Q1) You are hired as a data engineer for ShopSmart, a national retail chain that operates 100+ stores and an online e-commerce platform. ShopSmart wants to build a central analytics warehouse to analyze sales performance, customer behavior, and inventory trends across multiple channels.

Analytical Skill

- Ability to design enterprise-level data warehouse schemas (Star & Snowflake).
- Identification and modelling of Fact and Dimension tables aligned with business KPIs.
- Implementation of Slowly Changing Dimensions (SCD) to maintain accurate historical data.
- Performing advanced sales, inventory, and customer behaviour analytics.
- Building efficient ETL pipelines and optimizing warehouse performance for BI reporting.
- Ability to write complex SQL analytical queries for trend analysis, customer segmentation, product performance, etc.

Identify Fact and Dimension Tables

Fact Tables

Fact Table	Measures / Metrics
Sales_Fact	sales_amount, quantity_sold, discount_applied, profit
Inventory_Fact	stock_on_hand, reorder_level, units_sold
Promotion_Fact	promotion_discount, promotion_revenue, product_count

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Dimension Tables

Dimension	Attributes Table
Customer_Dim	customer_id, first_name, last_name, gender, birth_date, loyalty_level, city, state, region
Product_Dim	product_id, product_name, category, subcategory, brand, supplier_id, price
Store_Dim	store_id, store_name, city, state, region, store_manager
Time_Dim	date_key, date, day, week, month, quarter, year, holiday_flag
Promotion_Dim	promotion_id, promotion_name, start_date, end_date, discount_percent

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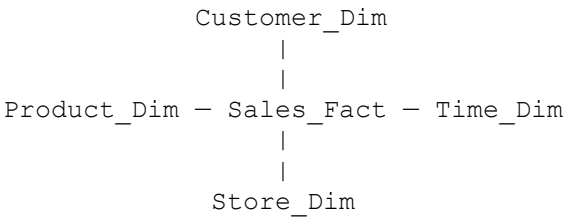
Star Schema Design

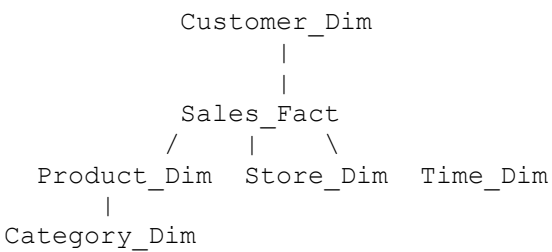
Star Schema: Fact tables in the center, directly connected to dimension tables.



- **Fact table:** `Sales_Fact`
- **Dimensions:** `Customer_Dim`, `Product_Dim`, `Store_Dim`, `Time_Dim` • Advantages:
  - Simple structure for **fast querying** ○ Denormalized dimensions reduce joins ○ Easy to write **analytical queries**

Snowflake Schema Design

Snowflake Schema: Dimension tables normalized into sub-dimensions.



- `Product_Dim` normalized to `Category_Dim` • `Store_Dim` could normalize city/state/region • Advantages:
  - ○ Reduces **data redundancy** ○ Smaller storage footprint
- Disadvantages:
  - More joins → **slower query performance**

Slowly Changing Dimensions (SCD)

- **Customer_Dim:** Address or loyalty level may change → Type 2 SCD
- **Product_Dim:** Product category updates → Type 2 SCD • This ensures **historical analytics** are accurate.

