Chapter 2
Conceptual Modeling

Basic Entity Relationship Diagrams

Objectives

- Definition of terms
- Importance of data modeling
- Write good names and definitions for entities, relationships, and attributes
- Model attributes, entities, binary relationships and cardinalities
- Draw basic E-R diagrams for common business situations

Business Rules

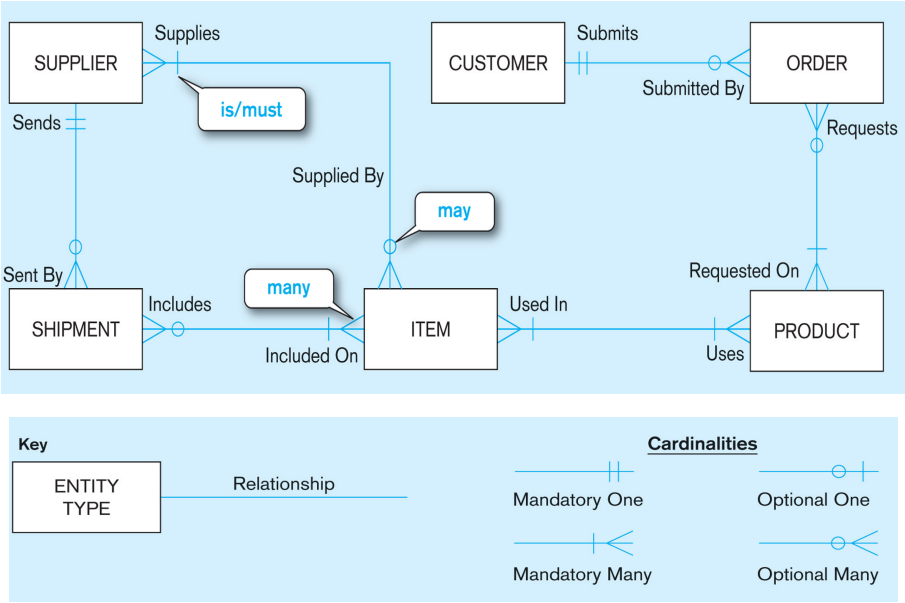
- Statements that define or constrain some aspect of the business
- Assert business structure
- Control/influence business behavior
- Are expressed in terms familiar to end users
- Govern how data are stored and handled.
- Our DB app will (hopefully) automate business rules

E/R Modeling

- The E/R model is used to construct a conceptual data model –

  a representation of the structure and constraints of a database and is the technology independent.

Sample E-R Diagram (Figure 2-1)

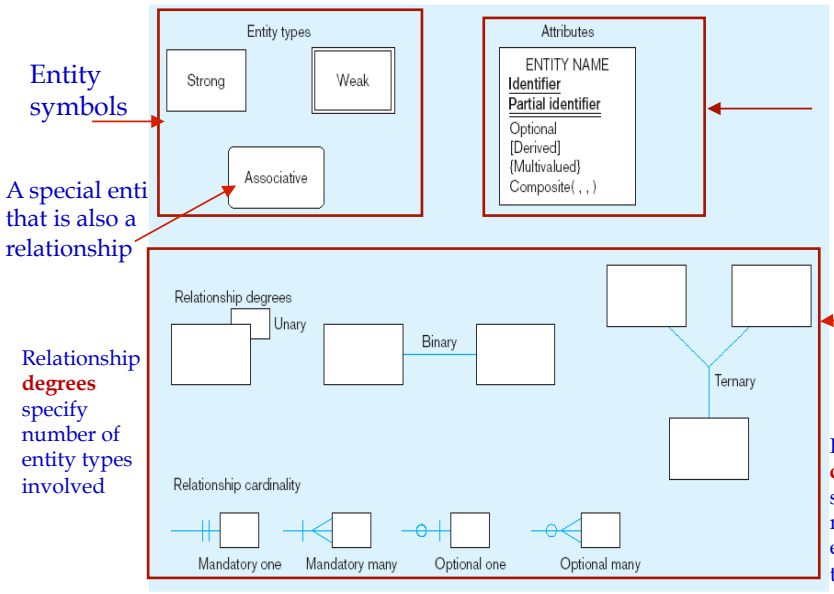


E-R Modeling

- An E-R model is based on:
  - Entities
  - Relationships between entities
  - Attributes of entities and relationships

