Data Modeling

Building the Blueprint for Your Database

Learning Objectives

By the end of this session, you will be able to:

- Explain why data modeling is essential for database design
- Identify the four building blocks of data models
- Apply business rules to create data models
- Compare different data modeling notations
- Analyze the evolution from relational to Big Data models

Context

Why do we need databases?

- **Data is everywhere** 📊
- Traditional file systems have critical limitations:
  - **Redundancy**
    - **Poor integrity (anomalies)**
    - **Security issues** 🔒
    - **High costs** 💰
  - **Structural & data dependencies**

Context (continued)

Database Management System

DBMS = Logically related data in a single logical repository

Core Functions:

- Data dictionary
- Data storage
- Data transformation
- Security
- Concurrency control
- Backup & recovery
- Data integrity
- SQL & APIs

Context (continued)

- Tease apart entities and minimize redundancies using the **normalization** process

Normal Form	Characteristic
1NF	Table format, no repeating groups, PK chosen
2NF	1NF + no partial dependencies
3NF	2NF + no transitive dependencies

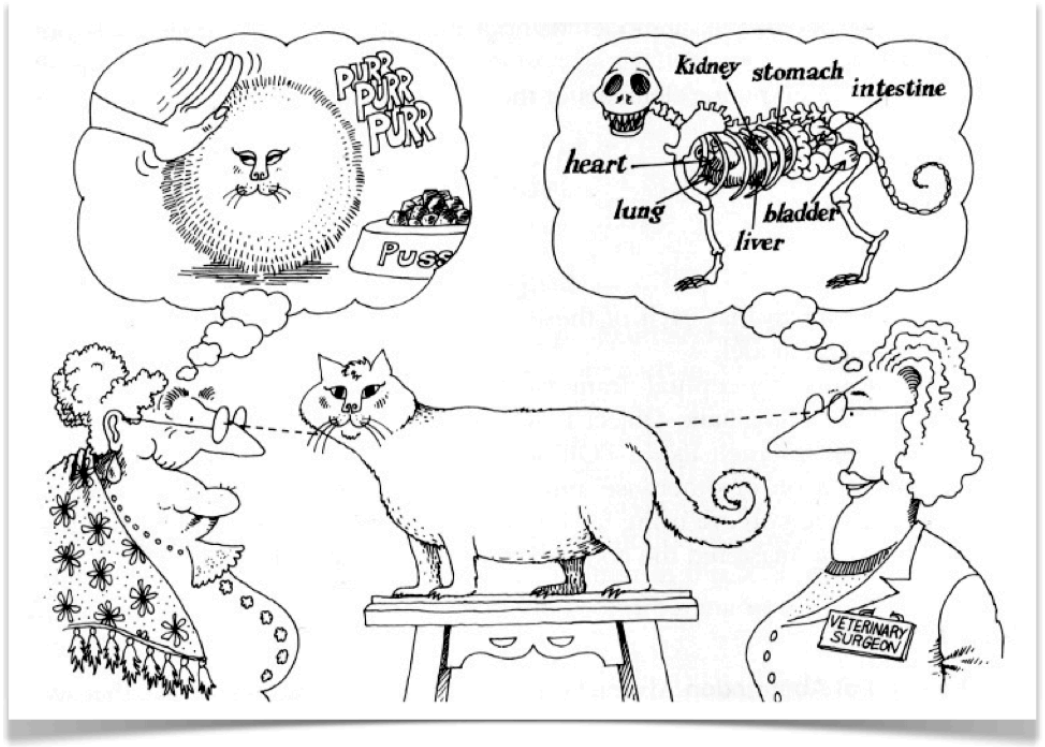
Key Question:

> Can we design our data model up front to control redundancies instead of always normalizing after the fact?

