Dimensional Modeling

Dimensional Modelling

Definition and Purpose

- Dimensional modeling is used in data warehouse design to improve query response times compared to traditional relational systems.
- Focuses on conceptual design with fewer tables and simpler relationships for efficient querying.

Concept and Components

- **Concept**: Designed for reading, summarizing, and computing numeric data in data warehouses.
- **Components**: Uses "fact" tables (numerical transaction data) and "dimension" tables (contextual reference data) to populate data cubes for OLAP management.

Steps in Dimensional Modeling

1. **Identify Business Process**
   - Select the business process for data warehouse implementation.
   - Define business objectives to avoid repeated processes and software defects.
2. **Identify Granularity**
   - Determine the level of detail needed (e.g., monthly, yearly).
   - Influences the size and scope of the data warehouse.
3. **Identify Dimensions and Attributes**
   - Define entities (e.g., products, time) and their attributes.
   - Specify primary keys and foreign keys for relational integrity.
4. **Build Schema**
   - Create database structure (e.g., star schema, snowflake schema, fact constellation).
   - Schema design should support business requirements and optimize query performance.

Strengths of Dimensional Modeling

- **Simplicity**: Easy to understand for stakeholders from designers to business clients.
- **Reduced Relationships**: Fewer table relationships simplify data access and querying.
- **Data Quality**: Enforces referential integrity through foreign key constraints.
- **Query Performance**: Optimizes performance with aggregate functions and efficient schema design.

Facts and Dimensions

- **Fact Tables**: Contain numeric measures (facts) and foreign keys to dimension tables.
- **Dimensions Tables**: Describe contextual background for facts, supporting OLAP operations.
- **Example**: Student registration case study could have facts like student_id, course_id, date_of_registration in a fact table linked to dimension tables like Student_details, Course_details, etc.

Star Schema in Dimensional Modeling

Definition and Purpose

- **Star Schema**: A multidimensional model where data is organized into facts (central table) and dimensions (smaller related tables).

- **Purpose**: Provides a simple and efficient structure for querying large data sets in data warehouses.

Features of Star Schema

- **Denormalized Database**: Data is stored in a denormalized format to optimize query performance.
- **Quick Query Response**: Faster query performance due to fewer join operations.
- **Flexibility**: Easy to change or add dimensions as needed.
- **Simplicity**: Reduces complexity for developers and end users alike.

Advantages of Star Schema

- **Query Performance**: Fast query response times, especially for single-table queries and simpler join paths.
- **Load Performance**: Efficient data loading due to separate fact and dimension tables.
- **Built-in Referential Integrity**: Ensures data integrity through foreign key relationships.
- **Ease of Understanding**: Intuitive structure makes it easy for users to navigate and analyze data.

