Entity-Relationship Diagram

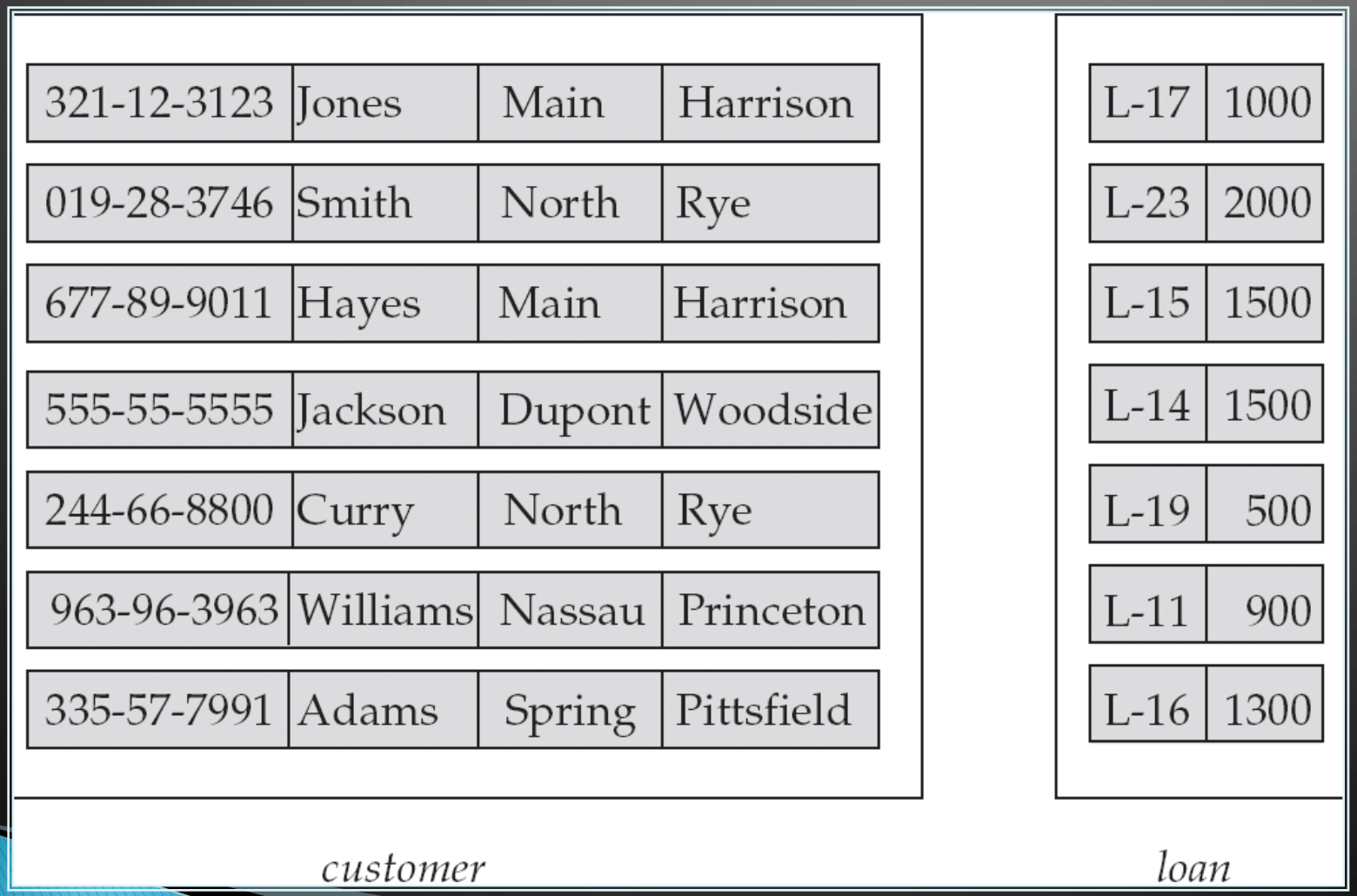
Entity-Relationship Model

- 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*



Relationship Sets

- A **relationship** is an association among several entities

  Example:

  Hayes (*customer* entity) — *depositor* (relationship set) — A-102 (*account* entity)

