BITS, PILANI – K. K. BIRLA GOA CAMPUS

Database Systems and Applications

(IS F243)

by

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Chapter 2: Entity-Relationship Model

- Entity Sets
- Relationship Sets
- Design Issues
- Mapping Constraints
- Keys
- E-R Diagram
- Design of an E-R Database Schema

Data model

- A data model is the collection of tools for describing data, data relationship and consistency constraints.

- Data models:
  - ER model- high level data model
  - Relational model- low level data model
  - Hierarchical model
  - Network model
  - Object oriented model
  - Object relational model

ER model

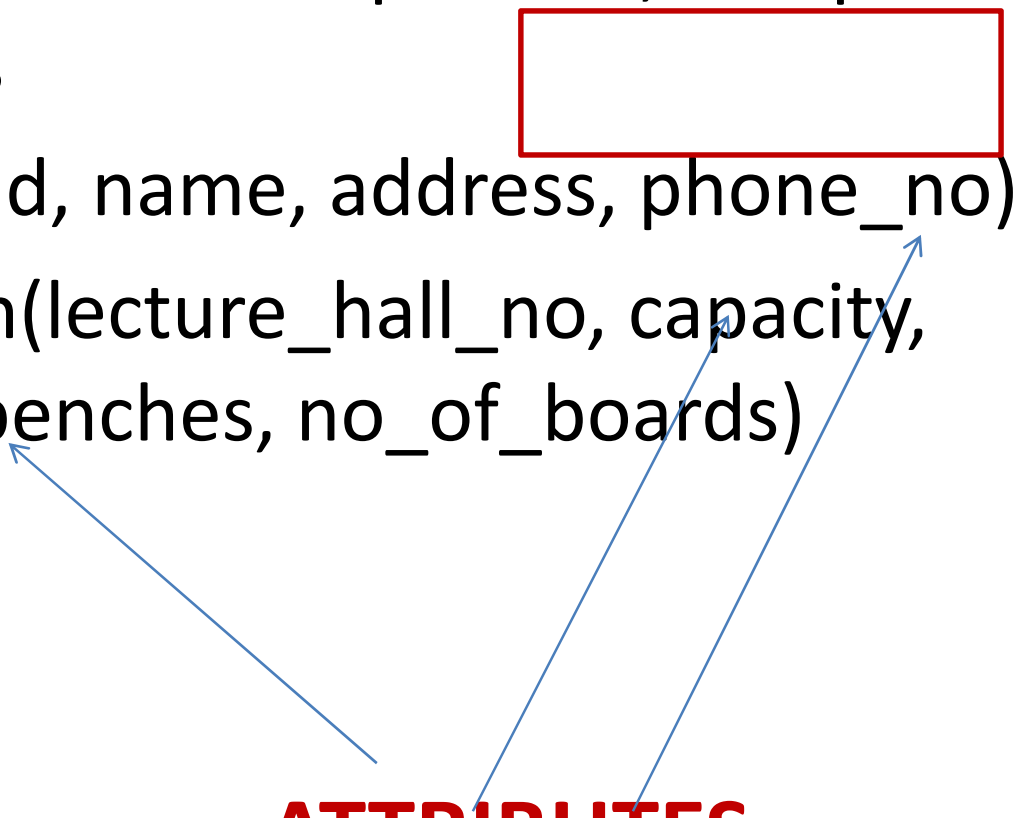
- **E**ntity **R**elationship model
- The ER model perceives the real world as consisting of basic objects, called **entities,** and **relationships** among these objects.
- **Entity:** An entity is an object that exists and is distinguishable from other objects.
  - Example: specific person, company, event, plant

ENTITY SET

- **Entity set:** An entity set is a set of entities of the same type that share the same properties.
  - Example: set of all persons, companies, trees, holidays

Person(uid, name, address, phone_no)

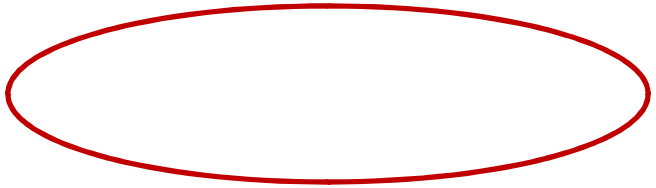
Classroom(lecture_hall_no, capacity, no_of_benches, no_of_boards)



ATTRIBUTES

ATTRIBUTE

- An entity is represented by a set of attributes, that is **descriptive properties** possessed by all members of an entity set.



Example:

customer = (customer-id, customer-name, customer-street, customer-city)

account = (account _no, balance_amt)

loan = (loan-number, amount)

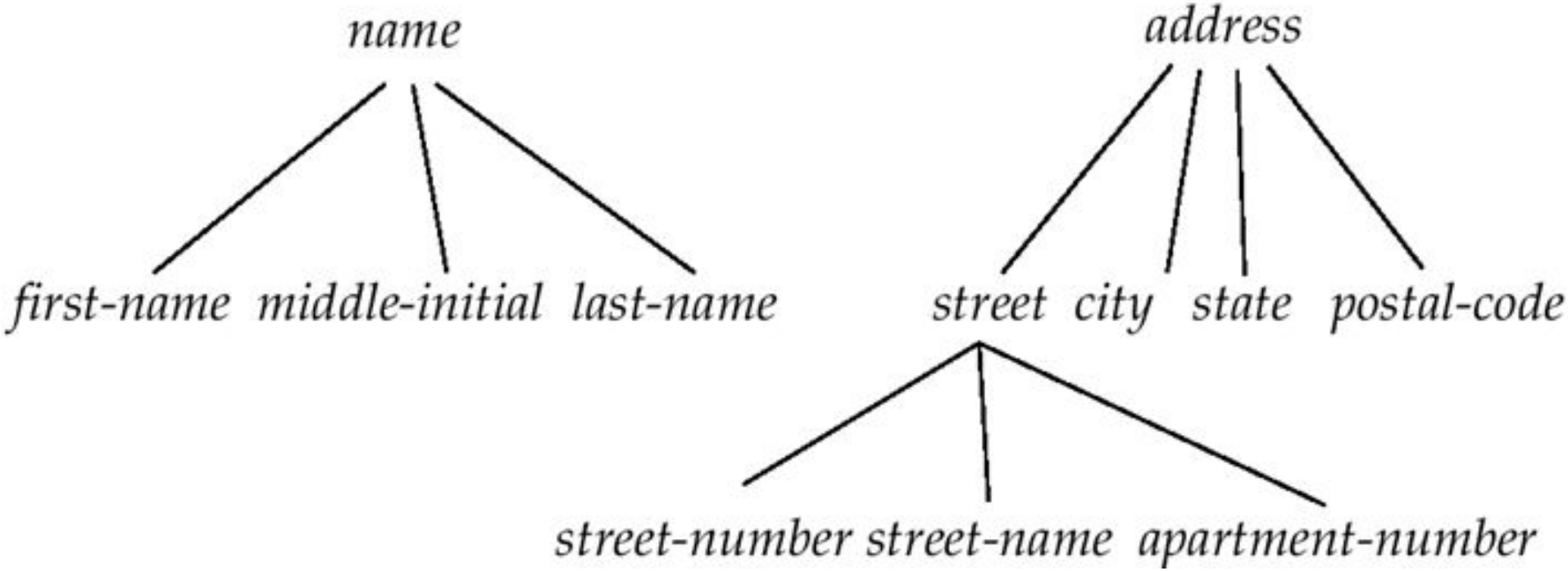
Notation: Ellipse

ATTRIBUTES (Contd…)

- **Domain/value set –** the set of permitted values for each attribute
- Eg:
  - size of shirt { L, XL, XXL }
  - id {alphanumeric values}
  - gender should be either **'M'** or **'F'**
  - course_no shoud start with **'AAOC'**, **'BITS'**, **'CS'**, …..
  - room_no should lie between **1** to **300**

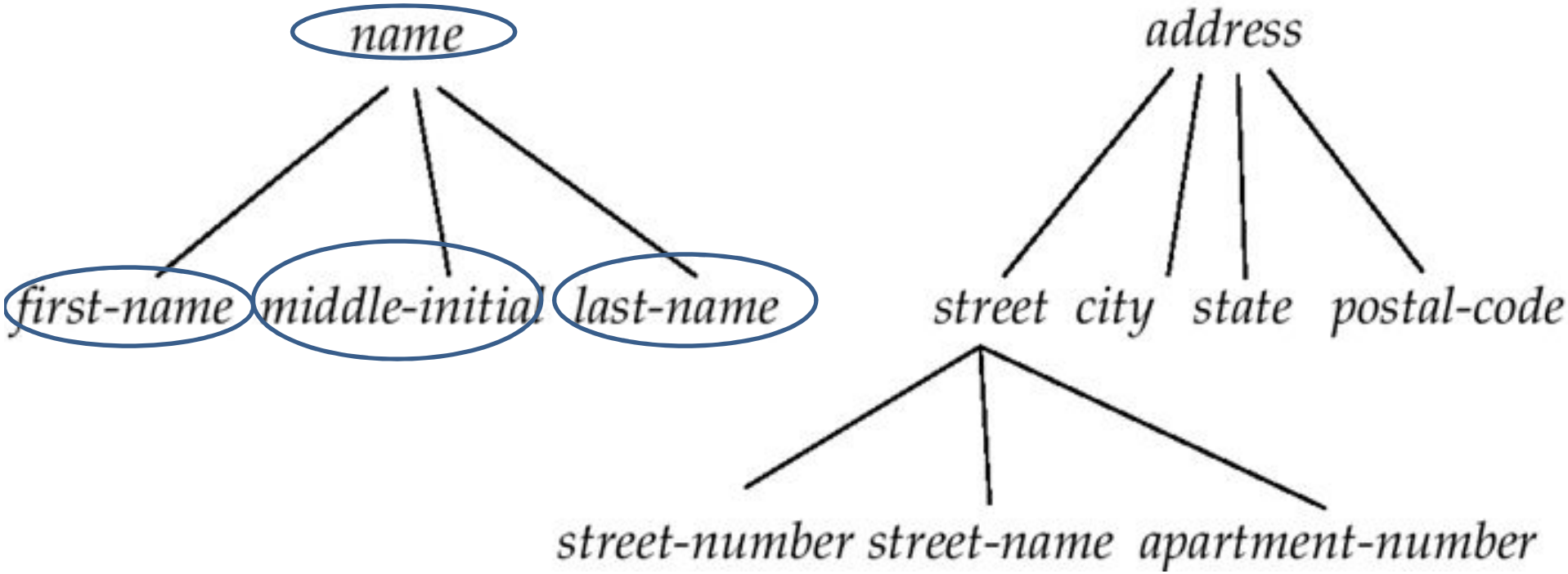
Composite attribute

- Example of attribute



Composite attribute (notation)

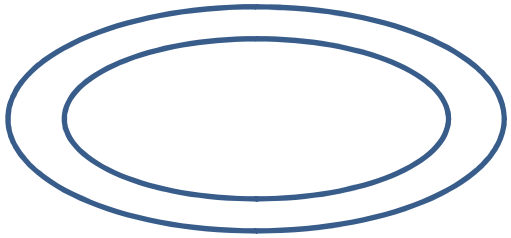
- Example of attribute



Composite attribute examples

- Aircraft location
  - Latitude
  - Longitude
  - Altitude

Multivalued attributes



Phoneno

Landline no mobile no officeno

Employee

Dependent1 Dependent2 Dependent3

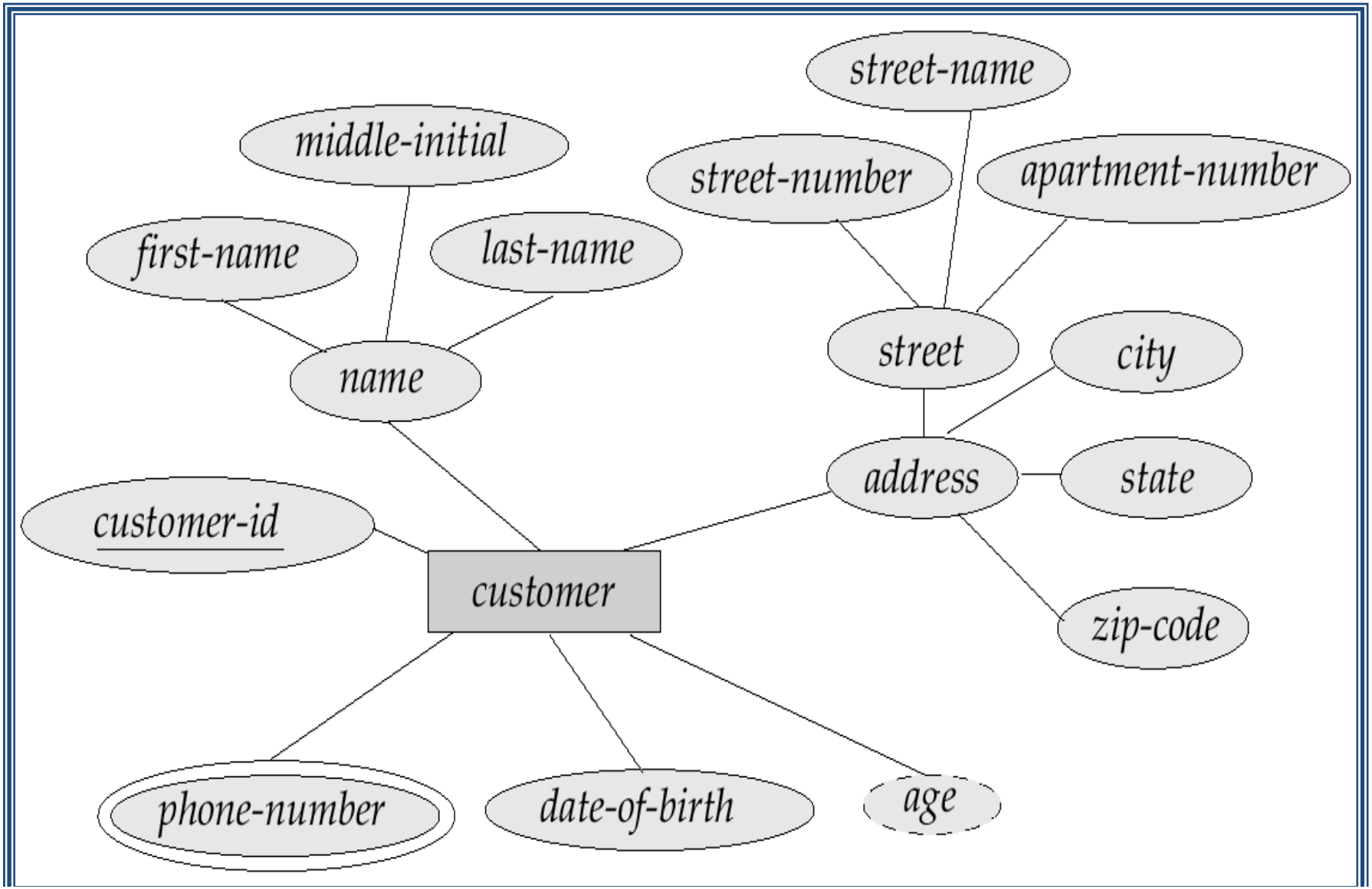
Derived attribute

- Age = today's date – date of birth
- Total marks= T1 + T2 + compre_marks
- Result = pass / fail depending on total marks
- Sal = no of days * hourly wages
- Annual salary= 12 * monthly salary
- Lib due= no of days exceeded * charge per day
- Notation : dashed ellipse

Types of attributes

- Simple and Composite
- Single valued and Multivalued
- Derived attribute

E-R Diagram with various types of Attributes



Example entity sets

BITS DB

- ❖student
- ❖course
- ❖instructor
- ❖dept

- **student**
  - st_id
  - st_name
  - birth_date
  - gender
  - address

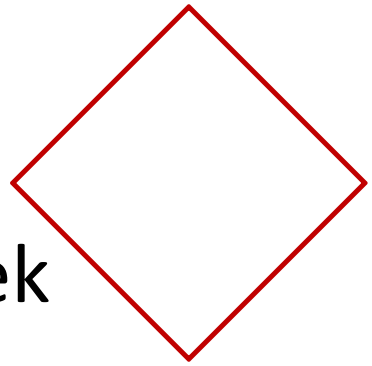
- **course**
  - course_no
  - course_title
  - units
  - l-t-p
  - Sections offered

- **instructor**
  - instructor_id
  - name
  - **dept_code**
  - specialization
  - tel_no

- **dept**
  - **dept_code**
  - dept_name
  - location

RELATIONSHIP AND RELATIONSHIP SET

- Relationship: an association among several entities.
- Relationship set: a set of relationships of same type.



E.g., Abhishek **registers** for DB course

DB course is allocated to Abhishek

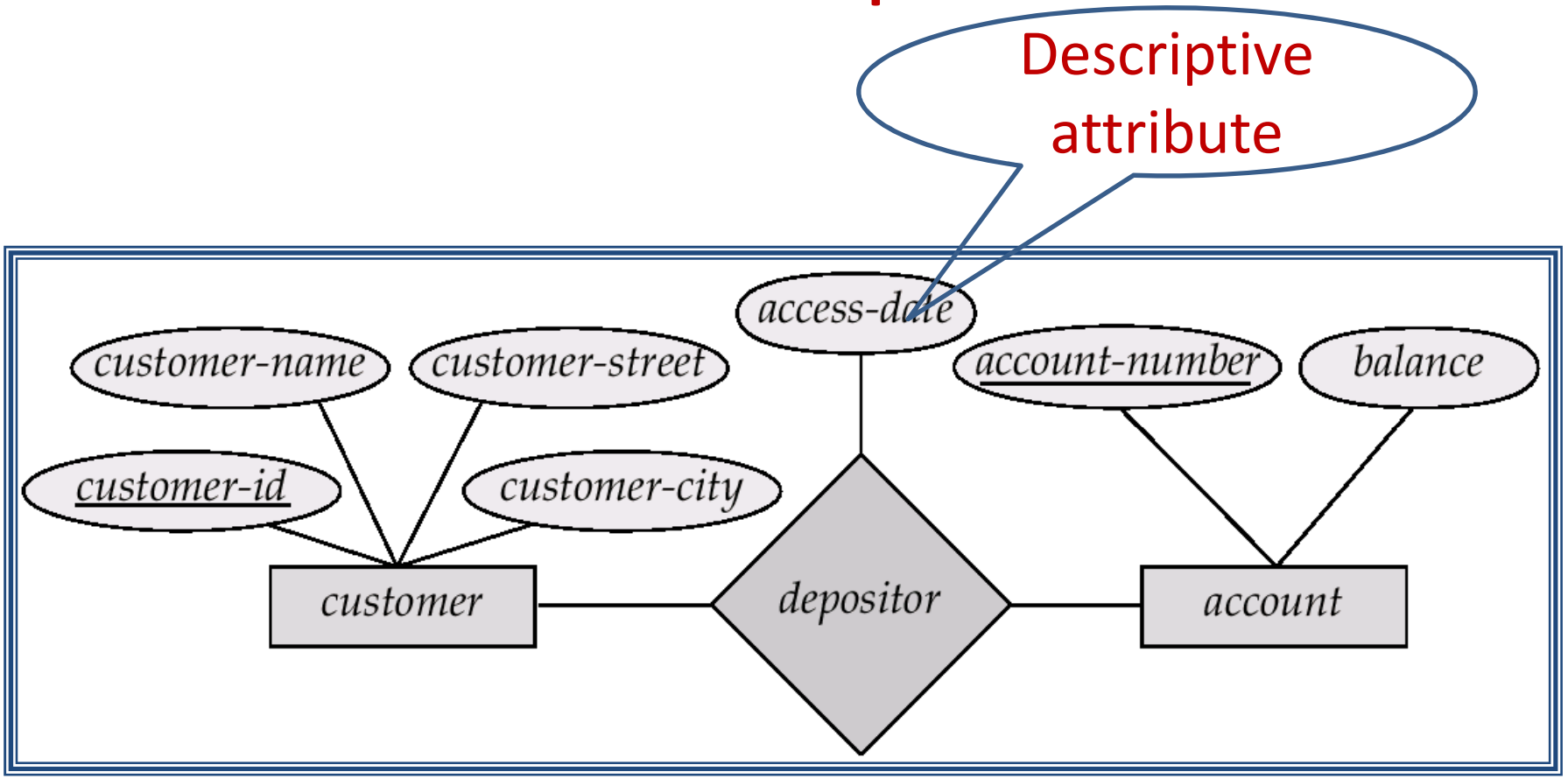
E.g., Customer C1 **holds** an Account A1