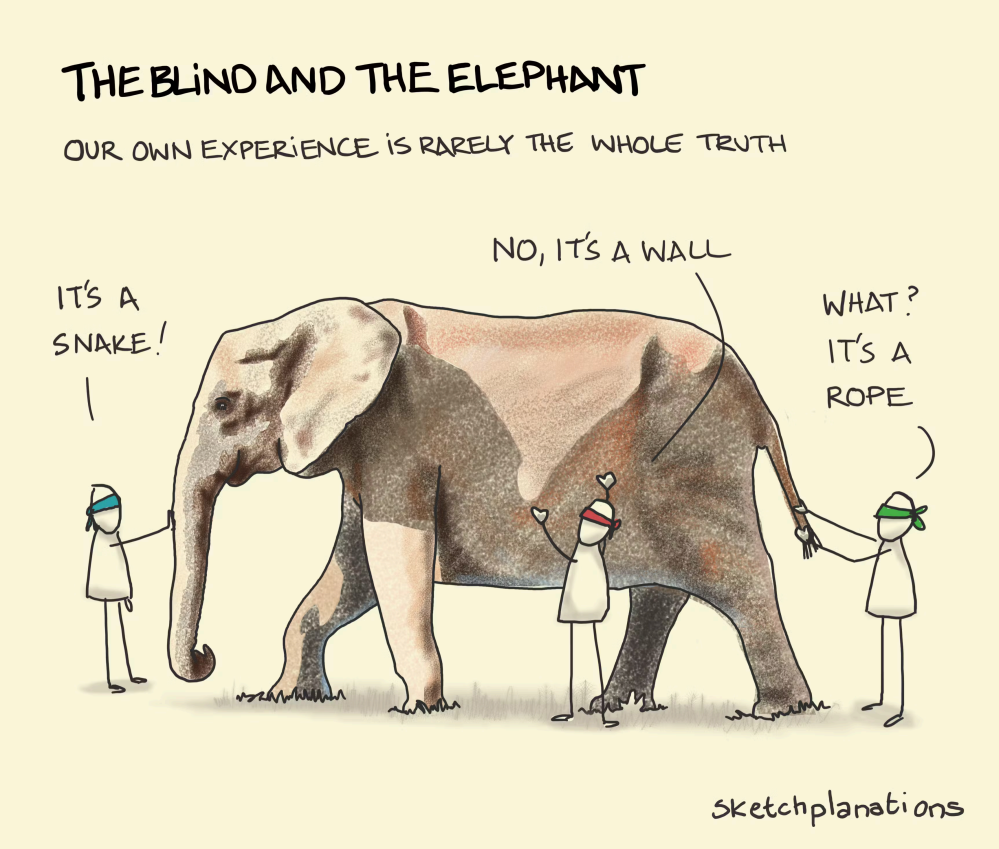
What is Data Modeling?

Creating a Blueprint

- **First step** in database design
- **Simple representation** (usually graphical) of complex real-world data
- An **abstraction** of a real-world problem domain



What is Data Modeling? (continued)



- Holistic view vs. department view
- Multiple "correct" models possible
- Progressive refinement

🏗️ The Four Building Blocks

Foundation of Every Data Model

1. **Entity** 👤
2. **Attribute** 📝
3. **Relationship** 🔗
4. **Constraint** ⚠️

Building Block 1: Entity

What is an Entity?

- A person, place, thing, concept, or event
- Data will be collected and stored about it
- Represents a **unique object** in the real world

Examples:

- Physical: `STUDENT`, `BUILDING`, `PRODUCT`
- Abstract: `FLIGHT_ROUTE`, `COURSE`, `APPOINTMENT`

Building Block 2: Attribute

Characteristics of an Entity

- Describes a specific property of an entity

Examples:

