadata from Vector DB

#### 3 Validation Agent

Executes queries and validates results against business rules

#### 4 Insight Narrator

Generates natural language insights with data attribution

### Agent Flow

Sequential processing with validation at each step. Agents communicate through a shared context, maintaining conversation history and data lineage throughout.

### Vector DB (Semantic Index)

#### Dataset Metadata

Schemas, relationships, data quality metrics

#### Metric Definitions

Revenue, profit, inventory formulas

#### Business Glossary

Common terms, synonyms, descriptions

#### Textual Summaries

Natural language dataset descriptions

### Governance & Security

#### RBAC

Role-based access control

#### Governed SQL Views

Pre-defined, secured data access paths

#### Pre-Validation

Results verified before response generation

### No-Hallucination Architecture

User Query



Intent Resolver



Query Planner + Vector DB



Validation Agent



Insight Narrator

### Key Benefits

- 100% accuracy via validation
- Full traceability & attribution
- Enterprise security compliance



### Governance-First Principle

**Governance enforced before generation, not after hallucination** — The Validation Agent blocks incorrect or unauthorized queries before LLM narrative generation

# Query Flow, Scale & Observability

## Query Flow Pipeline



**Metadata-Driven:** Vector DB retrieves relevant datasets, metrics, and business terms to build context-aware queries

## Scaling Mechanisms

- Partitioned Data**  
Date/region partitioning
- Pre-Aggregations**  
Materialized views
- Caching Layer**  
Redis/Databricks cache

## Performance Targets

&lt;2s

Simple Queries

&lt;10s

Complex Queries

## Observability & Monitoring

### Query Latency

P95/P99 response times

### LLM Usage

Token consumption, costs

### Validation Failures

Accuracy, security alerts

### Audit Logs

Query history, access trails

## Production Readiness

- ✓ **Scalability:** Distributed systems for production workloads
- ✓ **Reliability:** Multi-region deployment with auto-failover
- ✓ **Security:** End-to-end encryption, VPC isolation

## Architecture Validation

"Prototype demonstrates architecture; production follows the same design with distributed systems."