Database Concepts

- **What is a database?**

A database consists of a collection of interrelated data.

What is database management system (DBMS)?

A system which is used for creating new database, retrieving, inserting, deleting and updating database information, using a data definition language (DDL), and a data manipulation language (DML), respectively.

Advantages of Using Database Systems

- Centralized control of a firm's data

- Redundancy can be reduced
  (avoid keeping copies of the same data in many places)
- Inconsistency can be avoided to some extent
  (updating occurs at one place instead of many places)

Advantages of Using Database Systems (cont'd)

- The data can be shared
- Security restrictions can be applied (passwords)
- Integrity of data can be maintained (e.g., an instructor has to exist before being assigned to teach a class)

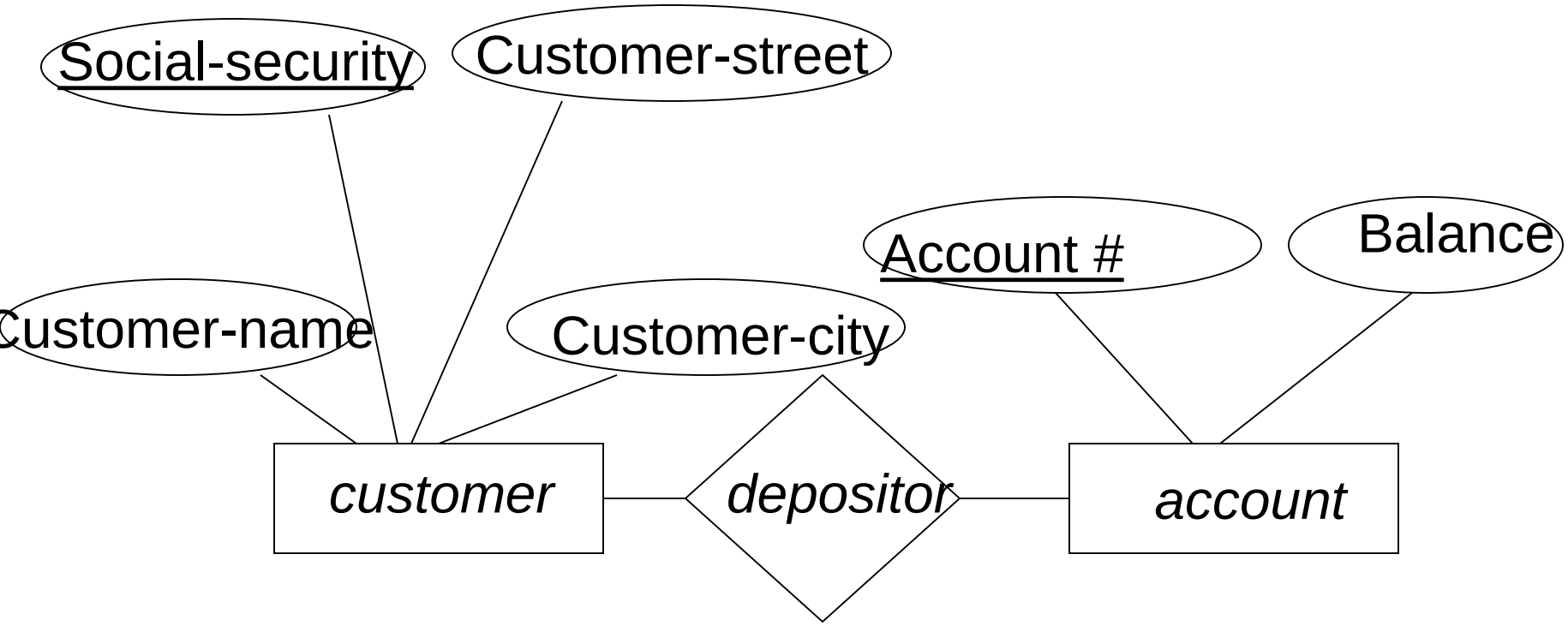
Data Models

"Underlying the structure of a database is the data model: A collection of conceptual tools for describing data, data relationship, data semantics, and constraints."

- **Object-based model**
  (1) entity-relationship model ←
  (2) object-oriented model

- **Record-based model**
  (1) relational data model
  (2) network model
  (3) Hierarchy model

Entity-Relationship (E-R) Model



An example of E-R diagram

• The E-R model is based on a perception of a real world that consists of a collection of basic objects, called ***entities***, and of ***relationships*** among these objects.

• An ***entity*** is a “thing” or “object” in the real world that is distinguishable from other objects. For example, each person is an entity, and each bank account can be considered to be an entity.

• Entities are described in a database by a set of ***attributes***. For example, the attributes "*account-#"* and "*balance"* describe one particular account in a bank.

