Database Analysis and Design

Lesson 3: Introduction to Data Model

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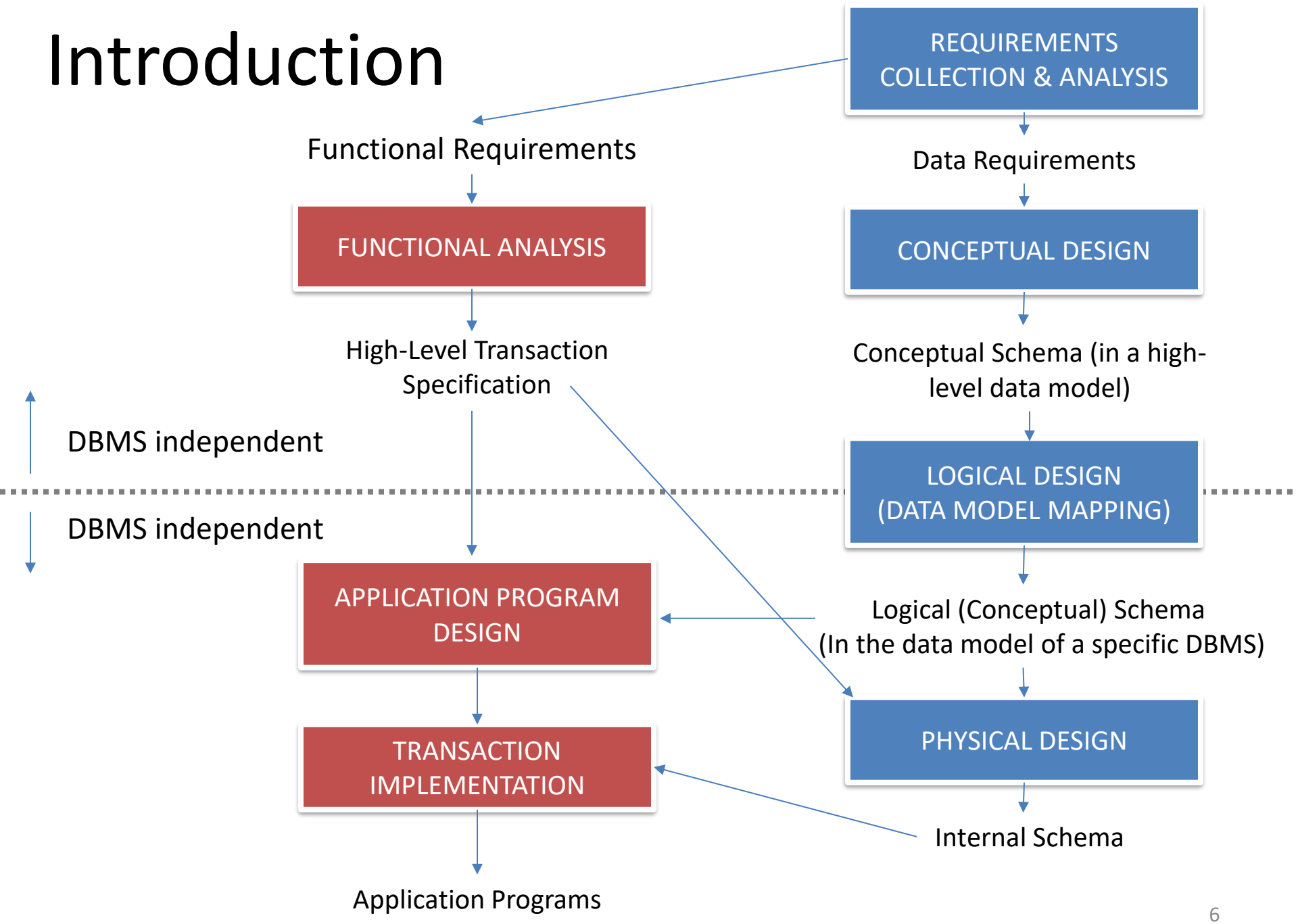
Keywords

Keyword	Description
Model	A description of observed or predicted behavior of some system, simplified by ignoring certain details. Models allow complex systems, both existent and merely specified, to be understood and their behavior predicted. A model may give incorrect descriptions and predictions for situations outside the realm of its intended use.
Database	A collection of persistent data that is used by information system or applications in a company (C. J. Date). A collection of information (data) which is arranged in individual records and is searchable.
Database Management System	A computer-based software system used to establish and manage data.

Introduction

- During the analysis phase, analysts need to understand the data that is used and created by the business system (e.g., customer data, order data).
- The data model presents the logical organization of data without indicating how the data are stored, created, or manipulated so that analysts can focus on the business without being distracted by technical details.
- Later, during the design phase, the data model is changed to reflect exactly how the data will be stored in databases and files.

Introduction



Definition

- Model is the representation of the real thing. It simplify the real thing by ignoring some detail.
  - Ex: a construction plan is representation (model) of a house (real thing).
  - Visualize the whole system
  - Clarify and trace out problems before development of the real system
- Data model is the representation of data of the real world in the comprehensible form
- Data model describes and standardizes how data elements relate to each other.

Definition

- Entities: real-world objects or concepts that have a distinct existence in the system.
  - Example: Customer, Product, Order
- Attributes: properties or characteristics of an entity.
  - Example: ID, name, address, phone number, email
- Relationships: connections between entities
  - Example: a customer places an order; a product belongs to a category.
- Constraints: Rules that define valid data
  - Example: a customer must have a unique ID, Orders cannot be placed without products.