Example Queries

Total Sales per Region per Month

```
SELECT
    t.year,
    t.month,
    s.region,
    SUM(f.sales_amount) AS total_sales FROM
Sales_Fact f
JOIN Time_Dim t ON f.time_key = t.date_key
JOIN Store_Dim s ON f.store_key = s.store_id
GROUP BY t.year, t.month, s.region
ORDER BY t.year, t.month, s.region;
```

Top 5 Products by Revenue

```
SELECT
    p.product_name,
    SUM(f.sales_amount) AS revenue
FROM Sales_Fact f
JOIN Product_Dim p ON f.product_key = p.product_id
GROUP BY p.product_name
ORDER BY revenue DESC
LIMIT 5;
```

Customer Retention Analysis

```
SELECT
    c.loyalty_level,
    COUNT(DISTINCT f.customer_key) AS active_customers
FROM Sales_Fact f
JOIN Customer_Dim c ON f.customer_key = c.customer_id
WHERE f.time_key BETWEEN '2025-01-01' AND '2025-12-31'
GROUP BY c.loyalty_level;
```

Justification of Schema Choice

Schema	Use Case	Pros	Cons
Star	Fast reporting, dashboards	Simple queries, good for BI	Slight data redundancy
Snowflake	Normalized data warehouse	Saves storage, reduces redundancy	Complex queries, slower joins

---

Business Impact

- Enables **360° sales visibility** across online & offline channels for smarter decision-making
- Improves **inventory forecasting** → reduces stockouts and excess storage cost
- Enhances **customer personalization** and loyalty program effectiveness

- Boosts **promotion success tracking** → higher ROI on marketing campaigns
- Provides **real-time KPI monitoring** for executives through dashboards
- Supports **faster reporting** → saves time for business users and accelerates strategic planning

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Q2 You are a data engineer for QuickEats, an online food delivery platform operating in multiple cities. QuickEats collects and processes data from multiple sources. Currently, the system struggles with scalability, real-time processing, and analytics performance. Suggest a suitable model.

Analytical Skill

- Capable of designing scalable data warehouse and lakehouse architectures
- Expertise in identifying Fact & Dimension structures optimized for food delivery analytics
- Efficient handling of real-time streaming and batch data pipelines
- Strong analytical querying for performance measurement: delivery time, customer loyalty, restaurant performance
- Proficient in choosing appropriate schema models (Star vs. Snowflake vs. Lakehouse) based on business needs
- Implementation of Slowly Changing Dimensions (Type 1 & Type 2) for accurate customer and partner history
- Ability to optimize BI dashboards for high-speed insights using modern warehouse systems

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Identify Fact and Dimension Tables

Fact Tables

Fact Table	Measures / Metrics
Orders_Fact:	order_amount, delivery_fee, discount_amount, total_payment delivery_time, order_status
Delivery_Fact:	delivery_time, distance_traveled, pickup_time, drop_time, delivery_rating
Payment_Fact:	payment_amount, tax_amount, commission, payment_status
App_Events_Fact:	click_count, session_duration, device_type, action_type

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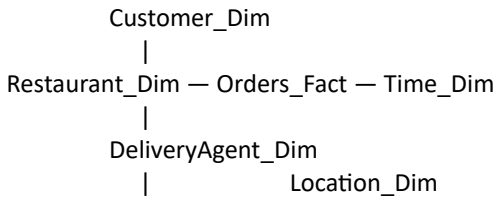
Dimension Tables

Dimension Table	Attributes
Customer_Dim:	customer_id, name, phone, email, signup_date, city, loyalty_level
Restaurant_Dim:	restaurant_id, restaurant_name, cuisine_type, city, rating, partner_since
DeliveryAgent_Dim:	agent_id, agent_name, vehicle_type, city, experience_level
Time_Dim:	time_id, date, day, week, month, quarter, year
Location_Dim:	location_id, city, state, region
PaymentMethod_Dim:	payment_method_id, method_name, provider

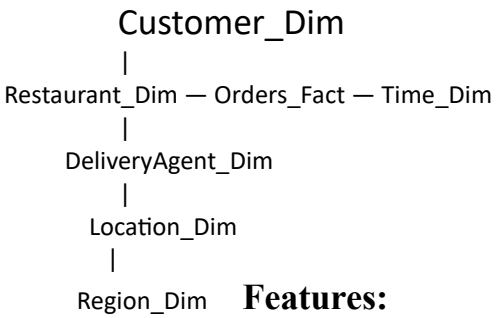
Star Schema Design (Recommended for BI Dashboards)



Advantages:

- Fast performance for reporting.
- Simple joins.
- Best for dashboards (Power BI, Tableau, Looker).