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

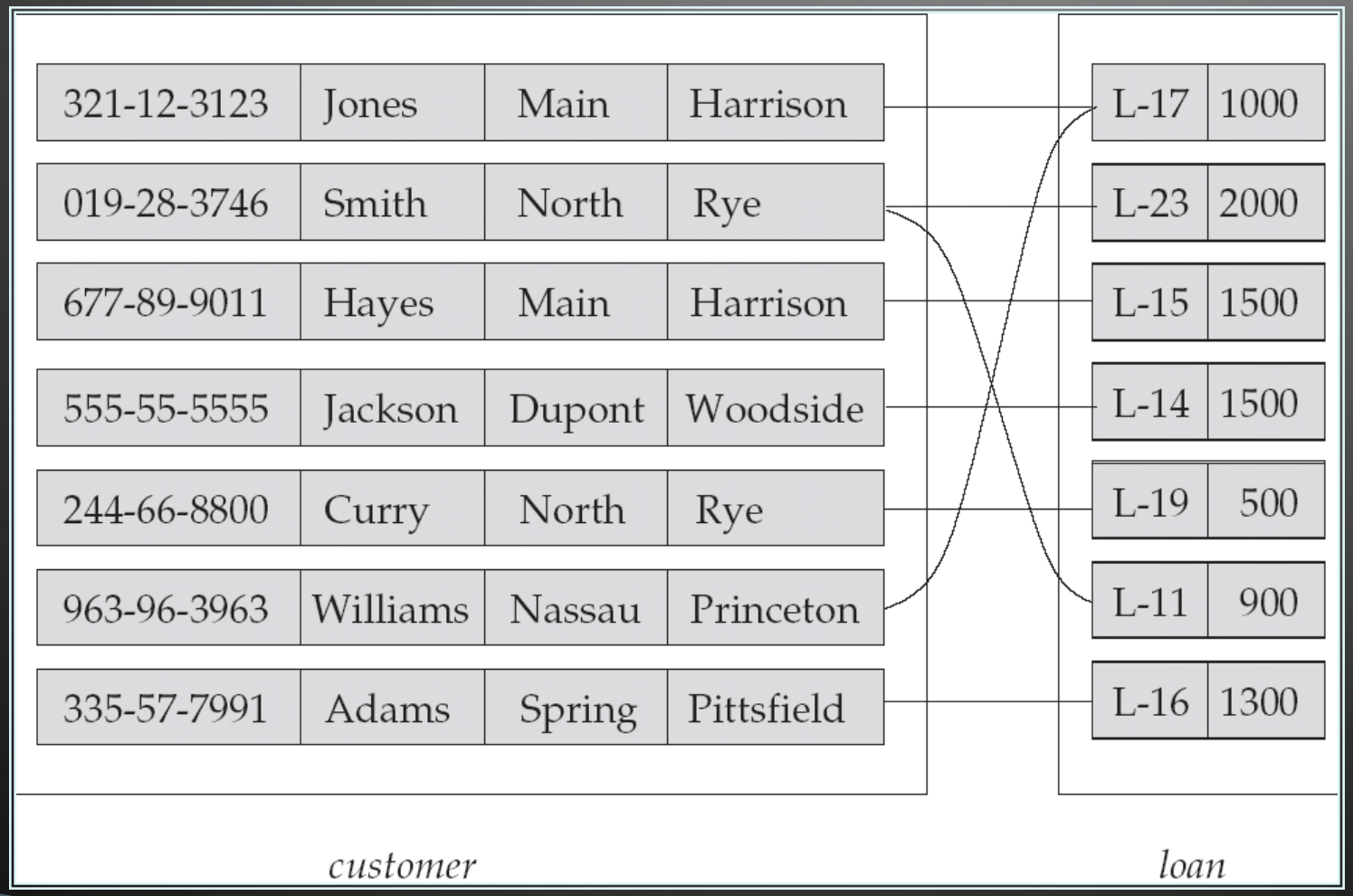
  $$\{(e_1, e_2, \ldots e_n) \mid e_1 \in E_1, e_2 \in E_2, \ldots, e_n \in E_n\}$$

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

  - Example:

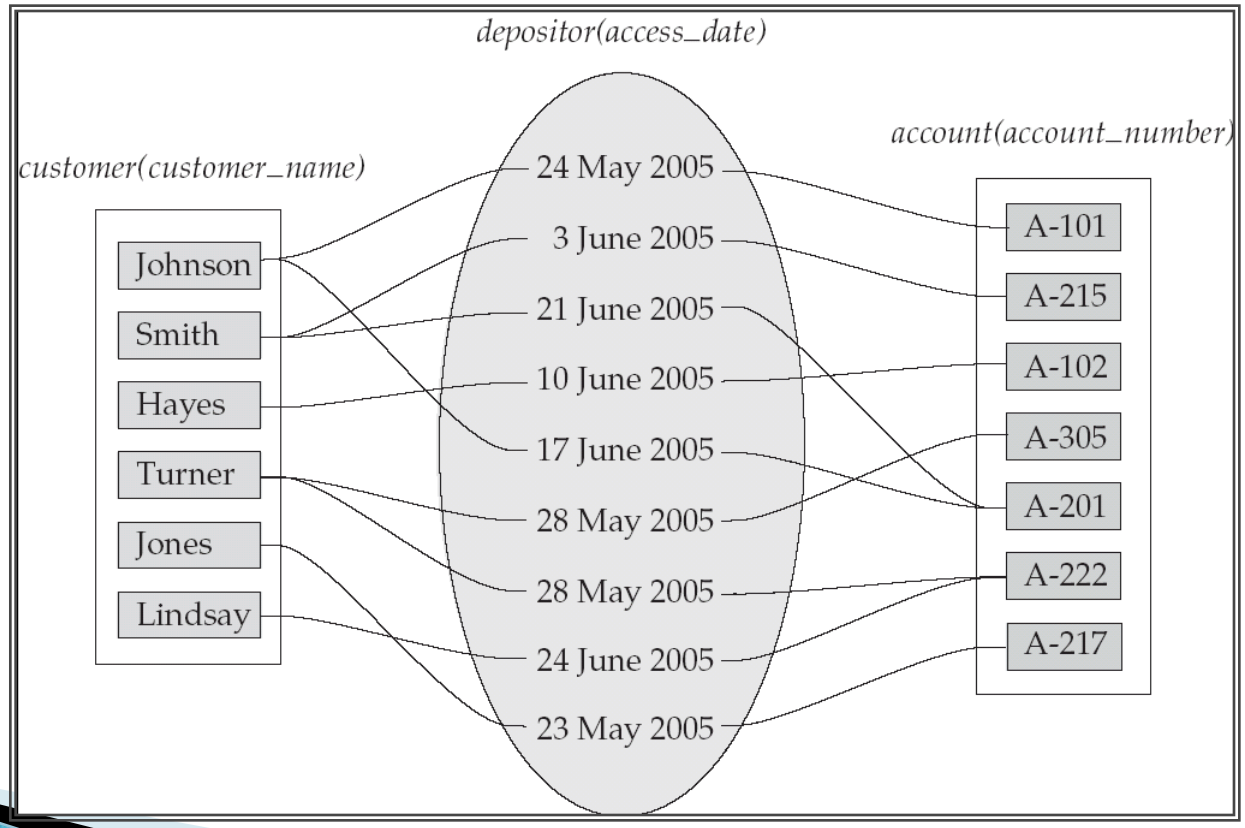
    (Hayes, A-102) $\in$ *depositor*

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.