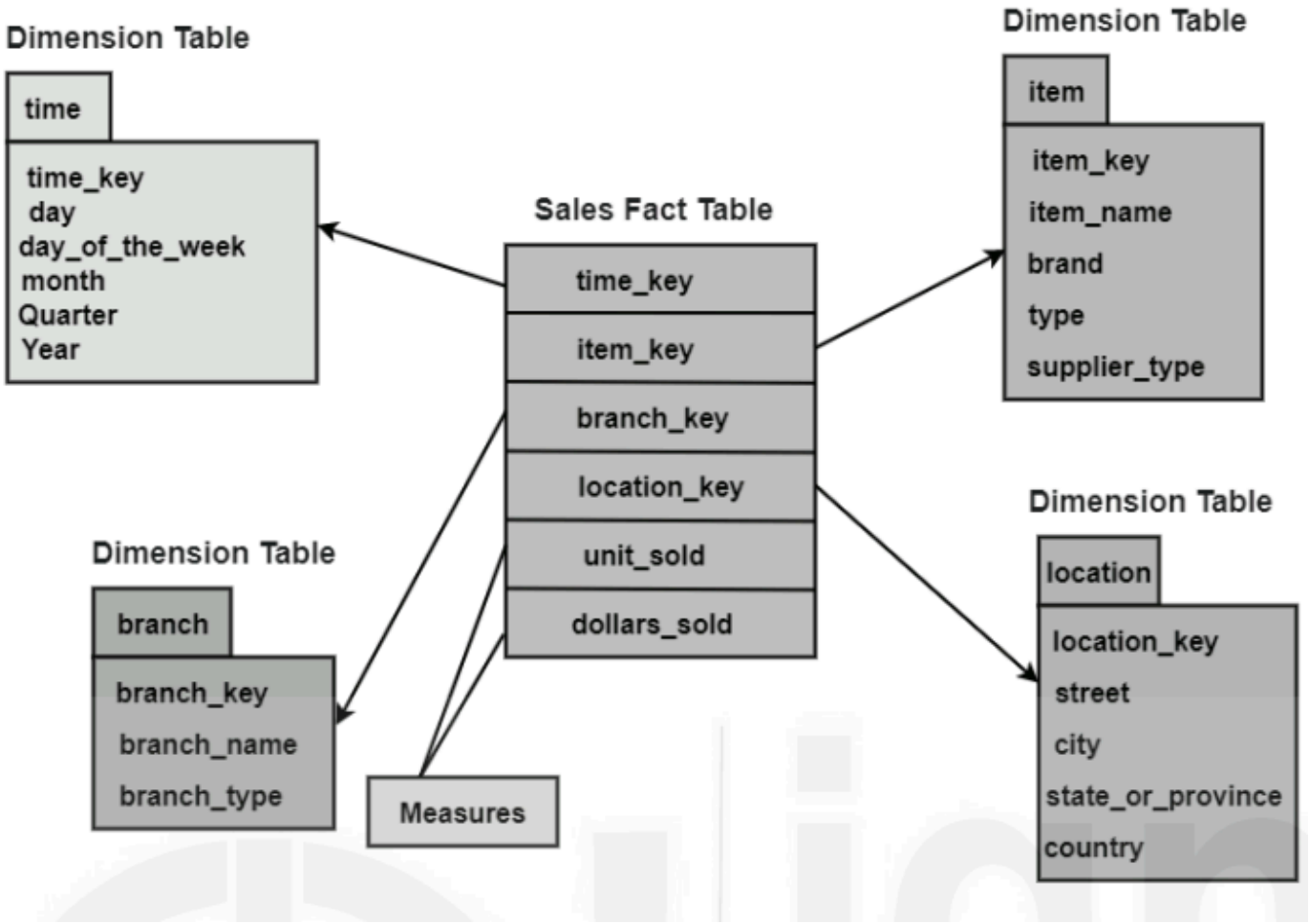
Disadvantages of Star Schema

- **Data Integrity Challenges**: Denormalized structure can lead to data anomalies with insert or update operations.
- **Limited Complex Queries**: Less suitable for handling diverse and complex analytical queries compared to normalized schemas.
- **Many-to-Many Relationships**: Inefficient for modeling many-to-many relationships without additional complexity.

Examples of Star Schema

- **Example 1**: A sales fact table linked to dimension tables for Time, Branch, Item, and Location.
- **Example 2**: Illustration of a grocery store purchase where sales data (fact) is connected to dimensions like Store, Customer, Sales Type, Product, and Time.

Visual Representation



Snowflake Schema in Dimensional Modeling

Definition and Purpose

- **Snowflake Schema**: An extension of the star schema that normalizes dimension tables to reduce redundancy and improve data integrity.
- **Purpose**: Provides a more structured approach to handling complex data relationships in multidimensional databases.

Features of Snowflake Schema

- **Normalized Tables**: Dimension tables are normalized into multiple smaller tables, reducing redundancy and improving data integrity.
- **Disk Space Efficiency**: Occupies less disk space compared to star schema due to normalized tables.
- **Complexity**: Requires more lookup time due to increased number of tables and joins.

Advantages of Snowflake Schema

- **Space Efficiency**: Occupies less disk space compared to star schema, which can be advantageous for large data warehouses.
- **Data Integrity**: Better data quality and fewer data anomalies due to normalized tables.

- **Structured Data**: Provides a more structured and organized approach to data storage and maintenance.

Disadvantages of Snowflake Schema

- **Complex Queries**: Queries involving multiple joins across normalized tables can be slower compared to star schema.
- **Performance**: Slower performance for complex queries and cube data processing compared to star schema.
- **Data Integrity Concerns**: While better than star schema, still requires careful handling to ensure data integrity after updates or inserts.