- For `STUDENT` entity:
  - `STU_EMAIL`
  - `STU_FNAME`
  - `STU_LNAME`
  - `STU_GPA`

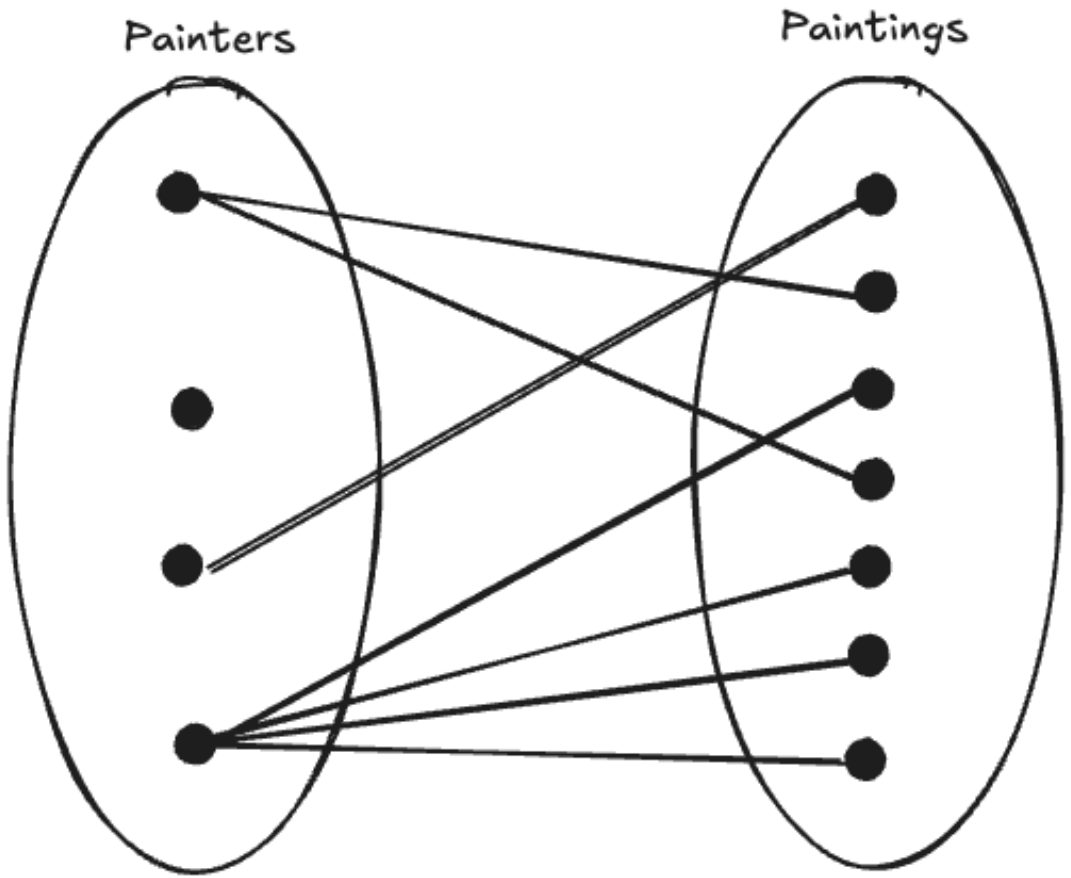
Building Block 3: Relationship

Associations Among Entities

Three Types:

1. **One-to-Many (1:M)**
2. **Many-to-Many (M:N)**
3. **One-to-One (1:1)**

One-to-Many Relationships (1:M)