• One or more attributes may uniquely identify the entity. For example, "*account-#"* can uniquely identify a particular account. "*account-#*" and "*balance*" as a combination can also uniquely identify a particular account.

• The set of all entities of the same type is called an *entity set*.

For example: The set of all accounts in a bank is called ***Account***. Similarly, the set of all customers of a bank is called ***Customer***.

The table representation of an entity set

An entity set is usually represented as a table in the database. The name of the table is the same name as the entity set. For example:

Customer

SSN	Name	Street	City
586-41-4125	Brown	2404 Maile	Honolulu
332-18-6752	Yang	809 Dole St.	Honolulu
121-898-5569	Gregson	211 Main St.	Chicago

The table representation of an entity set

In the table, columns are called ***attributes***, rows are called ***tuples***, ***observations***, or ***records***. Each row is an entity, and the table is an entity set.

Customer

SSN	Name	Street	City
586-41-4125	Brown	2404 Maile	Honolulu
332-18-6752	Yang	809 Dole St.	Honolulu
121-898-5569	Gregson	211 Main St.	Chicago

• A ***relationship*** is an association among entities in related entity sets. For example, a ***depositor*** relationship associates a customer with each account that she has. A *relationship* can also have its own attributes.

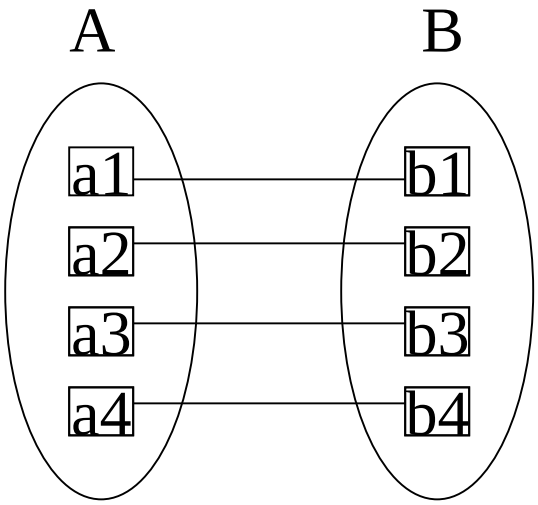
• An **Entity Relationship diagram** (*E-R diagram*) is built from the following components:

(1) **Rectangles**, which represent entity sets
(2) **Ellipses**, which represent attributes
(3) **Diamonds**, which represent relationships among entity sets.
(4) **Lines**, which link attributes to entity sets and entity sets to relationships

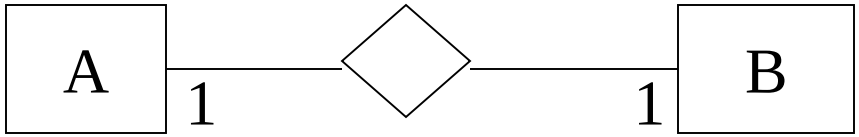
Mapping cardinalities express the number of entities to which another entity can be associated via a relationship.

- **One to one**.
- **One to many**.
- **Many to one**.
- **Many to many**.

<u>One to One</u>. An entity in *A* is associated with at most one entity in *B*, and an entity in *B* is associated with at most one entity in *A*.



One to One

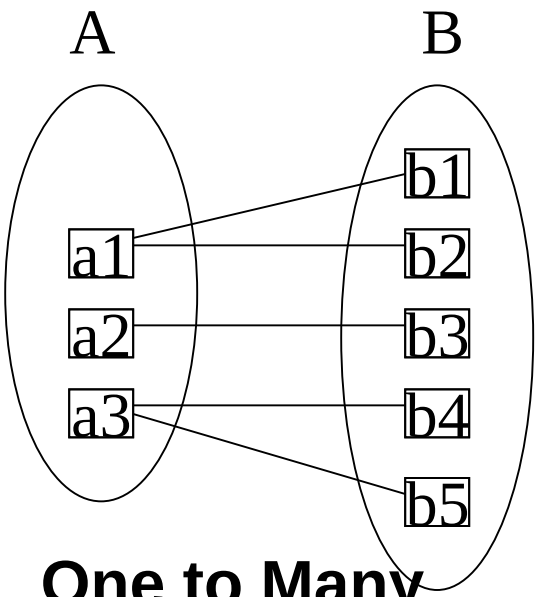


One to One. An example.

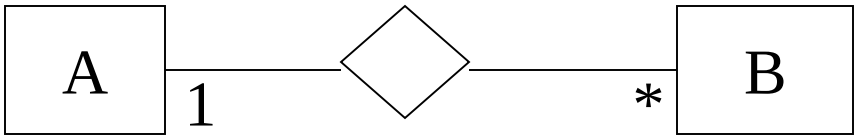
A: Husband

B: Wife

<u>One to Many</u>. An entity in *A* is associated with any number of entities in *B*. An entity in *B*, however, can be associated with at most one entity in *A*.



