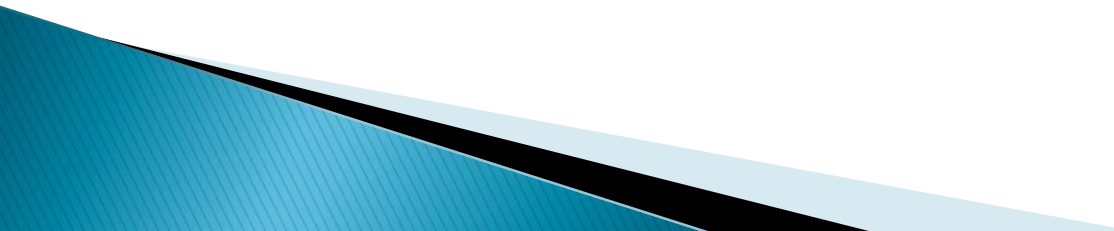


# Lecture-9

## Entity-Relationship Diagram

# Entity–Relationship Model

- ▶ Design Process
  - ▶ Modeling
  - ▶ Constraints
  - ▶ E–R Diagram
  - ▶ Design Issues
  - ▶ Weak Entity Sets
  - ▶ Extended E–R Features
  - ▶ Design of the Bank Database
  - ▶ Reduction to Relation Schemas
  - ▶ Database Design
  - ▶ UML
- 

# Modeling

- ▶ A *database* can be modeled as:
  - a collection of entities,
  - relationship among entities.
- ▶ An **entity** is an object that exists and is distinguishable from other objects.
  - Example: specific person, company, event, plant
- ▶ Entities have *attributes*
  - Example: people have *names* and *addresses*
- ▶ 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

# Entity Sets *customer* and *loan*

customer\_id   customer\_   customer\_   customer\_  
                  name        street        city

loan\_   amount  
number

321-12-3123	Jones	Main	Harrison
-------------	-------	------	----------

019-28-3746	Smith	North	Rye
-------------	-------	-------	-----

677-89-9011	Hayes	Main	Harrison
-------------	-------	------	----------

555-55-5555	Jackson	Dupont	Woodside
-------------	---------	--------	----------

244-66-8800	Curry	North	Rye
-------------	-------	-------	-----

963-96-3963	Williams	Nassau	Princeton
-------------	----------	--------	-----------

335-57-7991	Adams	Spring	Pittsfield
-------------	-------	--------	------------

L-17	1000
------	------

L-23	2000
------	------

L-15	1500
------	------

L-14	1500
------	------

L-19	500
------	-----

L-11	900
------	-----

L-16	1300
------	------

*customer*

*loan*

# Relationship Sets

- ▶ A relationship is an association among several entities

Example:

Hayes                      depositor                      A-102  
*customer* entity      relationship set      *account* entity

- ▶ A relationship set is a mathematical relation among  $n \geq 2$  entities, each taken from entity sets

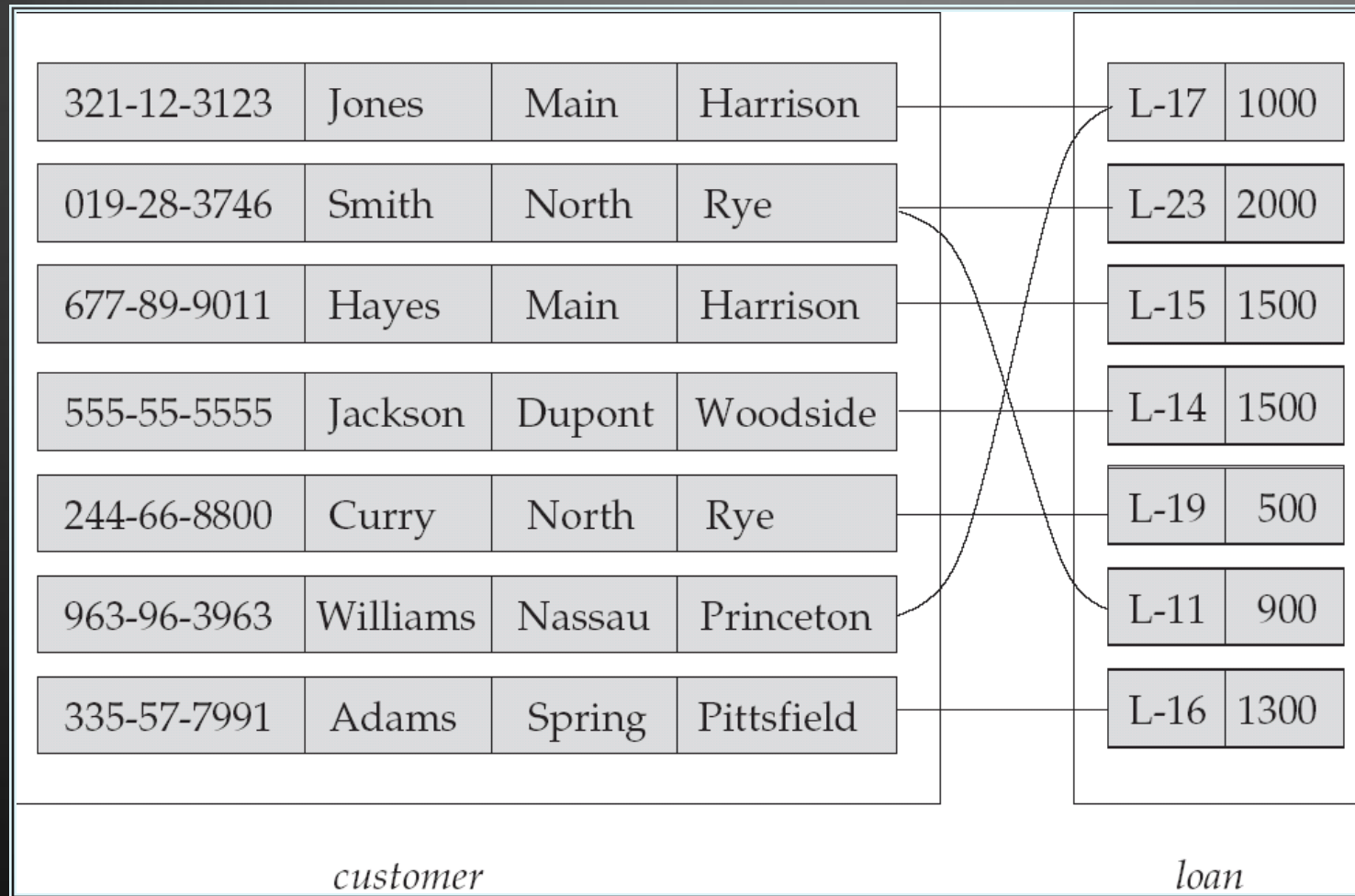
$$\{(e_1, e_2, \dots, e_n) \mid e_1 \in E_1, e_2 \in E_2, \dots, e_n \in E_n\}$$