- E-R diagram
  - a graphical representation of an E-R model

Basic E-R notation (Figure 2-2)



Entity symbols

A special enti that is also a relationship

Attribute symbols

Relationship symbols

Relationship **degrees** specify number of entity types involved

Relationship **cardinalities** specify how many of each entity type is allowed

Modeling Business Rules

- Business rules
  - Statements that define the business
  - Derived from policies and procedures
  - Expressed in natural language for end users
  - Expressed in data models for system developers

- A Good Business Rule is: (Table 2-1)
  - Declarative – what, not how
  - Precise – clear, agreed-upon meaning
  - Atomic – one statement
  - Consistent – internally and externally
  - Expressible – structured, natural language
  - Distinct – non-redundant
  - Business-oriented – understood by business people

A Good Data Name is:

- Related to business, not technical
- Meaningful and self-documenting
- Unique
- Readable
- Composed of words from an approved list
- Repeatable
- Written in standard syntax

Modeling Entities and Attributes

Entities

- Things in the real world, physical or not: person, place, object, event, concept
- Entity Type
  - collection of entities that share properties or characteristics
  - Entity type is always **SINGULAR**
  - Represented by a rectangle

- Entity Instance
  - each of the instances of an entity type

Entity Types and Instances

Entity type: EMPLOYEE

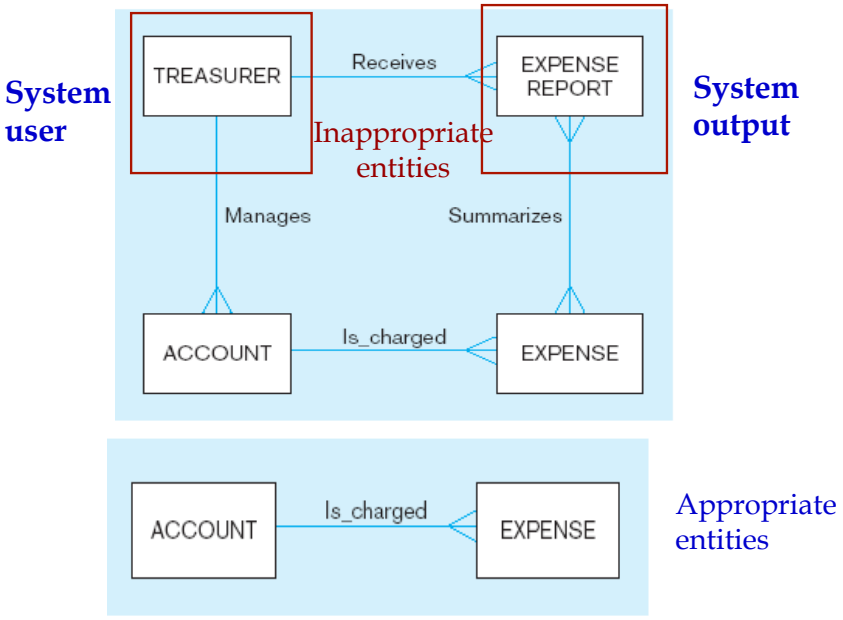
Attributes	Attribute Data Type	Example Instance	Example Instance
Employee Number	CHAR (10)	642-17-8360	534-10-1971
Name	CHAR (25)	Michelle Brady	David Johnson
Address	CHAR (30)	100 Pacific Avenue	450 Redwood Drive
City	CHAR (20)	San Francisco	Redwood City
State	CHAR (2)	CA	CA
Zip Code	CHAR (9)	98173	97142
Date Hired	DATE	03-21-1992	08-16-1994
Birth Date	DATE	06-19-1968	09-04-1975

FIGURE 2-3 Entity type EMPLOYEE with two instances

What Should an Entity Be?