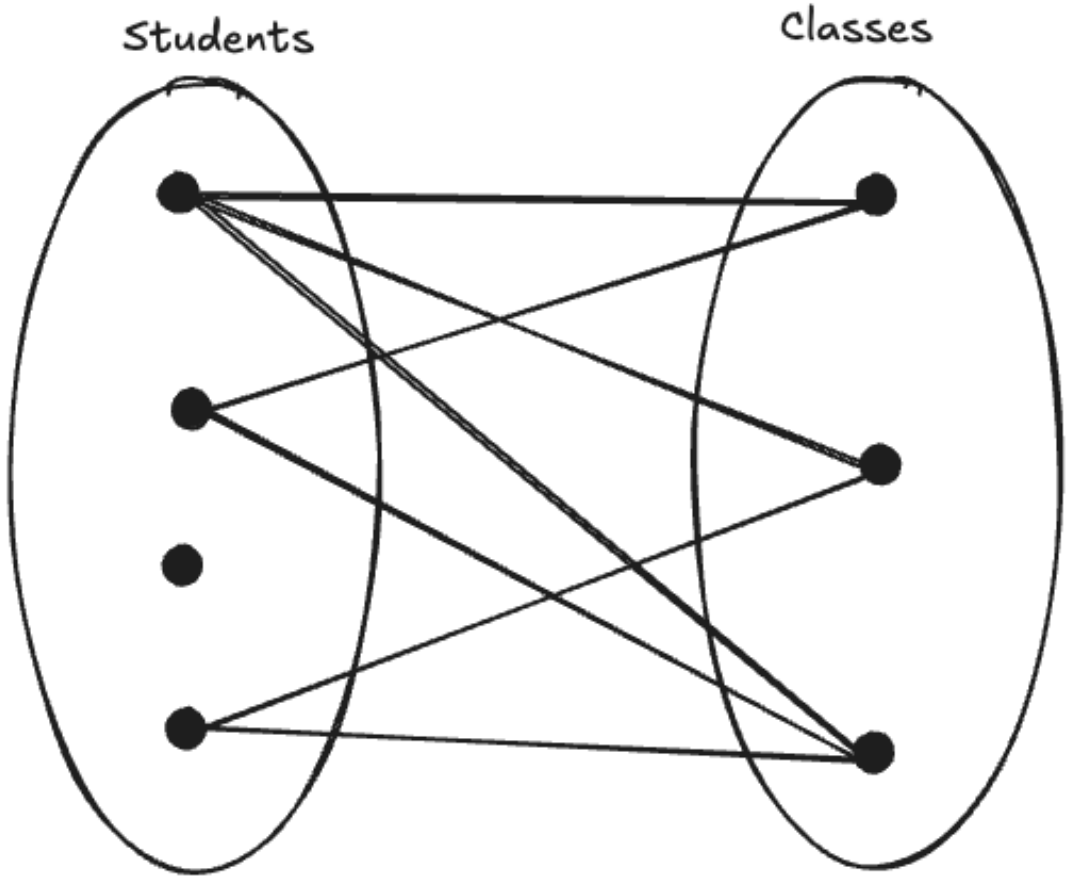


Example: A painter creates many paintings, but each painting has only one painter

Remember: Relationships are bidirectional!

1. **one** *painter* paints **many** *paintings*
2. **one** *painting* is painted by **one** *painter*

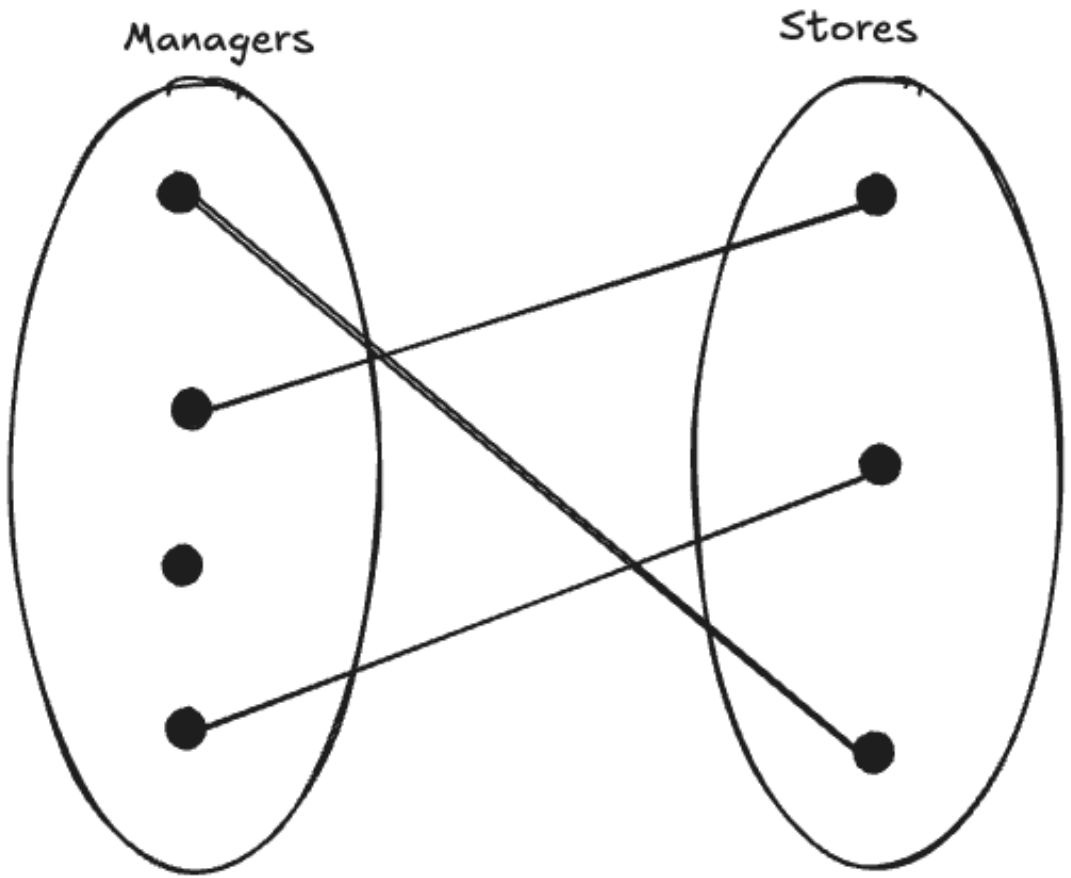
Many-to-Many Relationships (M:N)



