CP363: Database I

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Chatper 1: Introduction

1 Database Management Systems (DBMS)

A *DBMS* is a collection of software to enable a user to create, maintain and utilize a DB (Ex. Oracle, MySQL, etc).

1.1 Advantages of DBMS

- Efficient data access
- Data integrity and security
- Data administration
- Data independence
- Concurrent processing crash recovery
- Reduce application development time and cost

Concurrent Processing

{figure out diagram}

2 Logical Schema of a Database

- Schema is the data structureIBM had the hierarchical model, other companies created the Network and Lodeysol models
- Logical (conceptual) scheme is the logical data structure

3 Physical Schema

- How data is stored physically: tree, heap, etc
- View on the logical schema, different ways of viewing data; sometimes public facing

4 Logical Data Independence

- Changing to logical schema will not effect the view on it

5 Physical Data Independence

- Changing to physical schema will not effect the logical schema

5.1 Lingo

SQL

- DBMS language: SQL
- Definition Language: DDL (specify data schemas - by logical schema)
- Data Manipulation Language: DML (retrieve, update data of DB)

Not

- Embedded SQL: embed SQL into software

6 Data Models

- IBM had the hierarchical model, other companies created the Network and Lodeysol models

Chapter 2: Introduction to the Relational model

1 Relational DB Model

- Data is stored using tables, also known as relations
- Each column has a name, AKA attribute
- Each row is record

1.1 Schema

- Defining the structure of a relation

Example 1.

```
student_table(Id int(8),
              Name varchar(8),
              Major varchar(8),
              GPA float);
```

- Tables are defined as such: $R(A_1, ..., A_n)$
- An *instance* is a record in a table

A **database instance** is all the data in the DB. **Database schema** contains schemas for all tables in the form $S = R_1, ...R_m$.

The table must satisfy four constraints:

1. Domain constraint
2. Key integrity constraint
3. Entity integrity constraint

4. Referential integrity constraint

Example 2.

Eid	Name	Dependent
1234	*Tom*	Mary
1234	*Tom*	Peter
2345	*John*	Tim
2345	*John*	Jane
3456	David	Jim

Remember **NO** duplicates. Instead change those records to:

Eid	Name	Dependent
1234	*Tom*	Mary,Peter
2345	*John*	Tim,Jane
3456	David	Jim

Each attribute can only contain *atomic* values. Ex. Cannot contain a set of values. FFS, do this:

Eid	Name	Dependent 1	Dependent 2
1234	*Tom*	Mary	Peter
2345	*John*	Tim	Jane
3456	David	Jim	--

This is also **NOT** ideal.

R_1:

Eid	Name
1234	*Tom*
2345	*John*
3456	David

R_2:

Eid	Dependent
1234	Mary
1234	Peter
2345	Tim
2345	Jane
3456	Jim

1. Key Integrity Constraint

- Observation: No tuples in a table are the same; in other words, every tuple in a table needs to be unique..SO DONT STORE RECORDS TWICE
- $\Rightarrow$ Each record, tuple, can be <u>uniquely identified</u> by a certain set of attributes
- The *super key* is a set of attributes that can uniquely identify a record (tuple)
- The trivial super key is the one with all the attributes
- A minimal super key is called a *candidate key*
- A candidate key be picked as the *primary key* $\rightarrow$ Refer to next Example 3

- Every relation must have a primary key `student_table(Id,Name,Major,GPA)` where `Id` is the primary key

Example 3. `id,dept_name` are super keys but not candidate keys. But two candidate keys are `id,Name` as they are unique. Then pick on candidate to be the primary, this `Id` will be picked as the primary key.

Example 4.