Account A1 belongs to Customer C1

E.g., Customer C2 **borrows** a Loan L1

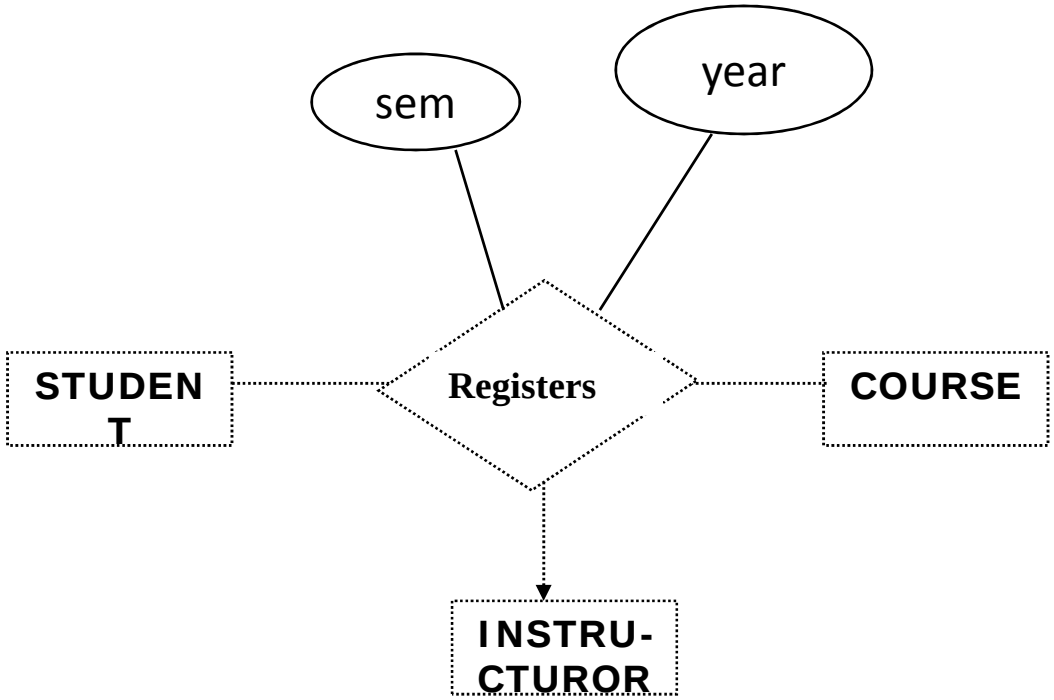
Loan L1 is taken by Customer C2

Example


Descriptive attribute
access-date
customer-name
customer-street
account-number
balance
customer-id
customer-city
customer
depositor
account

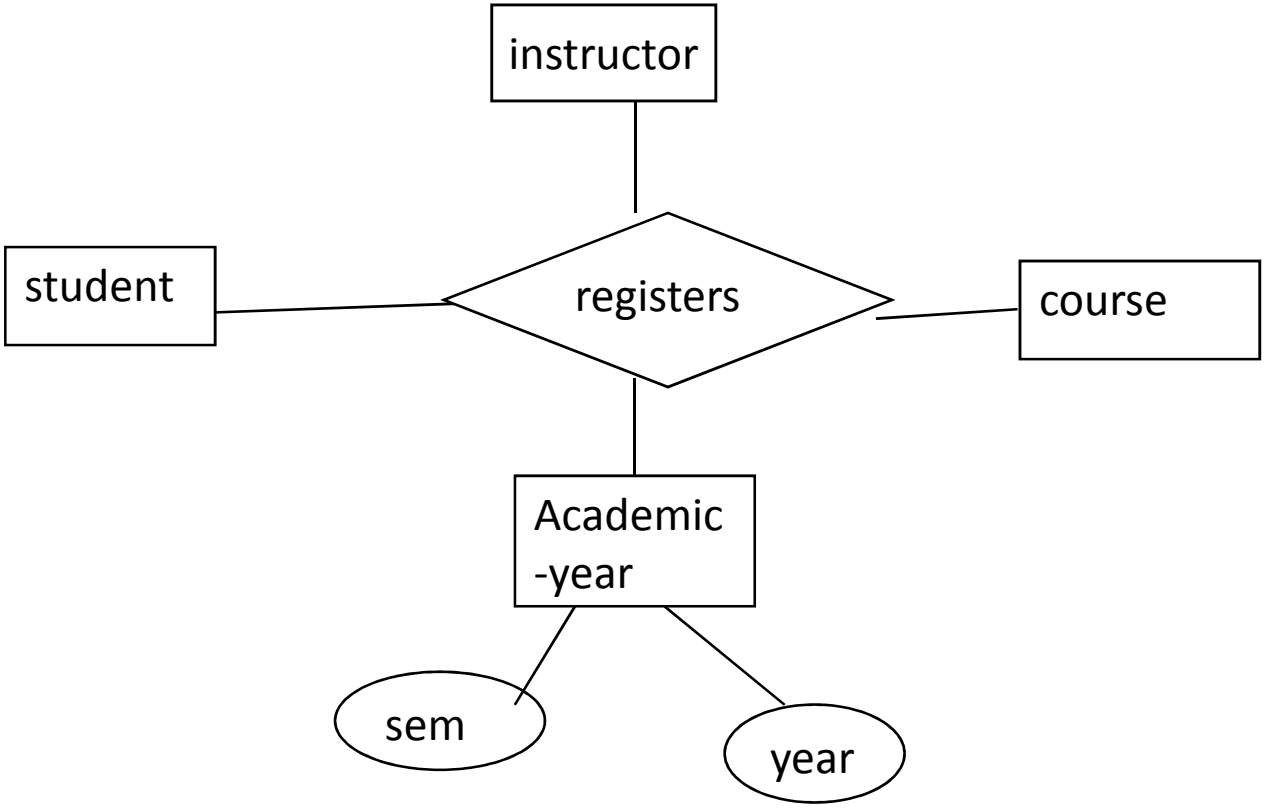
Attributes on Relationships

- Sometimes it is useful to attach an attribute to a relationship.
- Think of this attribute as a property of tuples in the relationship set.



Equivalent Diagrams Without Attributes on Relationships

- Create an entity set representing values of the attribute.
- Make that entity set participate in the relationship.



Degree of Relationships

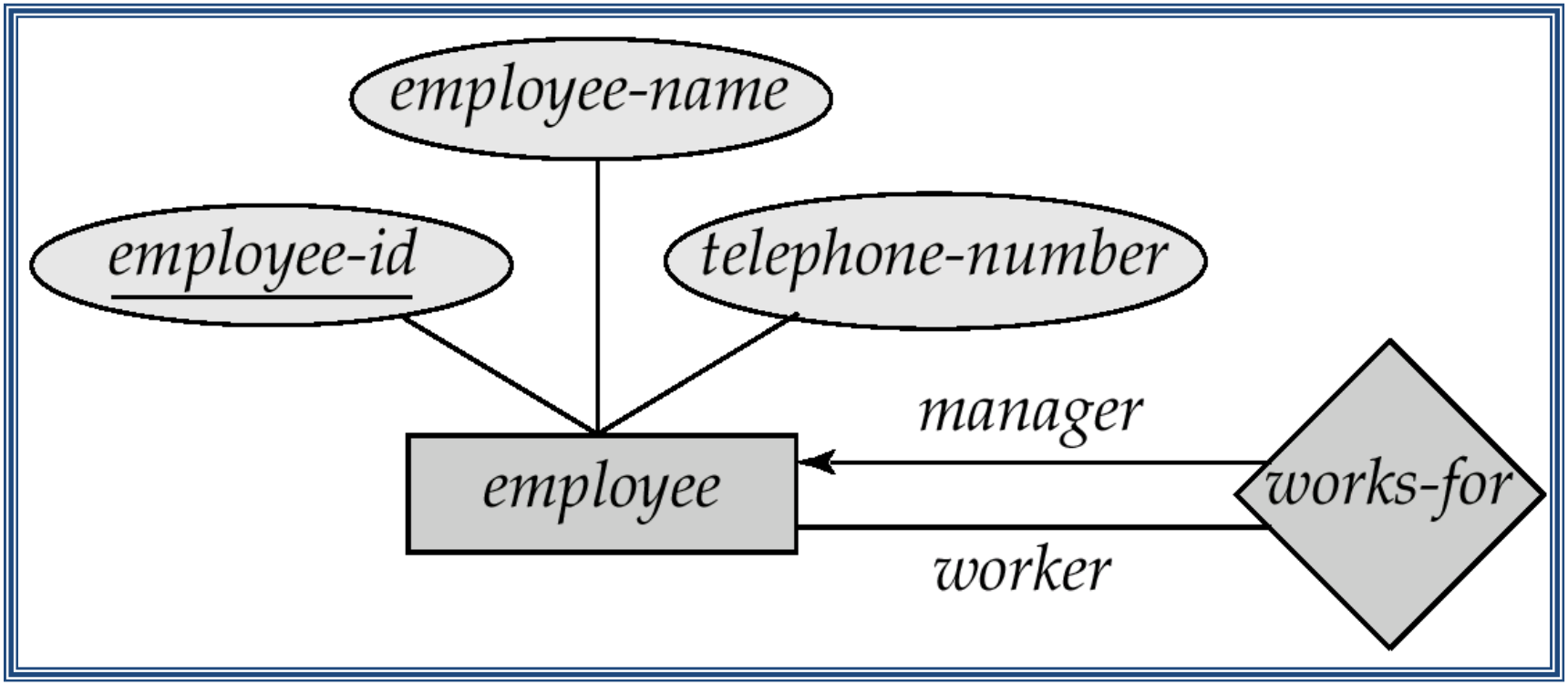
Unary, Binary, Ternary

- **Unary:** A relationship between the instances of a single entity set.

- **Binary:** A relationship between the instances of two entity sets.

- **Ternary:** A simultaneous relationship between the instances of three entity sets.

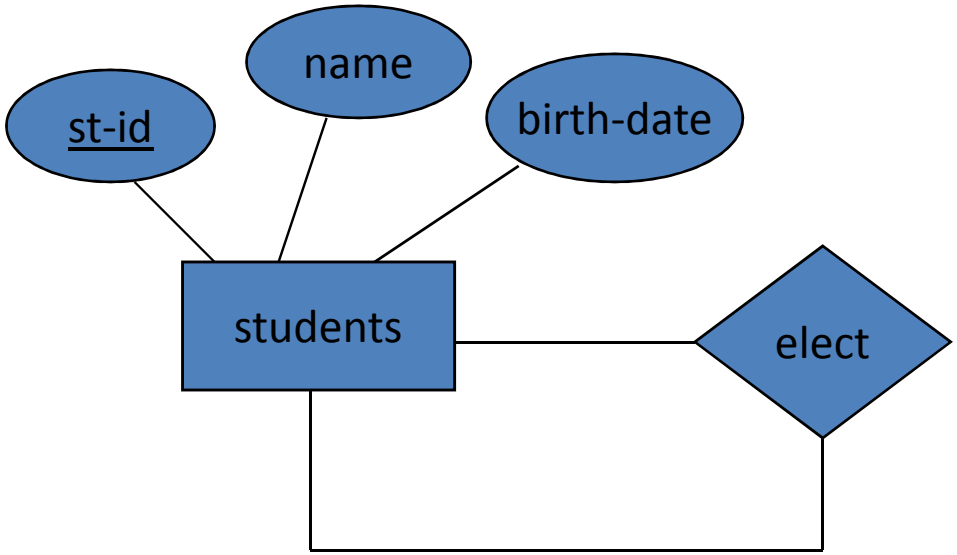
Example of Unary Relationship



Example of Unary Relationship

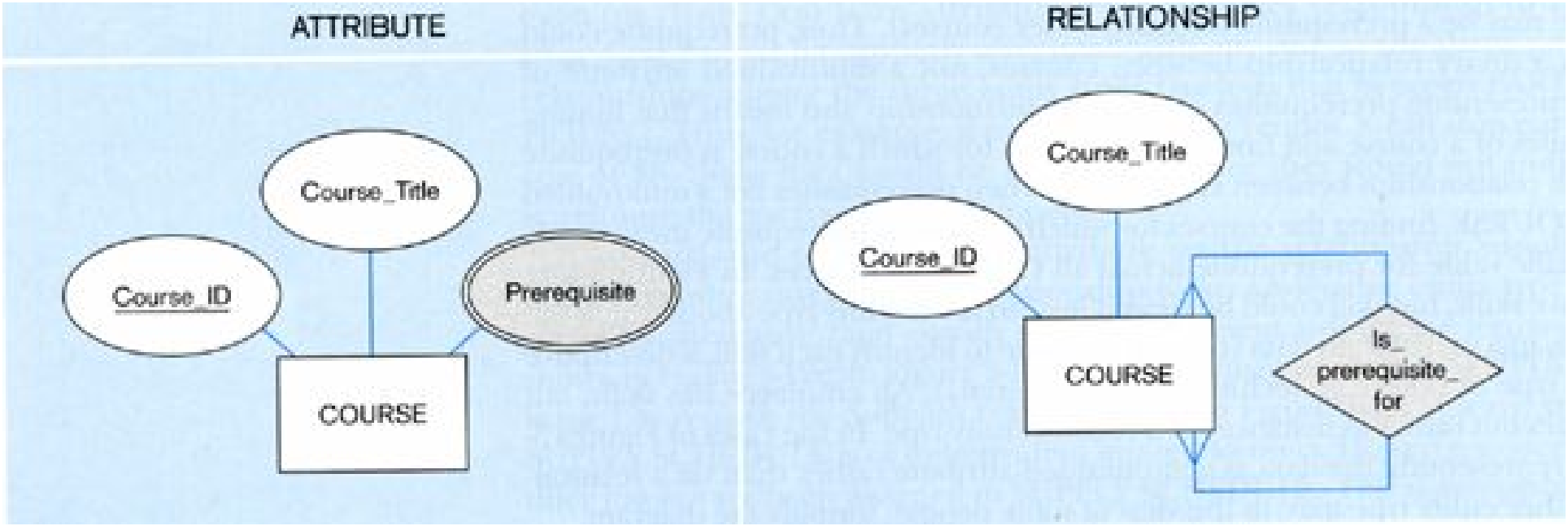
- The labels “manager” and “worker” are called **roles**; they specify how employee entities interact via the works-for relationship set.
- Roles are indicated in E-R diagrams by labeling the lines that connect diamonds to rectangles.
- Role labels are optional, and are used to clarify semantics of the relationship
- Also called as **recursive relationship**

Example of Unary Relationship

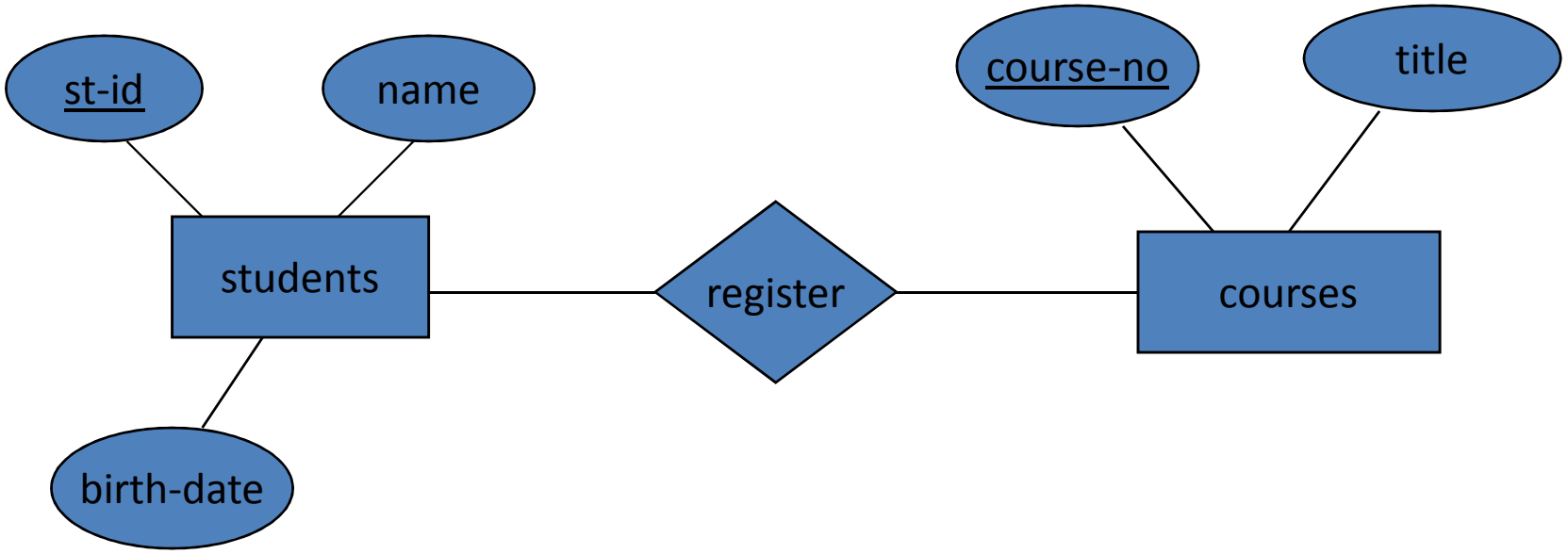


Unary relationship example

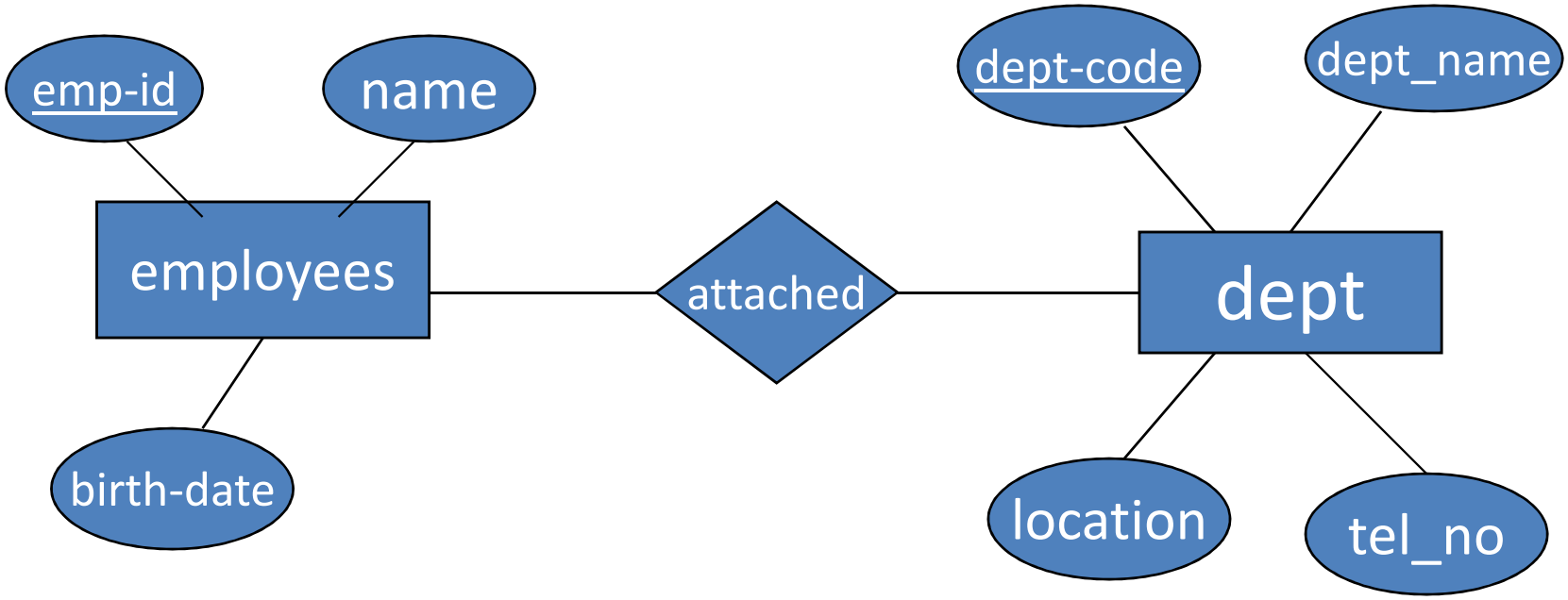
Course	Description	Prerequisite
CIS81	Programming	---
CIS209	VB	CIS81
CIS281	Systems Analysis	CIS 209, CIS330
CIS330	Networks	CIS209, CIS330