3 Levels of Data Models

1. Conceptual Data Model:
   - High-level abstraction
   - Represent a global view of the data within a system, focusing on identifying data entities, relationships, and constraints without delving into implementation details.
   - Example: Entity-Relationship Diagram (ERD) showing entities like Customer, Order and their relationships

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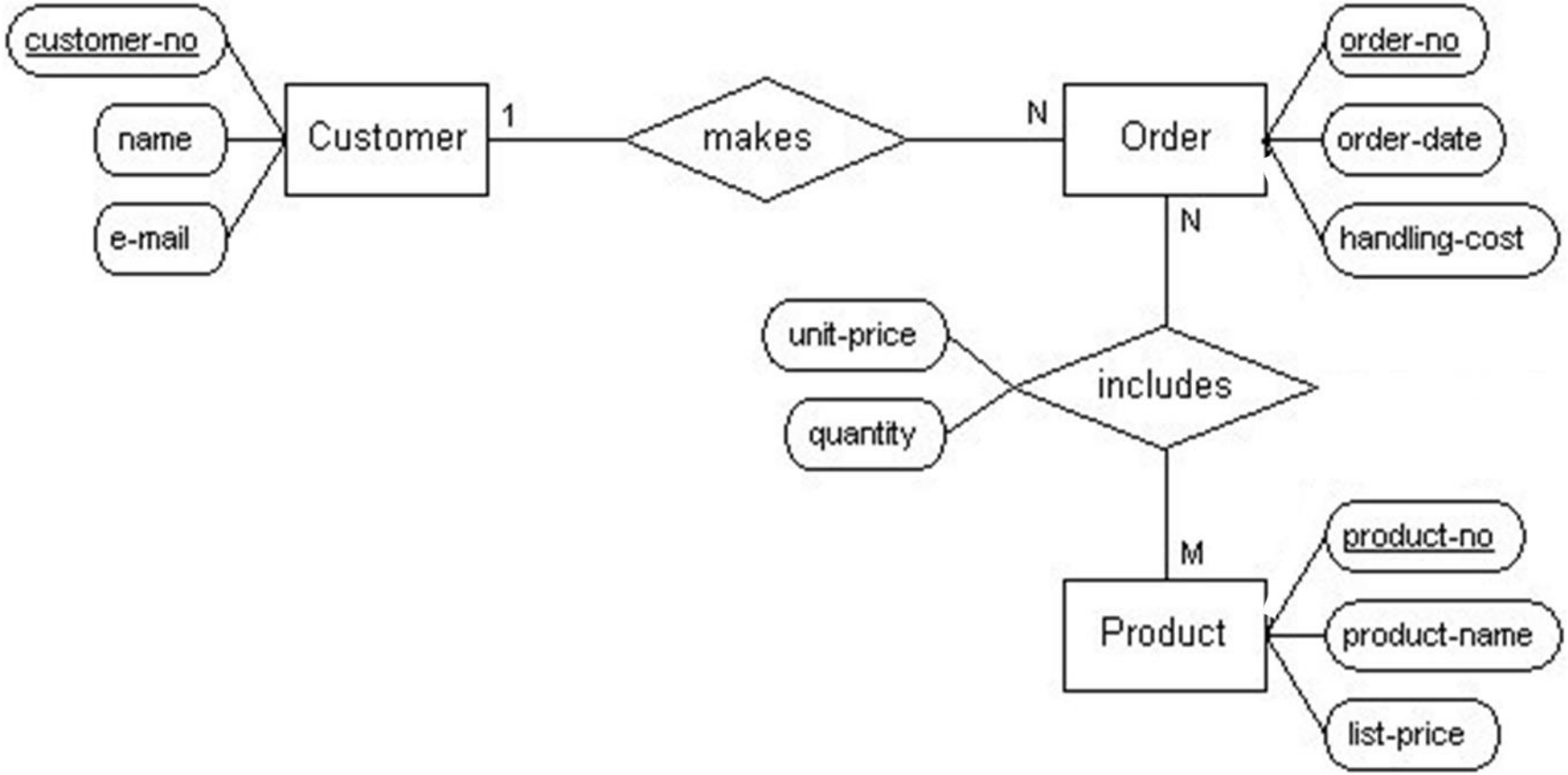
3 Levels of Data Models