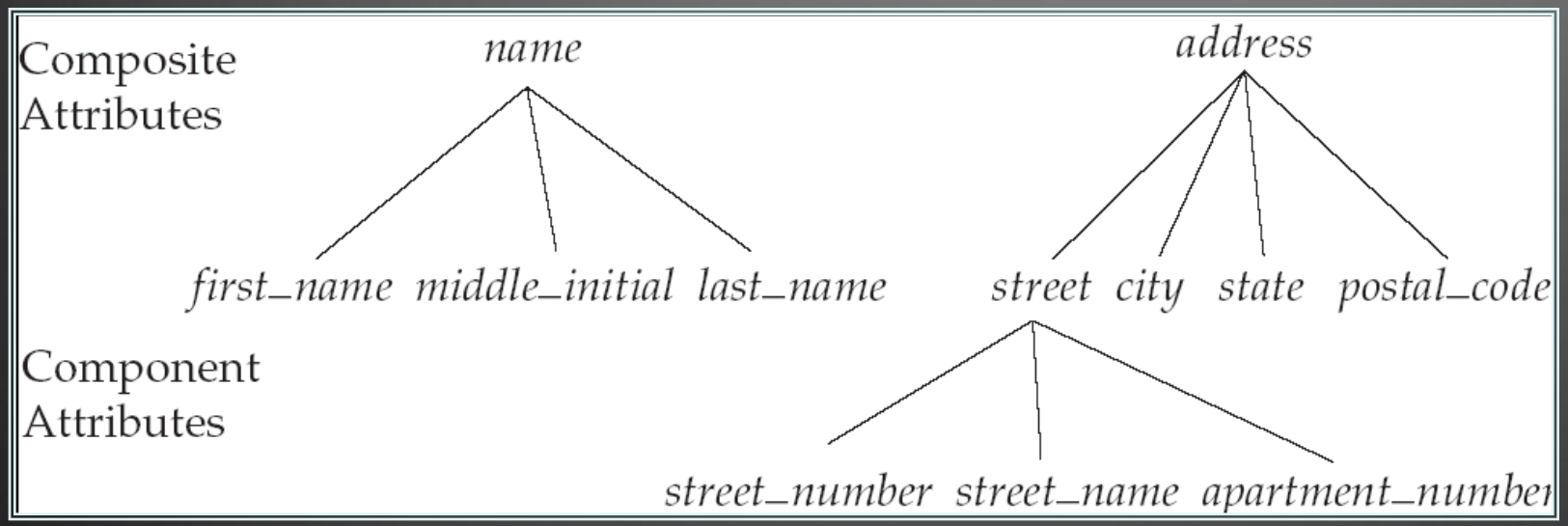
  Example:

  customer = (*customer_id, customer_name, customer_street, customer_city*)

  loan = (*loan_number, amount*)