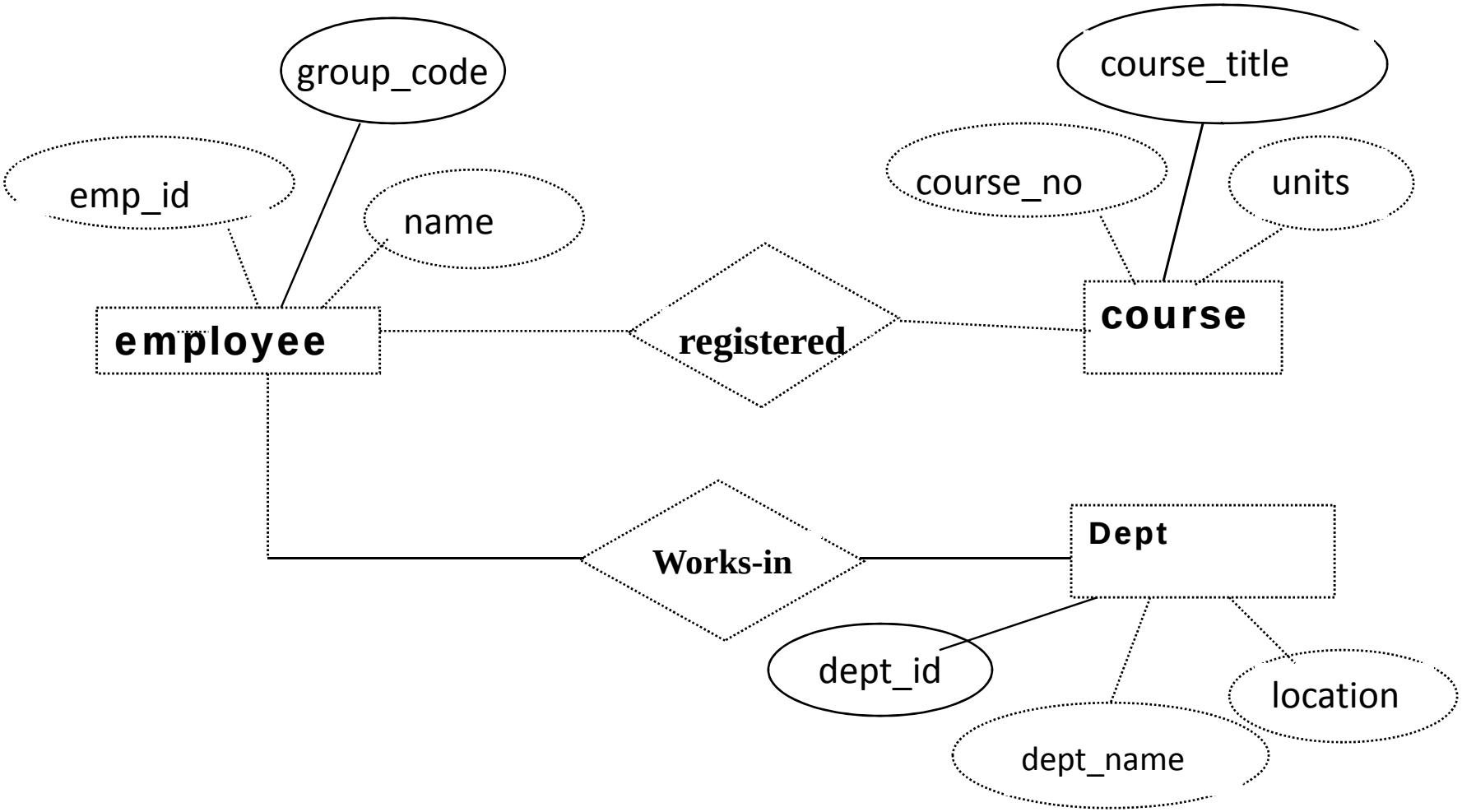
Example of Binary Relationship



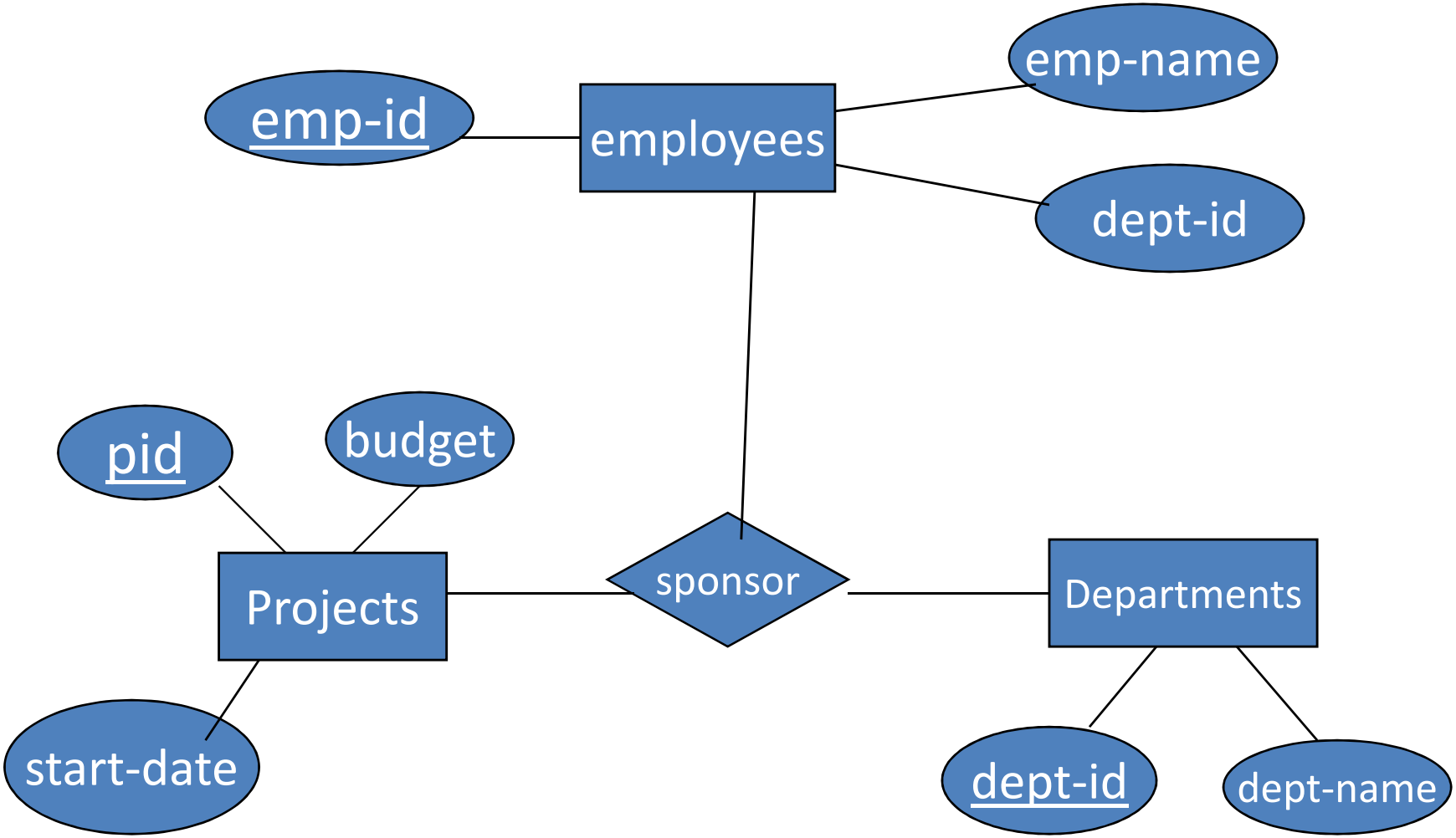
Example of Binary Relationship



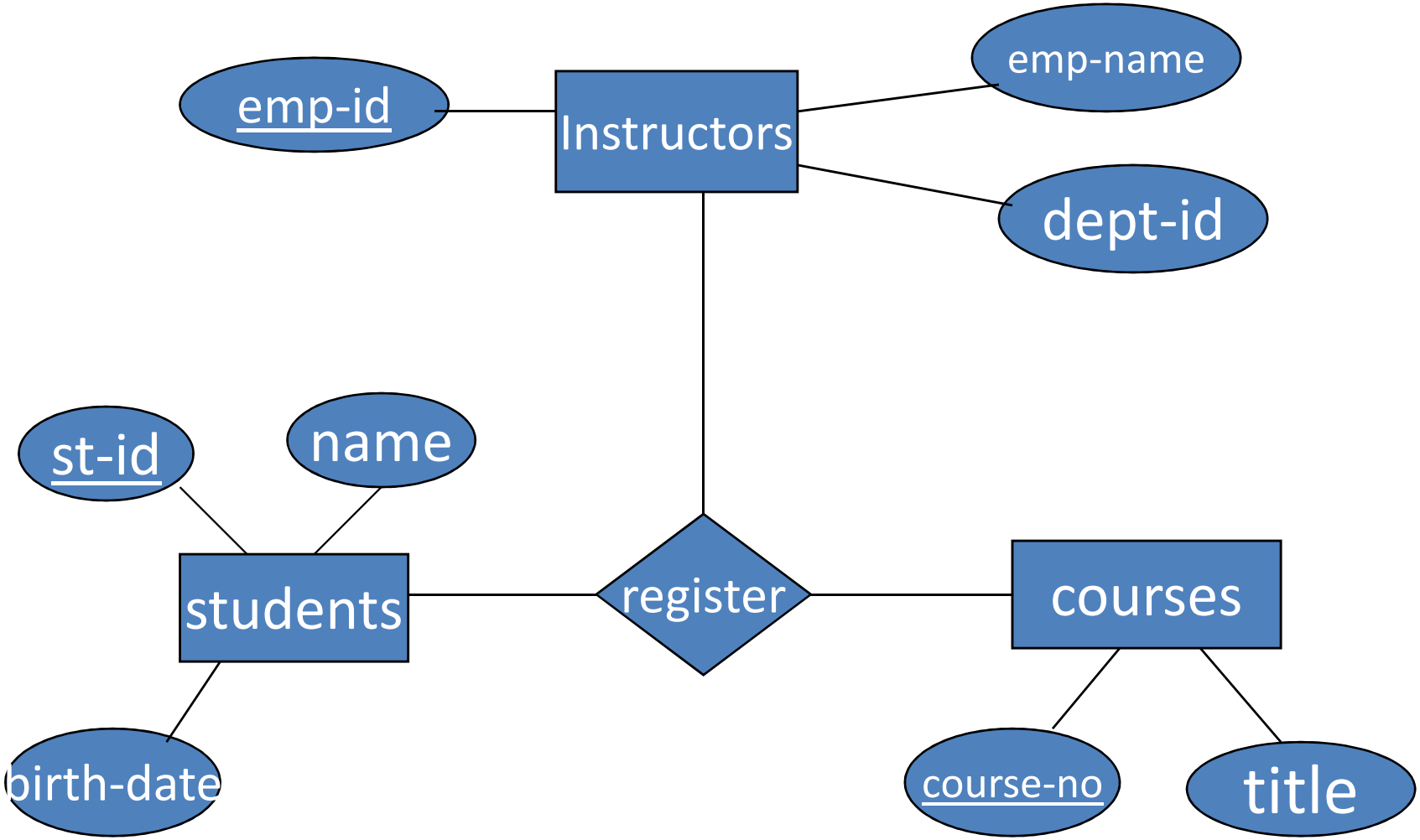
Example of Binary Relationship



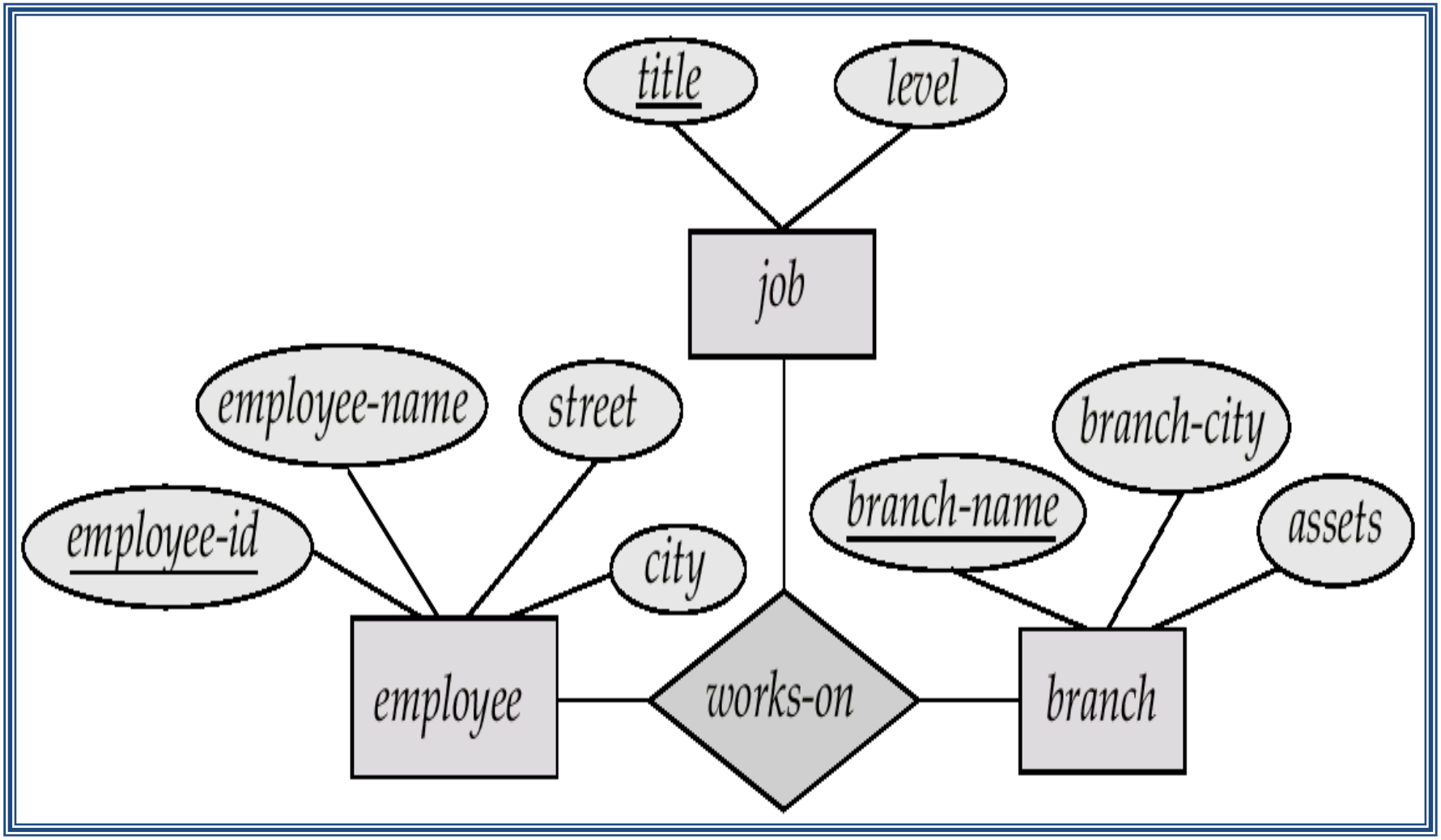
Example of Ternary Relationship



Example of Ternary Relationship



Example of Ternary Relationship

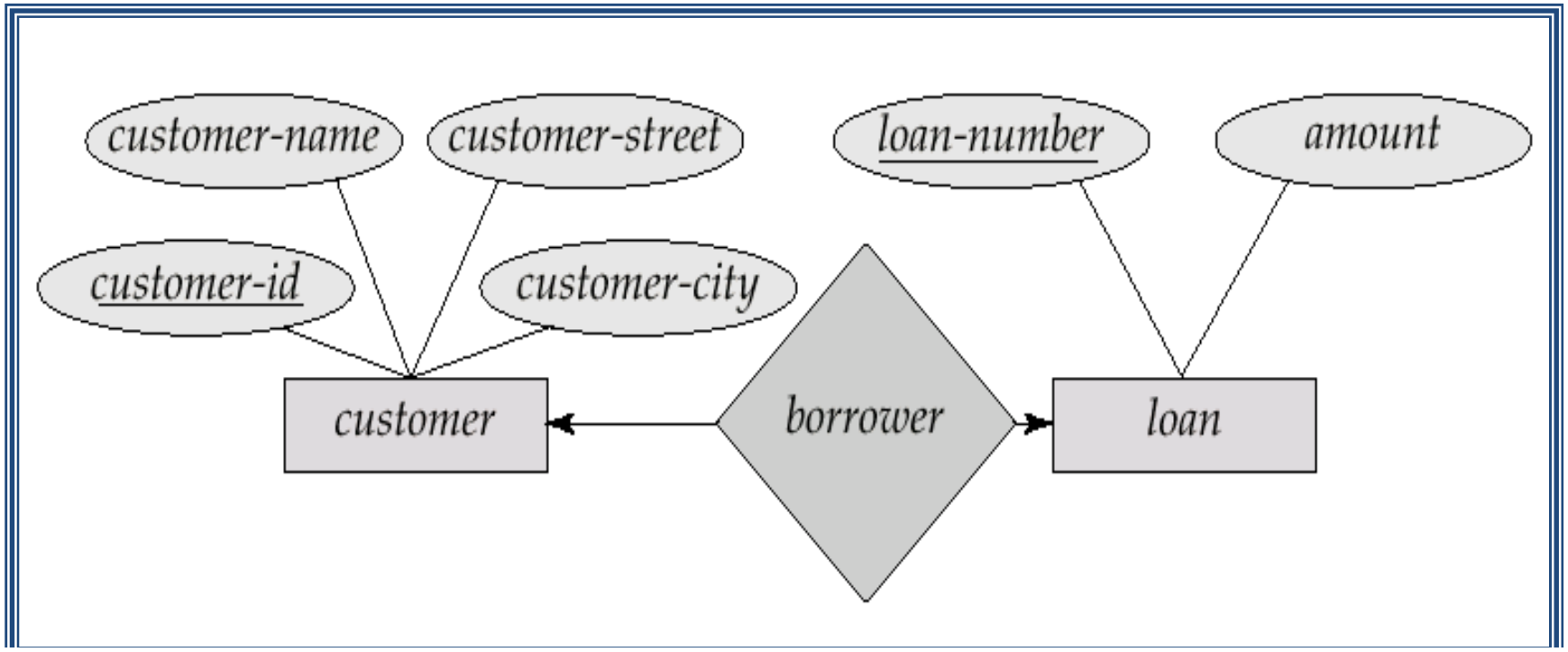


Example of Binary Relationship

One to one relationship

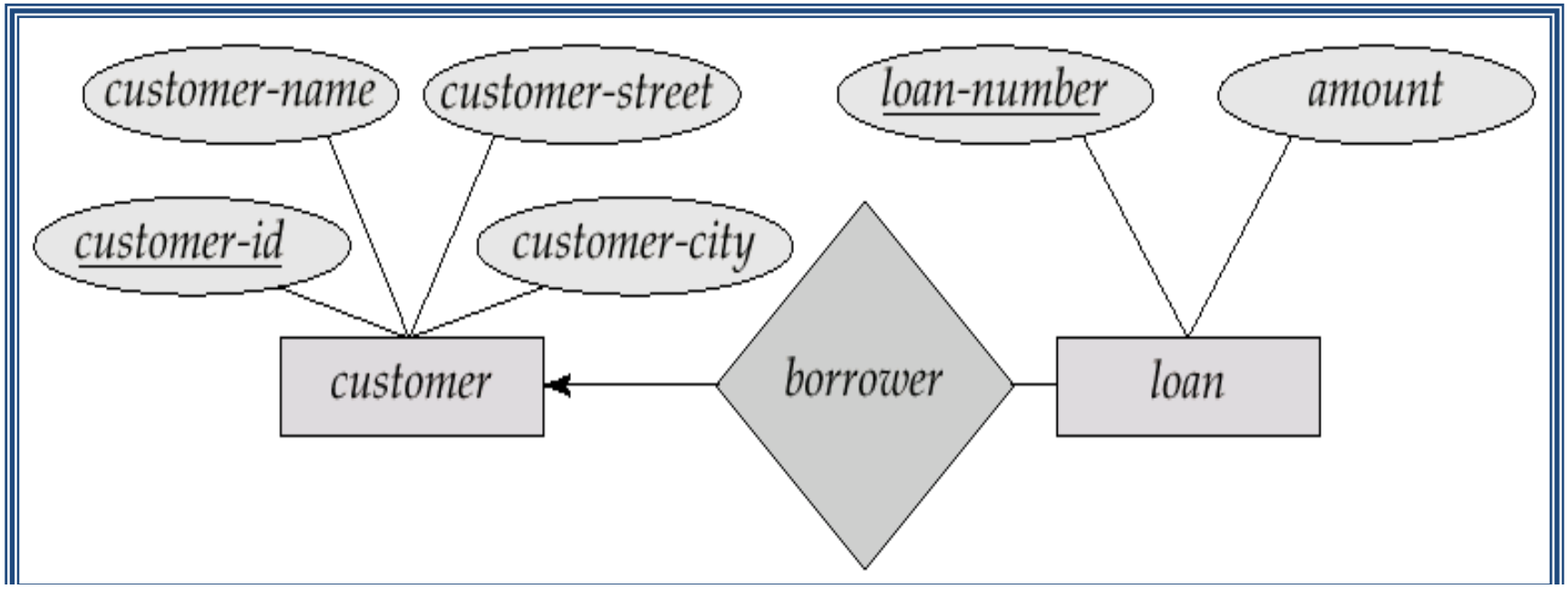
– A customer is associated with at most one loan via the relationship *borrower*

– A loan is associated with at most one customer via *borrower*



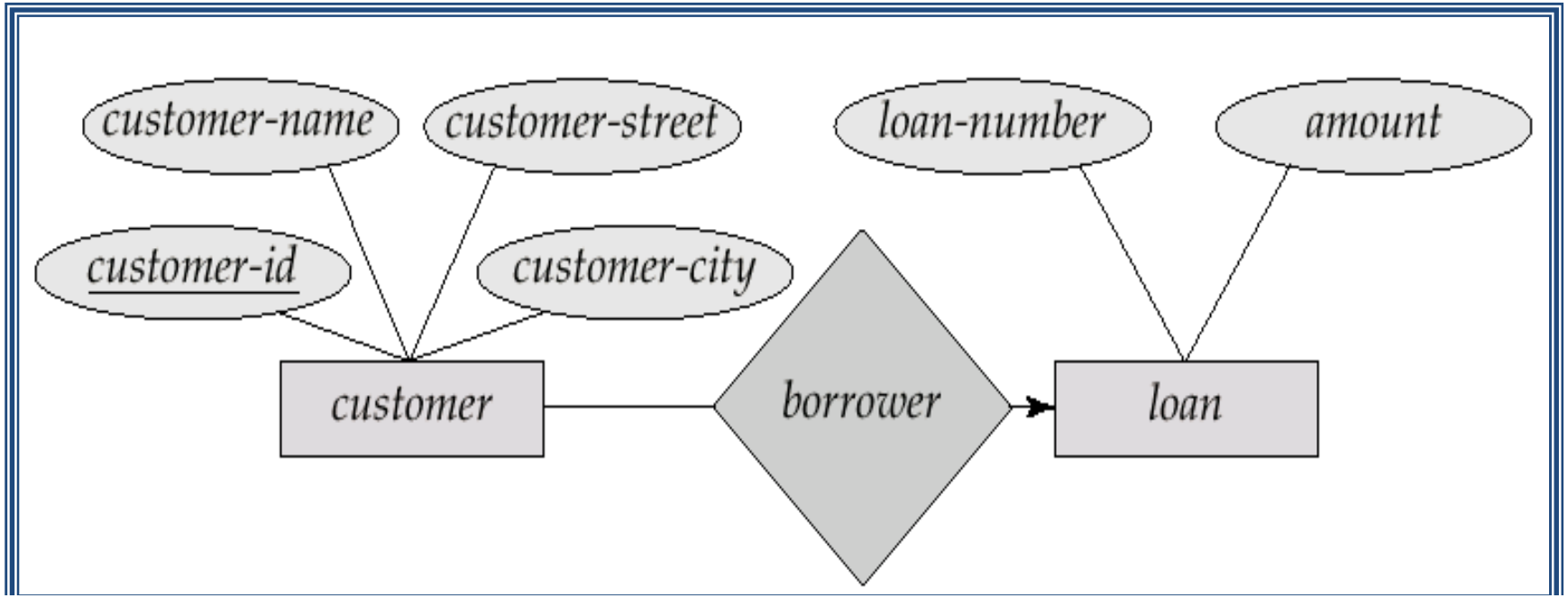
Example of Binary Relationship
One to many relationship

- A loan is associated with at most one customer via borrower,
- A customer is associated with several (including 0) loans via *borrower*



Example of Binary Relationship
Many to one relationship

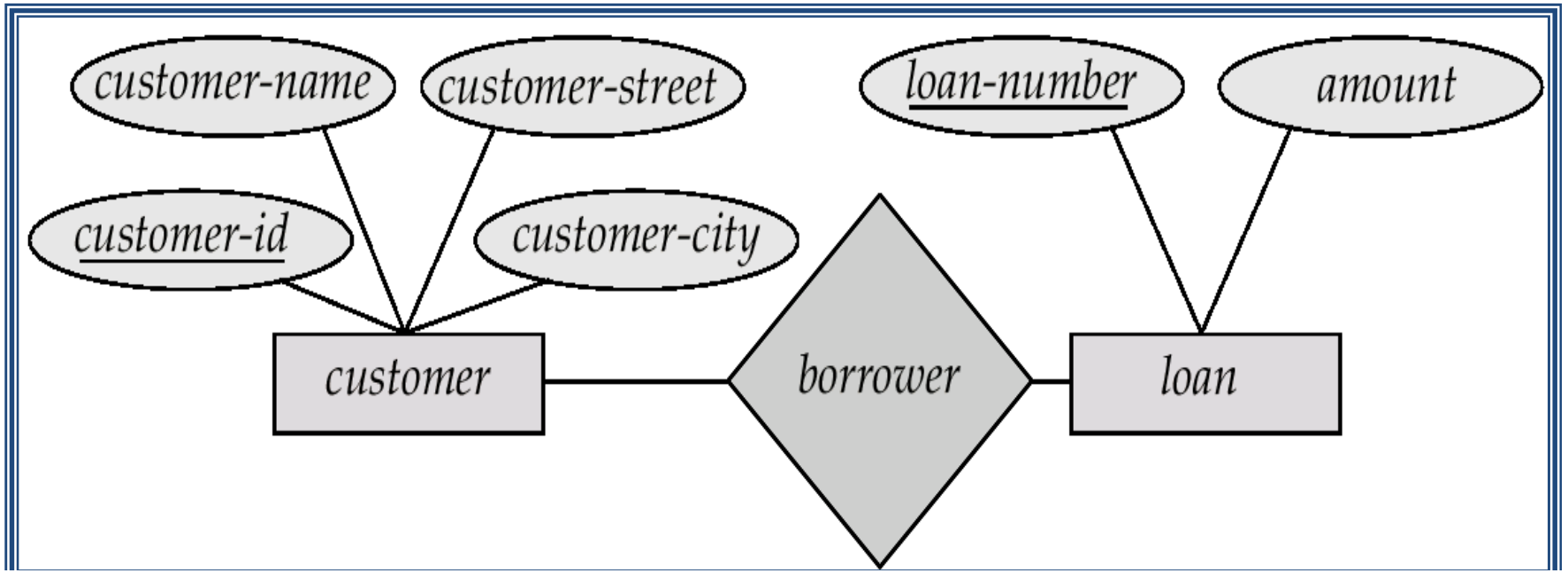
- A loan is associated with several (including 0) customers via *borrower*,
- A customer is associated with at most one loan via *borrower*



Example of Binary Relationship

Many to Many relationship

- A customer is associated with several (possibly 0) loans via borrower
- A loan is associated with several (possibly 0) customers via borrower



Types of Relationships/ Mapping Cardinality Constraints

- Types of binary relationship from entity set ‘A’ to entity set ‘B’

  one – one: an entity in A is related to

  at most one entity in B and vice versa

  many – one: an entity in A is related to

  at most one entity in B

  many – many: an entity in A is related to

  0 or more entities in B and vice versa

Cardinality constraint on a relationship

A cardinality constraint between two entities A and B, specifies the number of instances of entity B that can (or must) be associated with each instance of entity A.

- **Minimum cardinality**: the minimum number of instances of one entity that may be associated with each instance of another entity.

- **Maximum cardinality**: the maximum number of instances of one entity that may be associated with each instance of another entity.

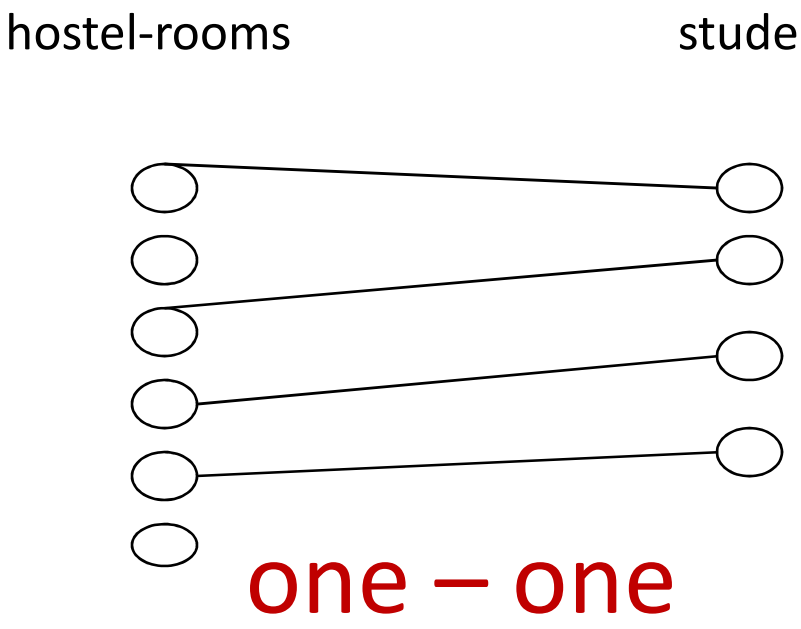
min-max constraints

- Suppose that each customer must have at least one account, but is restricted to at most two loans at a time, and that a bank branch cannot have more than 1000 loans. How does this show up as min-max constraints.
