CS422 Principles of Database Systems

Entity-Relationship Model

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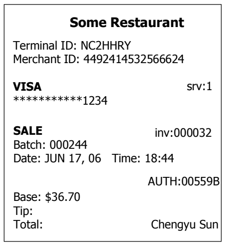
Designing Tables Is Not Easy

Problem in Real World



Some Restaurant

Terminal ID: NC2HHRY
Merchant ID: 4492414532566624

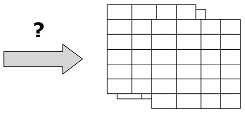
VISA srv:1
***********1234

SALE inv:000032
Batch: 000244
Date: JUN 17, 06 Time: 18:44

AUTH:00559B

Base: $36.70
Tip:
Total: Chengyu Sun

Tables in RDBM



Entity-Relationship (ER) Model

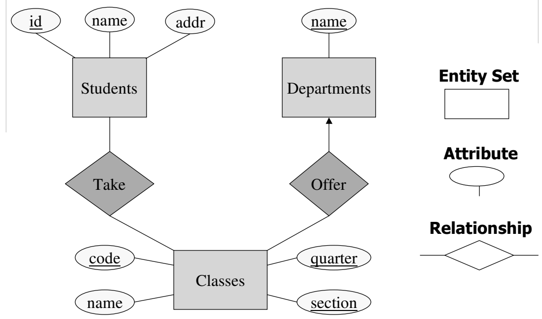
Problem ⟶ ER Model ⟶ Tables

- An *object-oriented* approach
- A visual representation of the design – ER Diagram
- Easily converted to relational model

Example: Problem Description

- Student
  - id, name, address
- Department
  - name
- Classes
  - code, name, quarter, section number
- Class offerings and enrollment

Example: ER Diagram



Entity Set and Attributes

- Entity Set is similar to *class* in an OO language
- Attributes are the properties of an entity set
  - Similar to the *class fields* in an OO language
  - Must have simple values like numbers or strings, i.e. *cannot be collection or composite type*

Keys

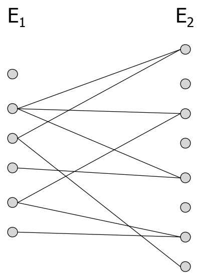
- A key is an attribute or a set of attributes that *uniquely* identify an entity in an entity set.
- Each entity set must have a key
- If there are multiple keys, choose one of them as the *primary key*

Types of Relationships

- Many-to-Many
- Many-to-One / One-to-Many
- One-to-One

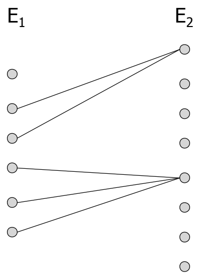
Many-to-Many Relationship

- Each entity in E_1 can be related to many entities in E_2
- Each entity in E_2 can be related to many entities in E_1



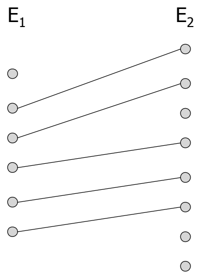
Many-to-One Relationship

- Each entity in E_1 can be related to one entities in E_2
- Each entity in E_2 can be related to many entities in E_1



One-to-One Relationship

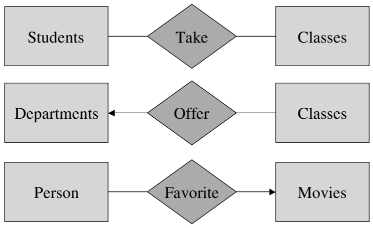
- Each entity in E_1 can be related to one entities in E_2
- Each entity in E_2 can be related to one entities in E_1



Relationship Type Examples

- Students and classes??
- Departments and classes??
- Person and Favorite movie??