One to Many

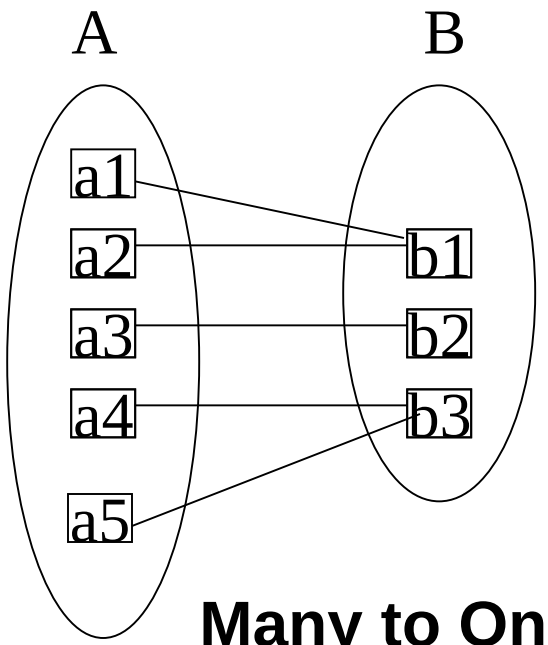


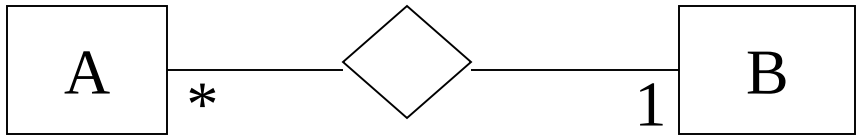
One to Many. An example.

A: Mother

B: Child

Many to One. An entity in *A* is associated with at most one entity in *B*. An entity in *B*, however, can be associated with any number of entities in *A*.





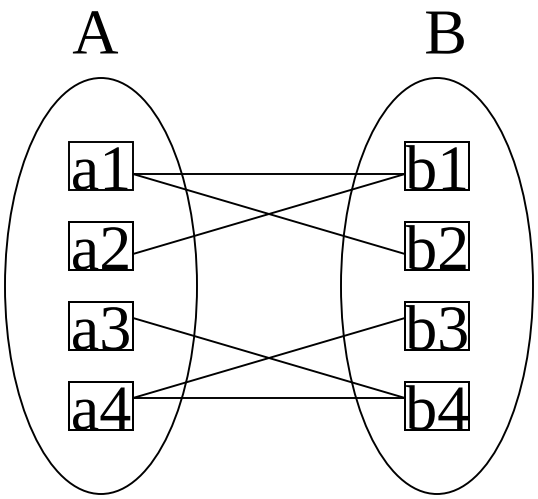
Many to One

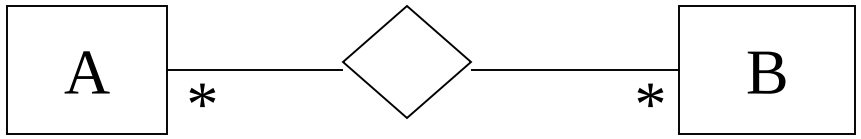
Many to One. An example.

A: Child

B: Mother

Many to Many. An entity in *A* is associated with any number of entities in *B*, and an entity in *B* is associated with any number of entities in *A*.





Many to Many

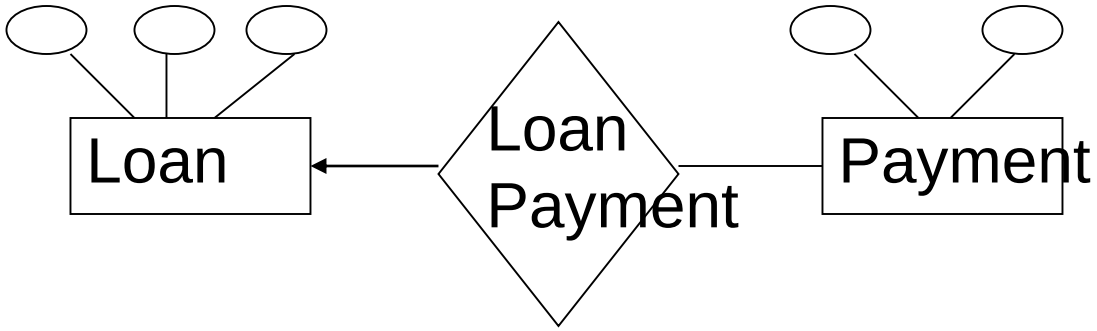
Many to Many. An example.