- Customer-Loan (0, 2)
- Customer-Account (1, N)
- Bank-Branch – Loan (0, 1000)

Example : One-One Relationships

Relationship Allocated between entity sets hostel-rooms and Students.

A room cannot be allocated to more than one student, and no student can have more than one room.

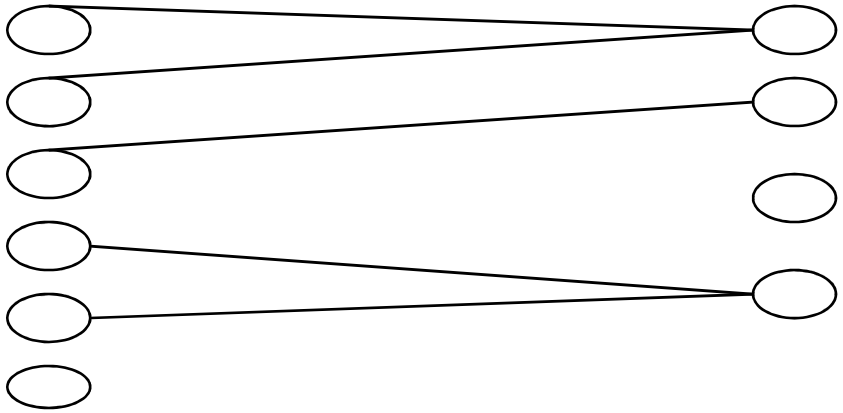


Example : Many-One Relationships

- Each entity of the first set is connected to at most one entity of the second set.
- But an entity of the second set can be connected to zero, one, or many entities of the first set.
- E.g. A student can do at most one major project and a major project can be done by more than one student

students

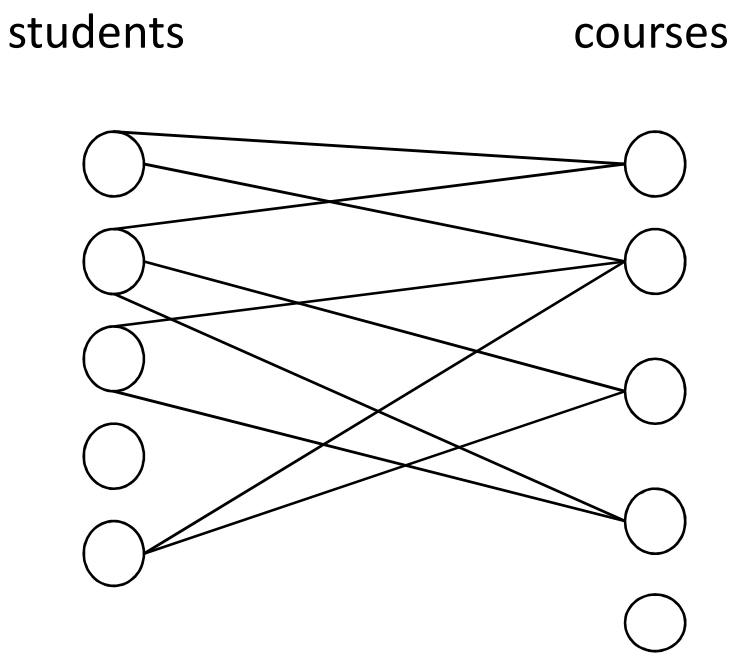
major-projects



many – one

Example : Many-Many Relationships

- Focus: binary relationships, such as **Registers** between **Students** and **Courses**.
- In a *many-many* relationship, an entity of either set can be connected to many entities of the other set.
- E.g., a student registers many courses; an instructor is allotted many courses.

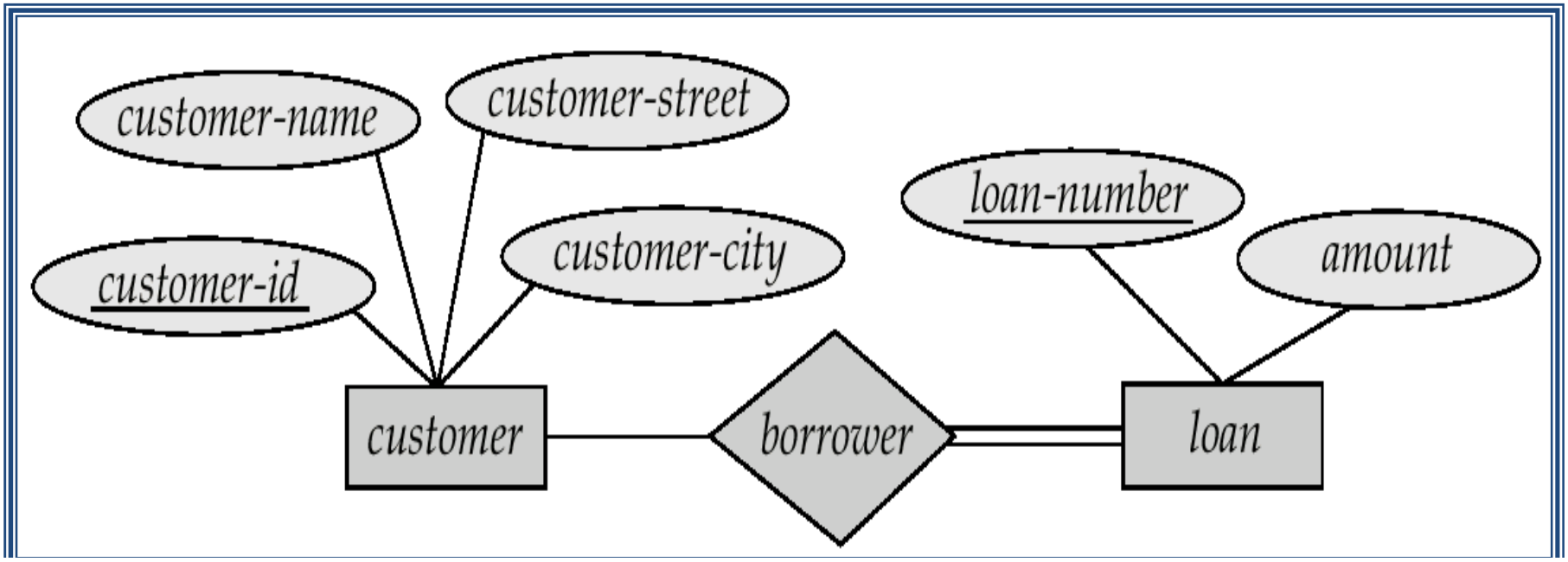


many - many

Participation of an Entity Set in a Relationship Set

Total participation

- every loan must have a customer associated to it via borrower
- participation of loan in borrower is **total**
- **Indicated by double line**



Participation constraint on a Relationship Set

Total participation : every entity in the entity set participates in at least one relationship in the relationship set

Partial participation: some entities may not participate in any relationship in the relationship set

E.g. participation of customer in borrower is partial

Indicated by single line

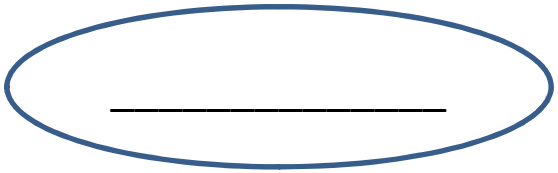
Keys

- Student (id, name, dob, city, street, state, hostel_no, mobile_no, email_id)
- **Superkey:** {id, name, dob, city, street, state, hostel_no, mobile_no, email_id}
- **Candidate keys:**
  - {id,name}
  - {name,mobile_no}
  - {id, email_id}
  - {email_id}
- **Primary key** {id} or {id,email_id}

Keys

- A **super key** of an entity set is a set of one or more attributes whose values uniquely determine each entity.
- A **candidate key** of an entity set is a minimal super key.
- Although several candidate keys may exist, one of the candidate keys is selected to be the **primary key**.