Relationship Types in ER Diagram

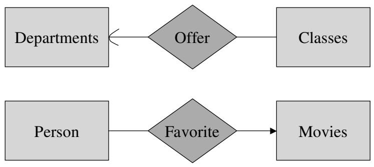


- ◈An arrow is used to indicate the “one” side

A Closer Look at “One” and “Many”

- ◈One
  - 0 or 1
  - Exactly 1 ➔ Referential Integrity
- ◈Many
  - 0..N
  - 1..N
  - N..M (*Example??)*

Referential Integrity in ER Diagram



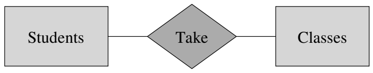
- ◈An circular arrow is used to indicate “Exactly 1”

One vs. Exactly One

- ◈Both lead to foreign key constraint in SQL
  - One: `foreign key` + `NULL`
  - Exactly one: `foreign key` + `NOT NULL`
- ◈It’s usually not too important to distinguish the two in ER design

Example: Grades

- ◈Store the grades the students received for their classes
- ◈A grade is a single letter `A`, `B`, `C`, `D`, or `F`



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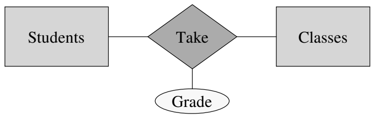
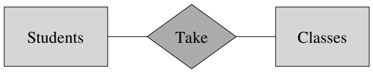
Relationship Attributes …

- ◈Sometimes it’s useful to attach an attribute to a relationship.



… Relationship Attributes …

- Some variations of ER model does not allow relationships to have attributes



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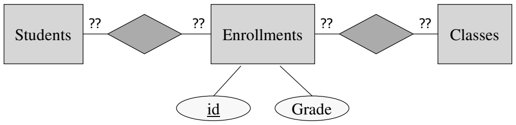
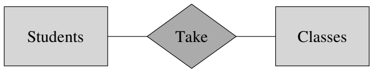
… Relationship Attributes

- If something needs an attribute, it probably should be an entity set



Example: More about Grades

- Make `Grades` an entity set



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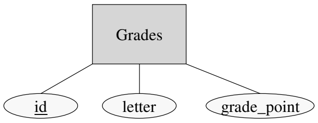
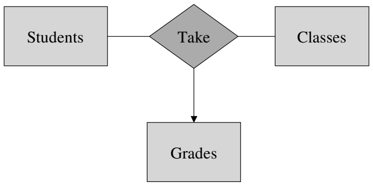


Multiway Relationship

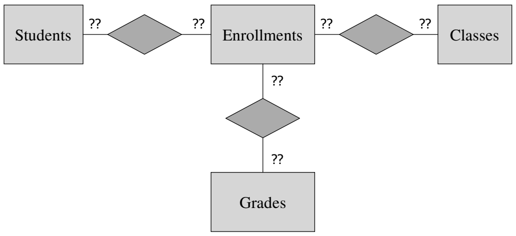


- Why there is an arrow pointing to `Grades`??

"Arrows" in Multiway Relationships

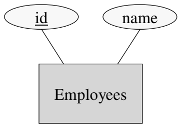
- In multiway relationships, an arrow points to an entity set **E** means that if we select one entity from each of the other entity sets in the relationship, those entities are related to at most one entity in **E.**

Convert Multiway Relationship to Binary Relationship



Example: Employees and Supervisors

- ◈Each employee has a supervisor
- ◈A supervisor is an employee



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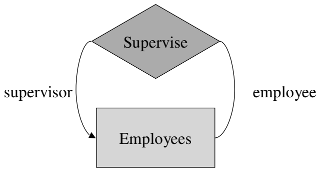
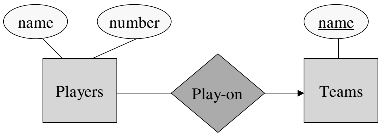
Roles

- ◈An entity set may appear in the same relationship more than once.
- ◈Label the edges with names called Roles



Example: Players and Teams

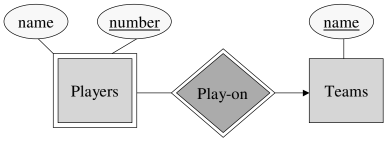


- ◈What's the key for *Players*??

Weak Entity Set

- ◈Entity set ***E*** is said to be weak if in order to identify entities of ***E*** uniquely, we need to follow one or more many-one relationships from ***E*** and include the key of the related entities from the connected entity sets.