A	B	C	D
a_1	b_2	c_1	d_2
a_1	b_2	c_3	d_2
a_1	b_2	c_2	d_1
a_2	b_3	c_4	d_1

We have the minimal super key = candidate key. $\{A, D\}$ is not a super key. $\{B, C\}$ is a super key. Is it a candidate key? No, thus, C is a super key $\Rightarrow$ C is a candidate key $\Rightarrow$ C is a primary key

2. Entity Integrity Constraint

- The primary key cannot be `null`; in our example, that means `Id` cannot be null
- The rest of the attribute can be `null`

3. Referential Integrity Constraint

- A *foreign key* must either contain a `null` value or a value in the **referenced key**

Example 5. Back to the example with R_1 and R_2. We have R_1`(Eid,Name)` and R_2`(Eid,Dependent)`.

Thus, `Eid`, is an foreign key in R_2 because `Eid` is the primary key in R_1. `Eid` in R_1 is the referenced key.

Chapter 7: DB Design

1. Requirement Analysis

- Data to be stored
- Applications
- Performance analysis

Example 6. Registration system

```
student records
class records
professor records
```

Actions:

- To register a student in the class

- Print class list
- Print professor schedule

2. Conceptual Database Design

- Entity-Relationship model (ER model)
- Entity is equivalent to record type
- The relationship between entities

3. Logical Database Design

- Convert the ER model into a relational model (ie. convert to tables - relations)

4. Scheme Refinement

- Theory of relational database - 1^{st}, 2^{nd}, 3^{rd}, 4^{th} BC (Boyce-Codd) normal forms

5. "Physical" Database Design

- Add index files to speed up certain applications

6. Application and Security Design

1 Entity-Relationship Model

Entity $\equiv$ record

- An entity is an object in the real word that is distinguishable from other objects
- A **diamond** indicates a relationship between two entities
- A **triangle** indicates a subclass of
- A **circle** represents an attribute
- A **rectangle** represents an entity

Example 7. A student record

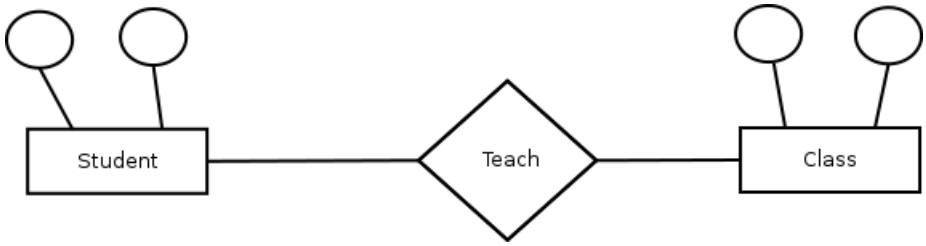
These are attributes

`Id` `Name` `GPA` `Major`

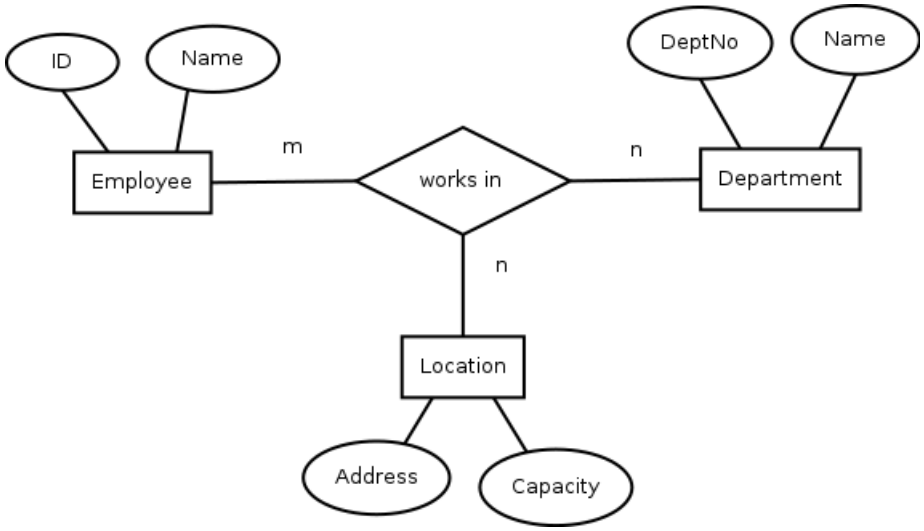
- An entity is a collection of entities of the same type
- All entities in the same set have the same attributes (cicles)
- *Student* is the entity and *{Id, Name, GPA, Major}* are the attributes (circles)
- Each entity has a primary key