Snowflake Schema Design (Normalized)



Features:

- Normalized dimensions like **Location → Region → Country**.
- Reduces duplicate data.

Slowly Changing Dimensions (SCD)

Dimension	Attribute Change Example	SCD Type
Customer_Dim	Loyalty level upgrade from Silver →	Type 2

	Gold	
Restaurant_Dim	Updated rating or menu expansion	Type 2
DeliveryAgent_Dim	Vehicle type change	Type 2
Location_Dim	City name correction	Type 1

Example Queries

Total Revenue by City

```
SELECT l.city, SUM(o.total_payment) AS revenue
FROM Orders_Fact o
JOIN Location_Dim l ON o.location_key = l.location_id
GROUP BY l.city
ORDER BY revenue DESC;
```

Top 5 Restaurants by Orders

```
SELECT r.restaurant_name, COUNT(o.order_id) AS total_orders
FROM Orders_Fact o
JOIN Restaurant_Dim r ON o.restaurant_key = r.restaurant_id
GROUP BY r.restaurant_name
ORDER BY total_orders DESC
LIMIT 5;
```

Average Delivery Time by Agent

```
SELECT d.agent_name, AVG(f.delivery_time) AS avg_delivery_time
FROM Delivery_Fact f
JOIN DeliveryAgent_Dim d ON f.agent_key = d.agent_id
GROUP BY d.agent_name
ORDER BY avg_delivery_time;
```

Suggested Modern Architecture for QuickEats

Layer	Technology
Data Ingestion	Kafka / AWS Kinesis (Real-time), Airbyte/Fivetran (Batch)
Data Storage	Data Lake (S3/Google Cloud), Warehouse (Snowflake/BigQuery)
Processing	Apache Spark, Flink (Real-time stream processing)
ETL/ELT	dbt + Airflow
BI Dashboard	Power BI, Tableau, Looker
Orchestration	Apache Airflow

Justification of Data Model Choice

Schema	Use Case	Advantages	Disadvantages
Star	Sales dashboards, business reporting	Fast queries, easy to maintain	Some redundancy
Snowflake	Large dimensional data	Saves space, normalized	More joins
Data Lakehouse (Recommended)	Real-time + Analytics	Supports batch + streaming, scalable	Slightly complex setup

Business Impact

- Enables real-time order tracking and faster issue resolution, higher customer satisfaction
- Improves delivery efficiency through analytics on agent performance and route optimization
- Reduces operational costs by highlighting delivery delays, high-fee areas, and partner performance gaps
- Provides executives with fast, actionable dashboards for better business decisions
- Builds a scalable data foundation to support rapid market expansion across cities

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Q3) You are a data engineer for StreamFlix, a global video streaming platform (like Netflix). StreamFlix collects millions of events per day. The company wants to build a high-performance analytics warehouse to support:

- Real-time viewer engagement analytics
- Top trending videos per region
- AI models for recommendation engines

Analytical Skill

- Skilled in designing **high-performance data warehouse and lakehouse models** for large-scale streaming platforms
- Expertise in **Fact & Dimension modeling** for user engagement, device analytics, and subscription revenue
- Strong capability to support **real-time analytics and AI recommendations**
- Advanced SQL/data processing skills for **trend analysis**, device usage analytics, and customer segmentation
- Ability to integrate **streaming data pipelines** using Kafka, Spark/Flink for scalable ingestion

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Identify Fact and Dimension Tables

Fact Tables

Fact Table	Measures / Metrics
	watch_duration, progress_percent, buffering_time, Viewership_Fact: resolution_played, watch_status
StreamingSession_Fact:	session_duration, device_time_spent, data_consumed_mb
Subscription_Fact:	subscription_amount, discount, renewal_status
Search_Fact:	total_searches, click_throughs, search_time
Recommendation_Fact:	recommendation_clicks, recommendation_impressions