where  $(e_1, e_2, \dots, e_n)$  is a relationship

- Example:

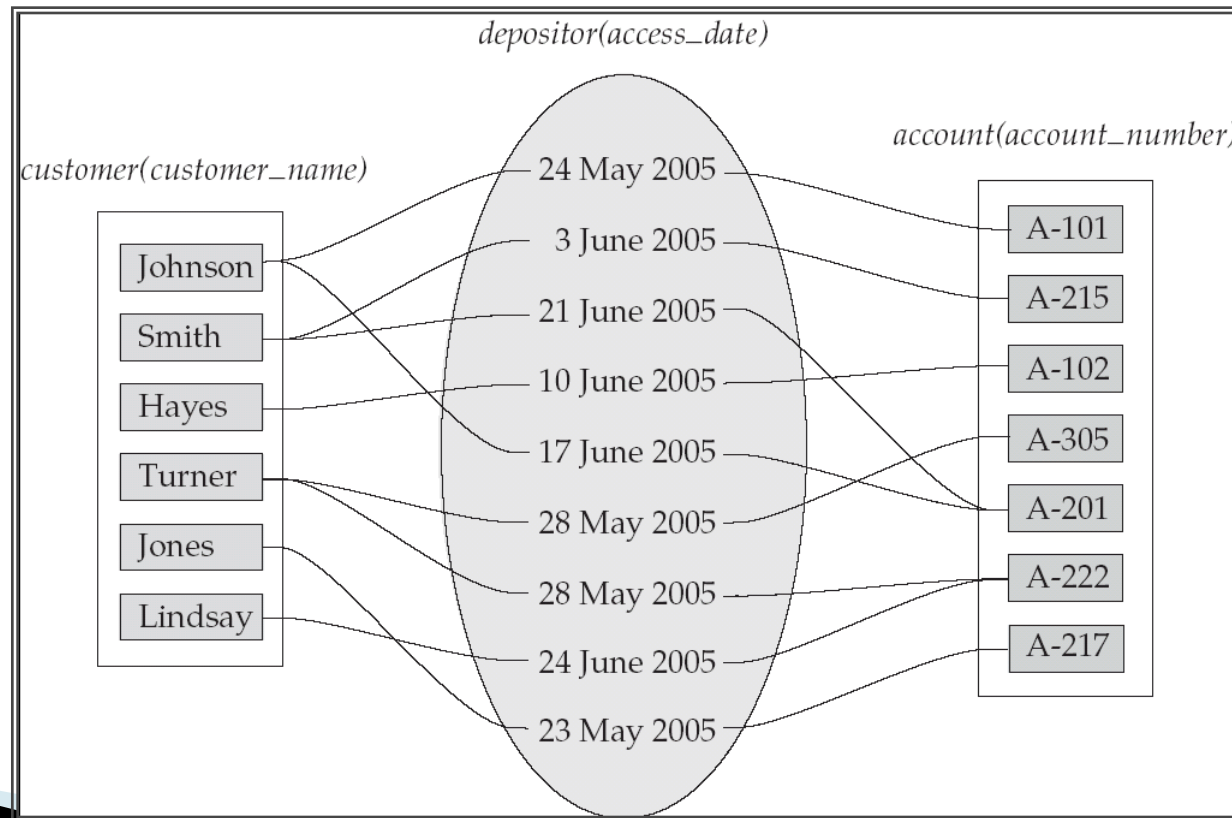
$(\text{Hayes}, \text{A-102}) \in \textit{depositor}$

# Relationship Set *borrower*



# Relationship Sets (Cont.)

- ▶ An attribute can also be property of a relationship set.
- ▶ For instance, the *depositor* relationship set between entity sets *customer* and *account* may have the attribute *access-date*



# Degree of a Relationship Set

- ▶ Refers to number of entity sets that participate in a relationship set.
- ▶ Relationship sets that involve two entity sets are **binary** (or degree two). Generally, most relationship sets in a database system are binary.
- ▶ Relationship sets may involve more than two entity sets.
  - ▶ Example: Suppose employees of a bank may have jobs (responsibilities) at multiple branches, with different jobs at different branches. Then there is a ternary relationship set between entity sets *employee*, *job*, and *branch*
- ▶ Relationships between more than two entity sets are rare. Most relationships are binary. (More on this later.)