1. Conceptual Data Model:

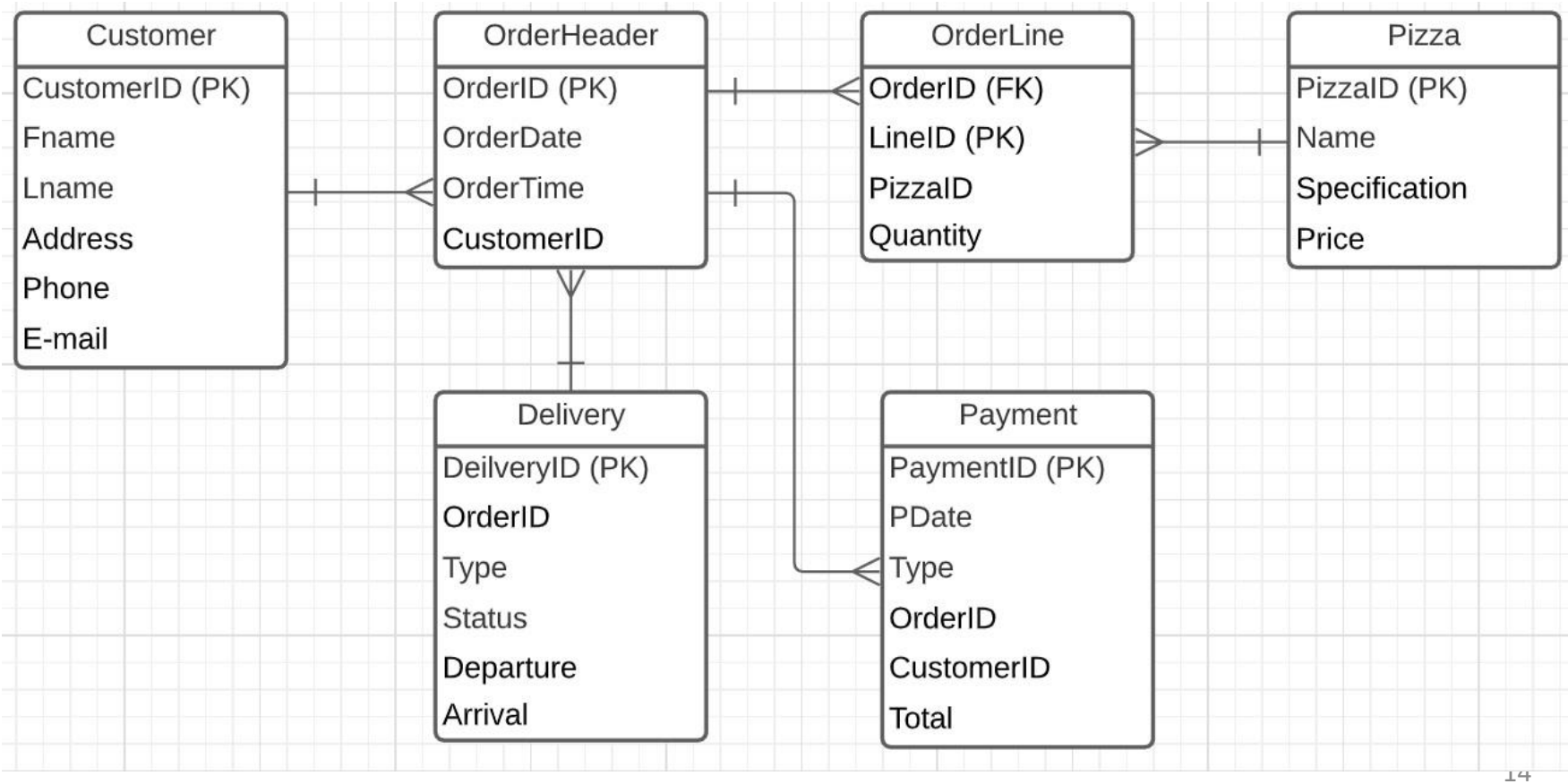


3 Levels of Data Models

2. Logical Data Model
   - Medium-level abstraction
   - Refines the conceptual model by specifying the attributes of each entity and the relationships between entities in more detail, but still independent of physical implementation.
   - Example: A diagram with details about tables, columns, primary keys, and foreign keys.