Keys



- **Primary key:**

  An attribute (or combination of attributes) that uniquely identifies each row in relation.

- **Composite key:**

  A primary key that consists of more than one attribute.

- **Foreign key:**

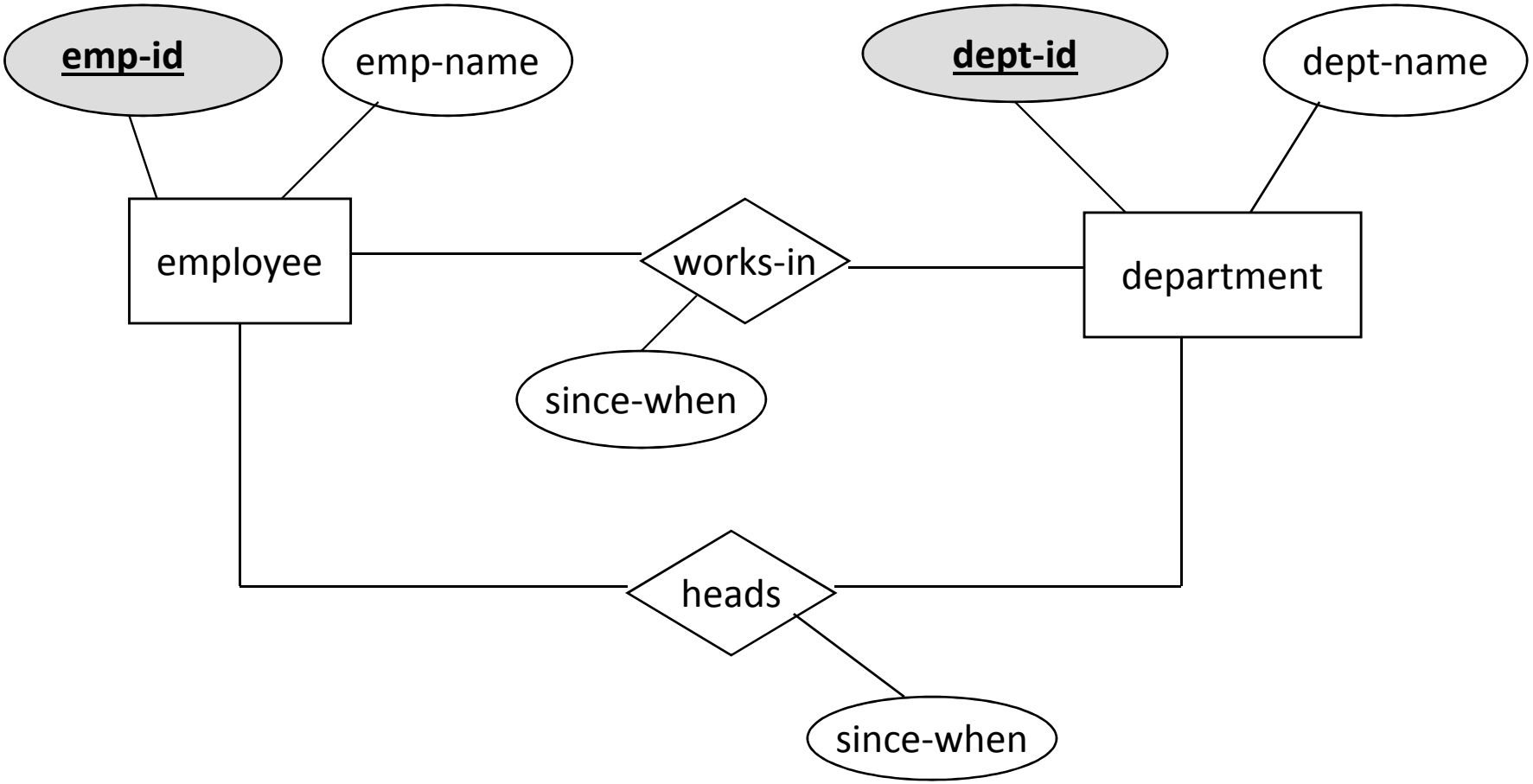
  An attribute in a relation that serves as the primary key of another relation in the same database.

Keys for Relationship Sets

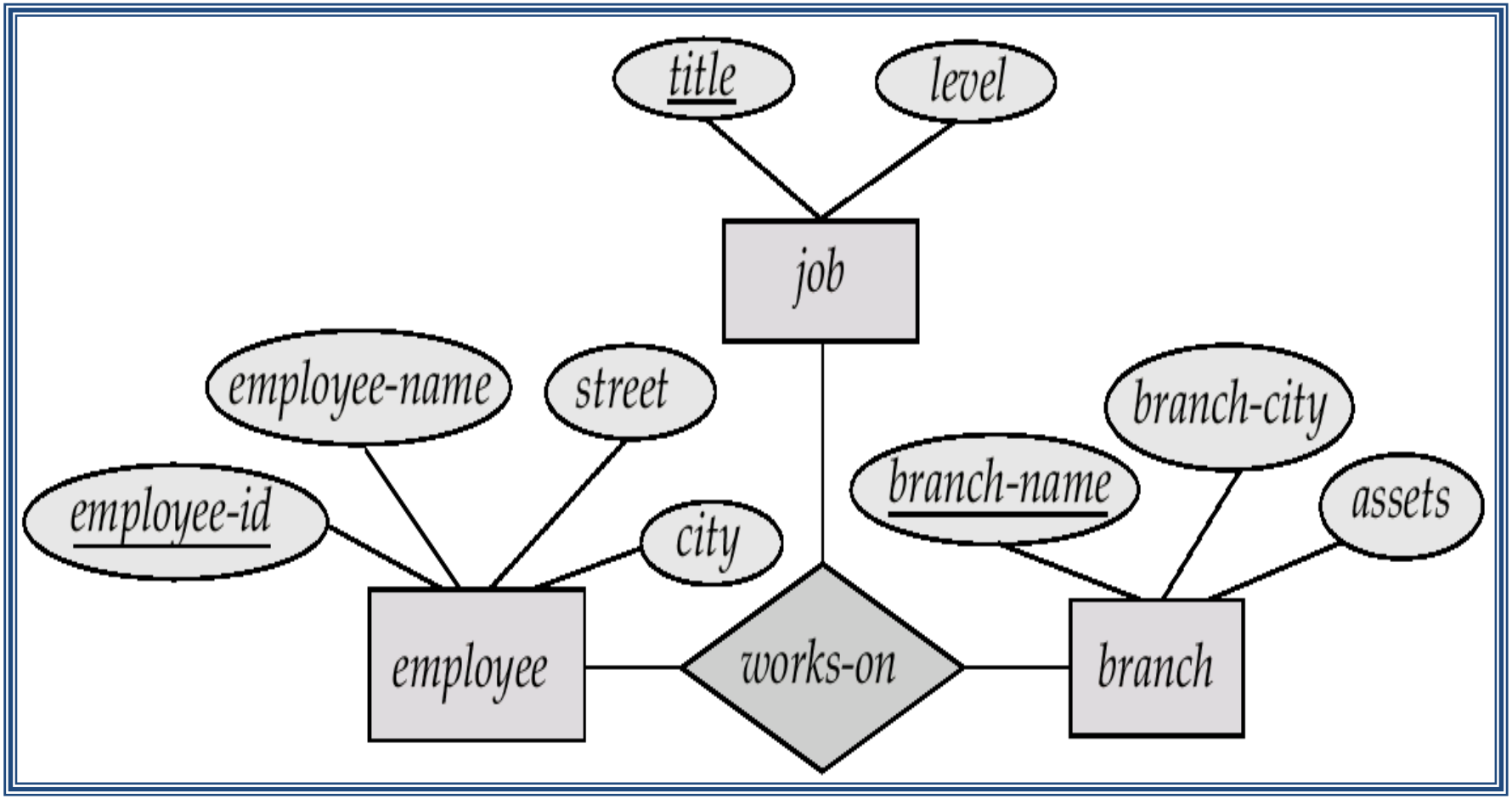
- The combination of primary keys of the participating entity sets forms a super key of a relationship set.
  - (*customer-id, account-number*) is the super key of *depositor*
  - *NOTE: this means a pair of entity sets can have at most one relationship in a particular relationship set.*

- Must consider the mapping cardinality of the relationship set when deciding the what are the candidate keys

Key Constraints



Key constraint in ternary relationship

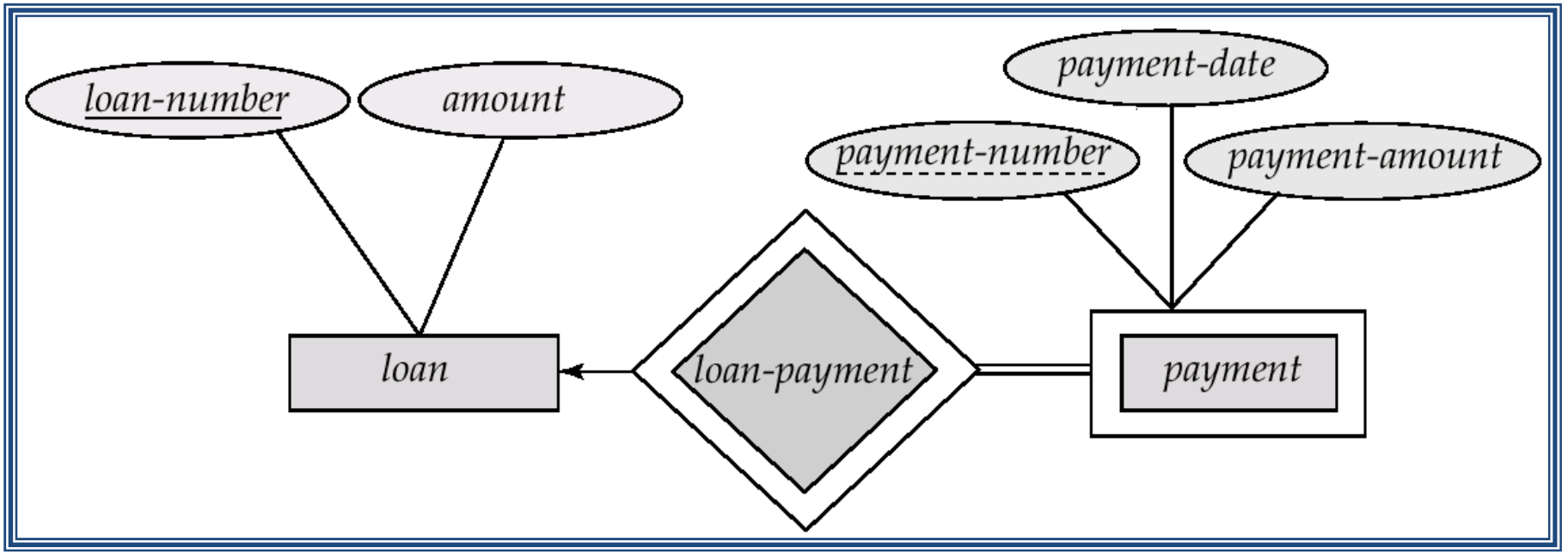


Consider Relation having loan details

Loan no	**Payment no / EMI**	**Payment-Amount**	**Payment-Date**
L1	P1	1 lakh	1st jan
L1	P2	1 lakh	1st feb
L2	P1	2 lakh	1st jan
L2	P2	5000	15th feb

Weak Entity Set

- Loan is a strong entity set and payment is a weak entity set
- Weak entity set is denoted by double rectangles.
- *payment-number* – discriminator of the *payment* entity set
- underline the discriminator of a weak entity set with a dashed line.
- Primary key for *payment* – (*loan-number, payment-number*)



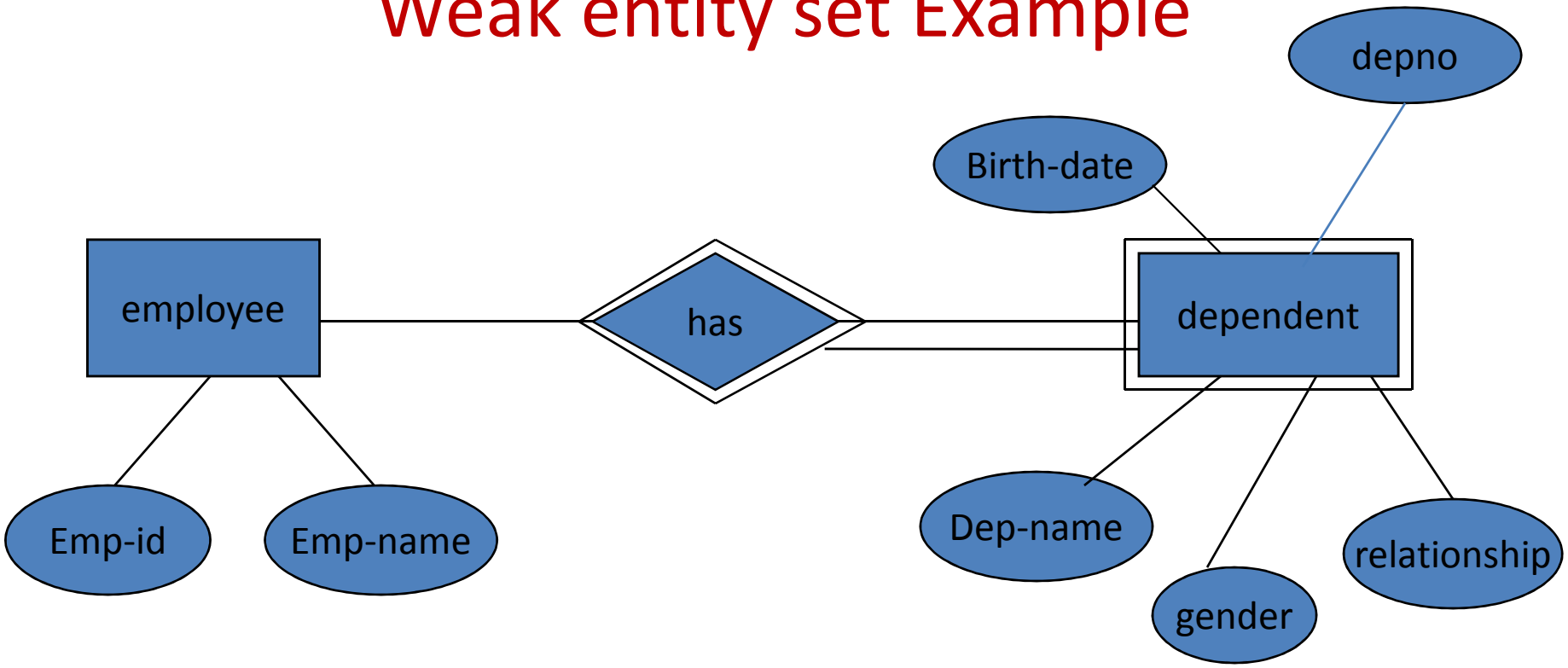
Weak Entity Sets (Cont.)

- An entity set that does not have a primary key is referred to as a weak entity set.
- The existence of a weak entity set depends on the existence of a identifying entity set (loan in above eg)
  - it must relate to the identifying entity set via a **total, one-to-many relationship set** from the identifying to the weak entity set
  - Identifying relationship depicted using a double diamond

Weak Entity Sets (Cont.)

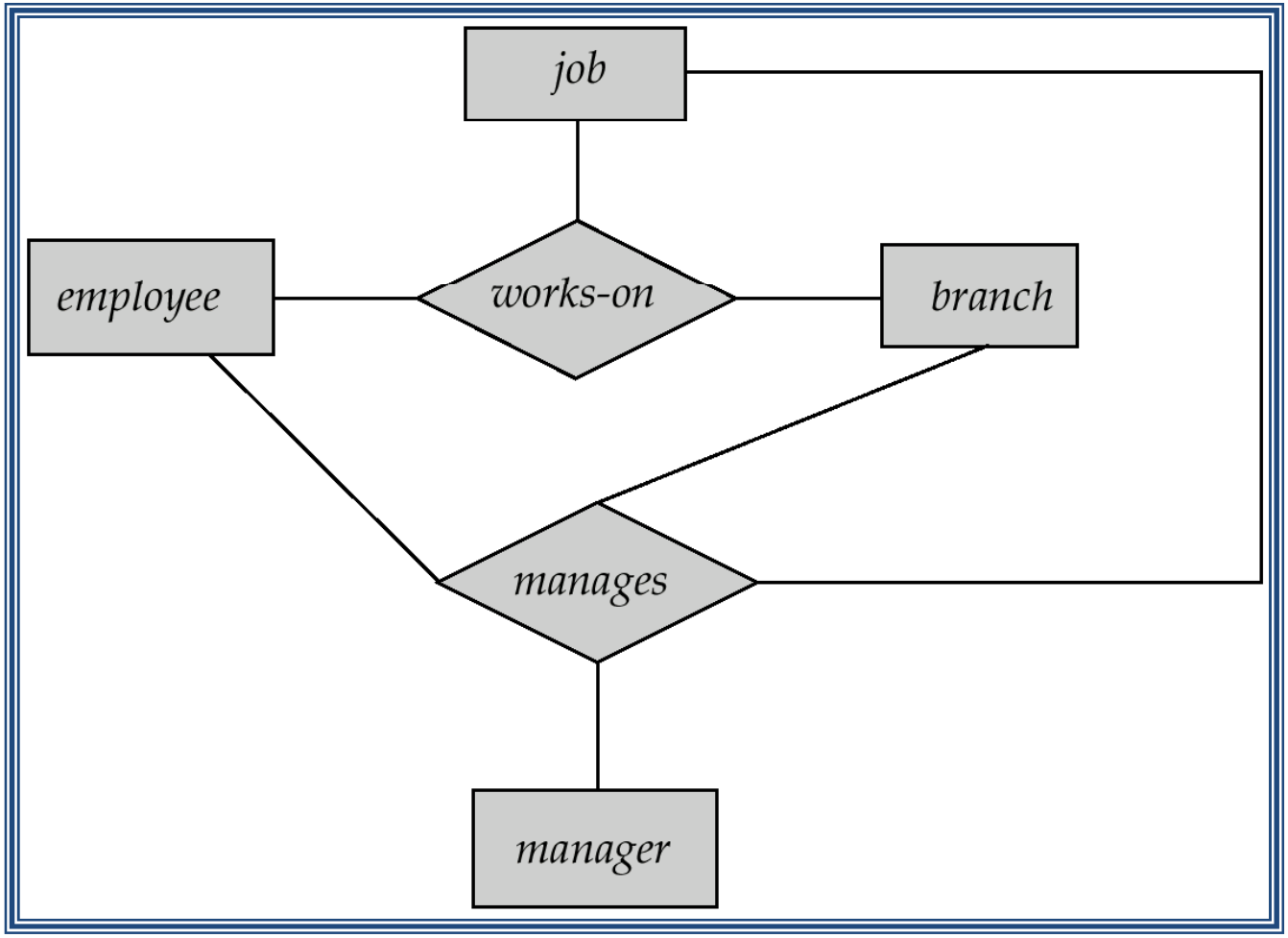
- The discriminator (or partial key) of a weak entity set is the set of attributes that distinguishes among all the entities of a weak entity set.
- The primary key of a weak entity set is formed by the primary key of the strong entity set on which the weak entity set is existence dependent, plus the weak entity set's discriminator.