# Attributes

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

Example:

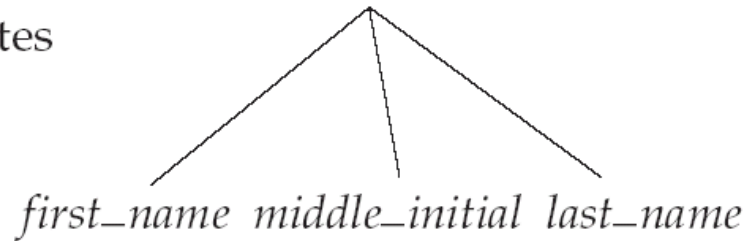
*customer = (customer\_id,  
customer\_name,  
customer\_street, customer\_city)*

- ▶ Domain – the set of permitted values for each attribute
- ▶ Attribute types:
  - *Simple* and *composite* attributes.
  - *Single-valued* and *multi-valued* attributes
    - Example: multivalued attribute: *phone\_numbers*
  - *Derived* attributes
    - Can be computed from other attributes
    - Example: age, given date\_of\_birth

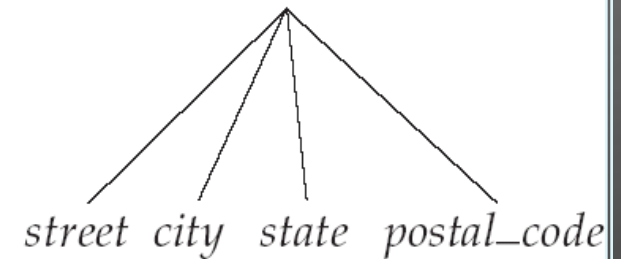
# Composite Attributes

Composite  
Attributes

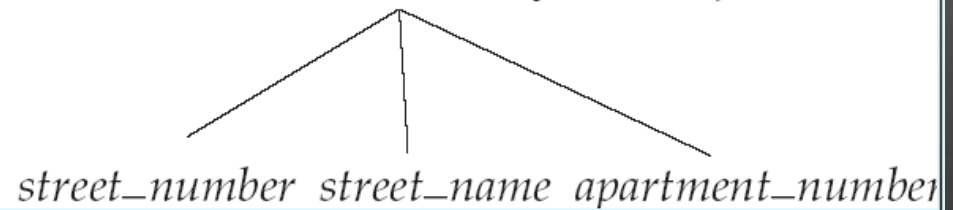
*name*



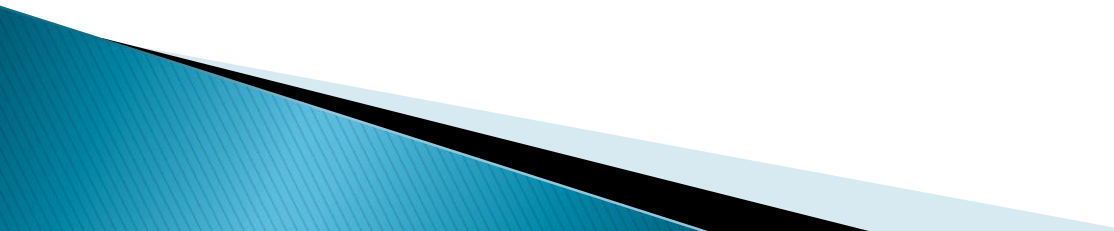
*address*



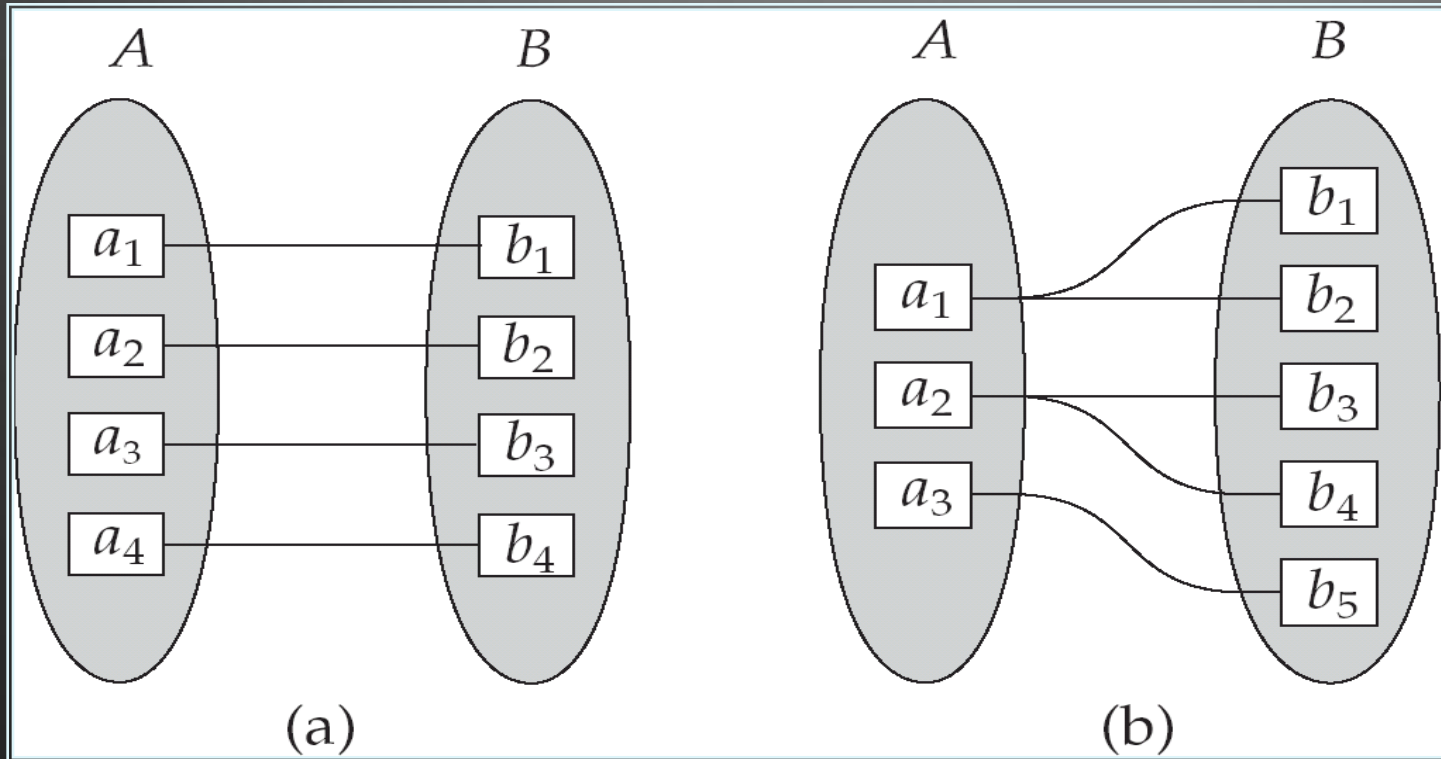
Component  
Attributes



# Mapping Cardinality Constraints

- ▶ Express the number of entities to which another entity can be associated via a relationship set.
  - ▶ Most useful in describing binary relationship sets.
  - ▶ For a binary relationship set the mapping cardinality must be one of the following types:
    - One to one
    - One to many
    - Many to one
    - Many to many
- 