A: Brother

B: Sister

Existence Dependency

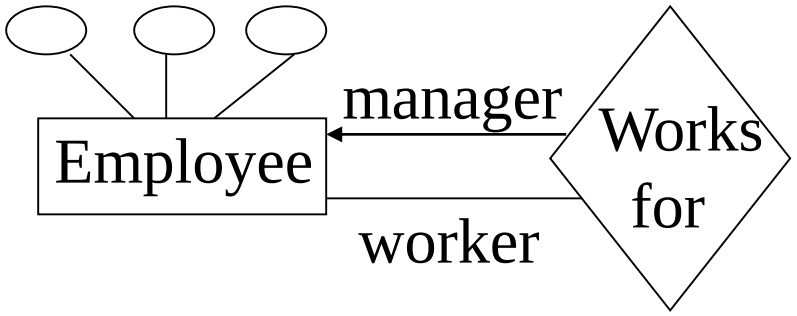
- If the existence of entity *X* depends on the existence of entity *Y*, then *X* is said to be existence dependent on *Y*. *Y* is a dominate entity and *X* is a subordinate entity.



-- If a “loan” entity is deleted, then all its associated payment entities must also be deleted

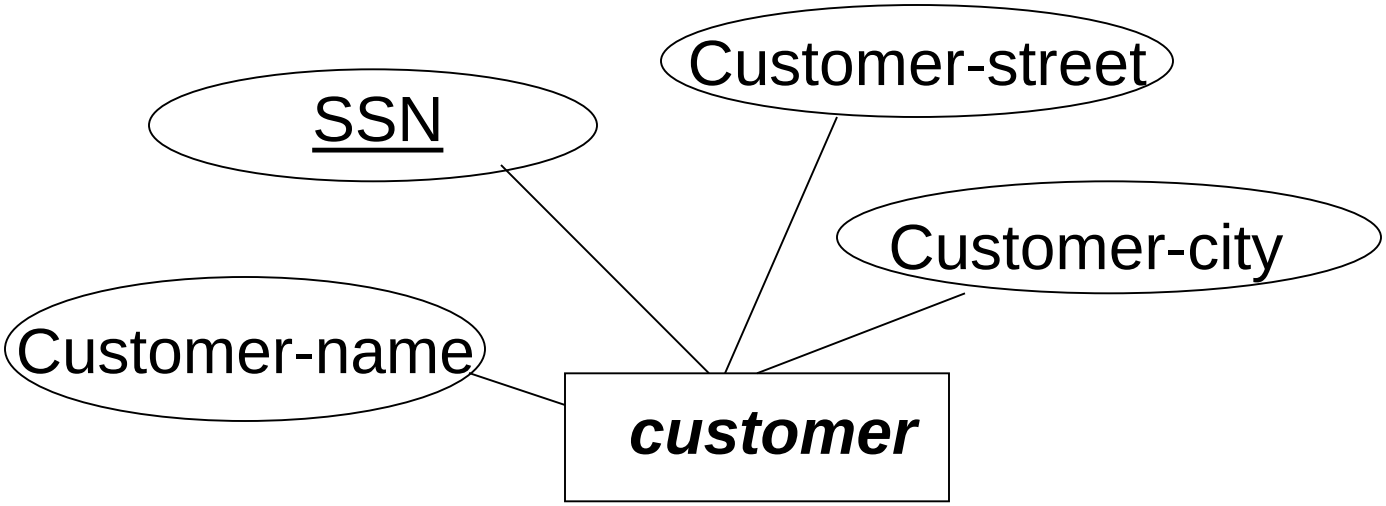
The role of an entity in a relationship is usually implicit, and is therefore not specified. However, when the entity sets of a relationship are not distinct, then the role of the entity should be specified.

For example,



Keys

It is important that any entity in an entity set be uniquely identifiable. Practically, we use the values of certain attributes to uniquely identify an entity. For example, when the clerk at a bank keys in a customer's SSN, the customer's full information can be brought up. Also, if she keys in both SSN and the customer's name, the same customer's information will be brought up.



In this particular case, the value of the combination of any attribute(s) with SSN can uniquely identify a particular customer.

Keys

Meanwhile, it is also obvious that some of these combinations may have redundant attributes.

Therefore, in theory, we systematically classify these combinations of attributes using three types of Keys: superkey, candidate key, and primary key.

Keys

(1) <u>Superkey</u>: is a set of attributes whose value can uniquely identify an entity in the entity set.