- SHOULD BE:
  - An object that we are trying to model
  - An object that will have many instances in the database
- SHOULD NOT BE:
  - A user of the database system
  - An output of the database system (e.g. a report)

Figure 2-4 Example of inappropriate entities



Attributes

- Attribute - property or characteristic of an entity type that is of interest to the organization.
- Classifications of attributes:
  - Required versus Optional Attributes
  - Simple versus Composite Attribute
  - Single-Valued versus Multi-valued Attribute
  - Stored versus Derived Attributes
  - Identifier Attributes

Required vs. Optional Attributes

Entity type: STUDENT

Attributes	Attribute Data Type	Required or Optional	Example Instance	Example Instance
Student ID	CHAR (10)	Required	876-24-8217	822-24-4456
Student Name	CHAR (40)	Required	Michael Grant	Melissa Kraft
Home Address	CHAR (30)	Required	314 Baker St.	1422 Heft Ave
Home City	CHAR (20)	Required	Centerville	Miami
Home State	CHAR (2)	Required	OH	FL
Home Zip Code	CHAR (9)	Required	45459	33321
Major	CHAR (3)	Optional	MIS	

Required – must have a value for every entity (or relationship) instance with which it is associated

Optional – may not have a value for every entity (or relationship) instance with which it is associated

Figure 2-7 A **composite** attribute

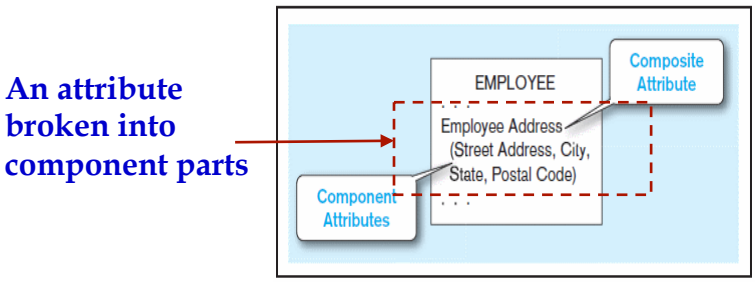
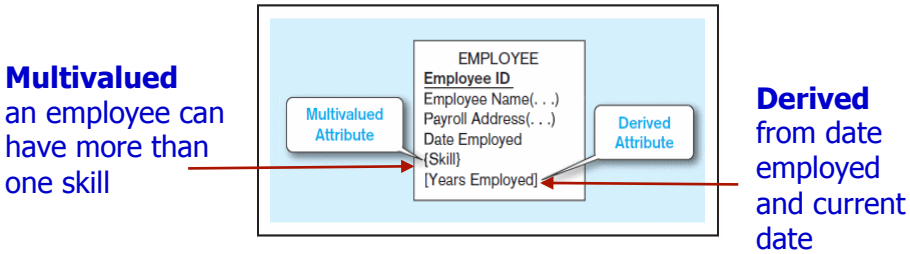


Figure 2-8 Entity with **multivalued** attribute (Skill) and **derived** attribute (Years Employed)