- **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

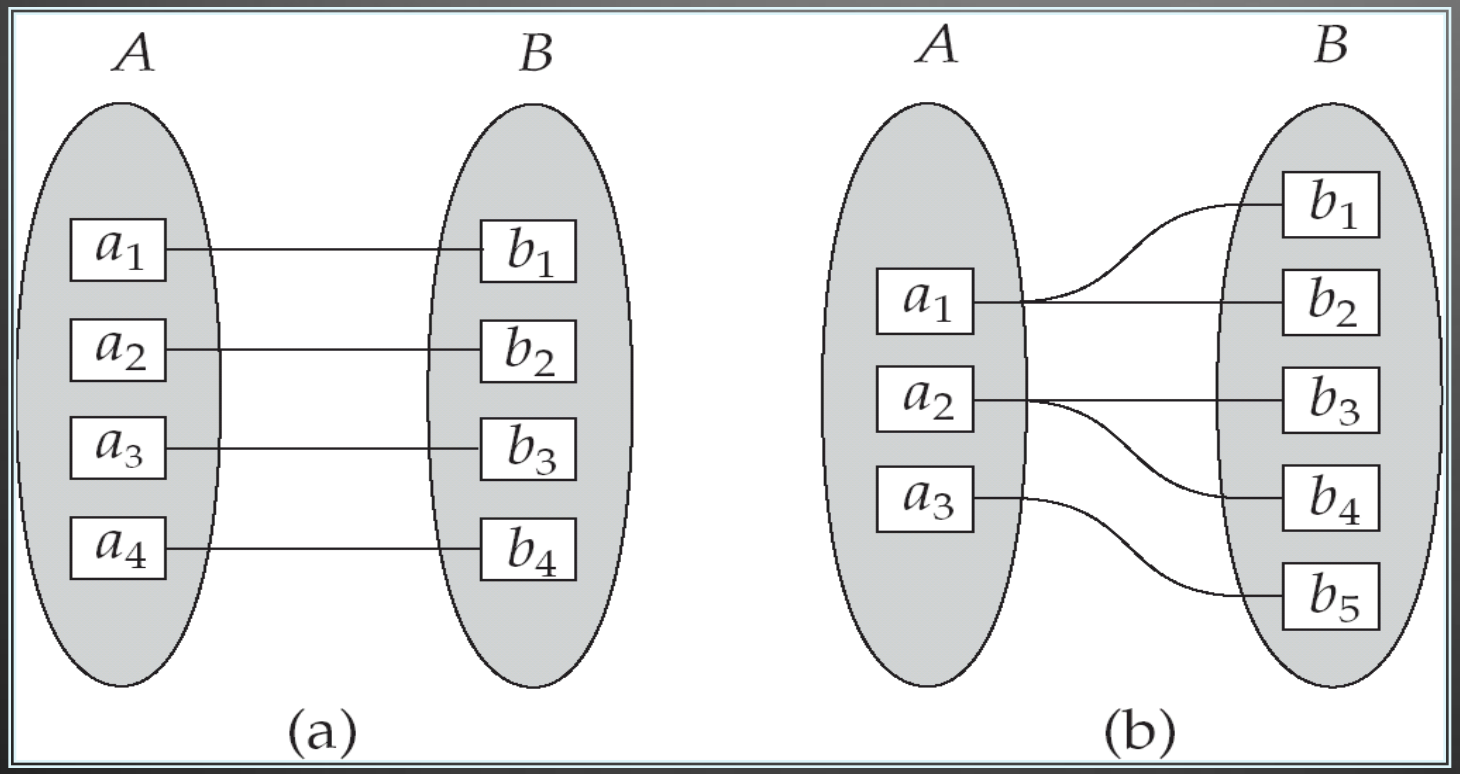
Composite Attributes



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

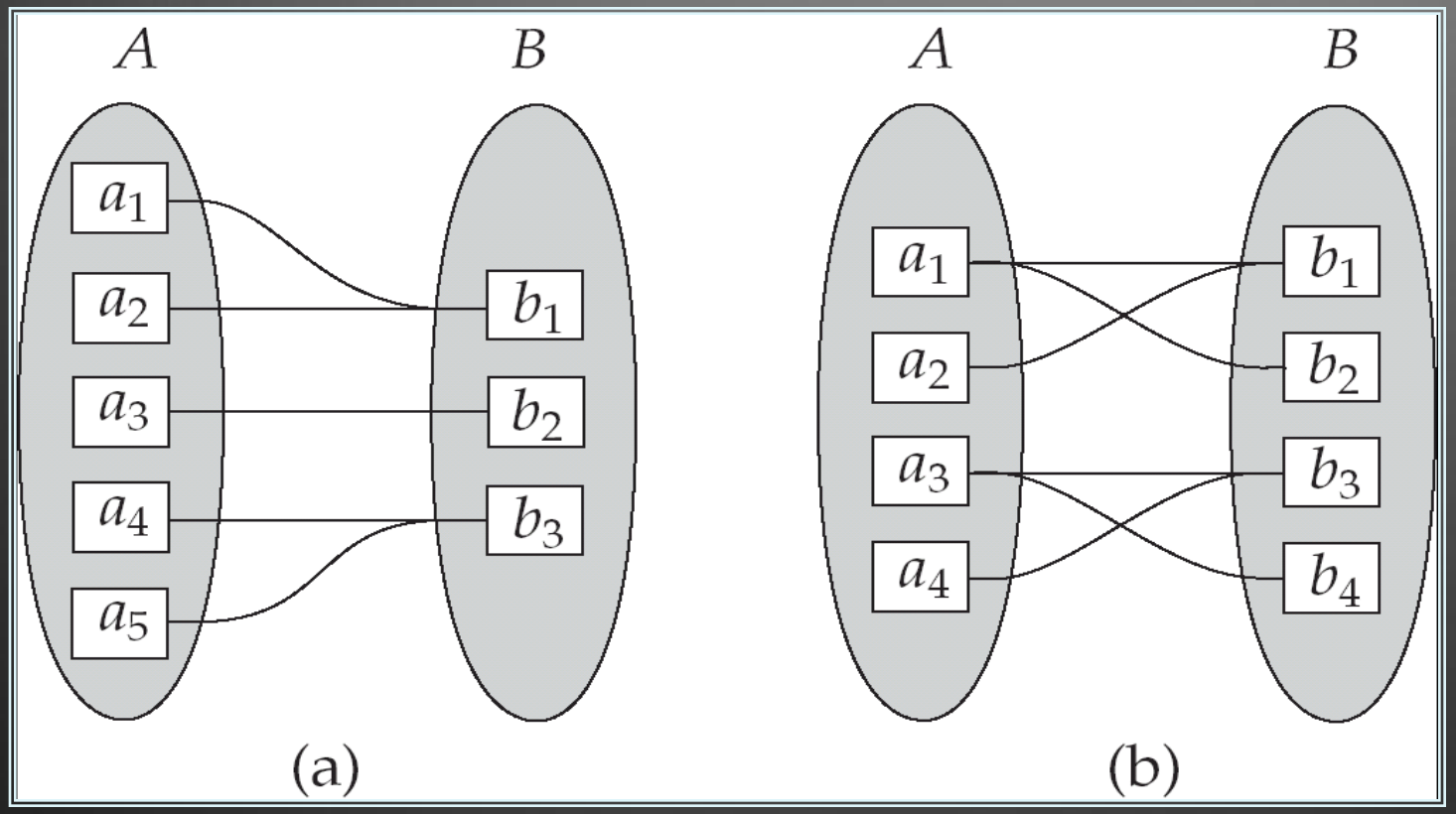


One to one

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

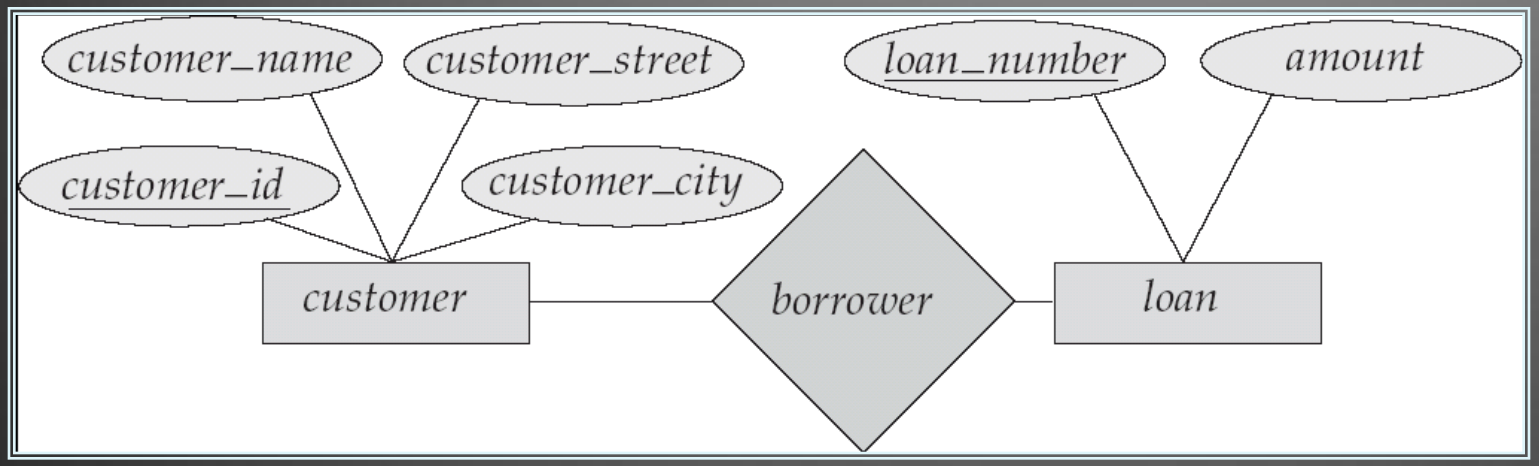
Keys

- 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