Weak entity set Example

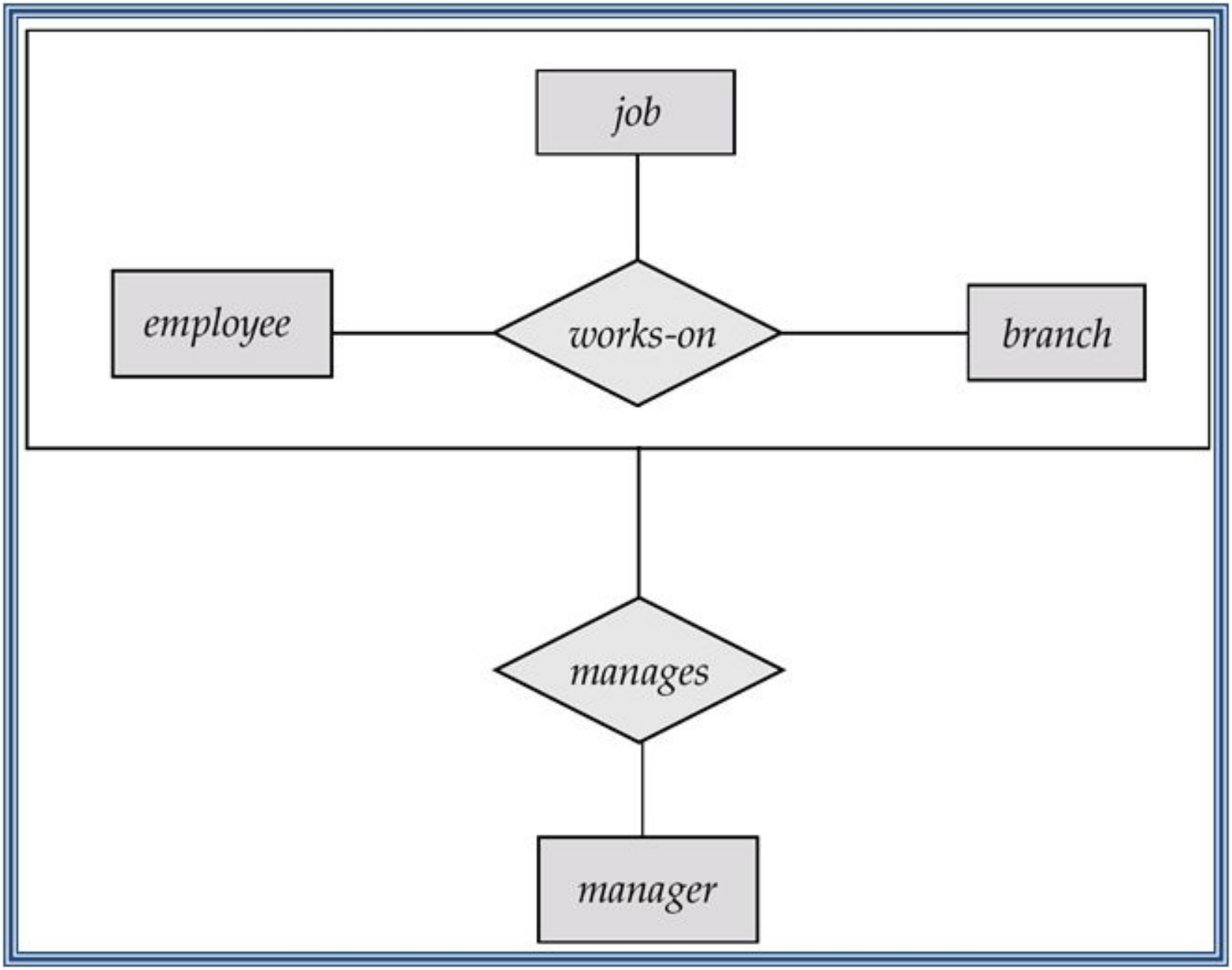


Aggregation

- Consider the ternary relationship works-on, which we saw earlier
- Suppose we want to record managers for tasks performed by an employee at a branch

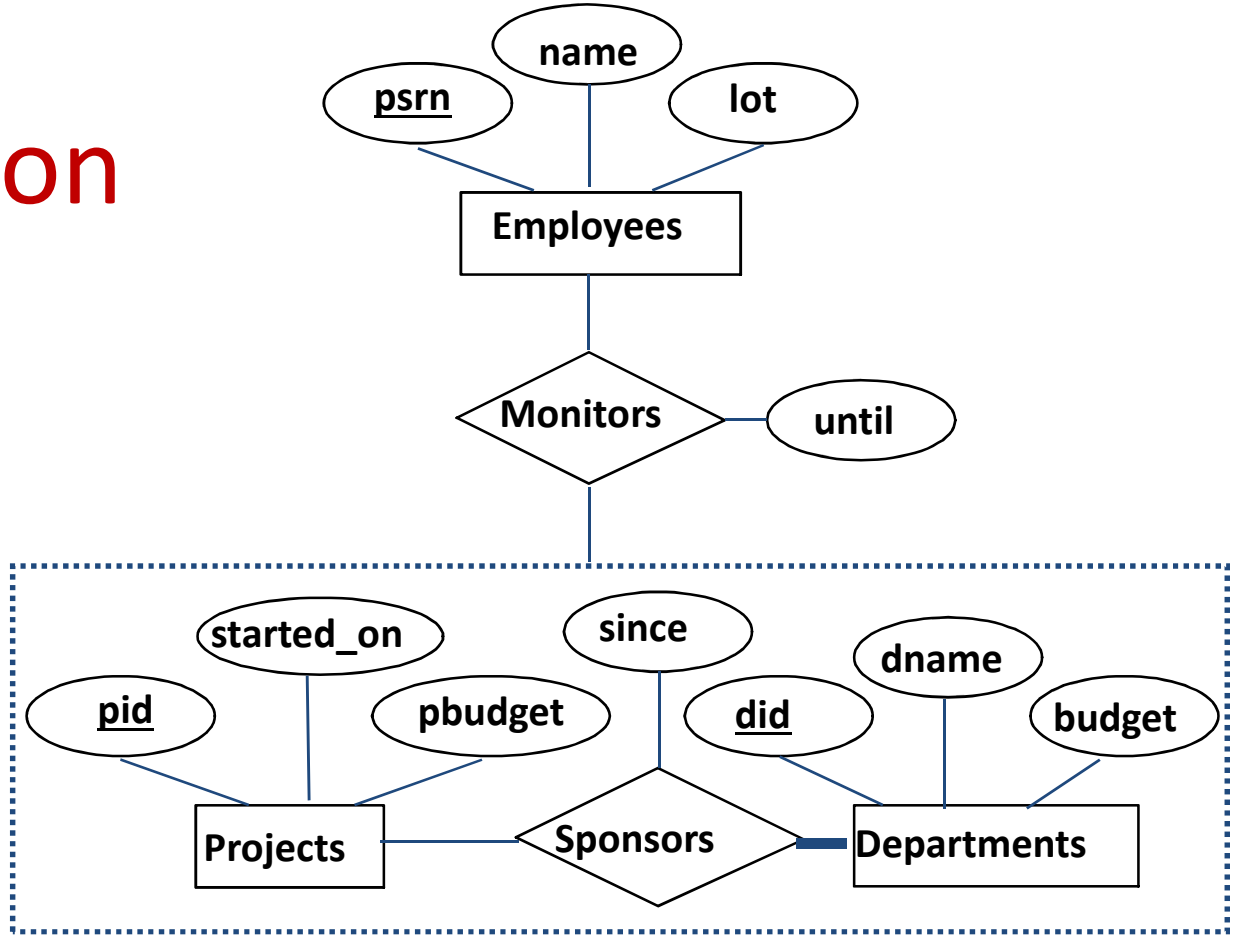


E-R Diagram With Aggregation



Aggregation

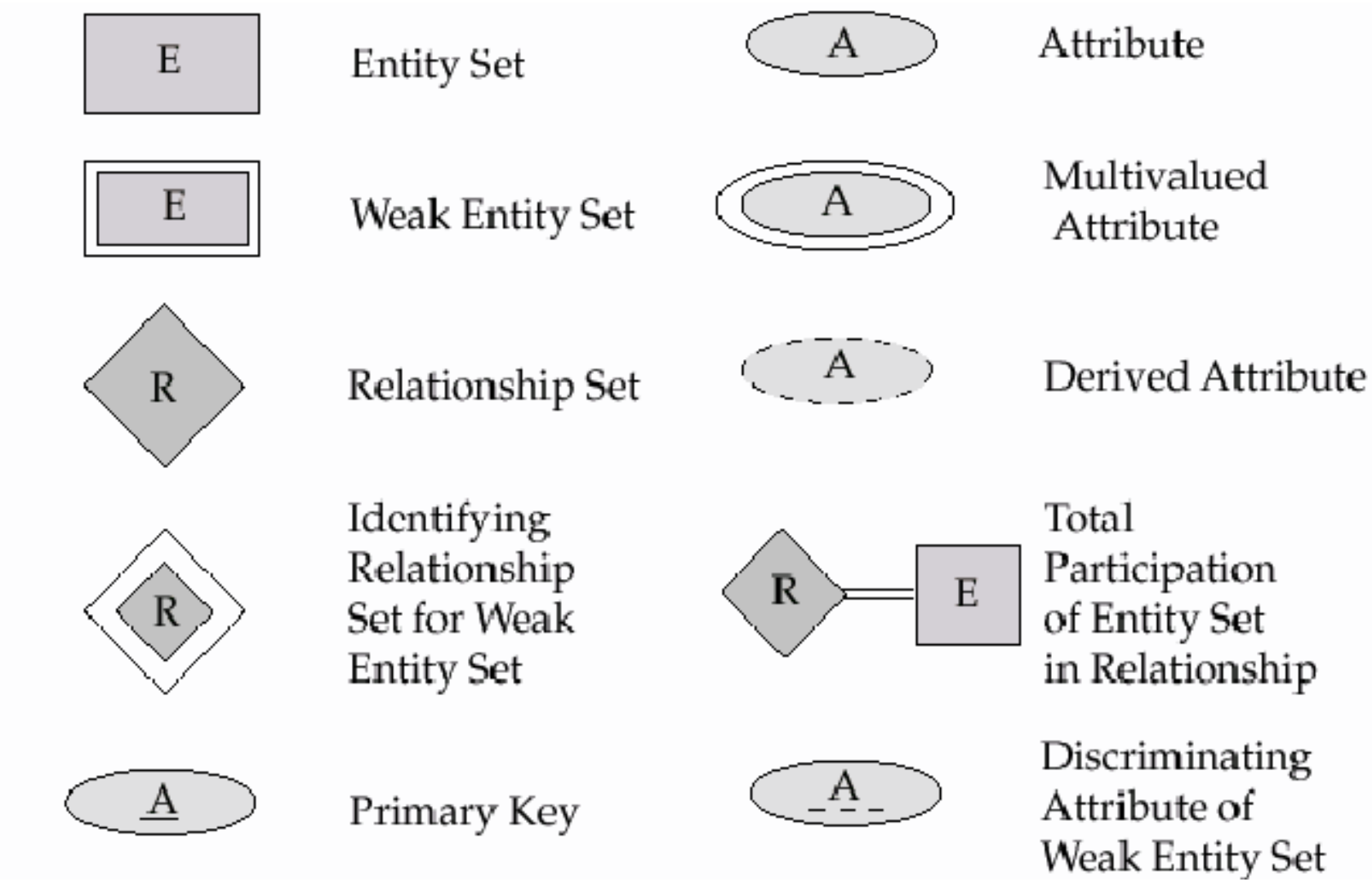
- Used when we have to model a relationship involving (entity sets and) a *relationship set*.
  - *Aggregation* allows us to treat a relationship set as an entity set for purposes of participation in (other) relationships.



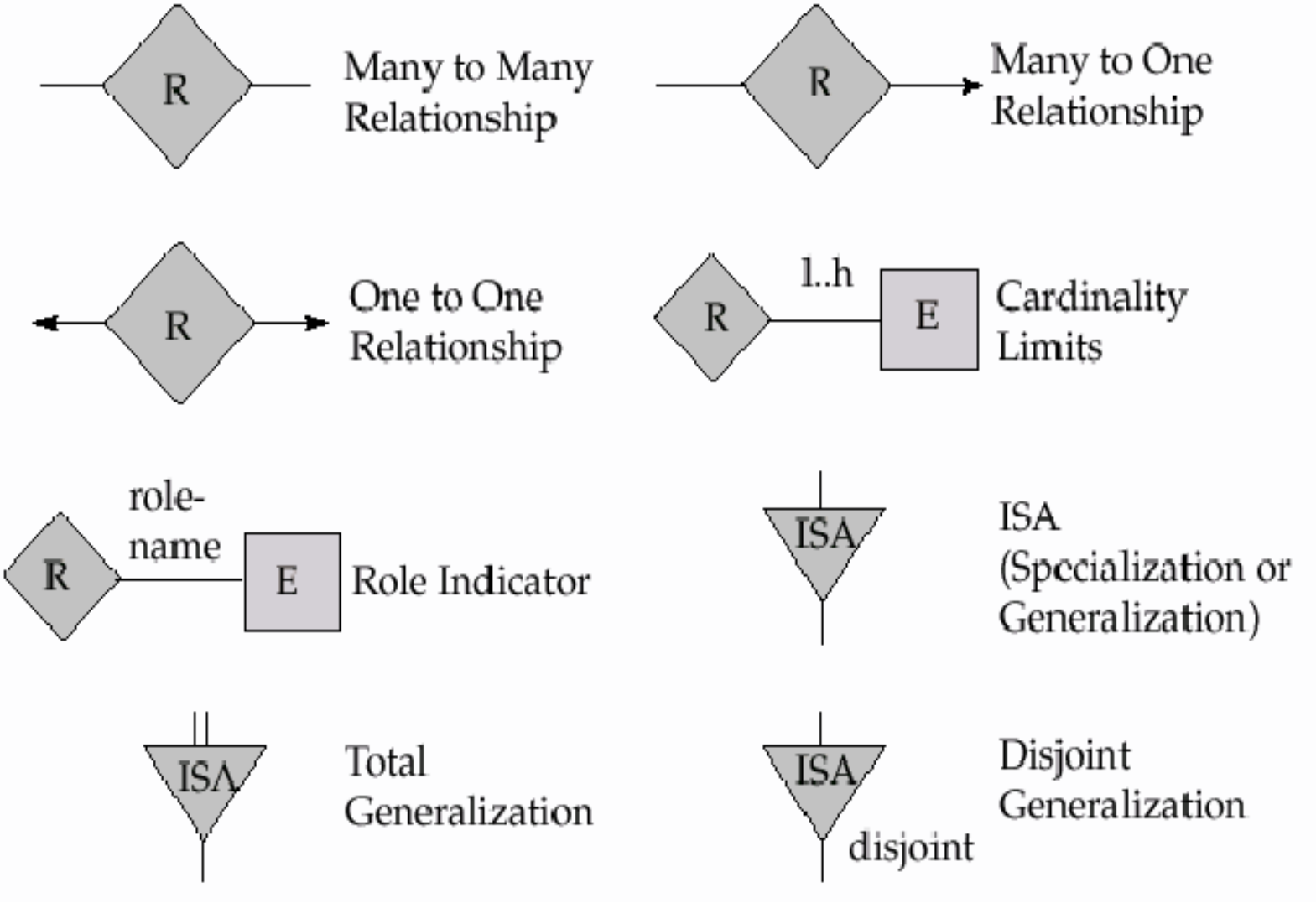
Aggregation vs. ternary relationship:

- Monitors is a distinct relationship, with a descriptive attribute. (i.e., until)
- Also, can say that each sponsorship is monitored by at most one employee.

Symbols used in ER diagram

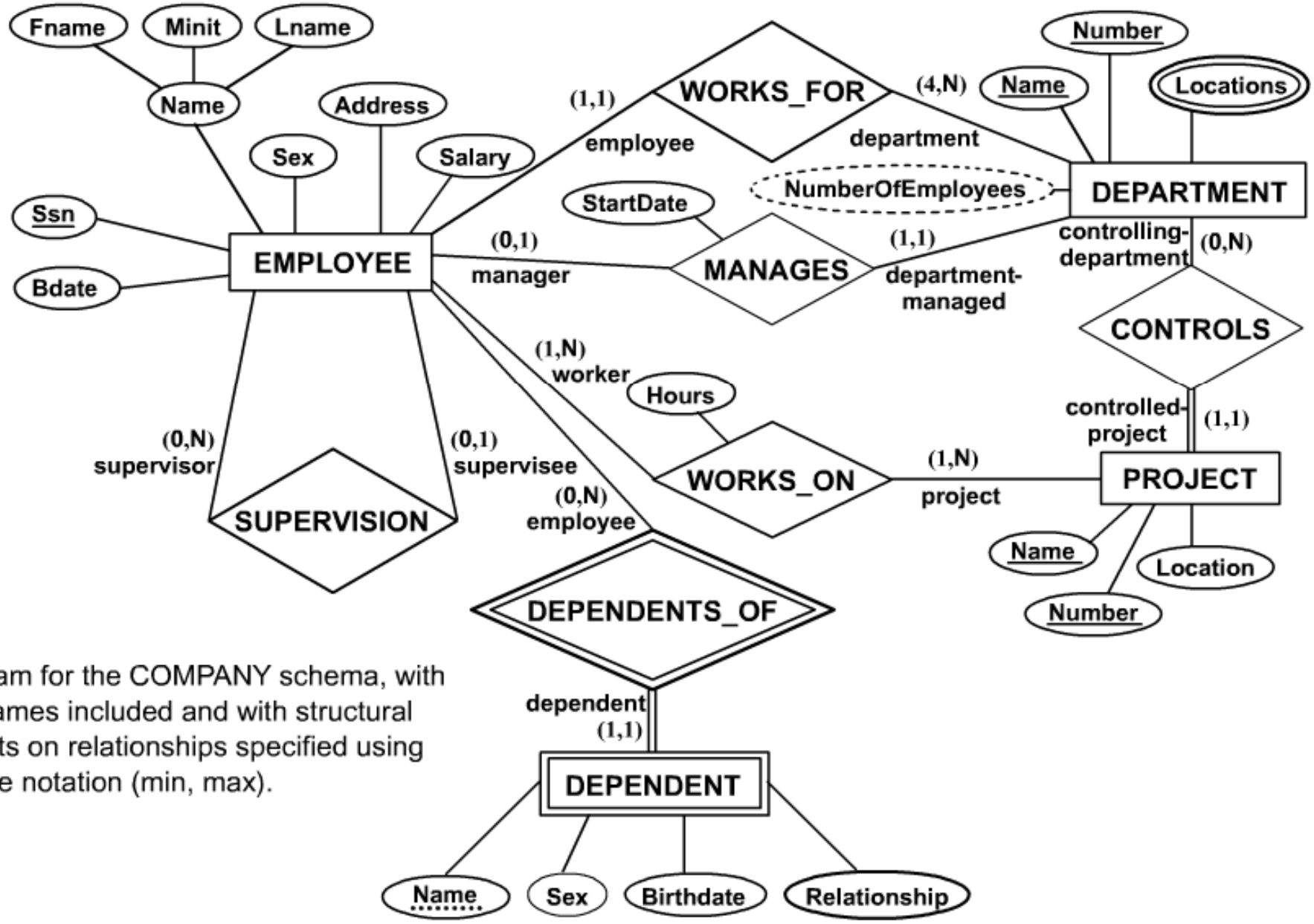


Symbols used in ER diagram



COMPANY ER Schema Diagram using (min, max)

Alternative ER Notations



ER diagram for the COMPANY schema, with all role names included and with structural constraints on relationships specified using alternative notation (min, max).

Entity Relationship (ER) modelling

Entity Relationship (ER) modelling

- a way of representing data and relationship among data
- is a tool for communication between requirement analysts and DB designer
- is a graphical representation of the database system
- provides a high-level conceptual data model
- supports the user's perception of the data
- is DBMS and hardware independent
- had many variants
- is composed of entities, attributes, and relationships and constraints(mapping and participation)

BANKING ENTERPRISE DATA REQUIREMENTS:

- DB user says: The name of our bank is Dena bank. We have few branches. Each located in a particular city and is identified by unique name. Basically the bank monitors the assets of each branch.
- DB user says: We have many customers. So its difficult for us to manage details of all in file system. It will be better if you design something good for us. The customers are identified by their account number. Also we need to know their name, street and city where they live. Customers may have accounts and may take loans. A customer may be associated with a particular banker, who may act a loan officer or a personal banker for that customer.