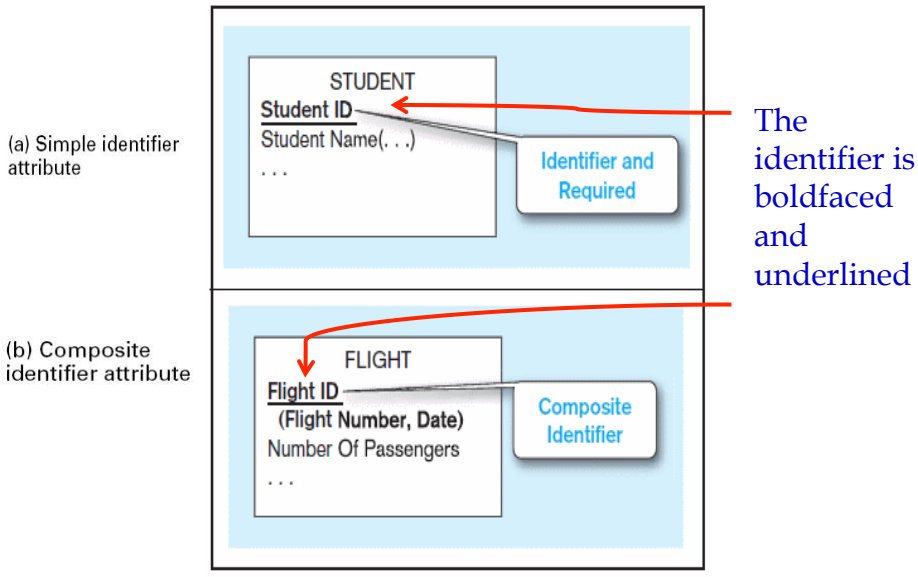
Identifiers (Keys)

- Identifier (Key) - an attribute (or combination of attributes) that uniquely identifies individual instances of an entity type
- Simple Key versus Composite Key
- Candidate Key – an attribute that could be a key… satisfies the requirements for being a key

Criteria for Selecting Identifiers

- Will not change in value over the life of each instance of the entity type.
- Will not be NULL.
- No intelligent identifiers (containing e.g. locations or people that might change)
- Substitute new, simple (e.g., *surrogate* attribute) keys for long, composite keys (e.g., entity type of Game: Game# instead of Home_Team and Visitor_Team)

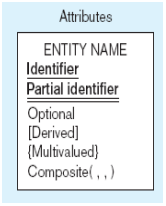
Figure 2-9 Simple and composite identifier attributes



Practice: Person

- Produce an E-R diagram for the following situation:

  We have one entity, called Person, with the following attributes: ID (the identifier); Name, which is composed of one or more given names and one or more family names; one or more aliases; an address (composed of street, city, state, zip); date of birth; and age, which can be calculated from the date of birth.



Relationships

- Association between two or more entities
- Represented by connecting lines

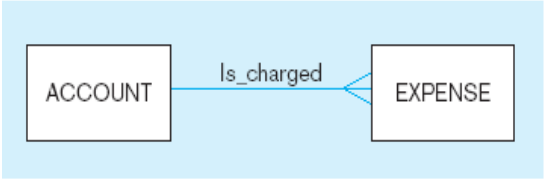
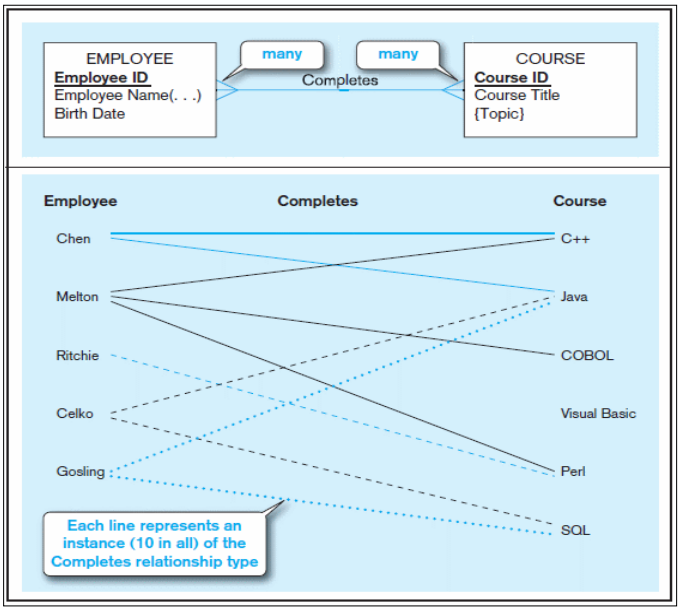