# Mapping Cardinalities

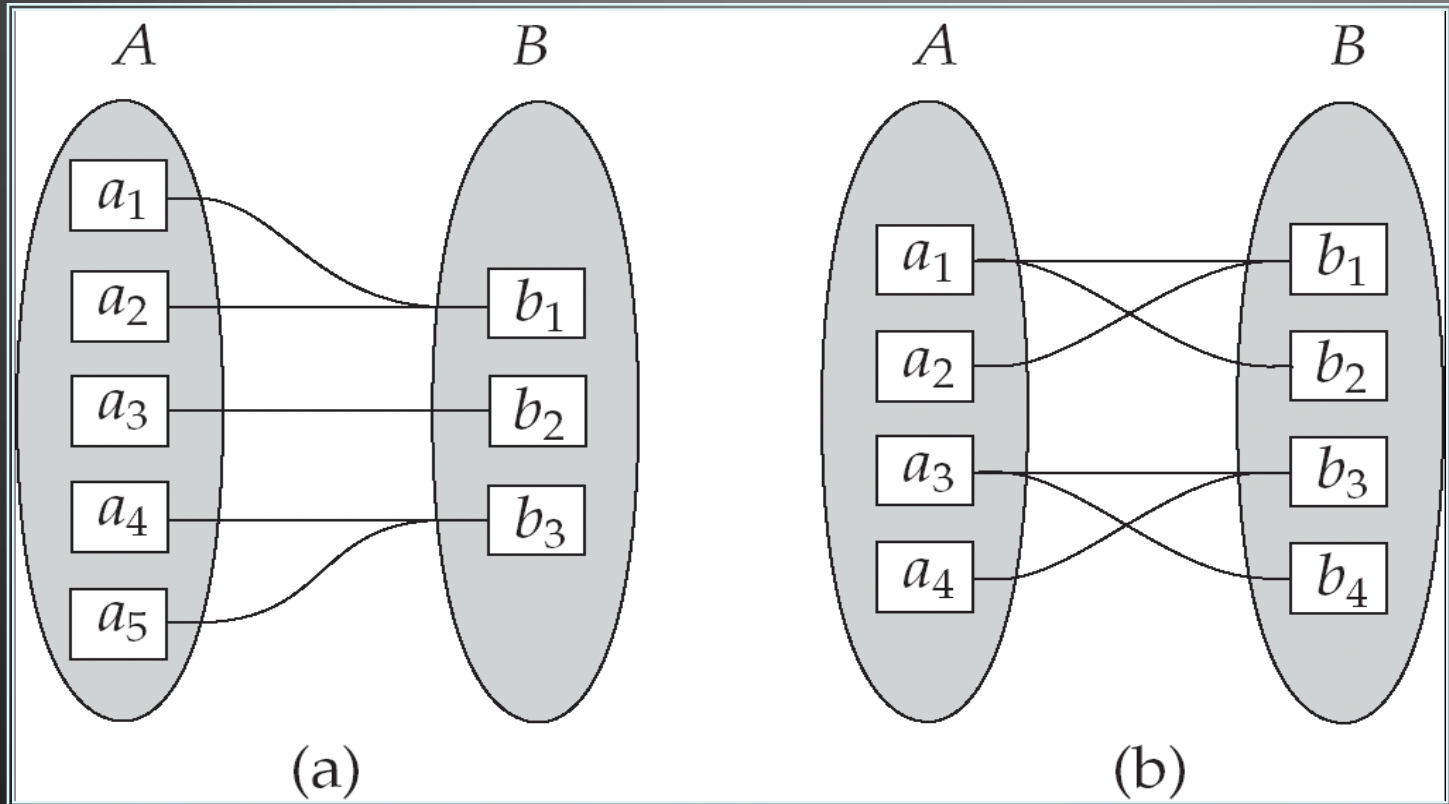


One to one

One to many

Note: Some elements in  $A$  and  $B$  may not be mapped to any elements in the other set

# Mapping Cardinalities



Many to one

Many to many

Note: Some elements in A and B may not be mapped to any elements in the other set