- RA asks: Is the customer_id same as account number?
- DB user says: No. One customer can have many accounts or some can have joint account.
- RA asks: If a customer wants a loan, is it necessary to have an account with the bank?
- DB user: No. not so necessary.
- DB user says: We also find difficult to manage employee details because many time new people joins and old people retires or some leaves job. So it will be good if you give us some structure where employee data can be stored in an organized way.

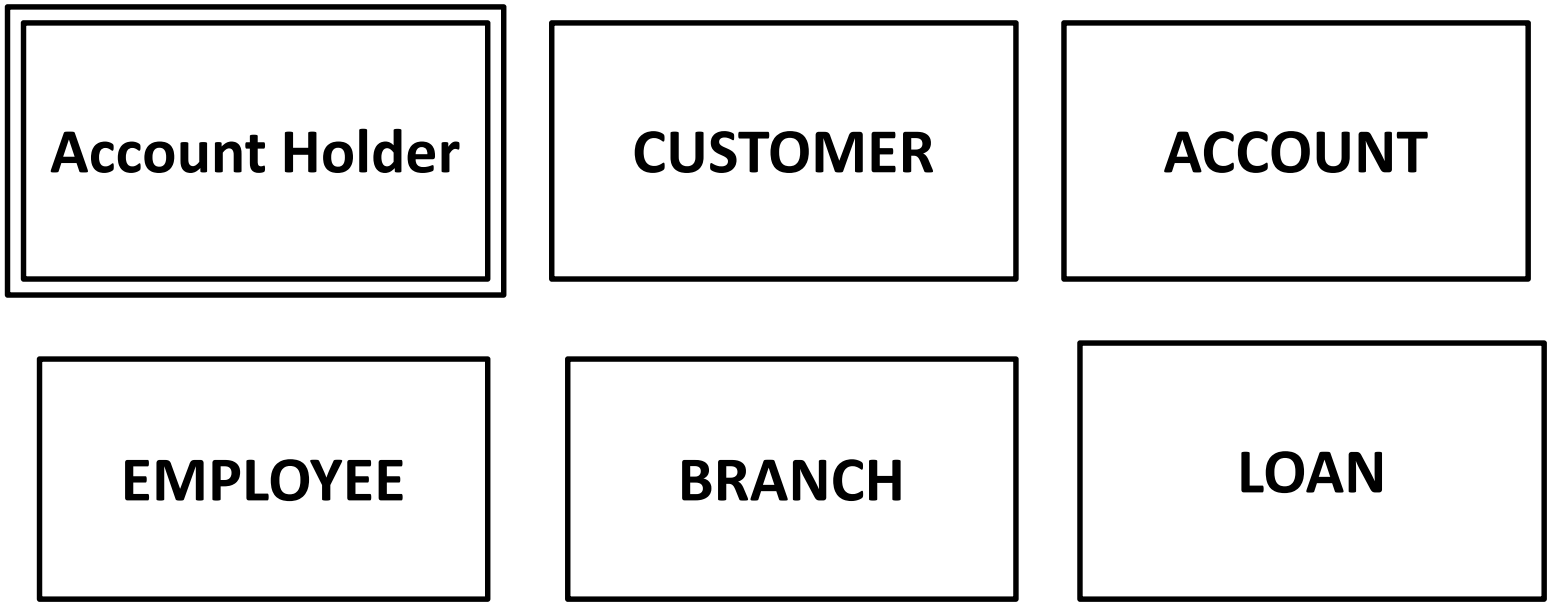
- DB user says: Bank employees are identified by their employee_id values. The bank administration need name, telephone number and the employee's dependents, and the employee_id of employee's manager. The bank also keeps track of the employee's start date and, thus, length of employment.

- DB user says: The bank offers two types of accounts-Savings and Checking account. Each account has unique account number. The bank maintains a record of each account's balance, and the most recent date on which the account was accessed by each customer holding the account. In addition, each saving account has an interest rate, and overdrafts are recorded for each checking account.

- DB user says: A loan originates at a particular branch and can be held by one or more customers. A loan is identified by a unique loan number. For each loan, the bank keeps track of the loan amount and loan payments. Although a loan payment number does not uniquely identify a particular payment among those for all bank's loans, a payment number does identify a particular payment for a specific loan. The date and amount are recorded for each payment.

Let us draw an ER diagram for a Banking system

ENTITY AND ENTITY SETS



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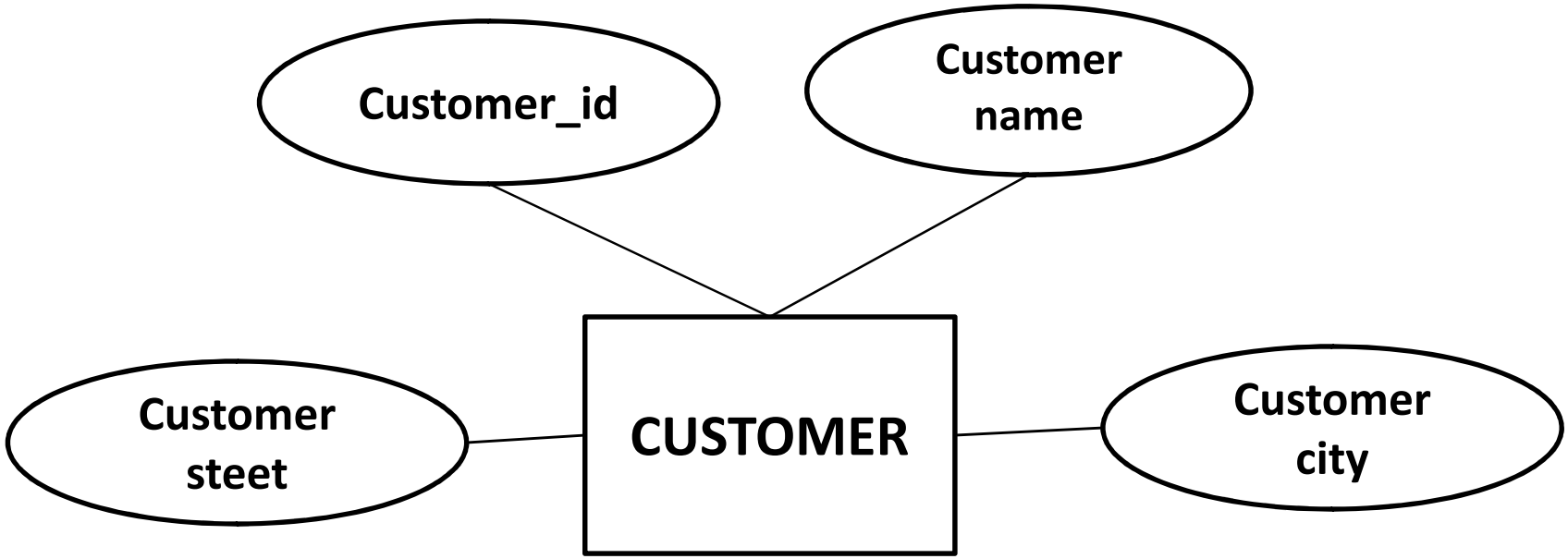
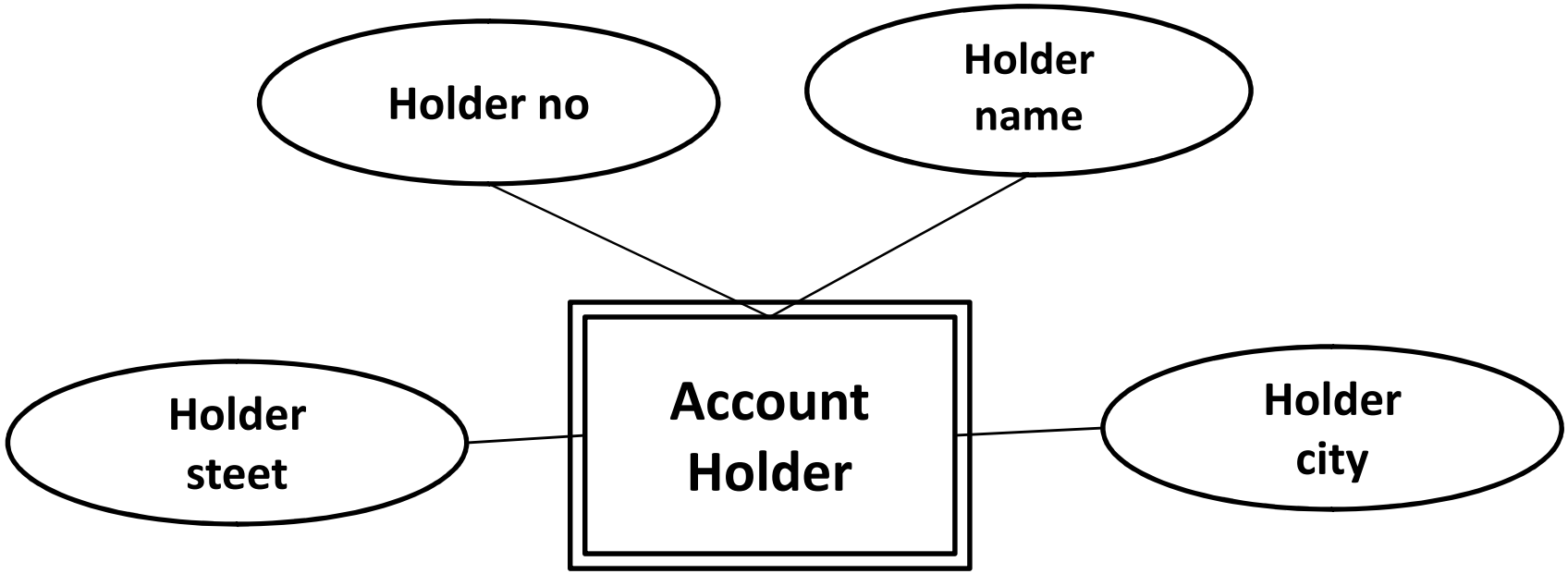
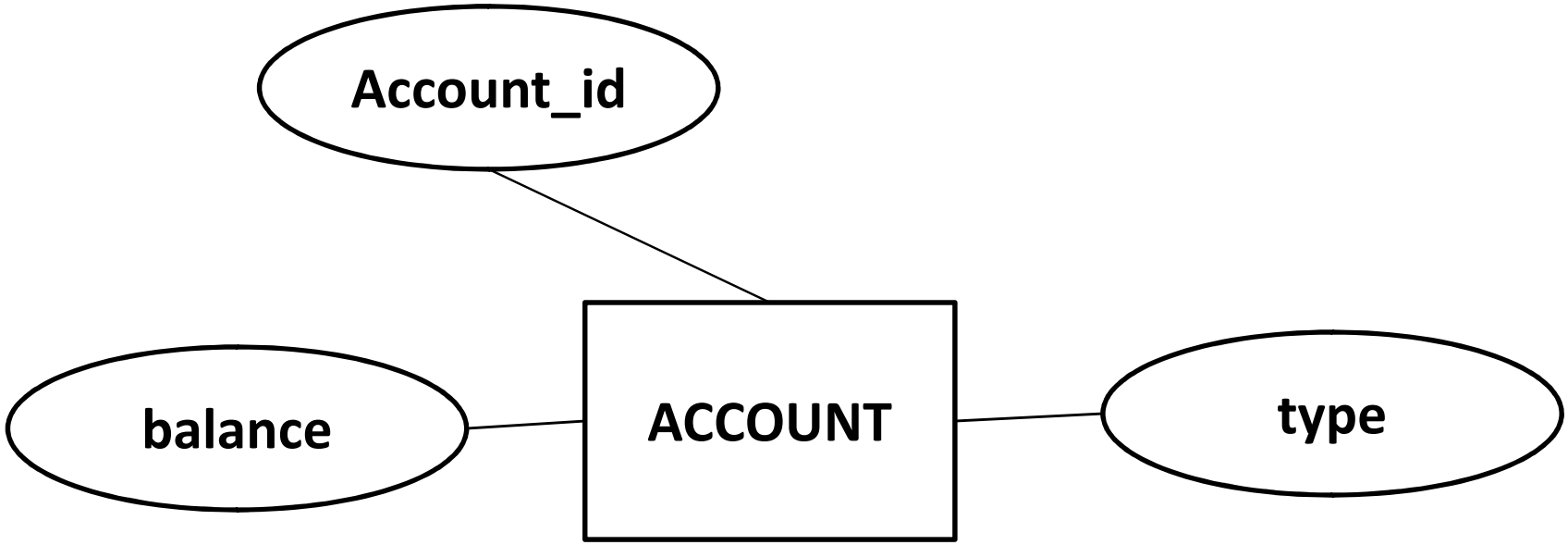

Customer_id
Customer name
Customer steet
CUSTOMER
Customer city

ATTRIBUTE


Holder no
Holder name
Holder steet
Account Holder
Holder city

ATTRIBUTE



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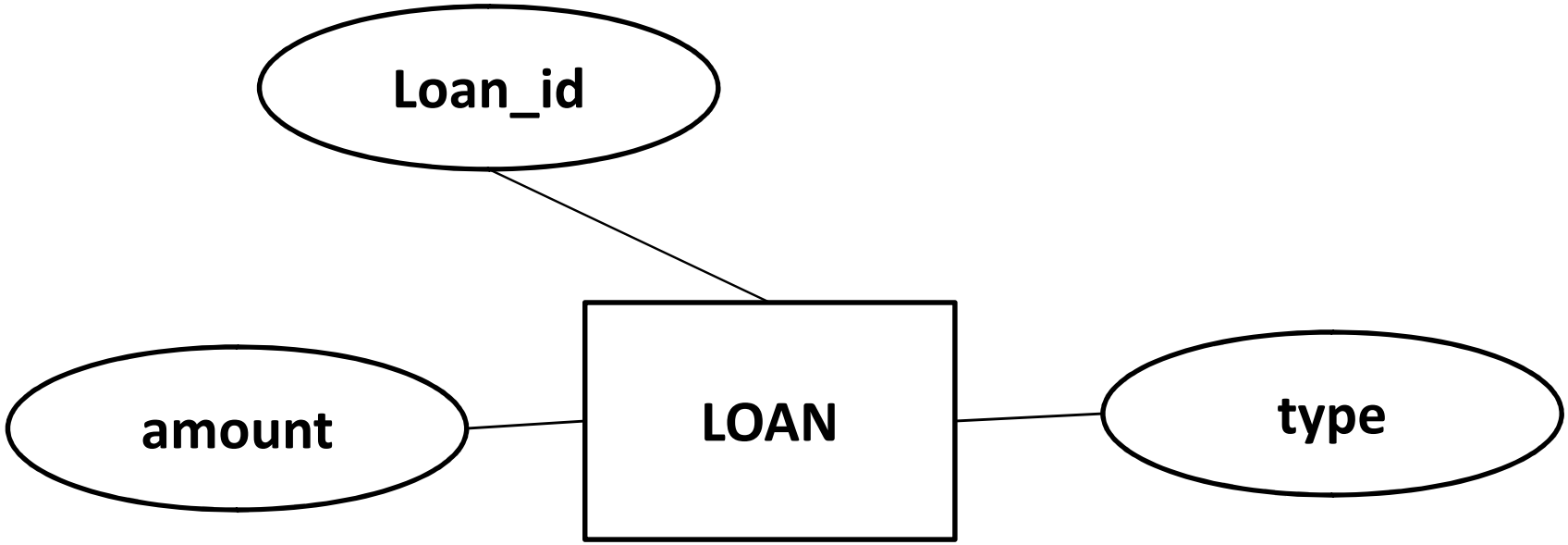

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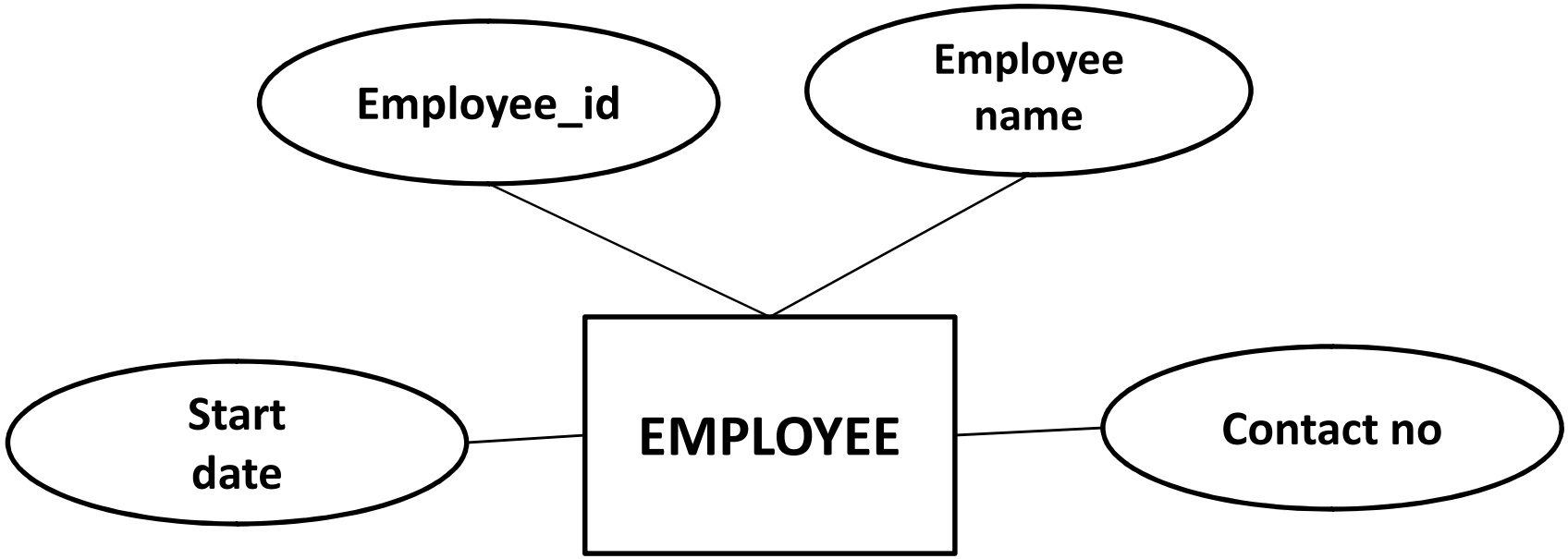