Figure 2-10 Relationship types and instances

a) Relationship type (Completes)

b) Relationship instances



Relationships

- Degree
  - Unary (next lecture)
  - Binary
  - Ternary (next lecture)
- Cardinality constraints
  - One-to-One
  - One-to-Many
  - Many-to-Many

Degree of relationships – from Figure 2-2

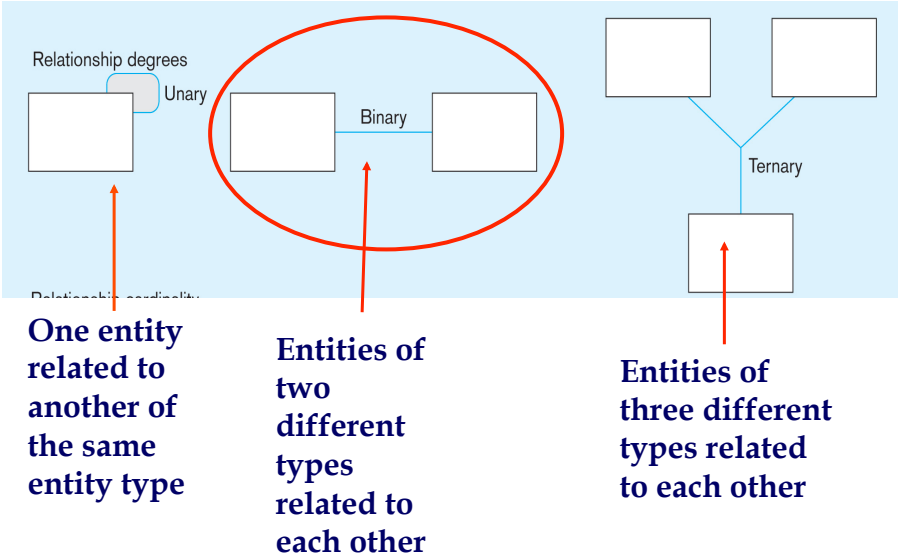
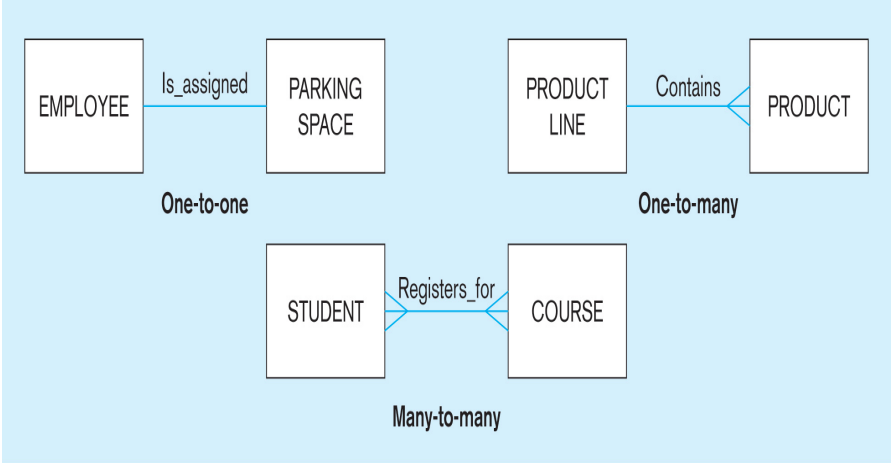


Figure 2-12 Examples of relationships of different degrees

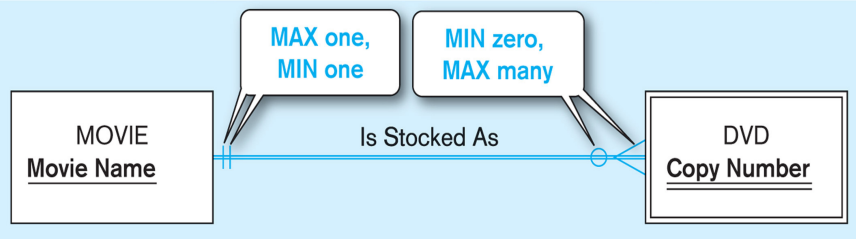
Binary relationships



Cardinality Constraints

- The number of instances of one entity that can/must be associated with each instance of another entity