Example:

1. **One** *student* takes **many** *classes*
2. **One** *class* has **many** *students*

One-to-One Relationships (1:1)



Example:

1. **One** *store* has **one** *manager*
2. **One** *manager* manages **one** *store*

🎯 Activity: Identify Relationships

Think-Pair-Share (3 minutes)

For each scenario, identify the relationship type:

1. A doctor treats patients
2. An employee has a parking space
3. Authors write books
4. A country has a capital city

Share your answers with a partner!

Building Block 4: Constraint

Rules That Restrict Data

- Enforces data integrity
- Ensures business rules are followed

Examples:

- Student GPA must be between 0.0 and 4.0
- Course enrollment minimum: 5 students
- Employee age must be ≥ 18

Business Rules

The Foundation of Your Model

> **Business Rule** = A brief, precise, and unambiguous description of a policy, procedure, or principle

Purpose:

- Define entities, attributes, relationships, and constraints
- Make data meaningful
- Reflect organizational reality

Business Rules Example

Organization: LWTech College

Rules:

1. A student can take 1-3 classes per quarter
2. A class must have at least 5 students

Resulting Model:

- Entities: `STUDENT`, `CLASS`
- Relationship: Many-to-Many
- Constraints: Min/max enrollment limits

Determining Relationships

The Two Key Questions

To find the relationship between entities A and B:

1. **How many instances of B** are related to one instance of A?
2. **How many instances of A** are related to one instance of B?

💡 These questions reveal the relationship type!

Naming Conventions

Best Practices

Entity Names:

- Singular form
- Descriptive
- Examples: `STUDENT`, `CUSTOMER`, `ORDER`

Attribute Names:

- Prefix with entity abbreviation
- Descriptive
- Examples: `STU_LNAME`, `CUST_EMAIL`, `ORD_DATE`

📝 Exercise: Business Rules

Individual Work (5 minutes)

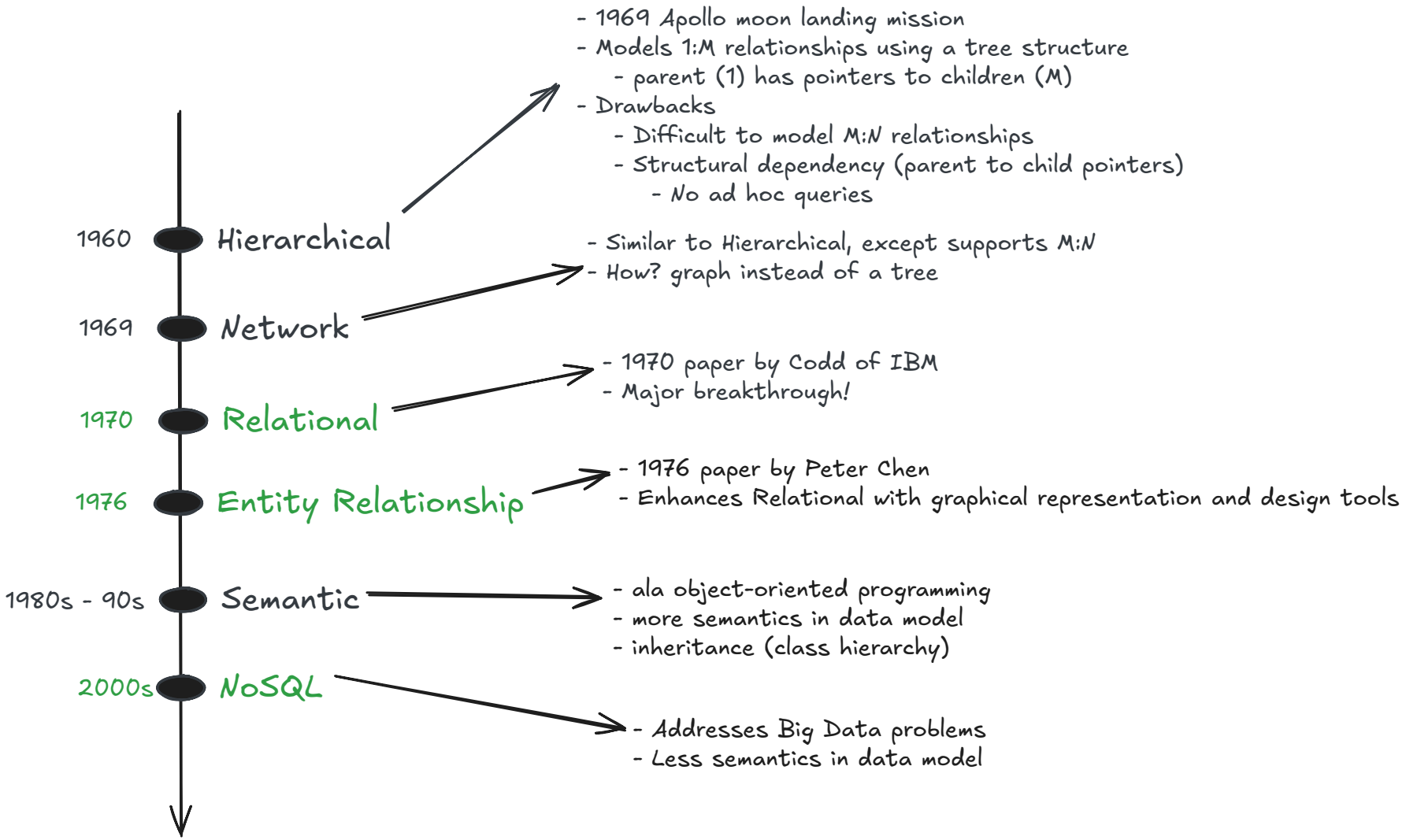
Scenario: *A patient takes medications prescribed by doctors*