Weak Entity Sets in ER Diagram

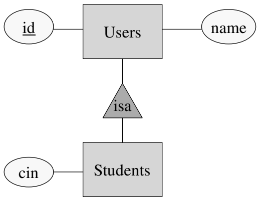


- ◈The key of a weak entity set consists of its own key attributes *and* the key attributes of the supporting set

From Weak to Strong

- ◈We can usually create unique IDs for entity sets

Subclass



- ◈Super class must have all the key attributes

Summary of ER Diagram

- ◈Entity Set
  - Attributes, key
  - Weak entity set
- ◈Relationship
  - Many-to-Many, Many-to-One, One-to-One
  - Attributes
  - Multiway relationship
  - Subclass

Relational Model

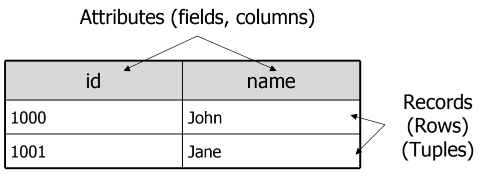
- ◈Proposed by Edgar F. Codd in early 1970's
- ◈Data is stored in tables (a.k.a. relations)
- ◈All major database systems these day are relational

student_id	first_name	last_name	birthday
2000001	John	Doe	1970-1-1
2000002	Jane	Doe	1971-1-1
2000003	Tom	Smith	1962-2-2

About Relational Model

- ◈Attributes must be of simple type
- ◈No order among attributes
- ◈No order among records

Table (Relation)


Attributes (fields, columns)

id	name
1000	John
1001	Jane

Records (Rows) (Tuples)

Students

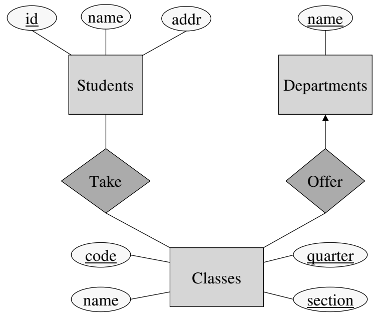
Table and Database Schema

- ◈Table schema
  - Name of the table, and the names and types of the attributes
  - E.g. `students(id:integer,name:string)` or just `students(id,name)`
- ◈Database schema
  - Schemas of all the tables in the database

Basic Rules of ER to Relational Conversion

- A entity set is converted to a table
- A many-to-many relationship is also converted to a table, including
  - Its own attributes
  - Key attributes from the associated entity sets
- A many-to-one relationship is merged into the "many" side with a foreign key to the "one" side

Conversion Example: ER Diagram

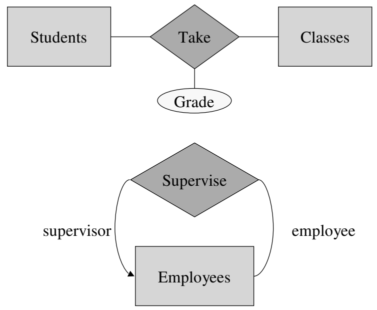


Conversion Example: Relational Schema

Students(id, name, address)
Departments (name)
Classes (code, name, quarter, section, department_name)

Takes(student_id, code, quarter, section)

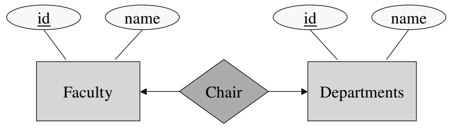
More Conversion Examples



Special Cases of Conversion

- One-to-One relationship
- Multiway relationship
- Weak entity set
- Subclass

Converting One-to-One Relationship …



… Converting One-to-One Relationship

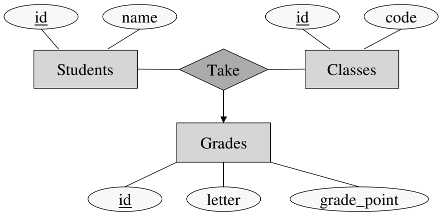
- Which one of the following makes more sense??

Faculty(id, name, chair_of_department)
Departments(id, name)

or

Faculty(id, name)
Departments(id, name, department_chair)

Converting Multiway Relationship

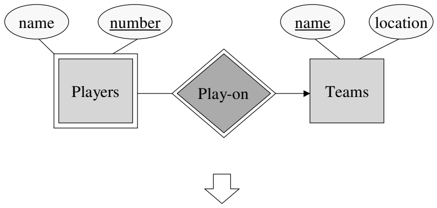


- Should this relationship be treated as many-to-many or many-to-one??