Basic relationship



Relationship with cardinality constraints

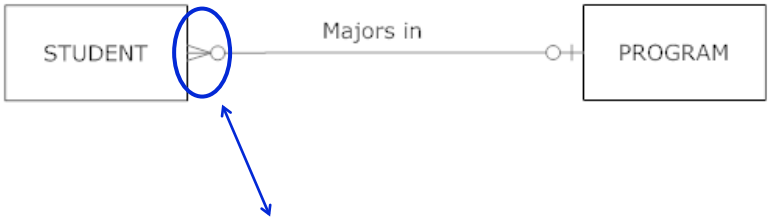
Cardinality Constraints

- Minimum Cardinality
  - If zero, then optional
  - If one or more, then mandatory
- Maximum Cardinality
  - The maximum number

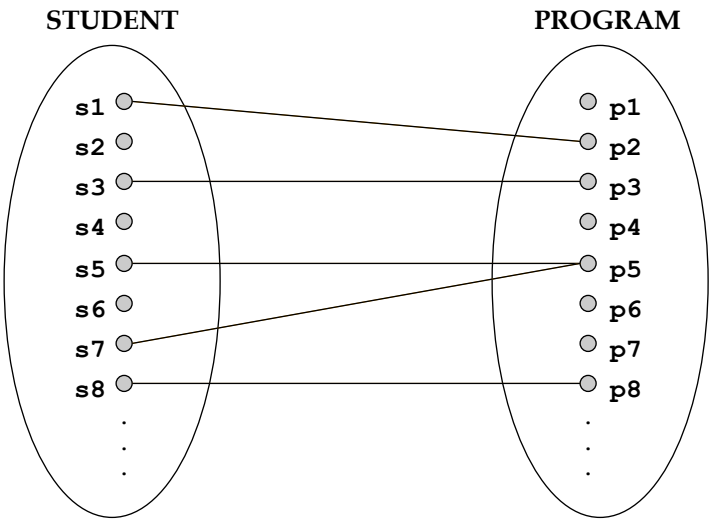
Interpreting Cardinalities

A student majors in zero or one programs.

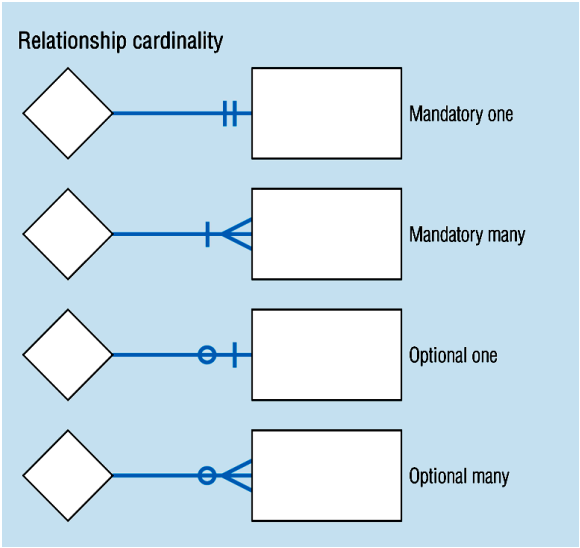
Interpreting Cardinalities



A program has zero or more students.



Cardinality Constraints



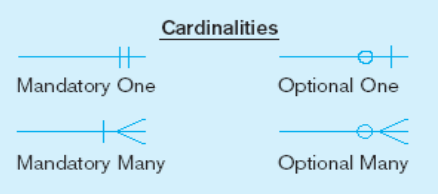
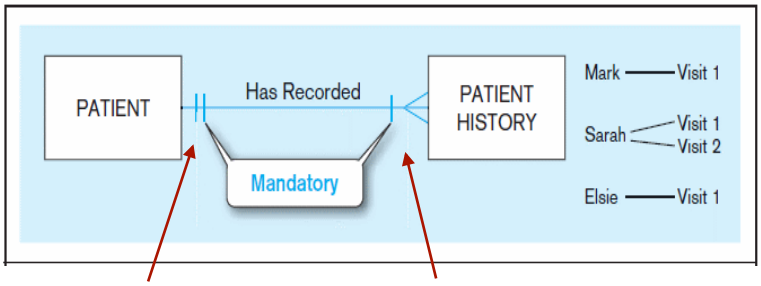