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Dimension Tables

Dimension Table	Attributes
User_Dim:	user_id, name, gender, age_group, country, subscription_type, join_date
Video_Dim:	video_id, title, genre, sub_genre, language, release_year, maturity_rating
Device_Dim:	device_id, device_type, os, app_version
Time_Dim:	time_id, date, hour, day, week, month, quarter, year
Location_Dim:	location_id, country, region, city
SubscriptionPlan_Dim:	plan_id, plan_name, price, resolution_limit, screens_allowed

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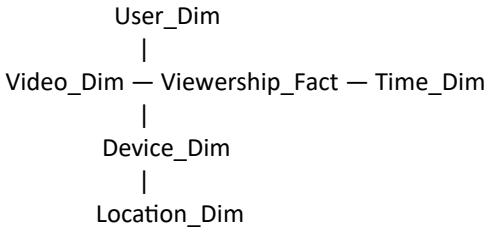
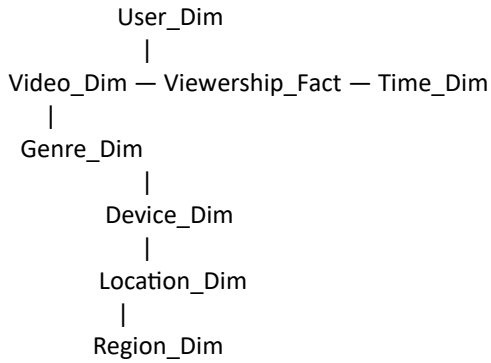
Star Schema Design (For Fast BI Reporting)



Advantages

- Optimized for query performance
- Simple structure for dashboards
- Ideal for daily analytics

Snowflake Schema Design (Normalized Model)



Advantages: Reduces redundancy
More joins → Slight slower performance

Handling Slowly Changing Dimensions (SCD)

Dimension	Change Example	SCD Type
User_Dim	Subscription changes from Basic → Premium	Type 2
Video_Dim	Video updated from SD → HD version	Type 2
Device_Dim	App version updates	Type 1
SubscriptionPlan_Dim	Plan pricing updates	Type 2

Example Analytical Queries

Top Trending Videos Per Region

```
SELECT l.region, v.title, COUNT(f.video_id) AS total_views
FROM Viewership_Fact f
JOIN Video_Dim v ON f.video_key = v.video_id
JOIN Location_Dim l ON f.location_key = l.location_id
GROUP BY l.region, v.title
ORDER BY total_views DESC
LIMIT 10;
```

Average Watch Time by Subscription Type

```
SELECT u.subscription_type, AVG(f.watch_duration) AS avg_watch_time
FROM Viewership_Fact f
JOIN User_Dim u ON f.user_key = u.user_id
GROUP BY u.subscription_type;
```

Device Usage Analysis

```
SELECT d.device_type, COUNT(f.session_id) AS sessions
FROM StreamingSession_Fact f
JOIN Device_Dim d ON f.device_key = d.device_id
GROUP BY d.device_type;
```

Justification of Schema Choice

Model	Use Case	Pros	Cons
Star Schema	Viewer reports, dashboards	Fast query, simple	Some redundancy
Snowflake	Large metadata handling	Efficient storage	Complex joins
Lakehouse	Real-time + ML use cases	Supports streaming + batch + AI	Setup complexity

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Business Impact

- Enables real-time trending content insights, boosts user engagement & viewership
- Supports personalized recommendations, reducing churn and increasing watch hours
- Increases subscription revenue through better pricing, plan optimization & retention analytics
- Improves streaming quality by analysing buffering, device performance & resolution patterns
- Helps content teams invest in high-performing genres and regions, smarter licensing decisions
- Provides leaders with instant global performance dashboards, faster strategic actions