- The key should depend on a real life situation and not the current set of data

2 Relationship Between Entities



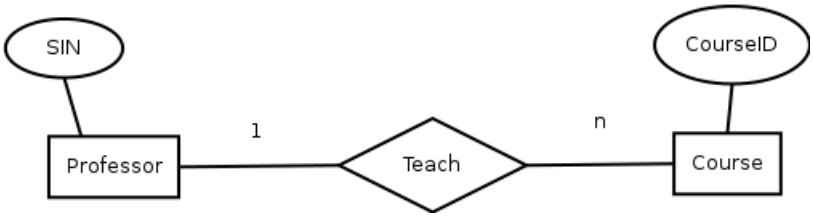
2.1 Many to Many Relationship



1. A student can take many courses

2. A class can have many students

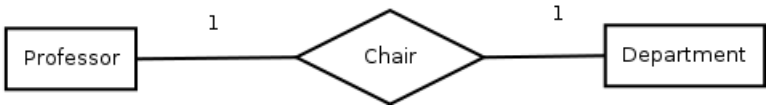
2.2 1 to Many Relationship



1. A professor can teach many classes

2. A class is taught by 1 professor

2.3 1 to 1 Relationship

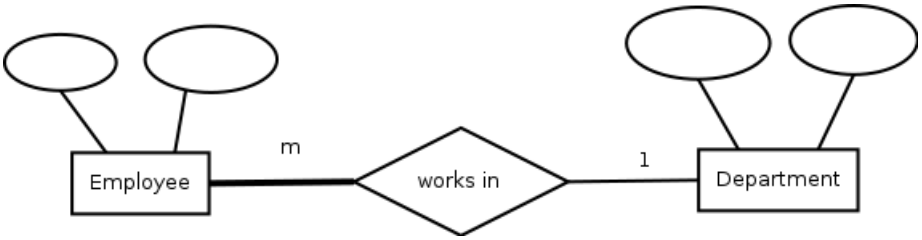


1. A department has only one chair
2. A professor is the chair of only one department

Note: Every entity has a key and every relationship has a key.

A relationship does not have to be binary.

2.4 Total Participation



- Everyone is involved ⇒ total participation (**thick line**)

2.5 Recursive Relationship

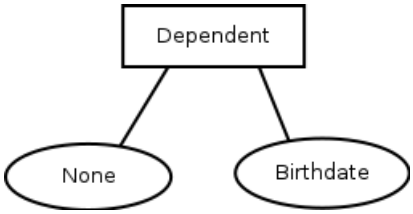
- An entity can only appear once in a design
- The key for the relationship (Id) - in our example

2.6 Weak Entity

- Entity without superkey

Note: Thick [box] lines implies weak entity.

Example 8.