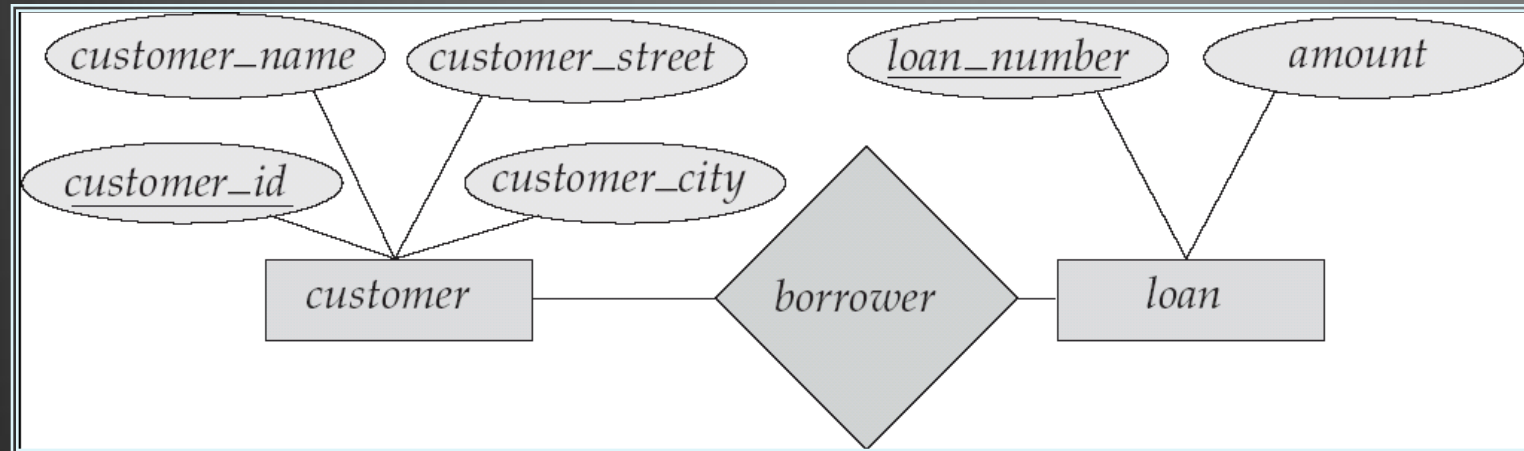
# Keys

- ▶ 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
  - *Customer\_id* is candidate key of *customer*
  - *account\_number* is candidate key of *account*
- ▶ Although several candidate keys may exist, one of the candidate keys is selected to be the **primary key**.

# 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.*
    - Example: if we wish to track all *access\_dates* to each account by each customer, we cannot assume a relationship for each access. We can use a multivalued attribute though
- ▶ Must consider the mapping cardinality of the relationship set when deciding what are the candidate keys
- ▶ Need to consider semantics of relationship set in selecting the *primary key* in case of more than one candidate key