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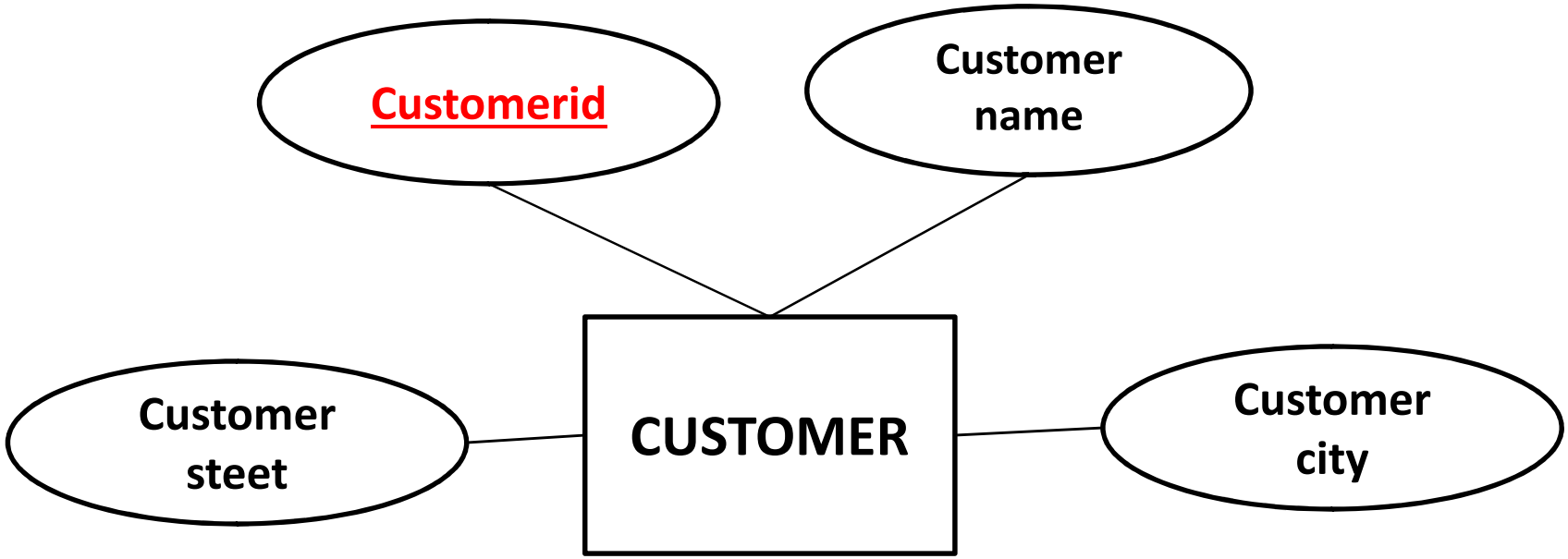
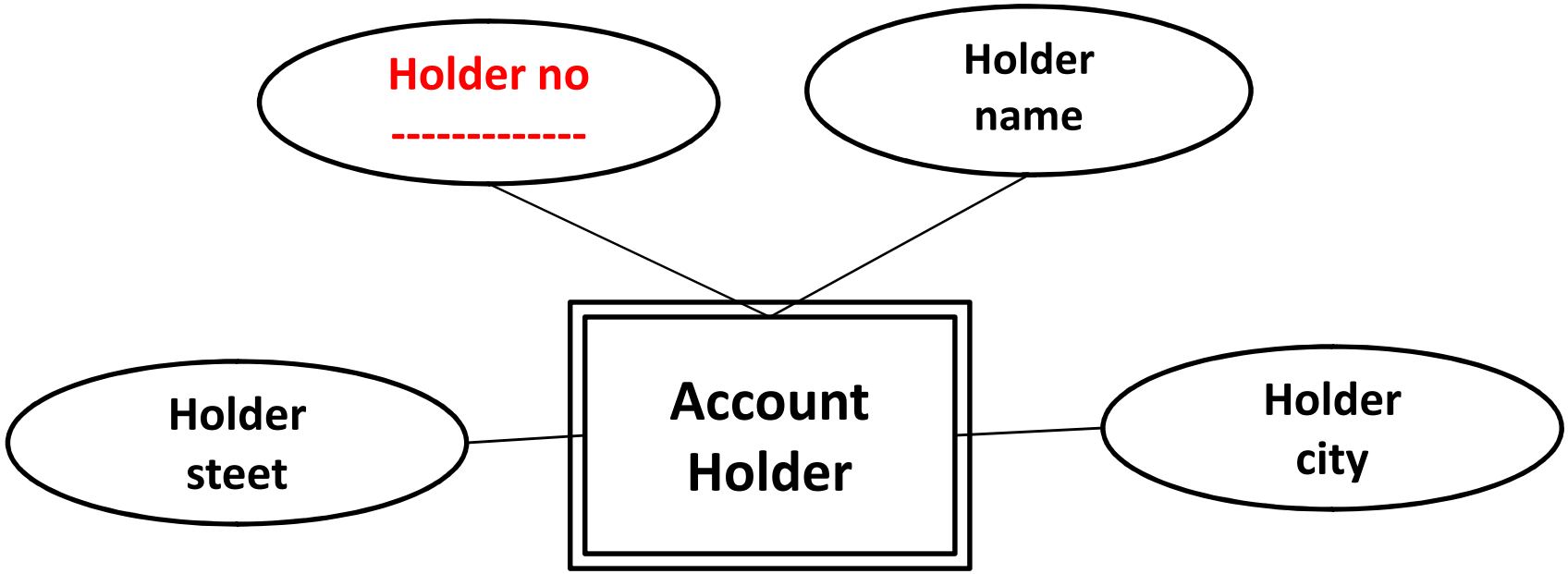
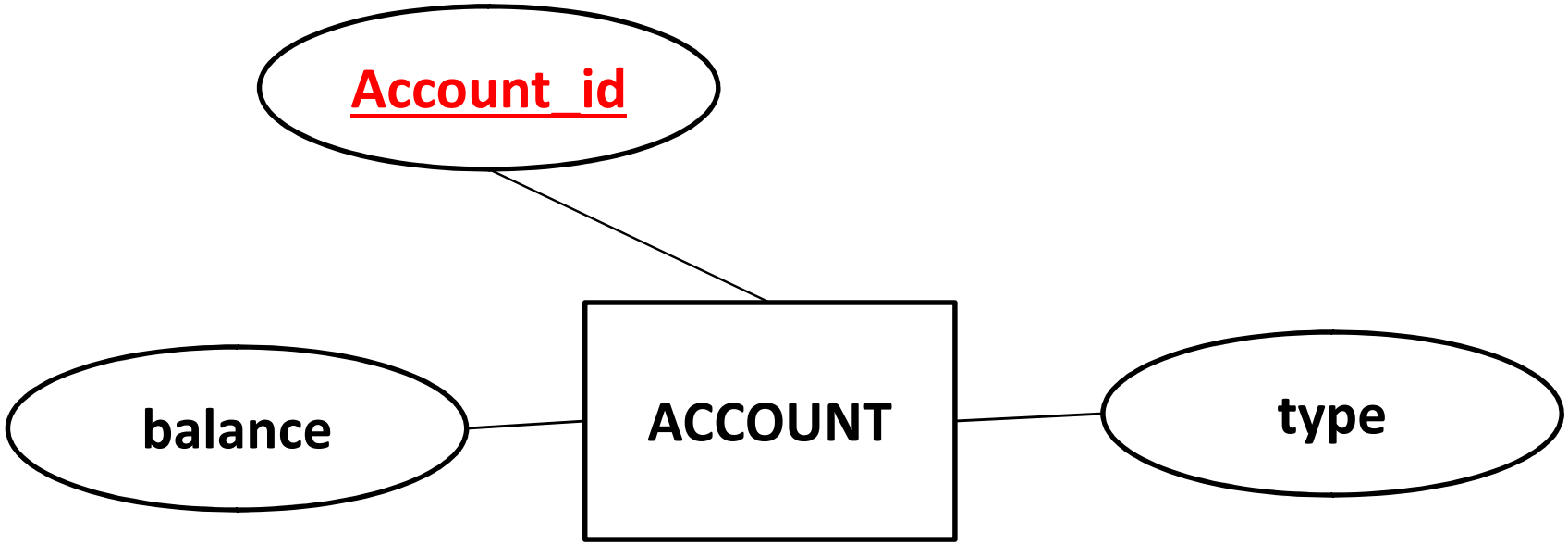

Customerid
Customer name
Customer steet
CUSTOMER
Customer city

KEY


Holder no

Holder
name
Holder
steet
Account
Holder
Holder
city

KEY



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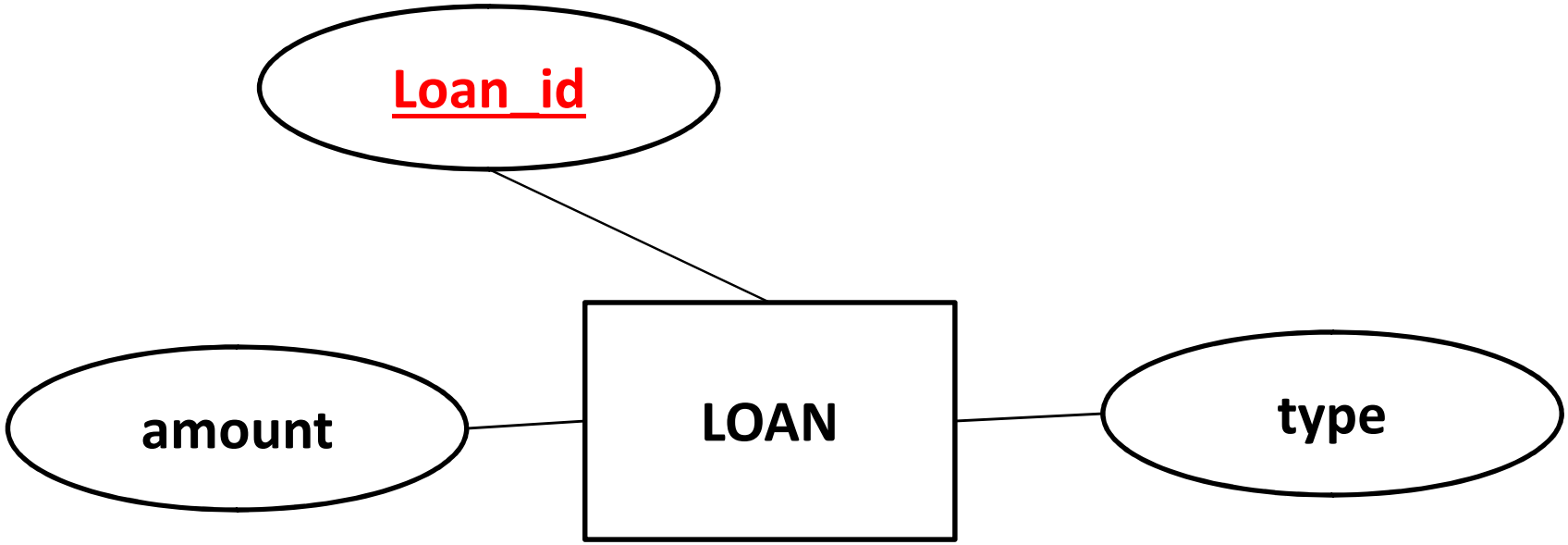

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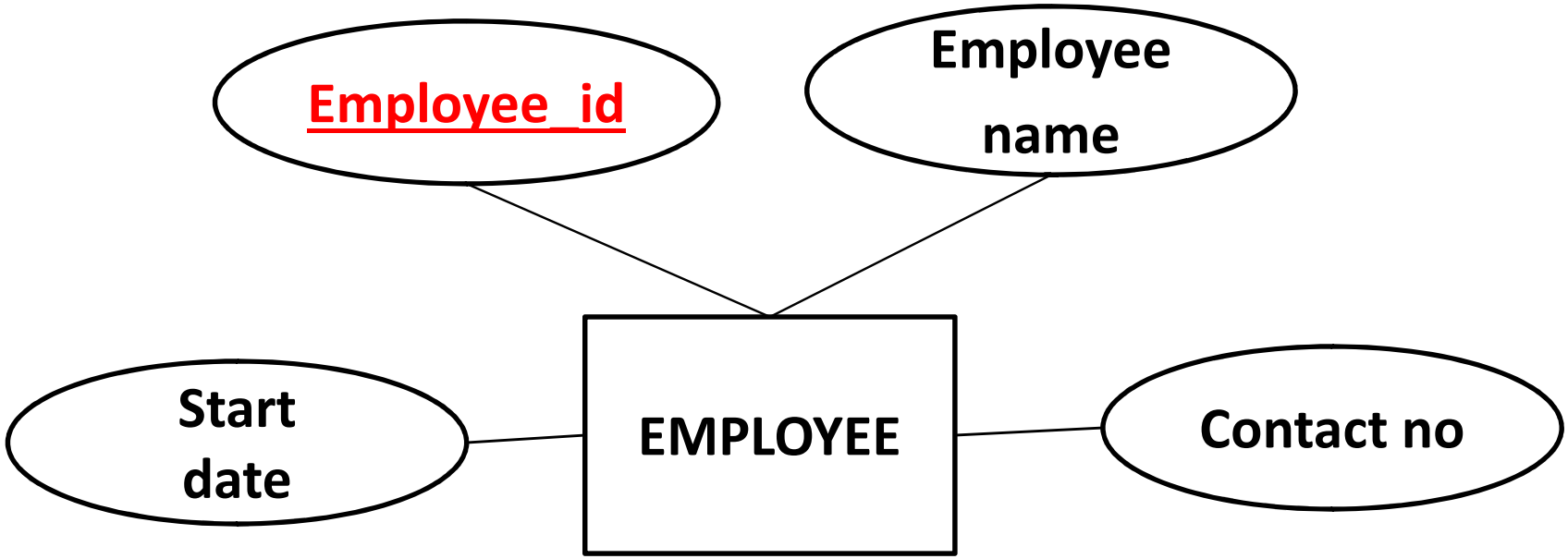
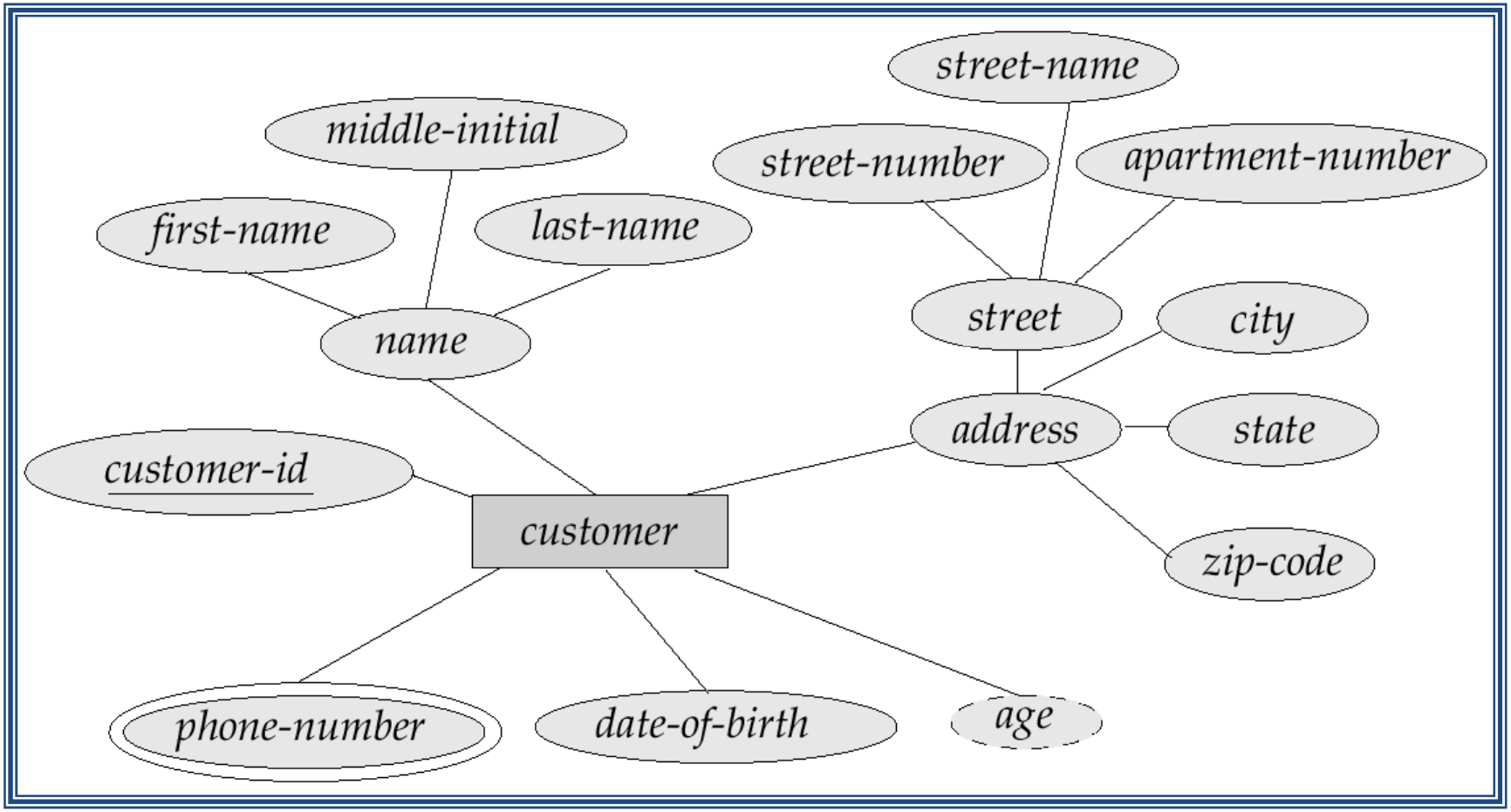


E-R Diagram With Composite, Multivalued, and Derived Attributes



Constructing an ER model

Before beginning to draw the ER model, read the requirements specification carefully. Document any assumptions you need to make.

- Identify entities - list all potential entity types. These are the object of interest in the system. It is better to put too many entities in at this stage and them discard them later if necessary.
- Remove duplicate entities - Ensure that they really separate entity types or just two names for the same thing.
- Also do not include the system as an entity type

Constructing an ER model...

- List the attributes of each entity (all properties to describe the entity which are relevant to the application).
  - Ensure that the entity types are really needed.
  - are any of them just attributes of another entity type?
  - if so keep them as attributes and cross them off the entity list.
  - Do not have attributes of one entity as attributes of another entity!
- Mark the primary keys.
  - Which attributes uniquely identify instances of that entity type?
  - This may not be possible for some weak entities.
- Define the relationships
  - Examine each entity type to see its relationship to the others.

Constructing an ER model…

- Describe the cardinality of the relationships
  - Examine the constraints between participating entities.

- ER modelling is an iterative process, so draw several versions, refining each one until you are happy with it. Note that there is no one right answer to the problem, but some solutions are better than others!

How about doing an ER design interactively on the paper?

Problem statement

Design a database that manages information about publishers, authors, and books. A publisher has a name and address for the headquarters. Each publisher also has a set of branches, each branch having an address and two phone numbers. An author has a name and an address. A book is published by a publisher and has a list of authors associated with it. An author can write several books & a book can be published by only one publisher. Draw an E-R diagram for the given system.

Draw an E-R diagram for the given system.

- We wish to create a database for a company that runs training courses. For this, we must store data about the trainees and the instructors.
- Each trainee is identified by a code. Store the other information of trainee like surname, age, gender, place of birth, address and telephone number, previous employers(and periods employed), the courses attended and the final assessment for each course.
- We also need to represent the conferences that each participant is attending at present and, for each day, the places and times the classes are held.
- Each course has a code and a title and any course can be given any number of times.
- Each time a particular course is given, we call it an ‘edition’ of the course.

Draw an E-R diagram for the given system.

- For each edition, we represent the start date, the end date, and the number of participants.
- For each instructor, we will show the surname, age, place of birth, the edition of the course taught, those taught in the past and the courses that the tutor is qualified to teach. The instructor's telephone numbers are also stored.
- If a trainee is self-employed, we need to know his/her area of expertise.
- For somebody who works for a company, we store the level and position held.

Problem statement

Draw an ER diagram for University database consisting of four entities: Student, Faculty, Course and Department.

- Student has unique id, the student can enroll for more than one course and can have at most one elective.
- Faculty must belong to one department and faculty can teach multiple courses.
- Each course is taught by one faculty
- Every student will get grade for the course he/she has enrolled.

Draw an ER diagram for a Library system

- A college library holds resources of information for its members to borrow.
- Resource can be text book, journal or magazine.
- Each resource is identified by unique catalogue number.
- Each text book may have more than one copy.
- Each member can borrow one or more resources.
- The member can issue at the most 10 resources of information.
- If no copies of a wanted book are currently in stock, a member may make a reservation for the title until it is available.
- If books are not returned on time a fine is imposed and if the fine is not paid the member is barred from borrowing any other books until the fine is paid.
- Librarians are the managers of the libraries in the system. and each library has more than one librarian.
- Librarian can also be the member of library.