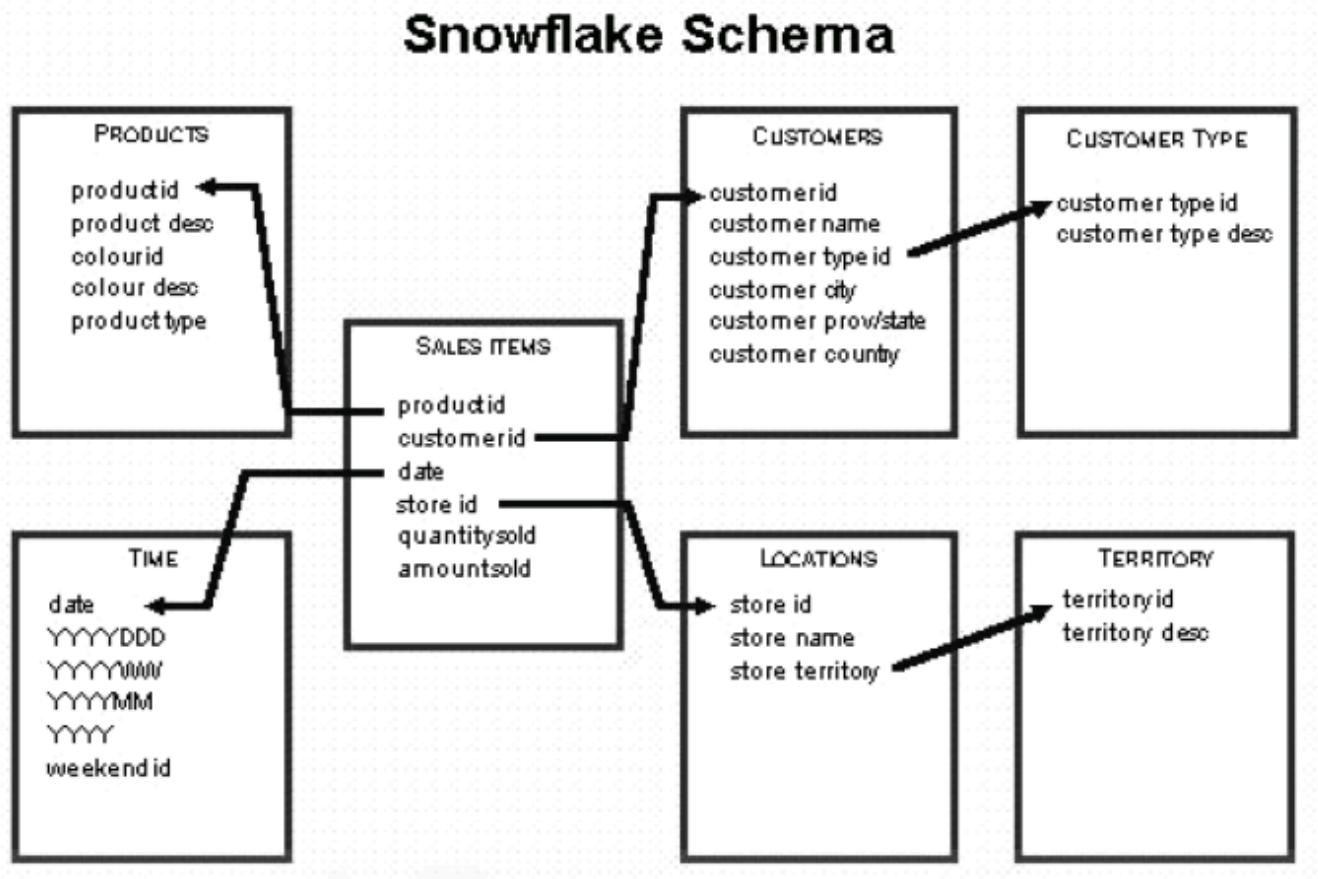
Star Schema vs Snowflake Schema

Features	Star Schema	Snowflake Schema
Normalized Dimension Tables	Dimension tables are denormalized.	Dimension tables are normalized into multiple tables.
Query Performance	Faster query execution due to fewer joins.	Slower query execution due to more joins and normalization.
Storage Space	Requires more storage space due to denormalization.	Requires less storage space due to normalization.
Usage	Suitable for simpler relationships (1:1 or 1:many).	Suitable for complex relationships (many:many).
Dimension Tables	Each dimension typically has one table.	Each dimension may have multiple tables.

Example of Snowflake Schema

- **Example**: A schema for customers, sales, products, and locations, with dimensions like customer type and sales territory further normalized.

Visual Representation



Fact Constellation Schema

Definition and Purpose

- **Fact Constellation Schema**: A collection of multiple star schemas that share common dimensions, forming a complex data structure resembling a galaxy of interconnected stars.