3 Levels of Data Models

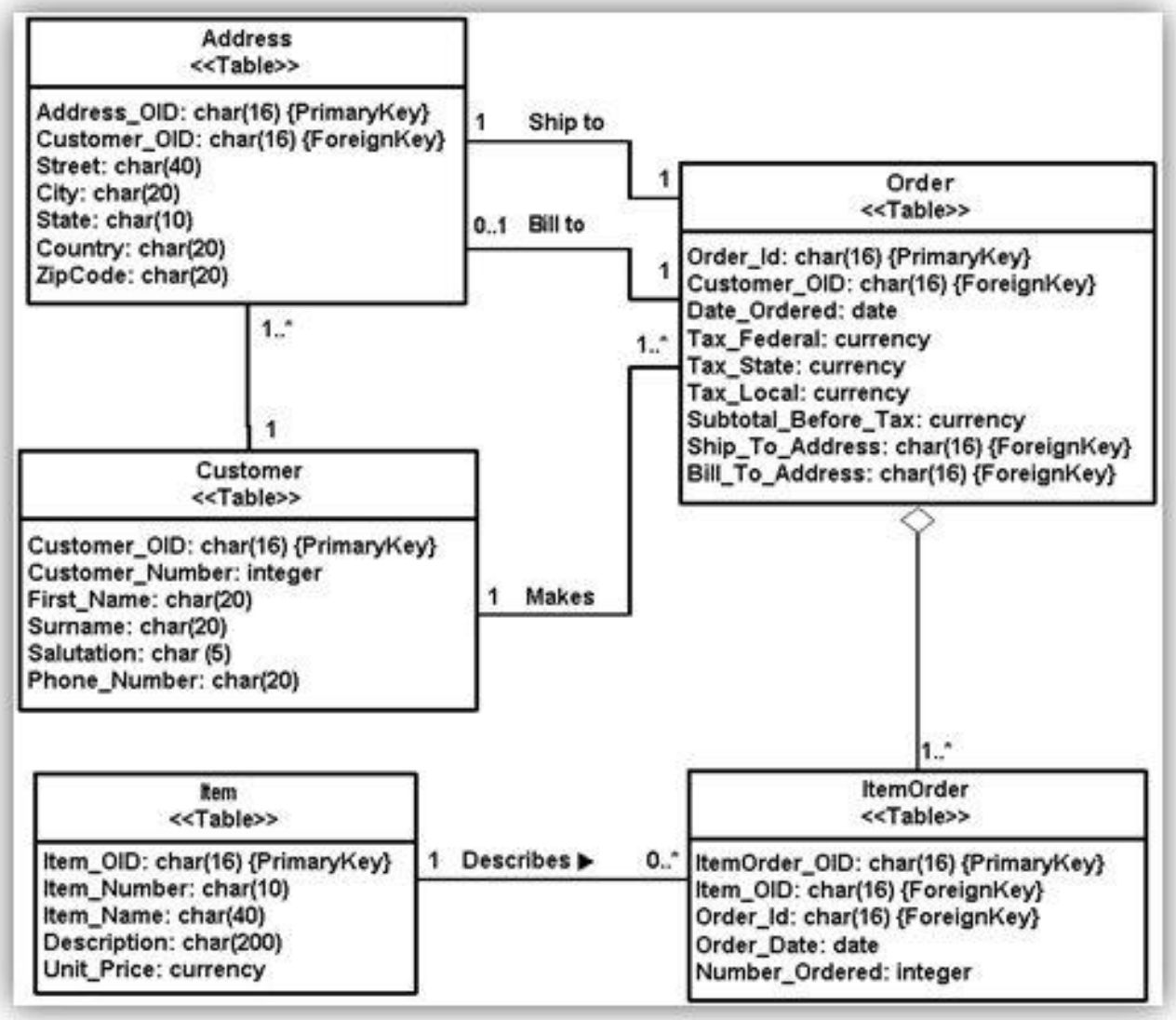
2. Logical Data Model



3 Levels of Data Models

3. Physical Data Model
   - Low-level abstraction
   - It details about the DBMS, data types, indexes, and storage structures.
   - Example: SQL schema design with data types and database-specific features like indexes and partitions.

3 Levels of Data Models



3 Levels of Data Models

When working with databases, we often uses:

	Description	Issue	Input	Output
a.	Conceptual Design Create model that captures major entities, relationships among entities, and attributes of entities required for a particular system.	- Capturing all data - Capturing relationships - Data integrity	- Functional specs - General understanding of problem	- ER diagram
b.	Logical Design Transform the major entity/attribute /relationship requirements into high level specification for database	- Providing location for all data - Data integrity	- ER diagram	- Relational database schema
b2	Improving Logical Design Improve the high-level database specification.	- Minimizing redundancy - Minimizing ambiguity	- Relational database schema	- Relational database schema
c.	Physical Design Transform the high-level specifications for database into detailed specifications for how to construct actual database in a specific relational database software.	- Performance - Data integrity	- Relational database schema - Meaning of data	- Technical specifications for construction of the database

Importance of Data Models

- **Blueprint for database design**: data models are used to design databases by organizing data into entities, attributes, and relationships.
- **Facilitate communication**: they provide a clear and structured way to communicate data requirements between business stakeholders and technical teams.
- **Ensure data integrity**: data models help in enforcing data integrity and consistency by specifying rules and relationships.