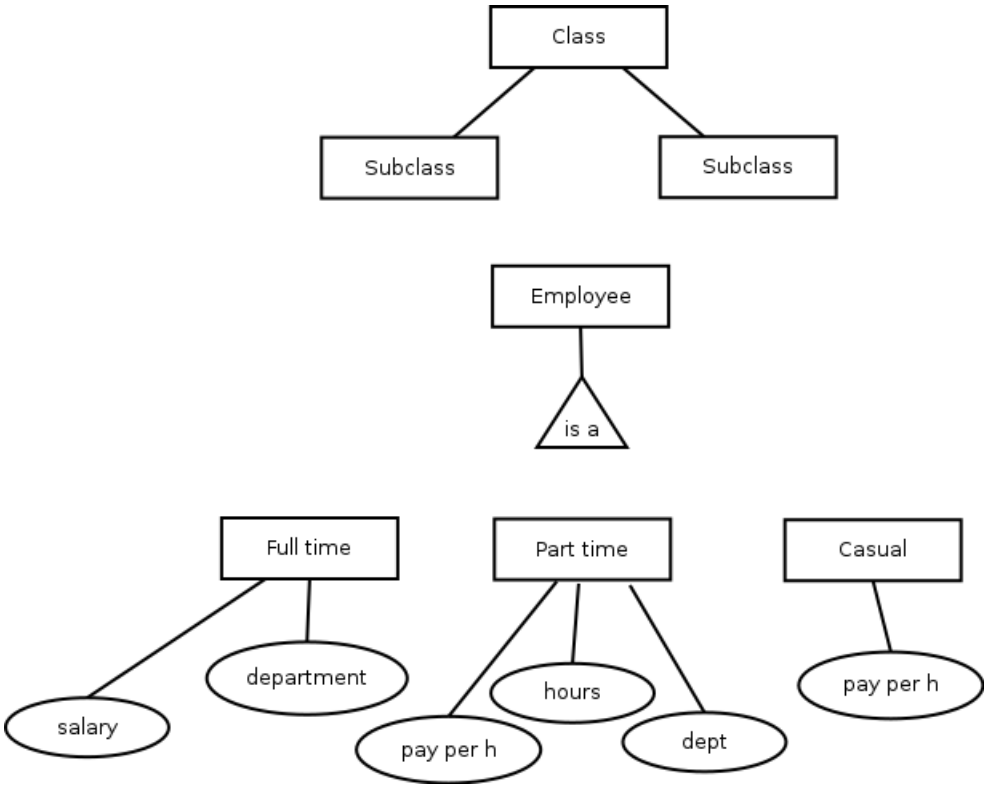


2.7 Strong Entity

- Entity with a super key (primary key)

- Everything so far is a strong entity

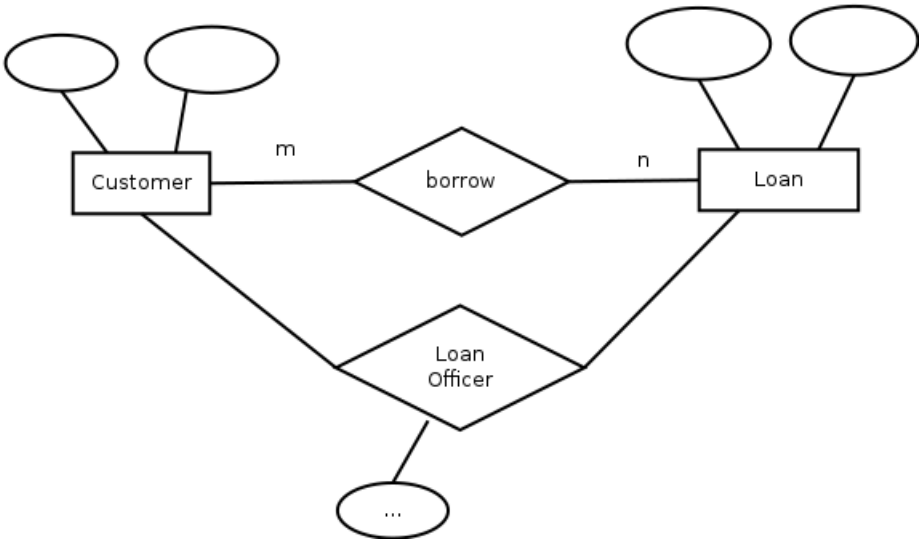
3 Class Hierarchies



The subclasses are disjoint.