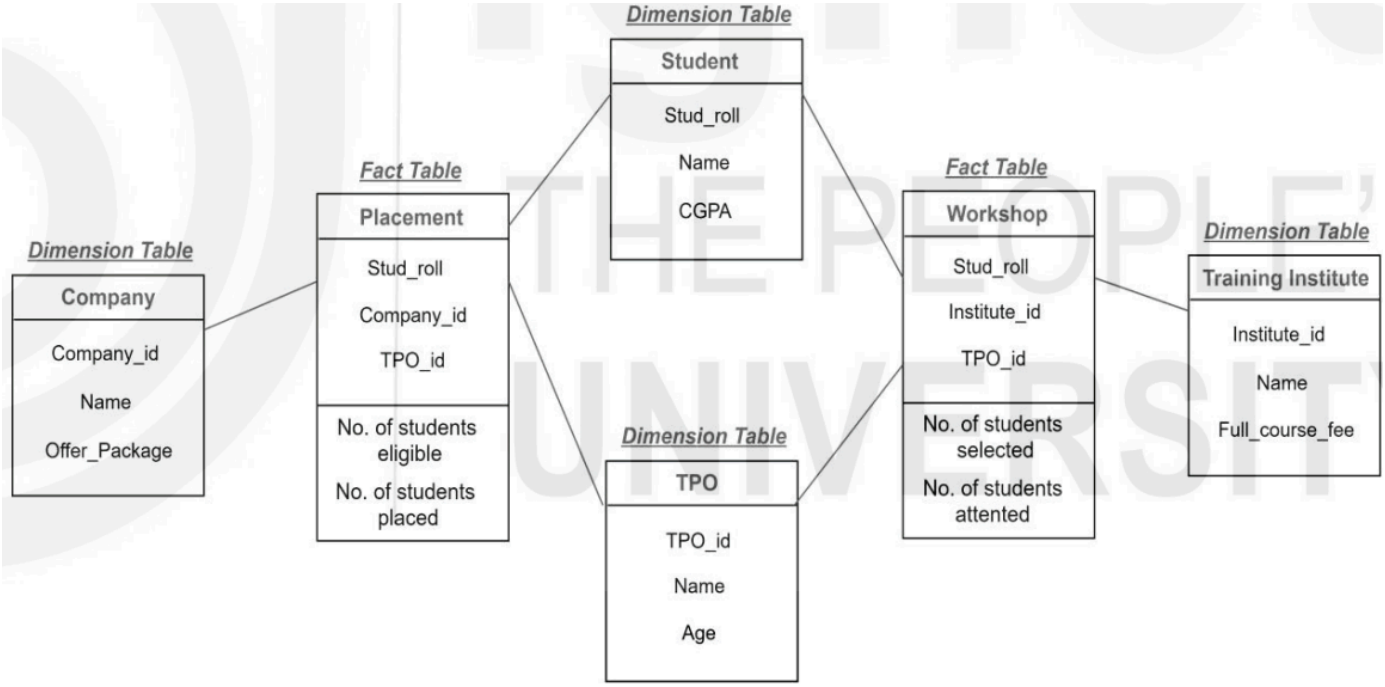
Features

- **Multiple Fact Tables**: Includes two or more fact tables connected through shared dimensions.
- **Complexity**: More flexible than single star schemas but adds complexity to implementation and maintenance.

Advantages and Disadvantages

- **Advantage**: Offers a wider perspective and flexibility in data analysis by connecting multiple facts.
- **Disadvantage**: Complex to implement and maintain due to interconnecting multiple star schemas.

Visual Representation



Aggregate Tables in Dimensional Modeling

Definition and Purpose

- **Aggregate Tables**: Also known as summary tables, these tables store pre-computed and partially summarized data from base fact tables to enhance query performance in data warehouses.

Key Points about Aggregate Tables

- **Summary Tables**: They contain pre-computed aggregations of data warehouse schema.
- **Dimensionality Reduction**: Reduces the complexity and dimensionality of base fact tables.
- **Query Performance**: Improves query response time by providing aggregated data that can be quickly accessed.

Need for Building Aggregate Fact Tables

- **Purpose**: To speed up query response times by storing intermediate results of complex queries.
- **Space Efficiency**: Occupies less space compared to atomic fact tables.
- **Granularity Adjustment**: Helps adjust the granularity of data for different levels of reporting needs.
- **OLAP Operations**: Aggregate tables are generated through roll-up OLAP operations on base fact tables.