Converting Weak Entity Set …

- The table for a weak entity set includes its *complete key* as well as it's own non-key attributes
- A supporting relationship is redundant and yields no relation

… Converting Weak Entity Set



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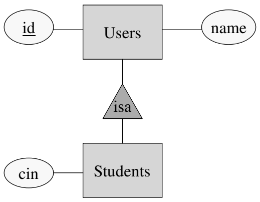
Converting Subclass …



… Converting Subclass

- Object-oriented approach
  - One table per class
  - Each entity belongs to exact one table
- ER approach
  - One table per class
  - Each entity may appear in multiple tables
- NULL approach
  - One table per class hierarchy

Object-Oriented Approach

id	name
1000	John

Users

id	name	cin
1001	Jane	212345678

Students

ER Approach

id	name
1000	John
1001	Jane

Users

user_id	cin
1001	212345678

Students

NULL Approach …

id	name	cin
1000	John	NULL
1001	Jane	212345678

Users

… NULL Approach

Discriminator field

id	user_type	name	cin
1000	staff	John	NULL
1001	student	Jane	212345677

Users

Comparison of Subclass Conversion Approaches

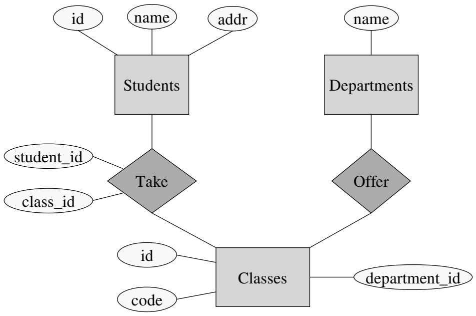
- Constraints and data integrity
- Query performance

Q1: find the number of users
Q2: find the number of students

Summary of ER to Relational Conversion

- Basic rules
  - Entity set
  - Many-to-many relationship
  - Many-to-one relationship
- Special cases
  - One-to-one relationship
  - Multiway relationship
  - Weak entity set
  - Subclass

Common Problems in ER Diagram



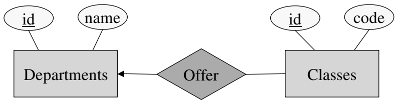
Common Mistakes of ER Design

- ER diagram
  - Missing arrows
  - Missing keys
  - Redundant foreign keys
- ER to relational conversion
  - Missing tables for many-to-many relationships

Variations of ER Model

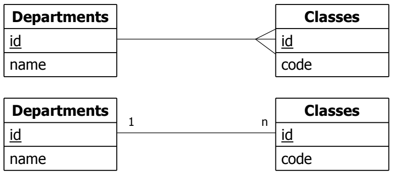
- Rule differences
  - Relationships cannot have attributes
    - Anything that have attributes should be an entity set
    - Simplifies ER diagram
  - No multiway relationship
    - Better mapping to OO languages
- Notational differences
  - Old school style
  - Tool friendly style

Old School ER Diagram



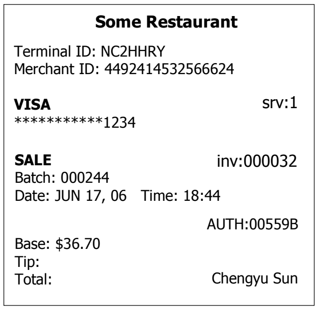
- Highlight three distinct components of a diagram
- Difficult to draw
- Can look mess even for a relatively simple schema

Tool Friendly ER Diagram



- Relationships cannot have attributes, and no multiway relationships
- Easier to draw, especially using OO design tools
- Looks cleaner

Design Example 1: Restaurant



Some Restaurant

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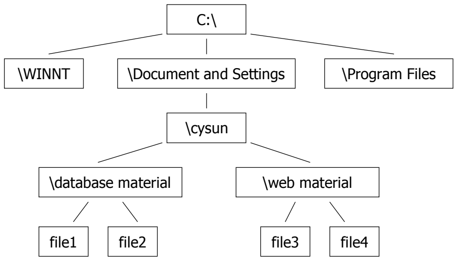
VISA srv:1
***********1234

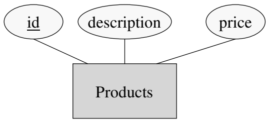
SALE inv:000032
Batch: 000244
Date: JUN 17, 06 Time: 18:44
AUTH:00559B
Base: $36.70
Tip:
Total: Chengyu Sun

Design Example 2: Folders and Files



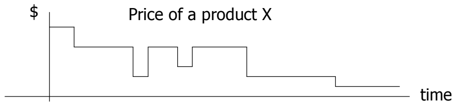
C:\
\WINNT
\Document and Settings
\Program Files
\cysun
\database material
\web material
file1
file2
file3
file4

Design Example 3: Price That Changes



id
description
price
Products

What if we want to model price that changes??



$
Price of a product X
time