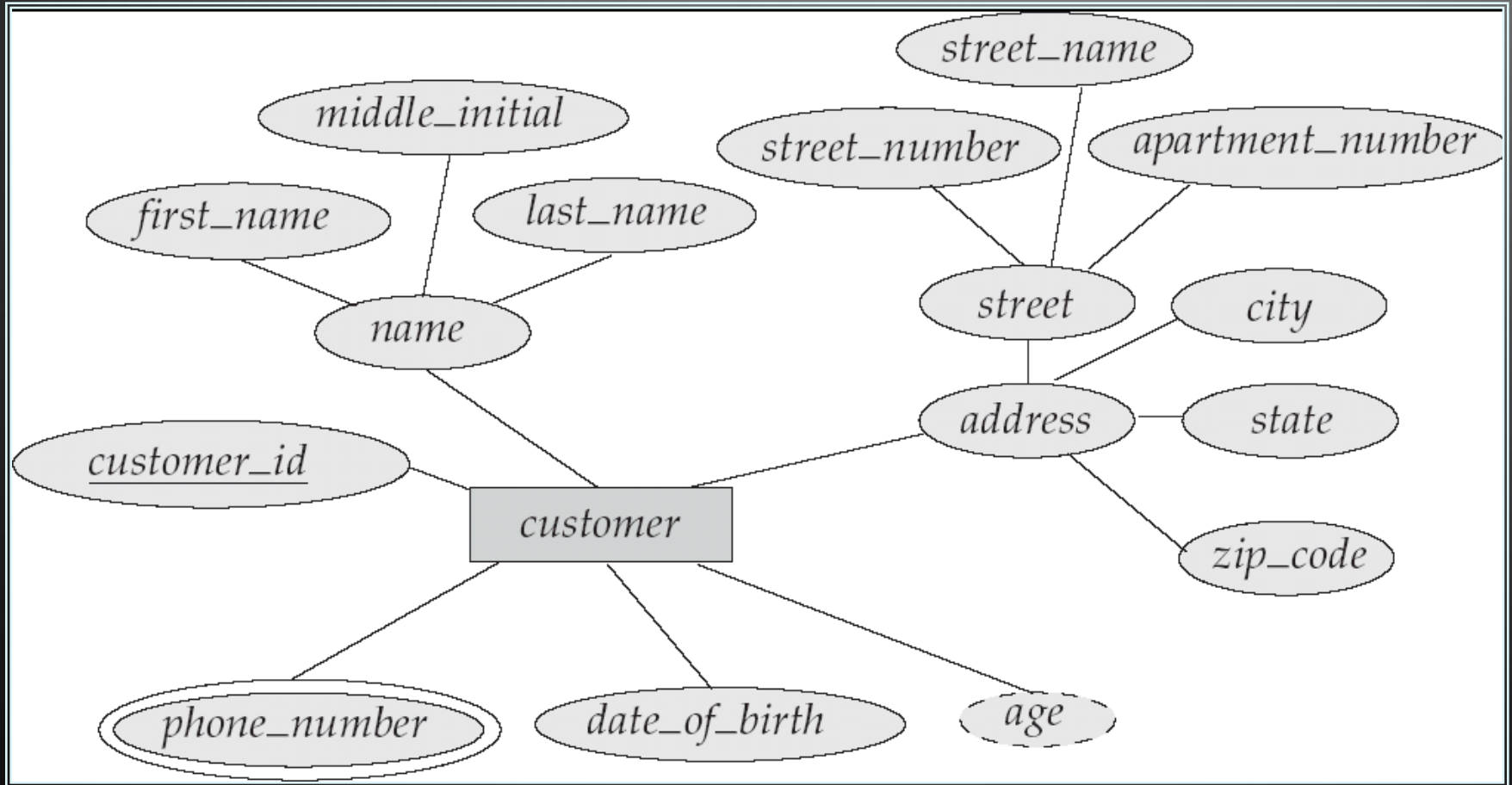
# E-R Diagrams



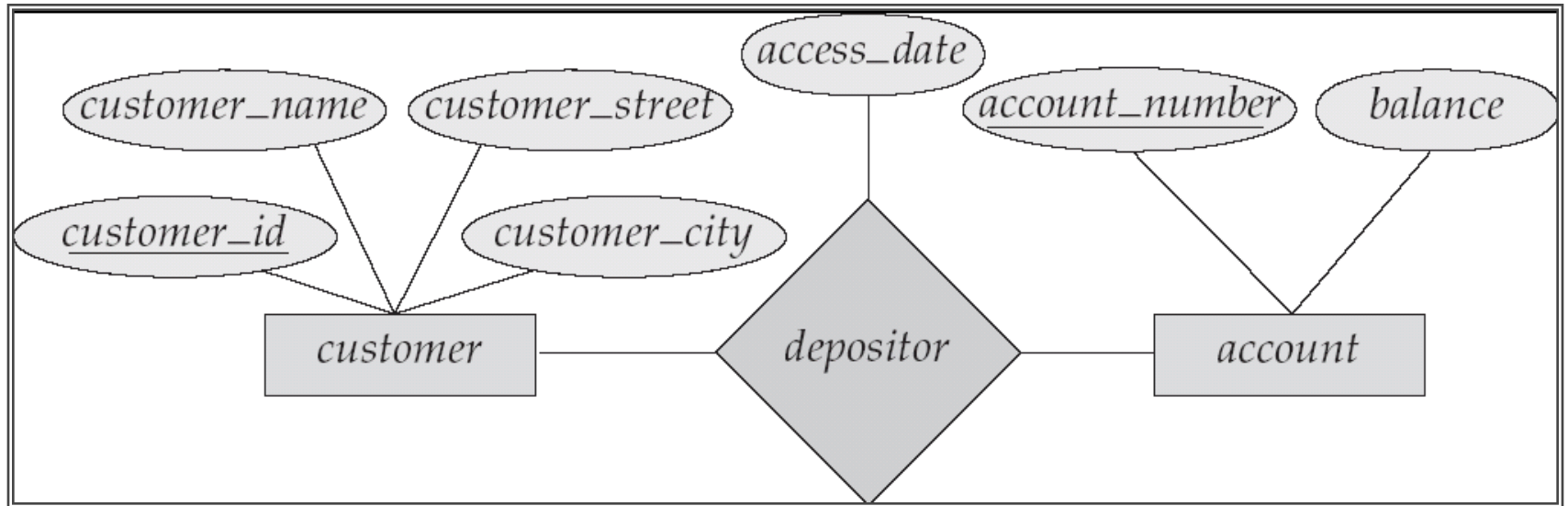
- n Rectangles represent entity sets.
- n Diamonds represent relationship sets.
- n Lines link attributes to entity sets and entity sets to relationship sets.
- n Ellipses represent attributes
  - | Double ellipses represent multivalued attributes.
  - | Dashed ellipses denote derived attributes.
- n Underline indicates primary key attributes (will study later)



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

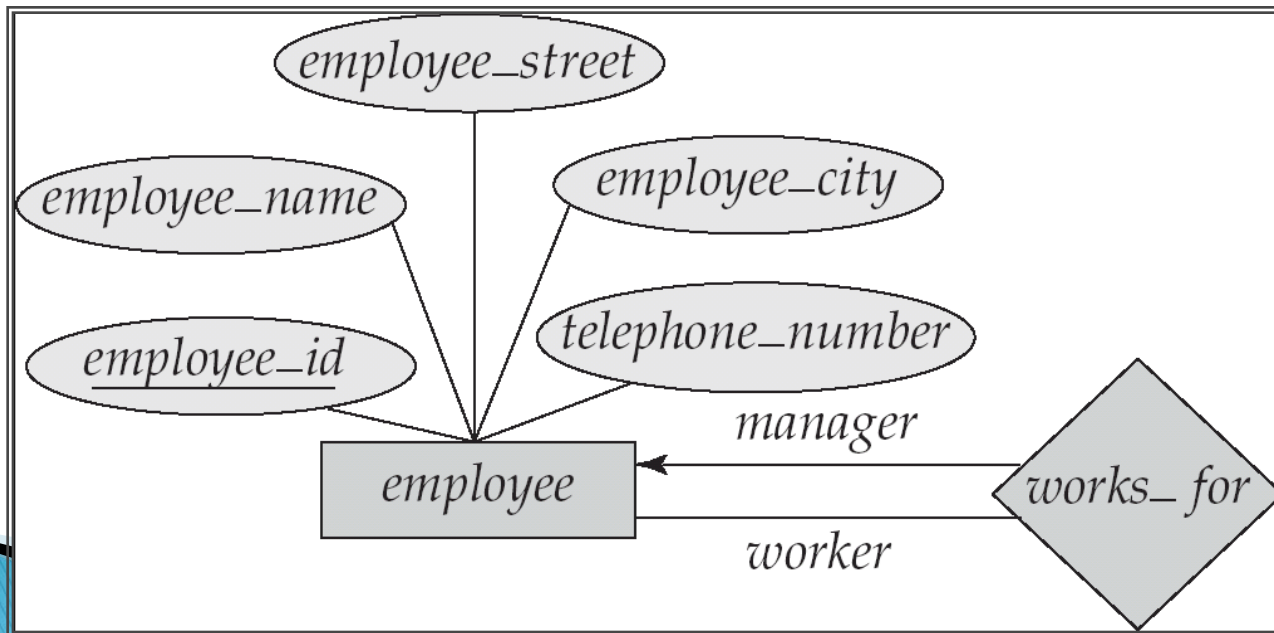


# Relationship Sets with Attributes



# Roles

- ▶ Entity sets of a relationship need not be distinct
- ▶ 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