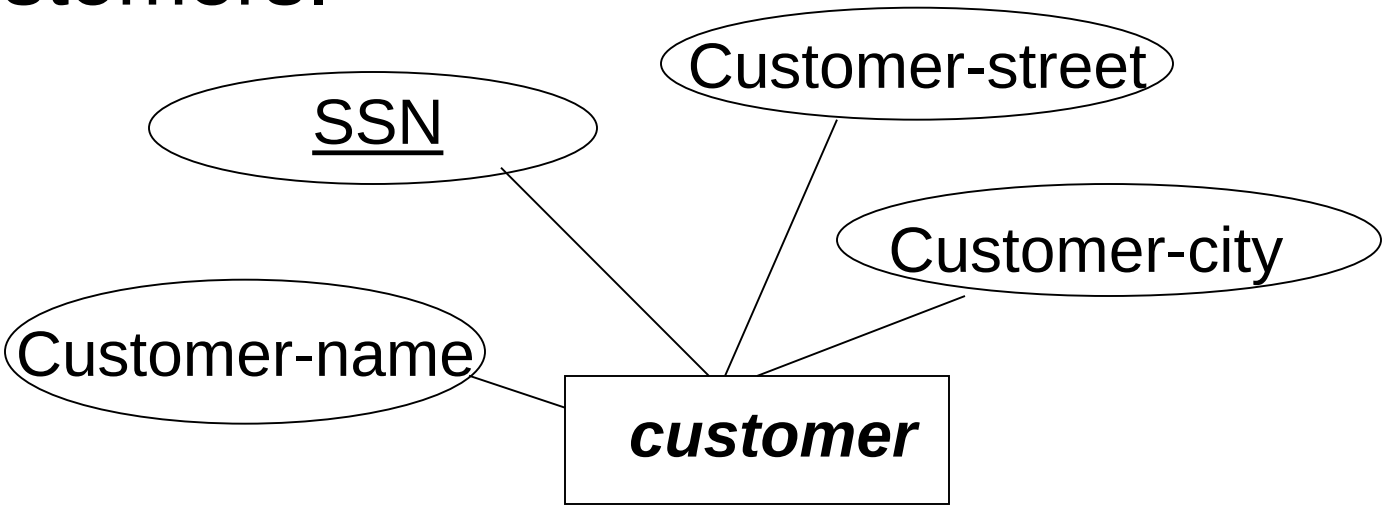
A superkey contains one or more attributes.

Example:

The combination of “SSN” and “Name” is a superkey of the following entity set ***customer***.

Because:

The value of attributes “SSN” and “Name”, such as 558-36-1234 and Susan, can uniquely identify that particular customer in ***customer*** entity set, which is the pool of all customers.



Notationally, we write,
Superkey: (SSN, name)

Other superkeys for the entity set ***customer***:

Superkey: (SSN)
Superkey: (SSN, Street)
Superkey: (SSN, City)
Superkey: (SSN, Name, Street)
Superkey: (SSN, Name, City)
Superkey: (SSN, Street, City)
Superkey: (SSN, Name, Street, City)

Superkey is the broadest definition of unique identifiers of an entity in an entity set.

We are unsurprisingly very interested in the most economical combination(s) of attributes that can uniquely identify any particular entity.

Therefore, we introduce **Candidate Key** next.

(2) **Candidate key**: is a set of one or more attributes whose value can uniquely identify an entity in the entity set, and any attribute in the candidate key cannot be omitted without destroying the uniqueness property of the candidate key. (It is minimal superkey).

Example:
(*SSN, Name*) is NOT a candidate key, because taking out "*name*" still leaves "*SSN*" which can uniquely identify an entity. "*SSN*" is a candidate key of ***customer***.
Candidate key could have more than one attributes.

Also, while most entity sets have only one candidate key, some entity sets could have more than one candidate key.

Example: Both “SSN” and “License #” are candidate keys of ***Driver*** entity set.

In building a database in a database software, the software will only allow to use one candidate key to be the unique identifier of an entity for an entity set.

(3) **Primary Key**: is the candidate key that is chosen by the database designer as the unique identifier of an entity. The database designer chooses only one candidate key as the primary key in building the system.