4 Aggregation

- Abstraction to group relationships



5 Issues in Conceptual Design Using the ER Model

1. Should a concept be modeled as an attribute or as an entity
    - Refer to employee one
    - Employees can have multiple addresses (sub address with employee to create new entity with attributes)
    - If we wanted to conduct searches in the address - it would be easier with address as an entity (ex. search for a city within a country)
    - Refer to picture - it is wrong, solution: look to next picture (make from and to as entity instead of attribute)

6 ER to Relational Database Mapping

Step 1

For each strong entity set, E, create a table (relation), R, that includes all attributes of E. The key for the entity will be the key for the table (relation).

$$\text{strong entity} \Rightarrow \text{table}$$

Step 2

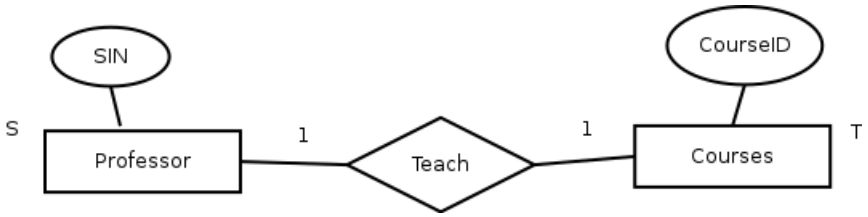
For each weak entity set, W, create a table, R, that includes all attributes of W and include it as a foreign key, the primary key of the owner entity. The key for the relation is the partial key and the key of the own entity.

{table for employee-dependents}

Step 3

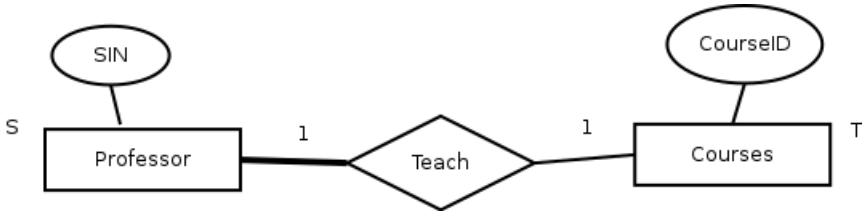
For each 1:1 relationship between two strong entitie, S and T. **No** new table (relation) is required. Just add the primary key of S as a foreign key in T.

Example 9.




```
professor(SIN, ..., ...)
courses(courseID, ..., ..., SIN)
```

If total participation exists in S, we should add the primary key of T as a foreign key to S.



Every professor much teach one course and the course cannot be taught by more than one professor.

Step 4

For each 1:n relationship between two strong entities S and T. No new table is required. Just add the primary key of S as a foreign key in T.

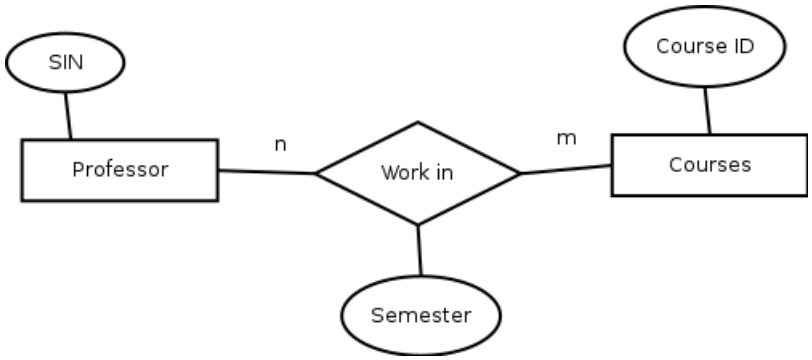
Example 10.

`Employee(id, ..., ..., departmentID)`
`                    -------------`

Step 5

For each many to many relatonship between S and T, create a new table (relation) that contains the primary key of S and T. The key for the new table is the primary key of both S and T together.

Example 11.



`Teaches(SIN, CourseID, semester)`

Example 12.