Aggregate Fact Table and Derived Dimension Tables

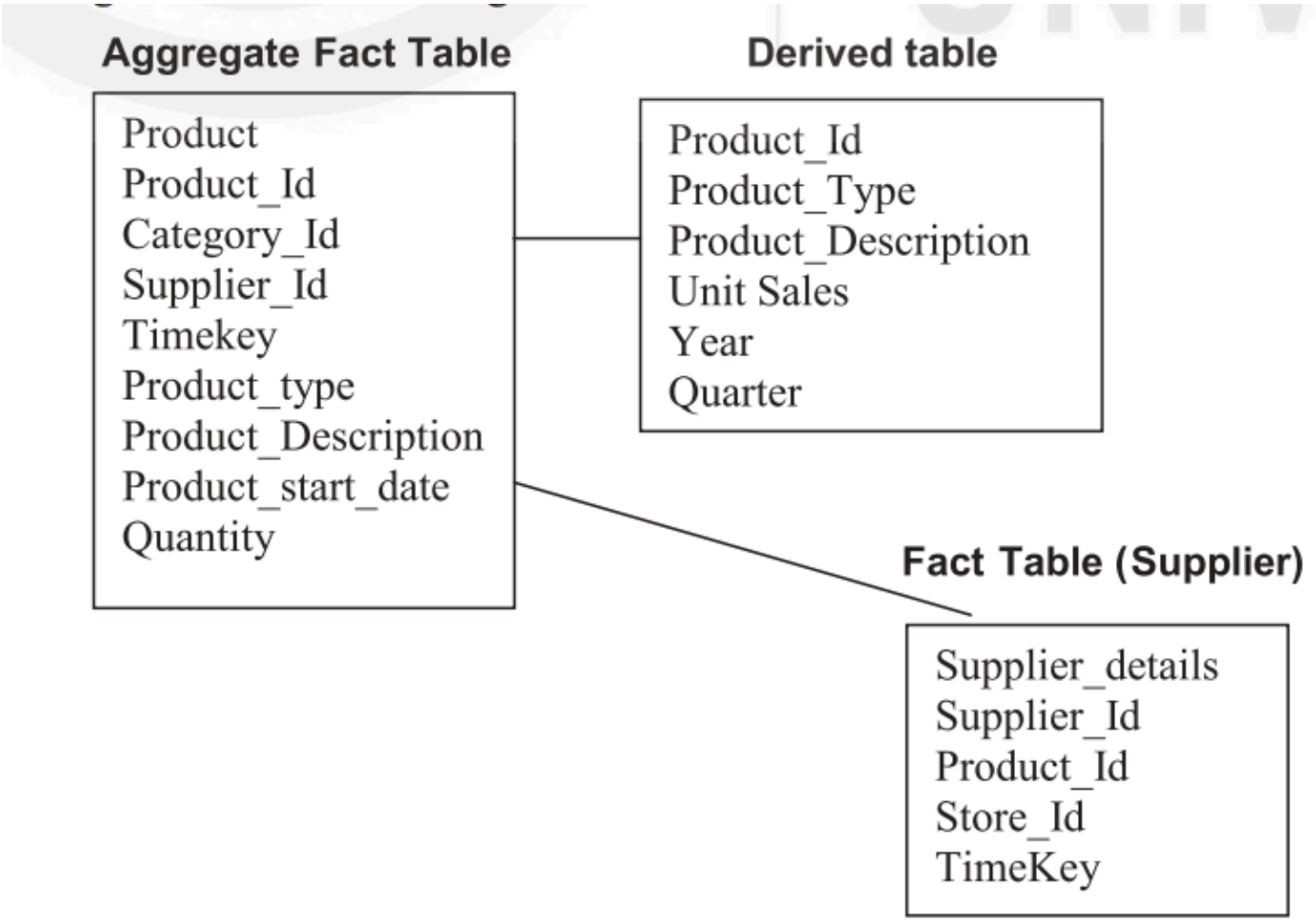
- **Aggregate Fact Tables**: Contain summarized measures using SQL aggregate functions like SUM, AVG, etc., for faster query handling.
- **Derived Tables**: Additional tables that extend the base fact table with new measures or foreign keys not present in the base fact table.

- **Conformed Dimension**: Dimensions shared across multiple data marts or subject areas without alteration.
- **Consolidated Fact Tables**: Combine data from different fact tables with a common grain to form a unified schema.

Advantages and Usage

- **Performance**: Significantly improves query performance by reducing the number of rows accessed.
- **Flexibility**: Allows for handling complex queries and diverse reporting needs efficiently.
- **Business Intelligence**: Essential for supporting business intelligence applications and tools.

Visual Representation



Check your progress-1

1. Discuss the characteristics of star schema?
2. Draw a Star Schema for a marketing employee staying in a NewYork city of the country USA. He buys products and wants to compute the total product sold and how much sales done?

Check your progress-2

1. Compare and contrast Star schema with Snowflake Schema?

2. Suppose that a data warehouse consists of dimensions time, doctor, ward and patient, and the two measures count and charge, where charge is the fee that a doctor charges a patient for a visit. Enumerate three classes of schemes that are popularly used for modeling.
    i. Draw a Star Schema diagram
    ii. Draw a Snowflake Schema diagram.

Check your progress-3

1. Discuss the limitations of Aggregate Fact tables.