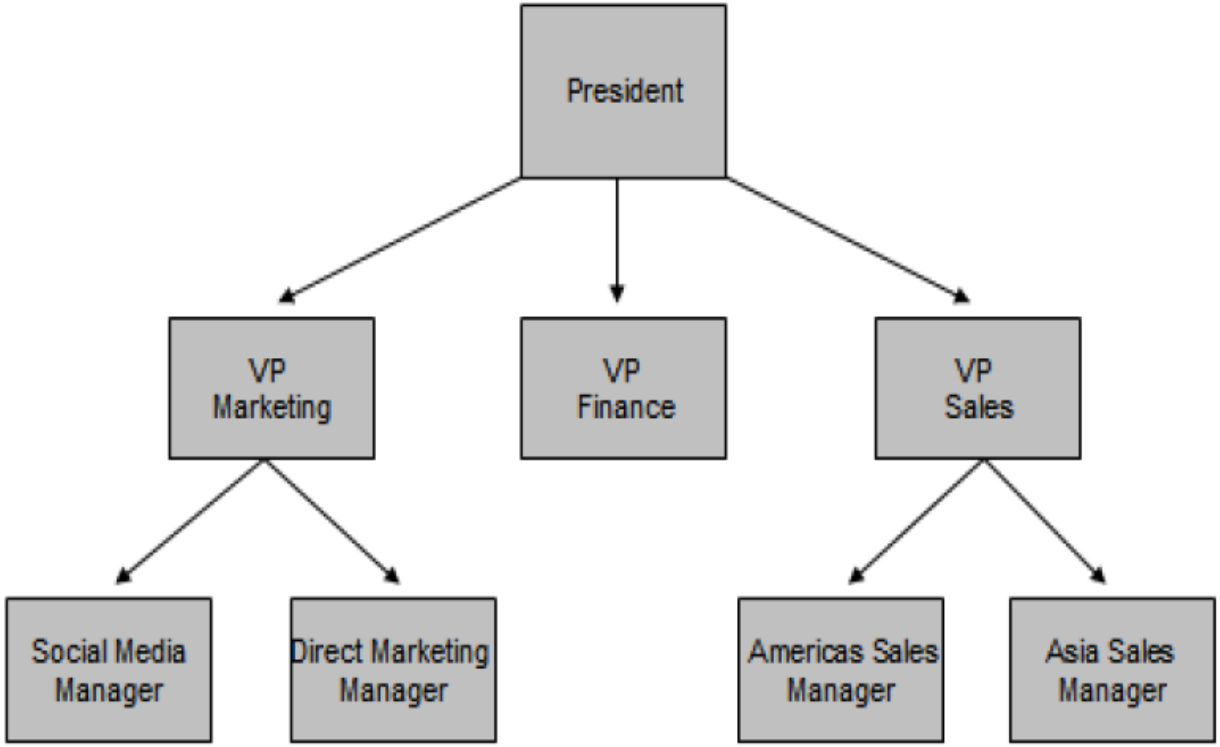
Different Kinds of Data Models

1. Hierarchical Data Model (1968 by IBM)
   - Structure: Tree-like structure where data is organized in a parent-child hierarchy.
   - The root of the tree is the parent followed by child nodes.
   - A parent can have many child nodes. A child node can have only one parent.
   - The node of the tree is the record type.
   - Example: file systems, early databases like IBM's IMS.
   - Limitations: difficult to represent complex relationships

Different Kinds of Data Models

1. Hierarchical Data Model

Example:



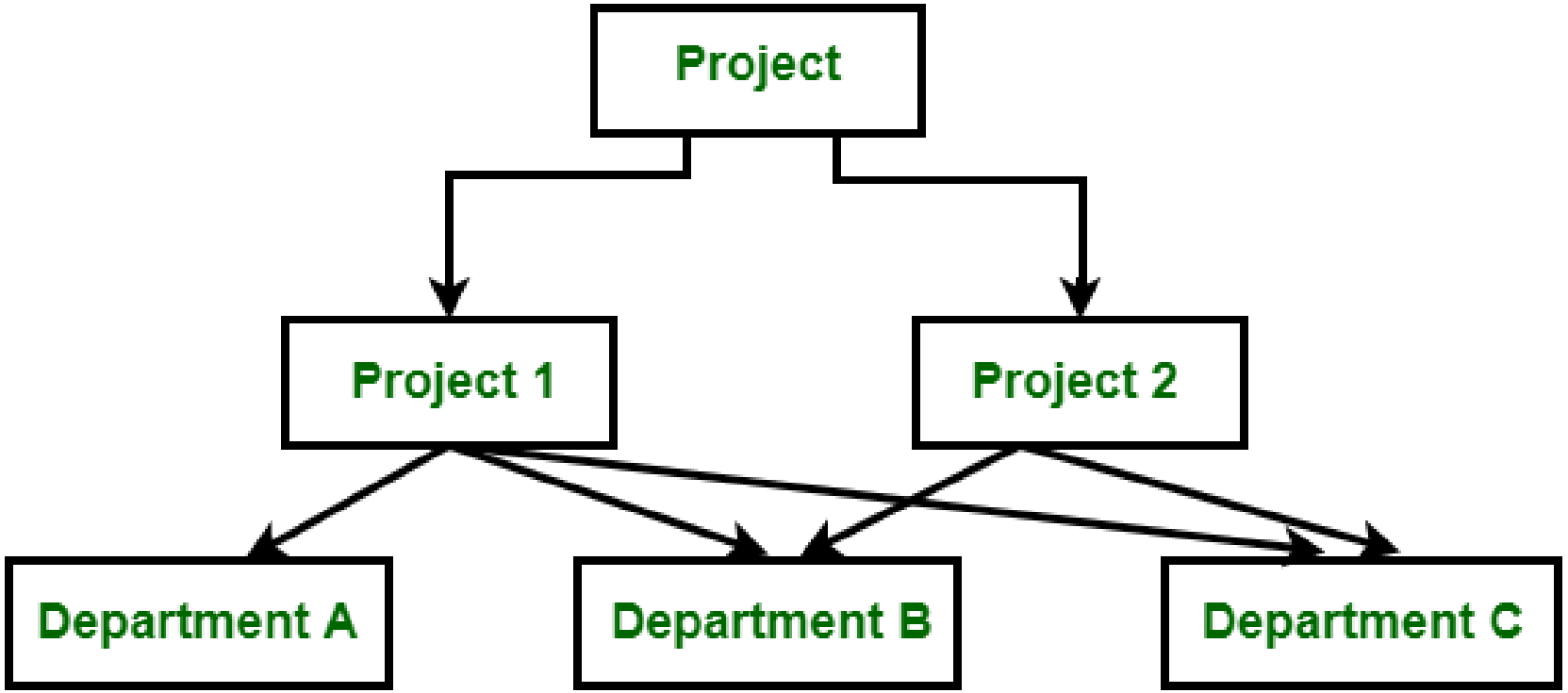
Different Kinds of Data Models

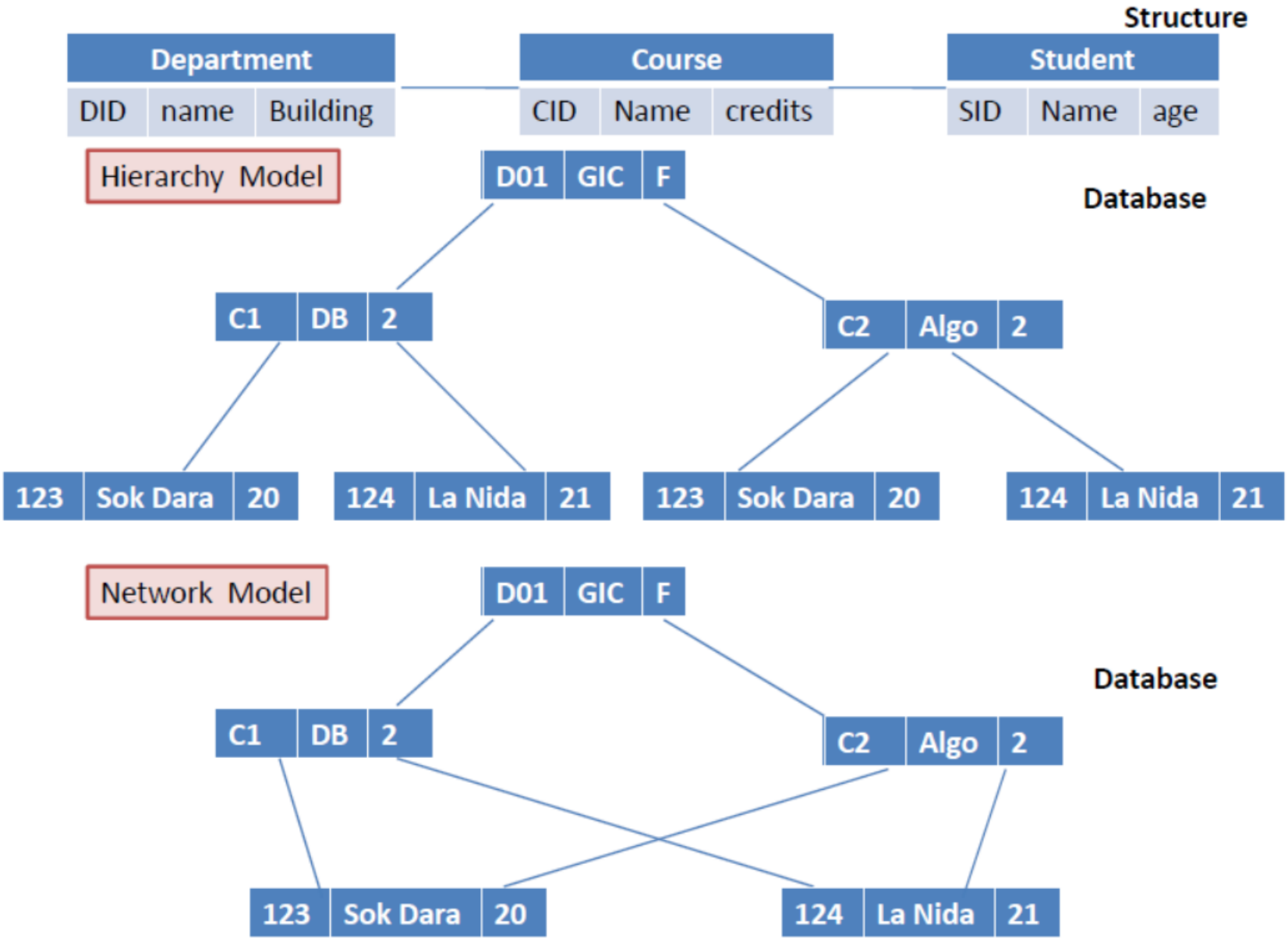
2. Network Data Model
   - Structure: Graph-like structure where entities are nodes, and relationships are edges
   - The node of the graph is a record type. A node can have many parents
   - Use case: telecommunications networks
   - Limitations: Complex to manage and navigate

Different Kinds of Data Models

2. Network Data Model

Example:

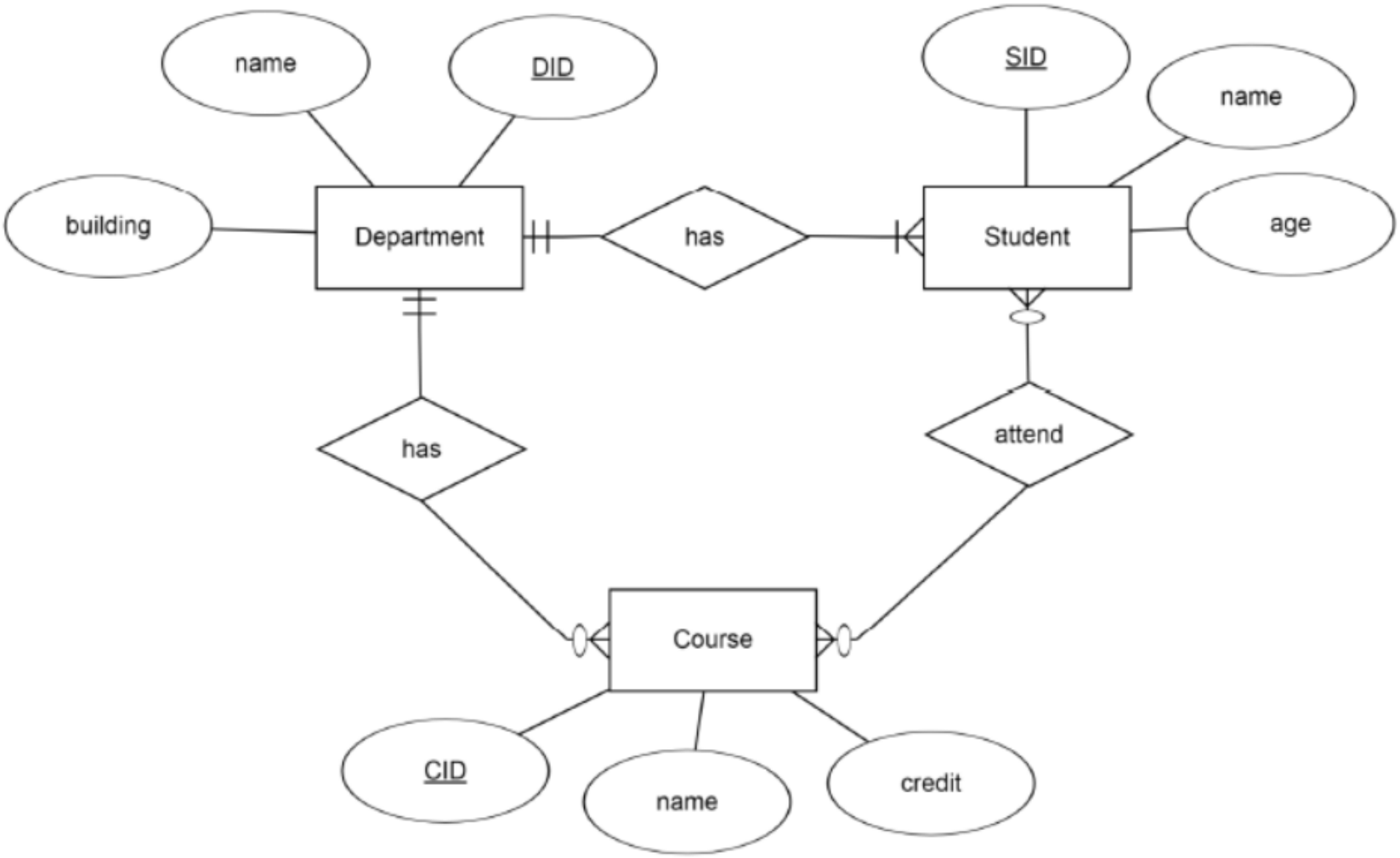



Structure
Department
DID
name
Building
Course
CID
Name
credits
Student
SID
Name
age
Hierarchy Model
D01
GIC
F
Database
C1
DB
2
C2
Algo
2
123
Sok Dara
20
124
La Nida
21
123
Sok Dara
20
124
La Nida
21
Network Model
D01
GIC
F
Database
C1
DB
2
C2
Algo
2
123
Sok Dara
20
124
La Nida
21

Different Kinds of Data Models

3. Entity-Relationship (ER) Data Model
   - Structure: uses entities to represent objects and relationships to represent the associations between them.
   - Example: Entity-Relationship Diagrams (ERD) used in database design.
   - Strengths: Visual, easy to understand for conceptual data modeling
   - Limitations: Focused more on design and abstraction rather than implementation

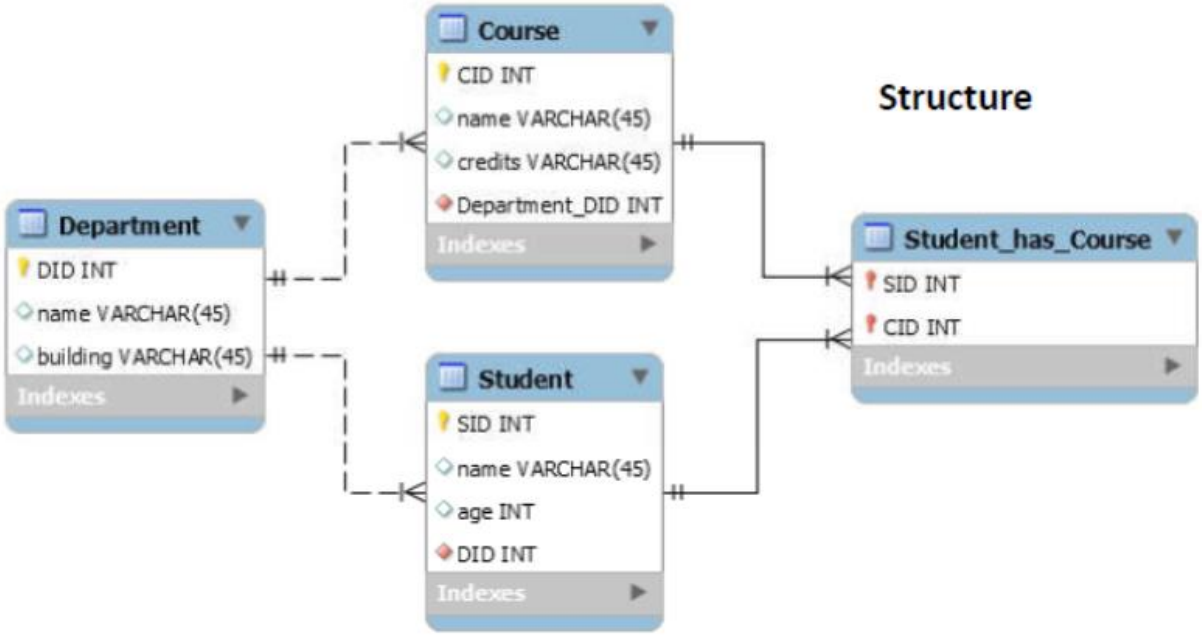
Entity Relationship Model



Different Kinds of Data Models

4. Relational Data Model
   - Structure: Data is organized into tables (relations), with rows (records) and columns (attributes), and relationships are defined using keys (primary and foreign)
   - Example: Most modern databases like MySQL, PostgreSQL, Oracle, Microsoft SQL Server
   - Limitation: Poor performance with highly interconnected data