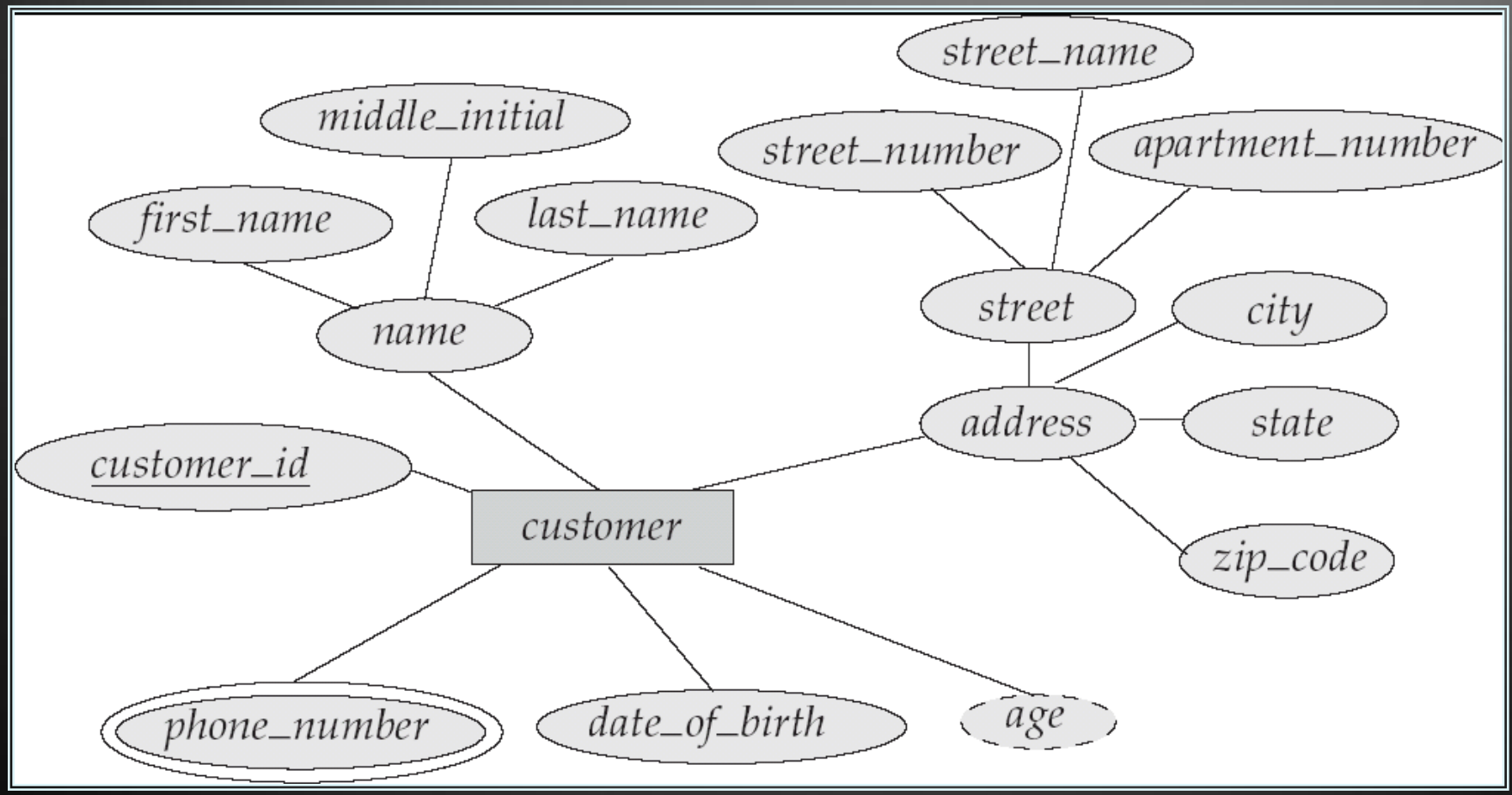
- The combination of primary keys of the participating entity sets forms a super key of a relationship set.
  - (*customer_id, account_number*) is the super key of *depositor*
  - *NOTE: this means a pair of entity sets can have at most one relationship in a particular relationship set.*
    - Example: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