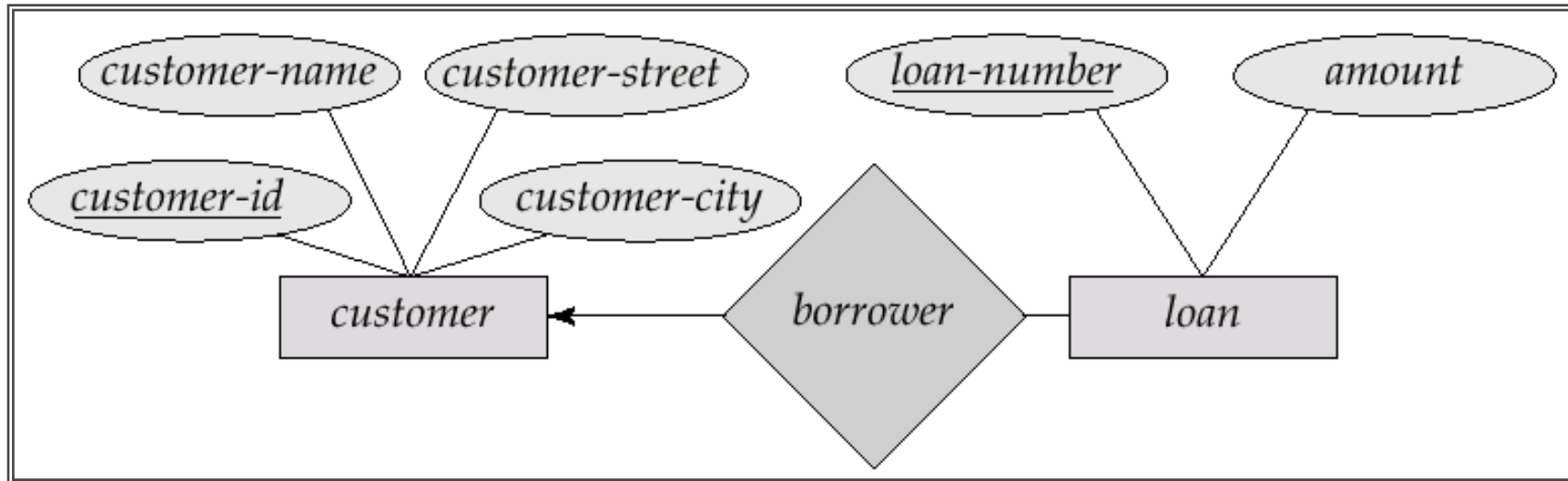


# Cardinality Constraints

- ▶ We express cardinality constraints by drawing either a directed line ( $\rightarrow$ ), signifying “one,” or an undirected line ( $—$ ), signifying “many,” between the relationship set and the entity set.
- ▶ 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*