Relational Model



Structure

DID	name	Building
D01	GIC	F

CID	Name	credits	DID
C1	DB	2	D01
C2	Algo	2	D01

CID	SID
C1	123
C1	124
C2	123
C2	124

Database

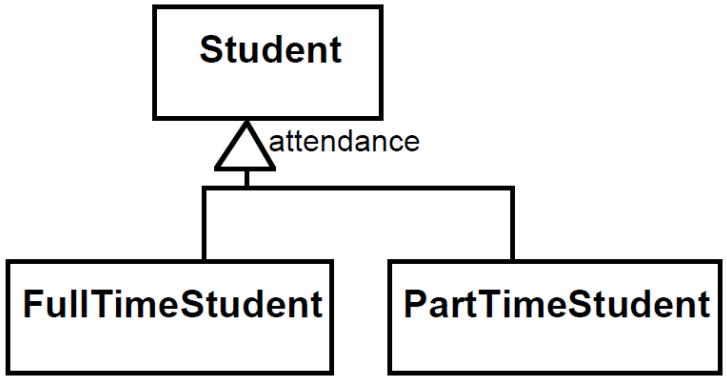
SID	Name	age	DID
123	Sok Dara	20	D01
124	La Nida	21	D01

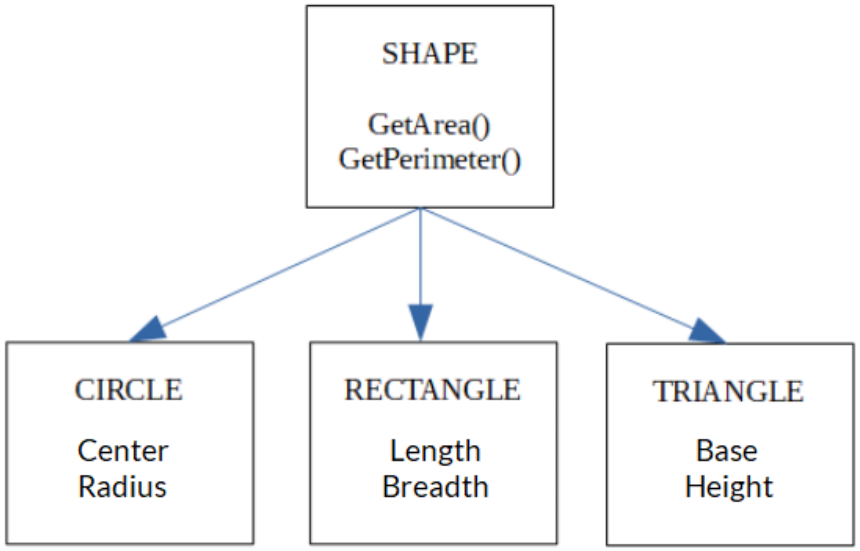
Different Kinds of Data Models

5. Object-Oriented Data Model
   - Structure: Data is organized as objects, similar to objects in OOP, where each object encapsulates both data and behavior.
   - Example: Object databases like db4o, ObjectDB
   - Strengths: Works well with OOP applications, support complex data types.
   - Limitations: Less widespread than relational models, can be more complex

Different Kinds of Data Models

5. Object-Oriented Data Model





Different Kinds of Data Models

5. Document-Oriented Data Model
   - Structure: Data is stored as documents, often in formats like JSON, BSON, or XML, allowing flexible schemas.
   - Example: NoSQL databases like MongoDB, Couchbase.
   - Strengths: Flexible schema, better suited for unstructured or semi-structured data
   - Limitations: Lack of strong ACID compliance (in some cases), more difficult to model complex relationships.

Different Kinds of Data Models

5. Document-Oriented Data Model

- Example: in JSON , XML format

```
{
  "name": "Richard",
  "age": "33",
  "hobbies": ["Biking", "Gaming", "Squash"],
  "city": "Port Land",
  "friends": [
    {"name": "Chris"   , "age": 23, "city": "New York"   },
    {"name": "Emily"   , "age": 19, "city": "Atlanta"    },
    {"name": "Joe"     , "age": 32, "city": "New York"   },
    {"name": "Kevin"   , "age": 19, "city": "Atlanta"    },
    {"name": "Michelle", "age": 27, "city": "Los Angeles"},
    {"name": "Robert"  , "age": 45, "city": "Manhattan"  },
    {"name": "Sarah"   , "age": 31, "city": "New York"   }
  ]
}
```

```
<Movies>
    <Movie title="Gone With the Wind">
        <Year>1939</Year>
        <Length>231</Length>
        <Genre>drama</Genre>
    </Movie>
    <Movie title="Star Wars">
        <Year>1977</Year>
        <Length>124</Length>
        <Genre>sciFi</Genre>
    </Movie>
    <Movie title="Wayne's World">
        <Year>1992</Year>
        <Length>95</Length>
        <Genre>comedy</Genre>
    </Movie>
</Movies>
```

Summary

No	Topic	Summary
1	Definition	Data model is the representation of data of the real world in the comprehensible form. It hides the storage detail of data. The components of data model are structure, constraint and query language of data. The levels of data model are conceptual model logical, and physical model
2	Uses of Data Model	Data model is used as the plan for implementing database. It is used as the support for communication during the design phase of a system. It is also used as the support for auto-generating database and programming code.
3	Different Type of Data Model	There are different type of data model: •Network data model •Hierarchical Model •Relational model •Object model •Entity relationship model •Document-oriented model