Write business rules that govern the relationships between:

- `PATIENT`
- `PRESCRIPTION`
- `DOCTOR`

Consider: Who prescribes? Who takes? How many?

Evolution of Data Models



The Relational Model (1970)

E.F. Codd's Breakthrough

Like shifting from manual to automatic transmission!

Relational Model: Key Ideas

1. Based on Relational Algebra

- Relations = **Tables**
- Rows = **Tuples** (entities)
- Columns = **Attributes**

2. Common Attributes Link Tables

Orders:

Order ID (PK)	Customer ID	Customer Name	Customer Email	Customer City	Order Date
1001	501	John Smith	john@email.com	New York	2024-01-15
1001	501	John Smith	john@email.com	New York	2024-01-15
1002	502	Jane Doe	jane@email.com	Los Angeles	2024-01-16
1003	501	John Smith	john@email.com	New York	2024-01-17

Products:

Product ID (PK)	Product Name	Category
201	Laptop	Electronics
202	Mouse	Electronics
203	Keyboard	Electronics
204	Monitor	Electronics

Order Line Items:

Order ID (PK, FK)	Product ID (PK, FK)	Price	Quantity
1001	201	$999.99	1
1001	202	$29.99	2
1002	203	$79.99	1
1003	204	$299.99	1

RDBMS Components

Relational Database Management System

Three Main Parts:

1. **End-user interface**
    - How users interact with data
2. **Collection of tables**
    - All data stored in table format
3. **SQL engine**
    - Executes queries behind the scenes