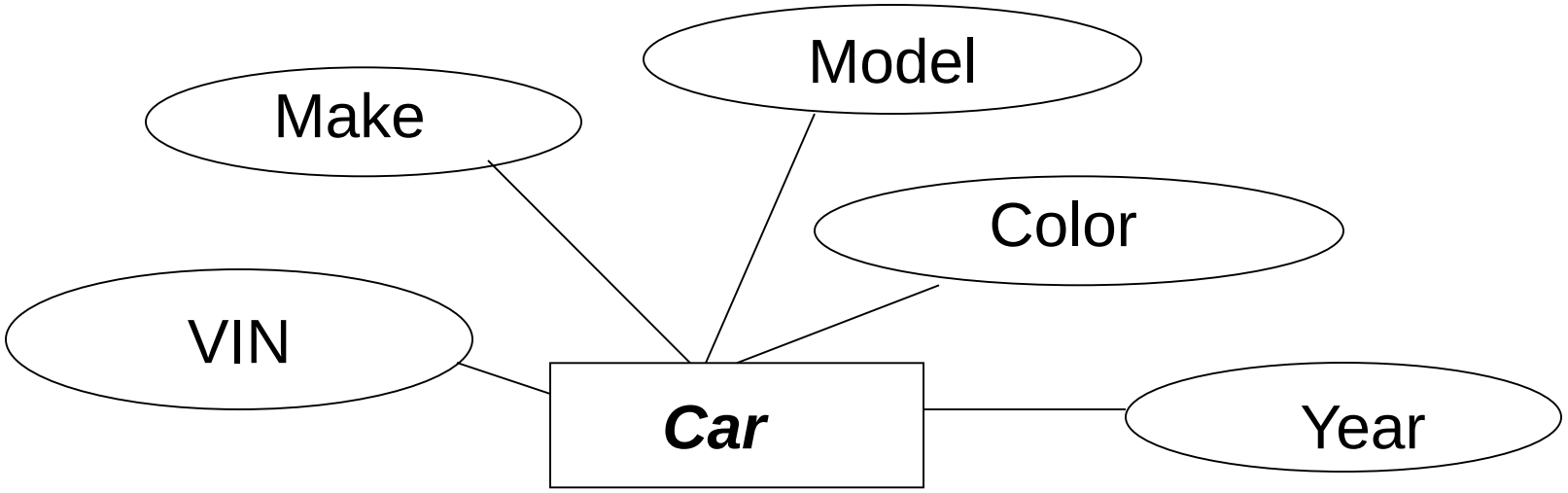
Example: "SSN" and "License #" are both candidate keys of ***Driver*** entity set. The database designer can choose either one as the primary key.

In an E-R diagram, we usually underline the primary key attribute(s).

Overall, superkey is the broadest unique identifier; candidate key is a subset of superkey; and primary key is a subset of candidate key.

In practice, we would first look for superkeys. Then we look for candidate keys based on experience and common sense. If there is only one candidate key, it naturally will be designated as the primary key. If we find more than one candidate key, then we can designate any one of them as primary key.

For example, think about the mental process of finding the primary key of the following entity set.