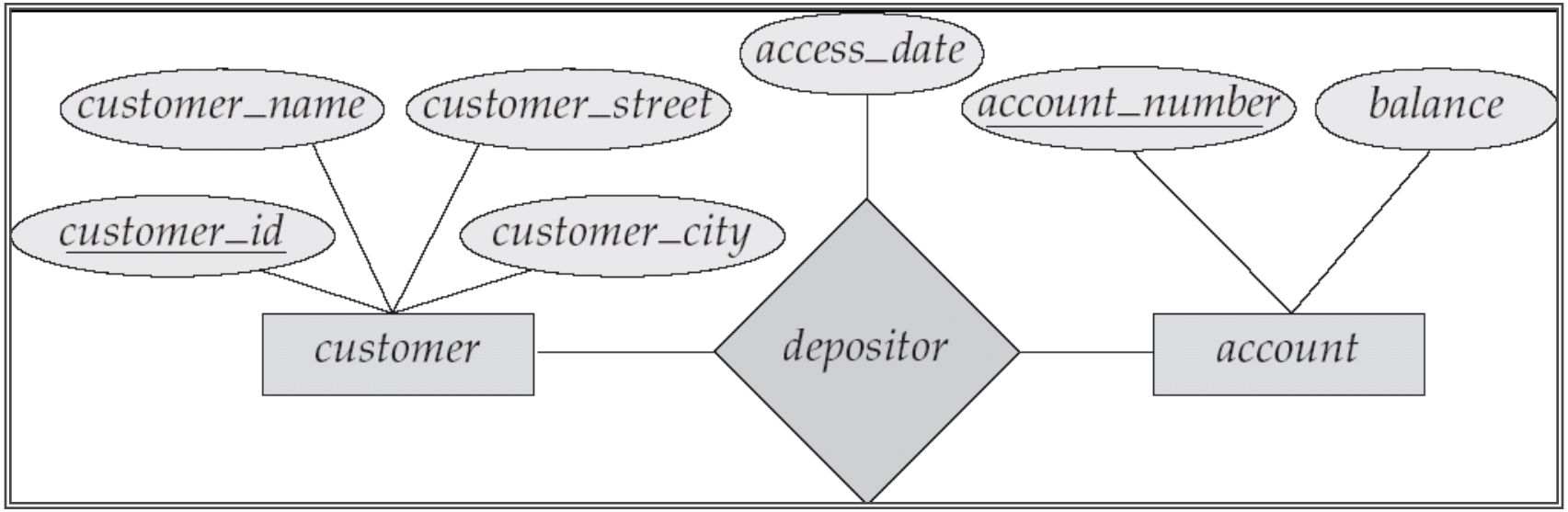


- Rectangles represent entity sets.
- Diamonds represent relationship sets.
- Lines link attributes to entity sets and entity sets to relationship sets.
- Ellipses represent attributes
  - Double ellipses represent multivalued attributes.
  - Dashed ellipses denote derived attributes.
- Underline indicates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