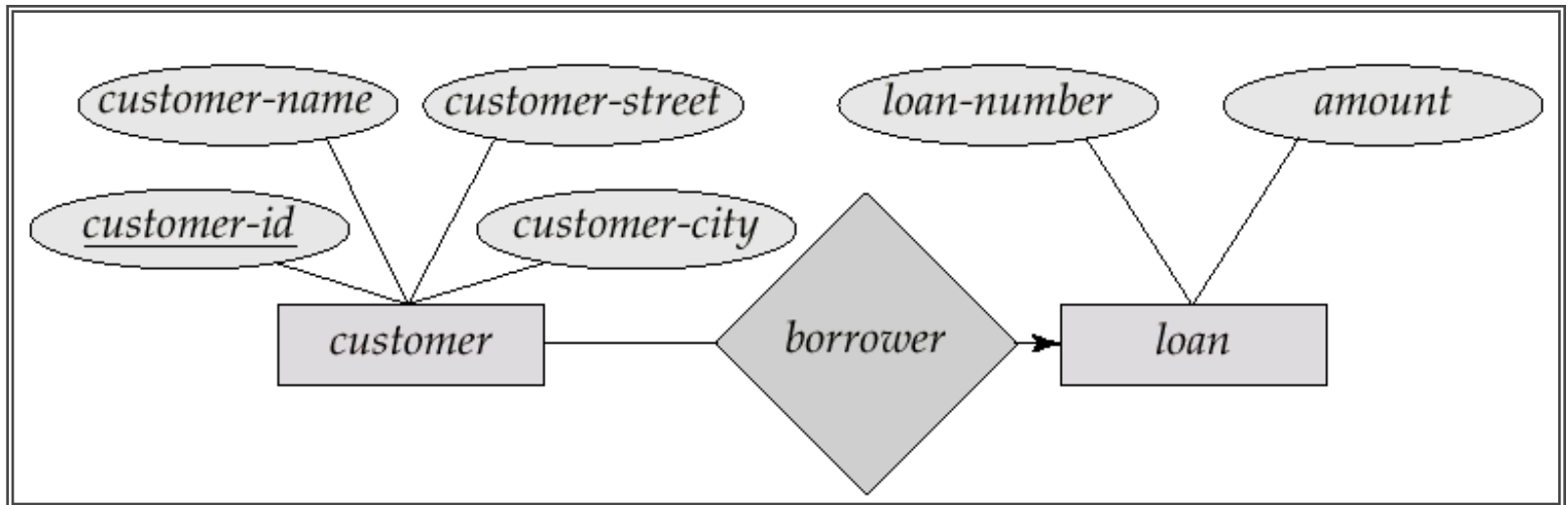
# One-To-Many Relationship

- ▶ In the 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*



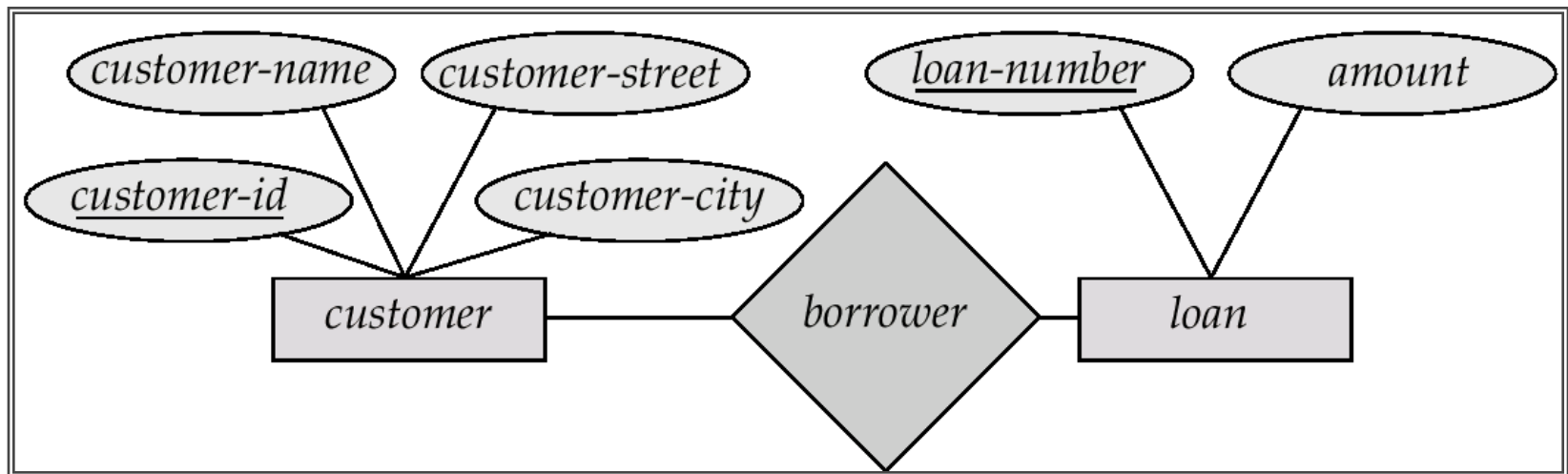
# Many-To-One Relationships

- ▶ In a 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*



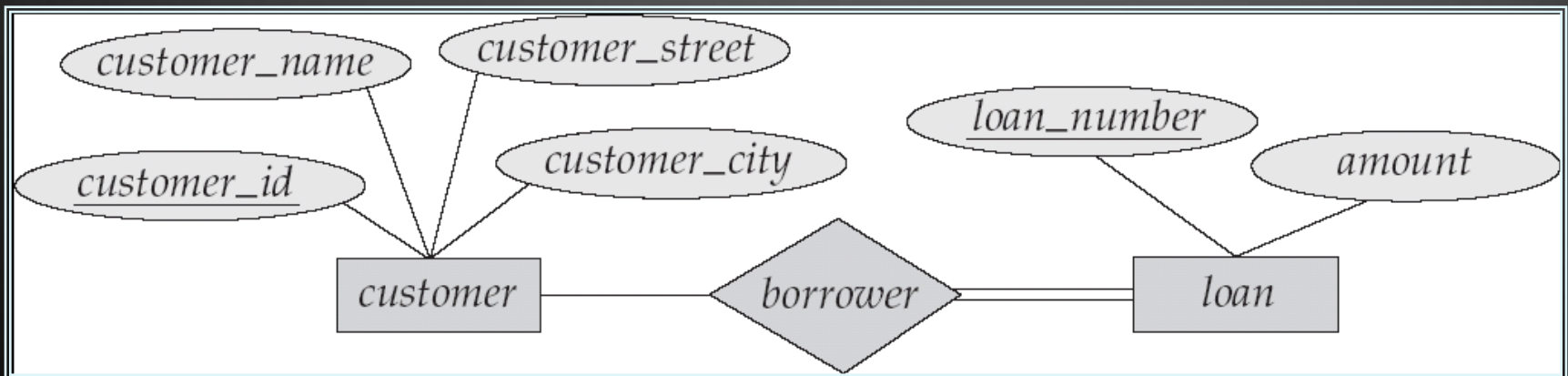
# Many-To-Many Relationship

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



# Participation of an Entity Set in a Relationship Set

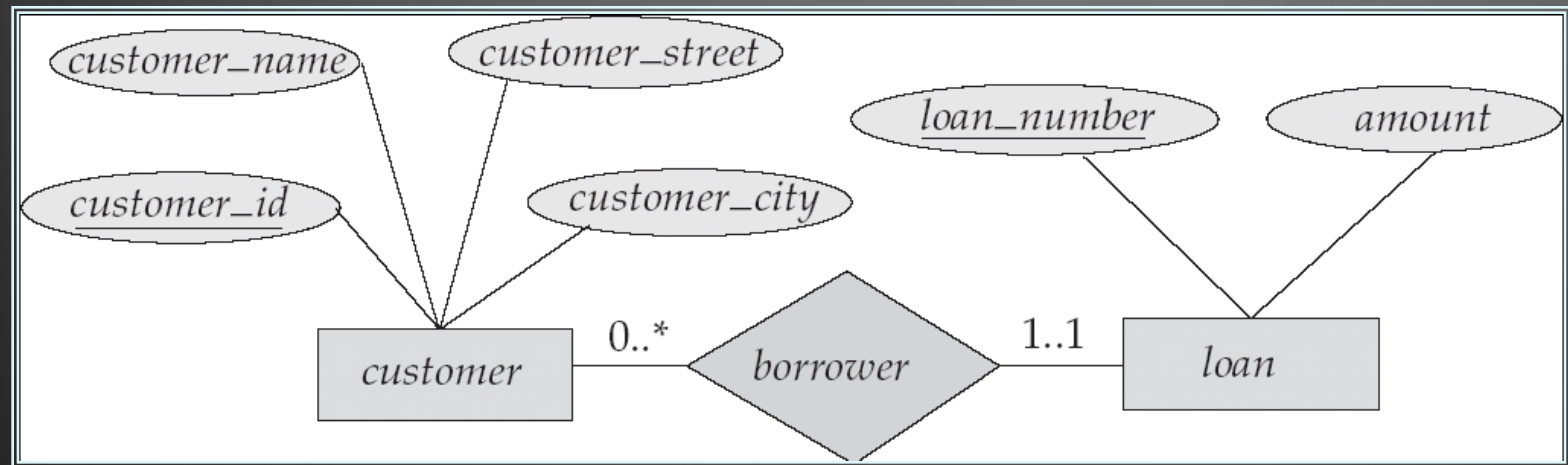
- n Total participation (indicated by double line): every entity in the entity set participates in at least one relationship in the relationship set
  - | E.g. participation of loan in borrower is total
    - ▶ every loan must have a customer associated to it via borrower
- n Partial participation: some entities may not participate in any relationship in the relationship set
  - | Example: participation of customer in borrower is partial





# Alternative Notation for Cardinality Limits

- n Cardinality limits can also express participation constraints



# E-R Diagram with a Ternary Relationship