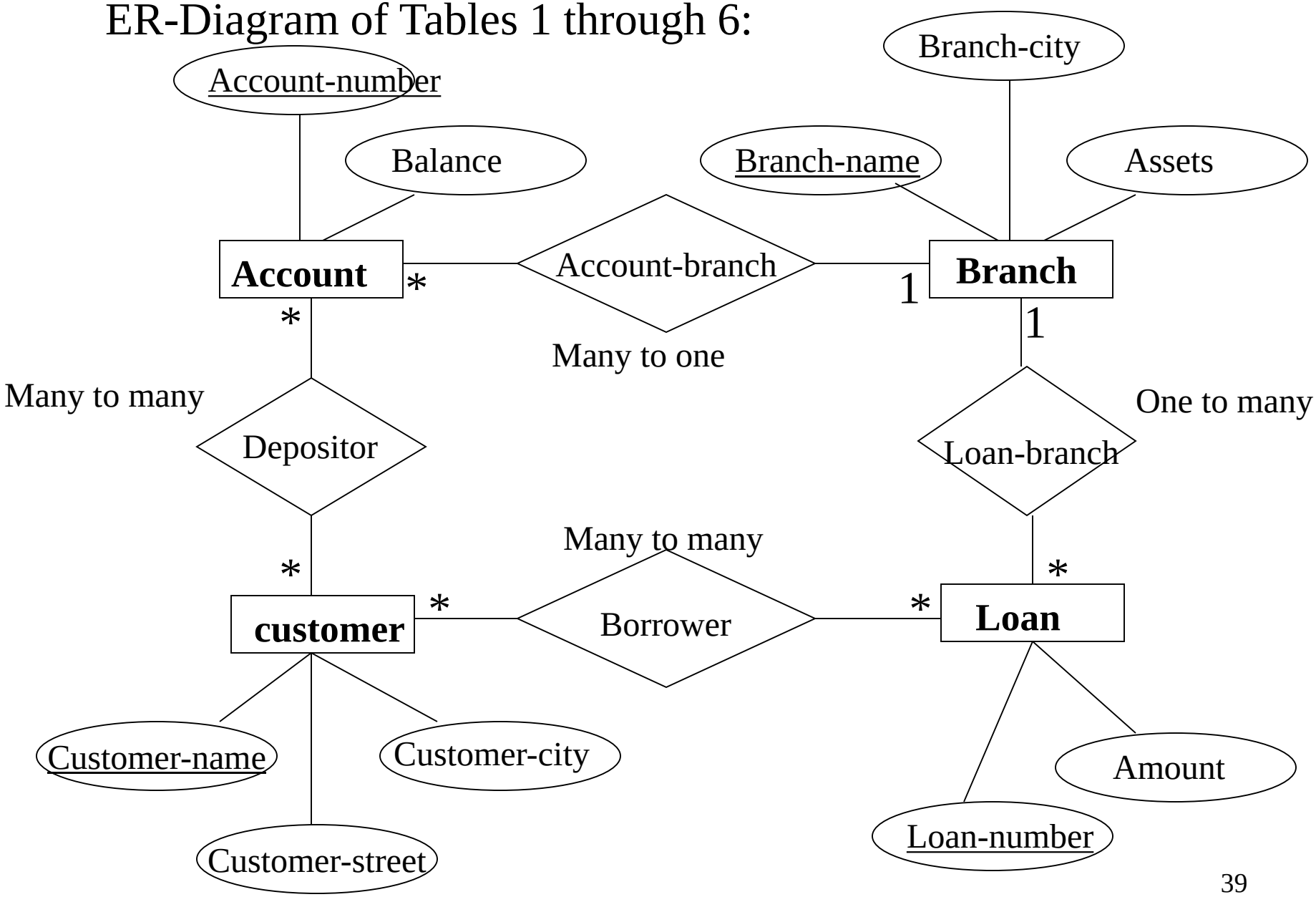
HW

Construct an E-R diagram for a university's registrar's office. The office maintains data about each class, including the instructor, the enrollment, and the time and place of the class meetings. For each student-class pair, a grade is recorded.

Specify the mapping cardinalities between all related entity sets.

(hint: there are three entity sets, instructor, student, and class)

ER-Diagram of Tables 1 through 6:



Creating Tables from E-R Diagram

Two Steps:

1. **Each entity set has its own table.**

Example: *account:* (account-number, balance)

branch: (branch-name, branch-city, assets)

Note: Primary key attribute(s) is (are) underlined.

Creating Tables from E-R Diagram (cont'd)

Two Steps:

2. Each relationship should be accounted for.

How to account for the relationships? →

- **One to One relationship**

We can do either:

(1) put the primary key of one entity set into the table of the other side.

Exception

If one entity set occurs prior to the other entity set, you can only put the primary key of the first entity set into the table of the second entity set, and NOT the other way around.

Or

(2) create a new table that contains the primary keys of both entity sets.

- **One to Many or Many to One.**

Put the primary key of the entity set on the “one” side into the table of the entity set on the “many” side.

Example: The relation of *account-branch* is accomplished by putting the primary key of *branch* into the table of *account*, and the relationship does not require a separate table. Now the *account* table becomes:

account: (account-number, balance, branch-name*)

“branch-name” is called **Foreign Key** in the *account* table and it is used to link the *account* table and the *branch* table.

Foreign key has an * beside it.

The same thing happens to the “loan-branch” relationship.

- **One to many or Many to one relationships (Exception).**

If the many entity set occurs first, you **cannot** put the primary key from the one side into the many side.

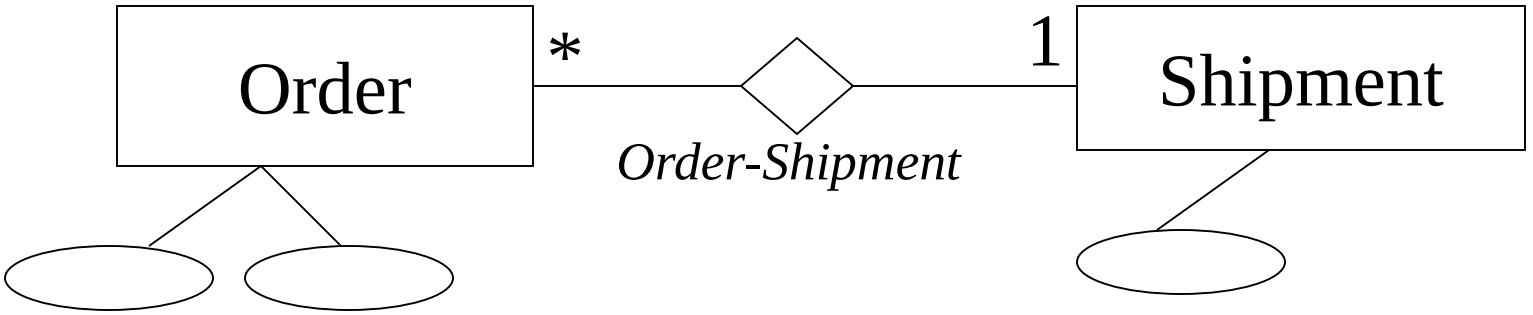
For example, the following model describes the relationship between customer order and shipment. It is a many-to-one relationship, meaning that each customer order can be delivered once, while each delivery can have several customer orders.

In this case, the following tables do **not** work.

Shipment: (Shipment-number, …)

Order: (Order-number, Shipment-number*, …)

This field has to be left blank
Until shipment occurred
This is wrong.