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

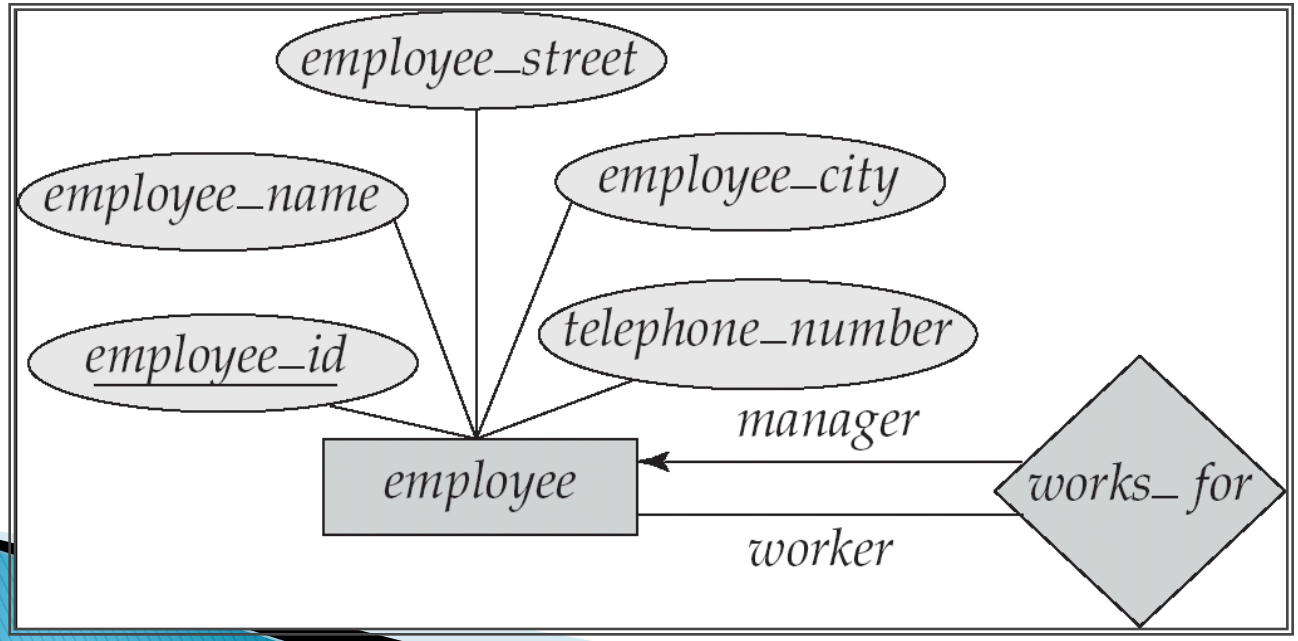


Relationship Sets with Attributes



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

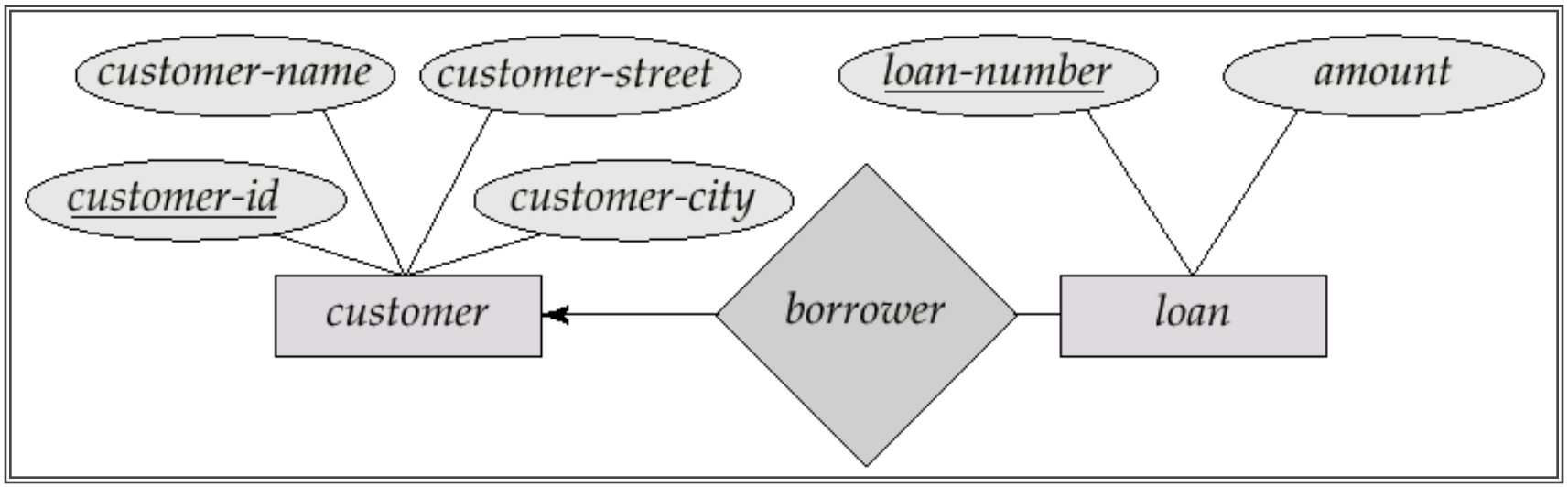


Cardinality Constraints

- We express cardinality constraints by drawing either a directed line (→), 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*