Examples: Oracle, MySQL, SQL Server, PostgreSQL

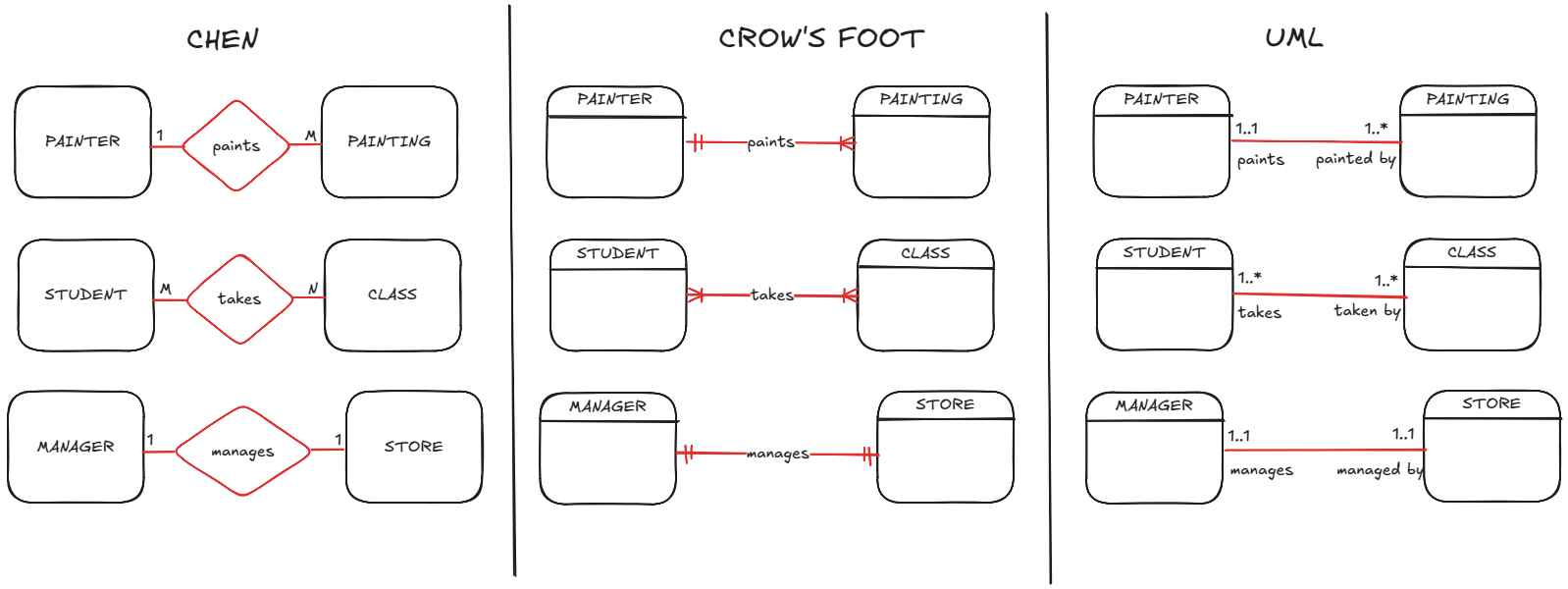
Entity Relationship Model (1976)

Peter Chen's Enhancement

- Adds **graphical representation** to relational model
- Introduces **Entity Relationship Diagrams (ERD)**
- Makes design more visual and intuitive

Connectivity = Relationship type (1:1, 1:M, M:N)

ERD Notations

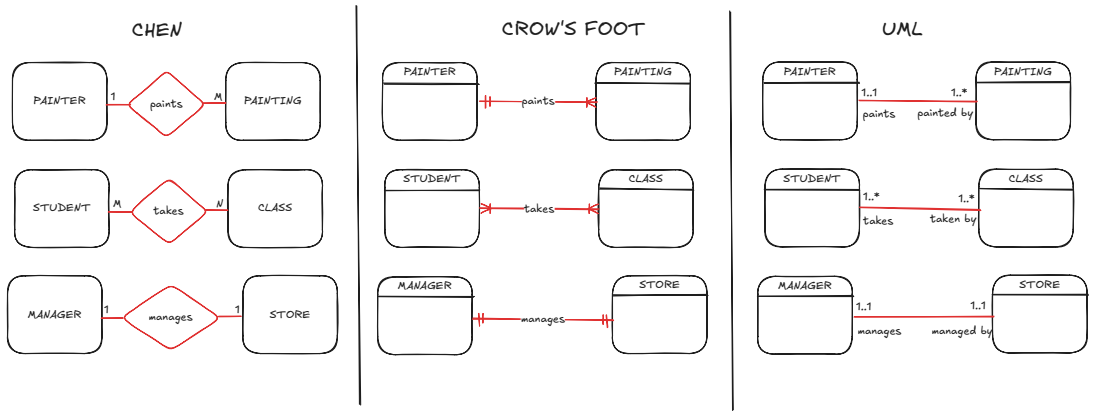


Three popular notations for drawing ERDs

Chen Notation

The Original

- Connectivity written next to entity box
- Diamond shape represents relationships
- Clear but can be verbose



Crow's Foot Notation

The Modern Standard

Symbols:

- ○ = Zero (optional)
- | = One (mandatory)
- 〈 = Many (crow's foot)

```mermaid
erDiagram
  PAINTER ||--o{ PAINTING : paints
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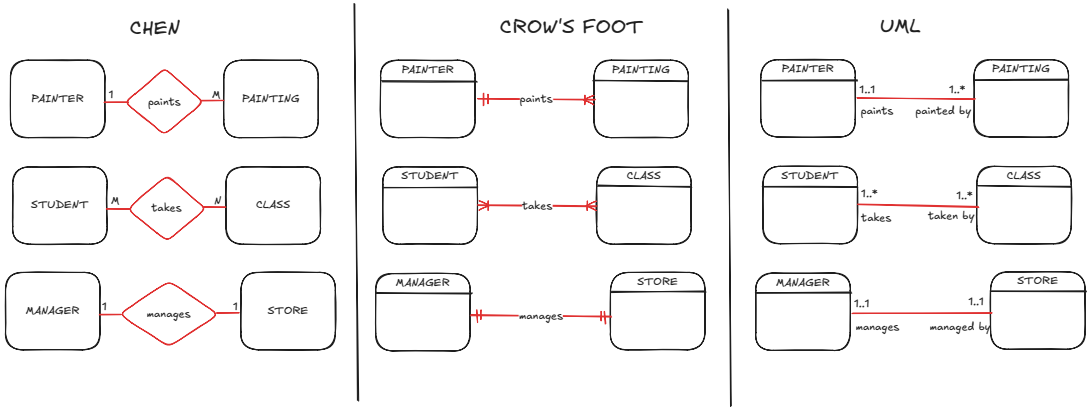
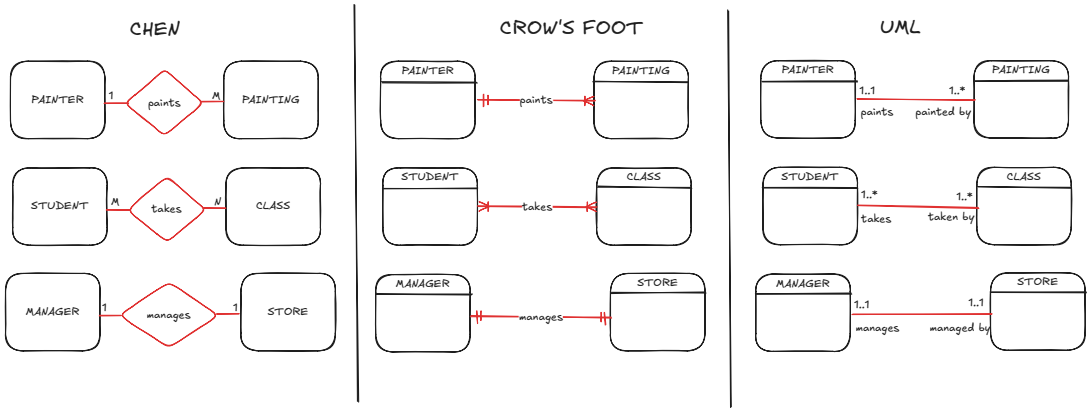


UML Notation

Object-Oriented Approach

- Uses min..max format (1..1, 1.., *0..*)
- Labels both sides of relationship
- Popular in software engineering



🎨 Activity: Create an ERD

Group Exercise (10 minutes)

Scenario: *A patient takes medications prescribed by doctors*

1. Identify entities
2. Determine relationships
3. Draw using Crow's Foot notation
4. Compare with another group

The Big Data Challenge

The 3 V's

📊 Volume

Amount of data being stored

⚡ Velocity

Speed of data processing needed

🔀 Variety

Multiple, loosely-structured formats

RDBMS struggles with all three!

Big Data Solutions

New Paradigms

Hadoop

- **HDFS**: Distributed file system
- **MapReduce**: Distributed processing

NoSQL

- Not based on relational model
- Highly distributed
- Types: Key-value, Document, Columnar, Graph

🤔 Reflection Activity

Think-Write-Discuss (5 minutes)

Consider a social media platform like Instagram:

1. What entities would you need?
2. What relationships exist?
3. Would you use RDBMS or NoSQL? Why?

Write your thoughts, then discuss with a neighbor.

Key Takeaways

What We've Learned

✅ Data modeling creates database blueprints

✅ Four building blocks: Entity, Attribute, Relationship, Constraint

✅ Business rules drive the model

✅ Multiple notation styles (Chen, Crow's Foot, UML)

✅ Evolution from Relational to Big Data