- In this case, we create a new table including the primary keys on both sides.

That is,

Shipment: (Shipment-number, …)

Order: (Order-number, …)

Order-Shipment: (Order-number*, Shipment-number*)

• Many to many relationship

Requires a separate table (**bridge**) to represent the relationship. The primary key of this bridge table consists of the primary keys of the entity sets on both sides of the relationship.

Example: The relationship “depositor” is implemented by table:

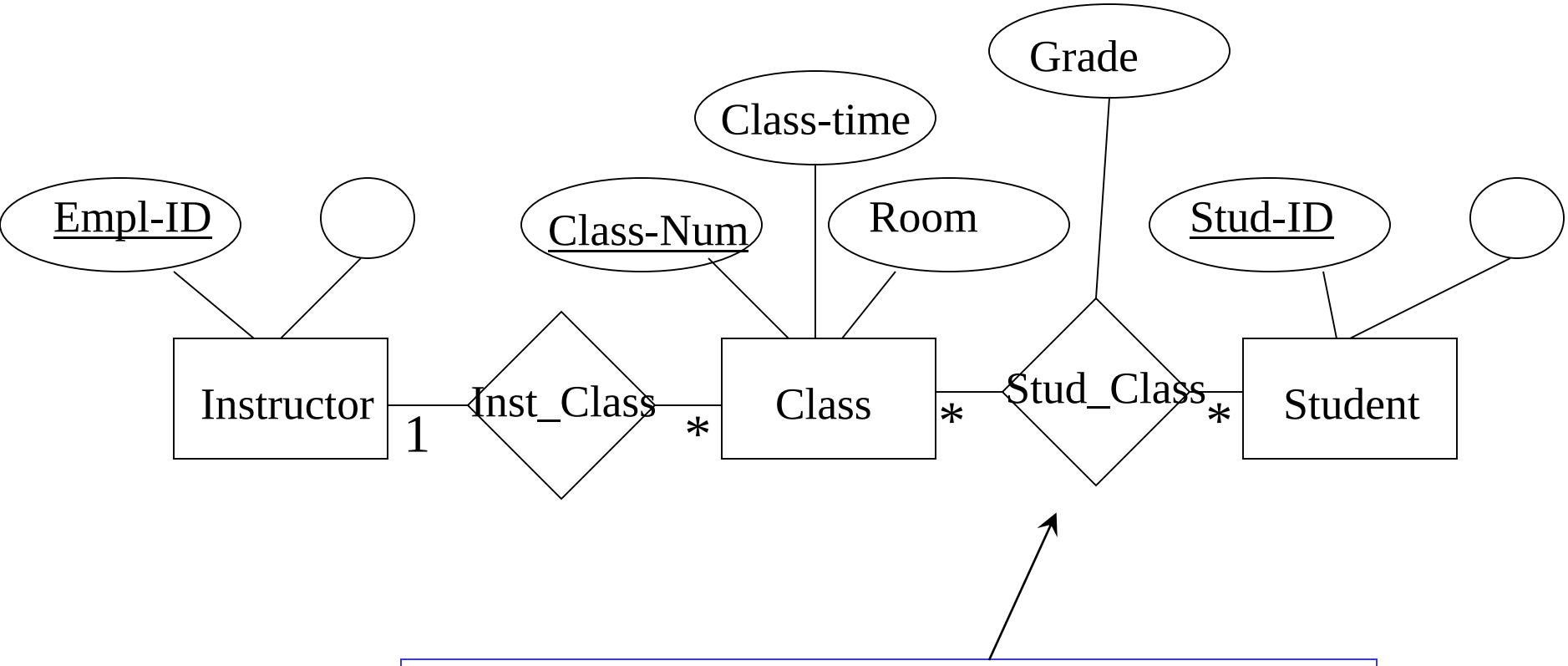
depositor: (customer-name*, account-number*)

The same happens to the “borrower” relationship.

Revisit the Example of Registrar's Office

Construct an E-R diagram for a university's registrar's office. The office maintains data about each class, including the instructor, the enrollment, and the time and place of the class meetings. For each student-class pair, a grade is recorded. Specify the mapping cardinalities between all related entity sets.
(hint: there are three entity sets, instructor, student, and class)

E-R Diagram and Mapping Cardinalities:



Note: A relationship sometimes has it own attribute(s). In such case, the relationship has to be a separate table.

Suggested Structure of Tables:

Instructor:

(Empl-ID, Empl-name, Empl-address, Empl-phone)

Class:

(Class-Num, Class-time, Room, Empl-ID*)

Student:

(Stud-ID, Stud-name, Stud-address)

Stud_Class:

(Class-Num*, Stud-ID*, Grade)

Homework (no need to turn in):

Create the structure of tables for the E-R diagram of the customer database in the bank.