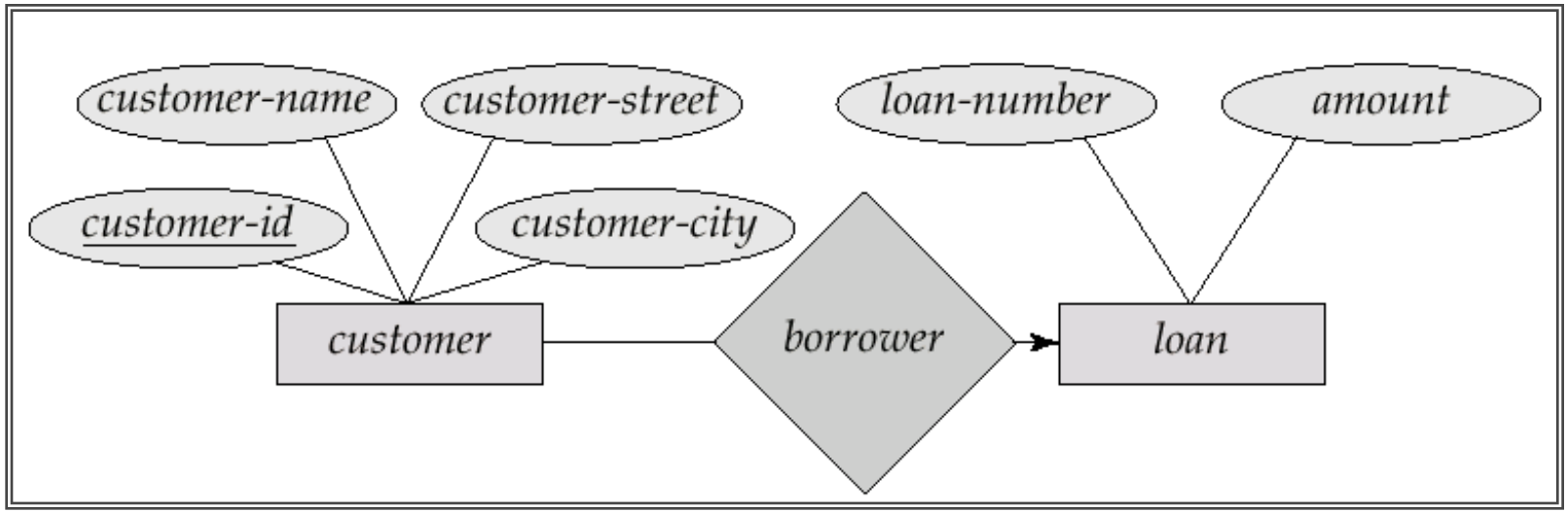
One-To-Many Relationship

- 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*



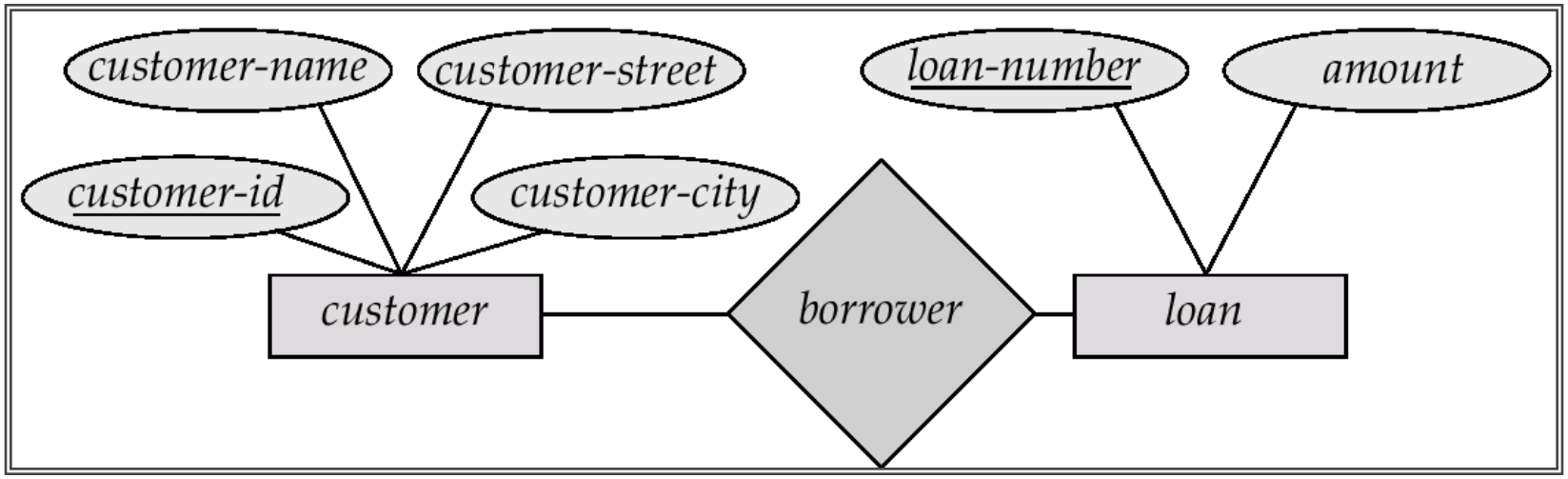
Many-To-One Relationships

- 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*



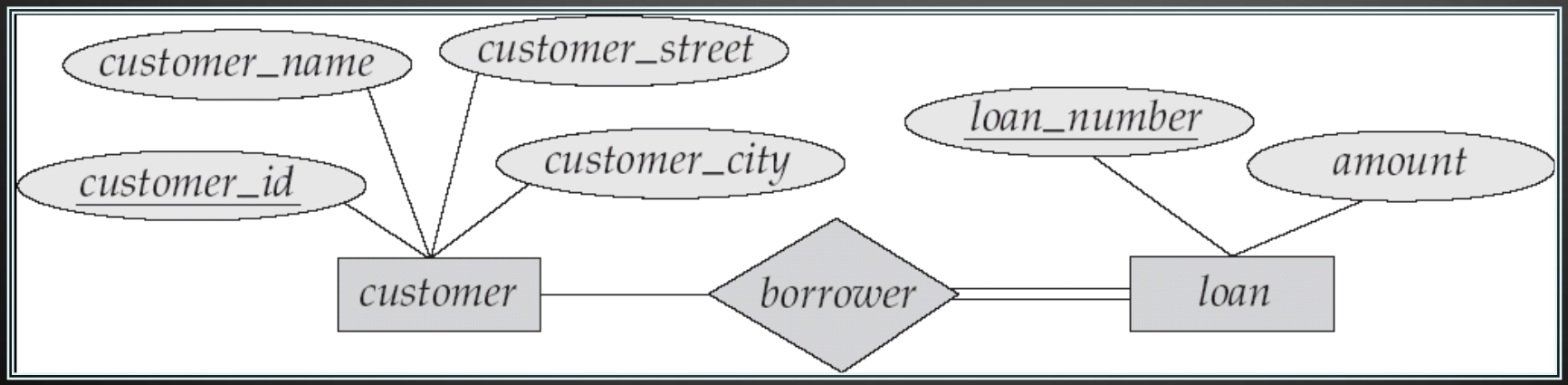
Many-To-Many Relationship

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



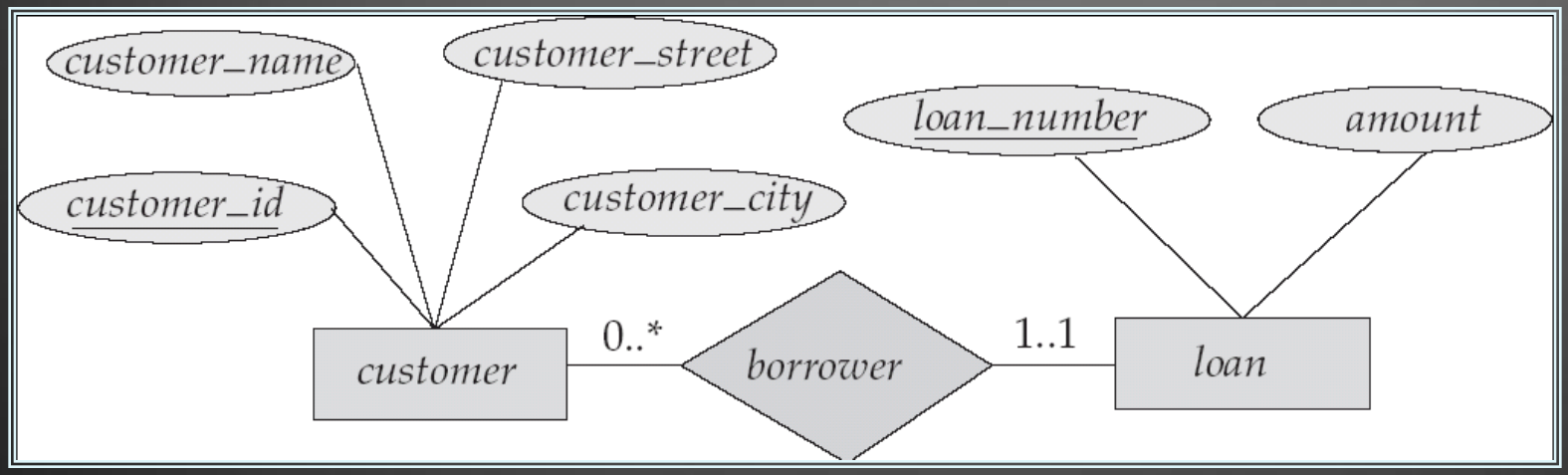
Participation of an Entity Set in a Relationship Set

- 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
- 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

- Cardinality limits can also express participation constraints



E-R Diagram with a Ternary Relationship