Figure 2-17 Examples of mandatory cardinalities



A patient history is recorded for one and only one patient

A patient must have recorded at least one history, and can have many

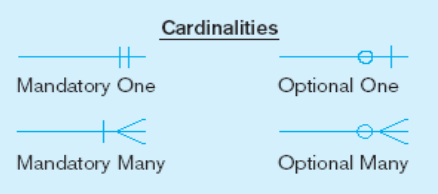
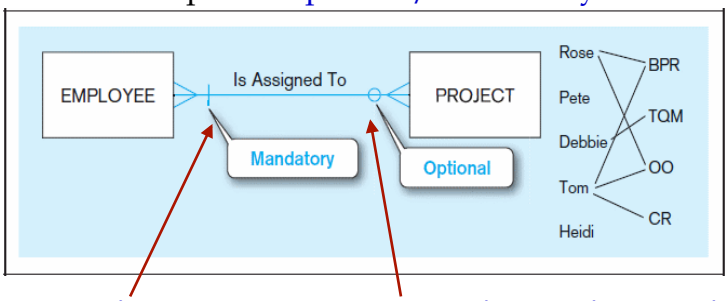


Figure 2-17 Examples of optional / mandatory cardinalities

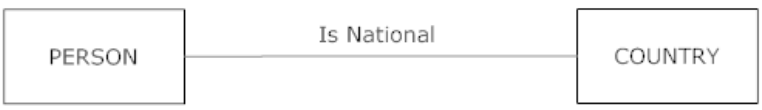


A project must be assigned to at least one employee, and may be assigned to many

An employee can be assigned to any number of projects, or may not be assigned to any at all

Quick Check

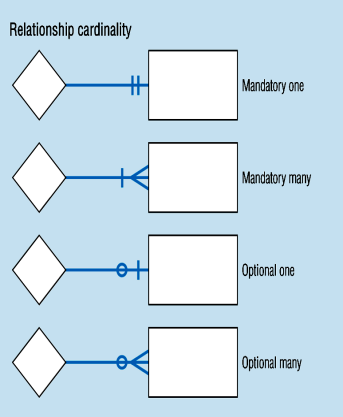
- So now you try it. Add cardinality constraints to the following diagram
  - A person is national of zero or more countries
  - A country has one or more people ….



Practice Cardinality Constraints

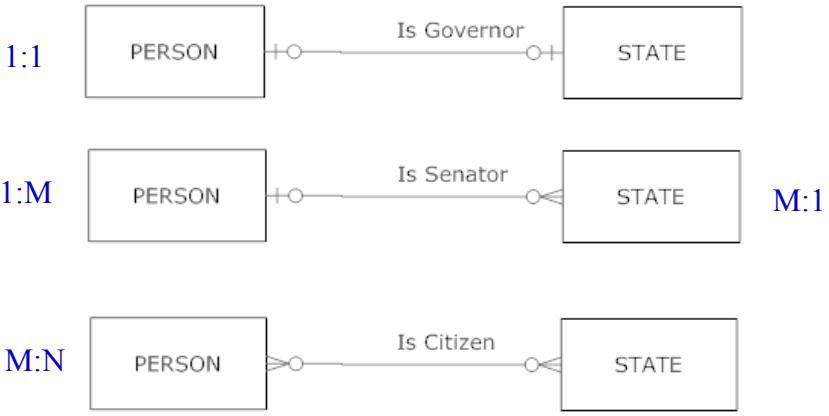
Draw an example for each type of cardinality constraint:

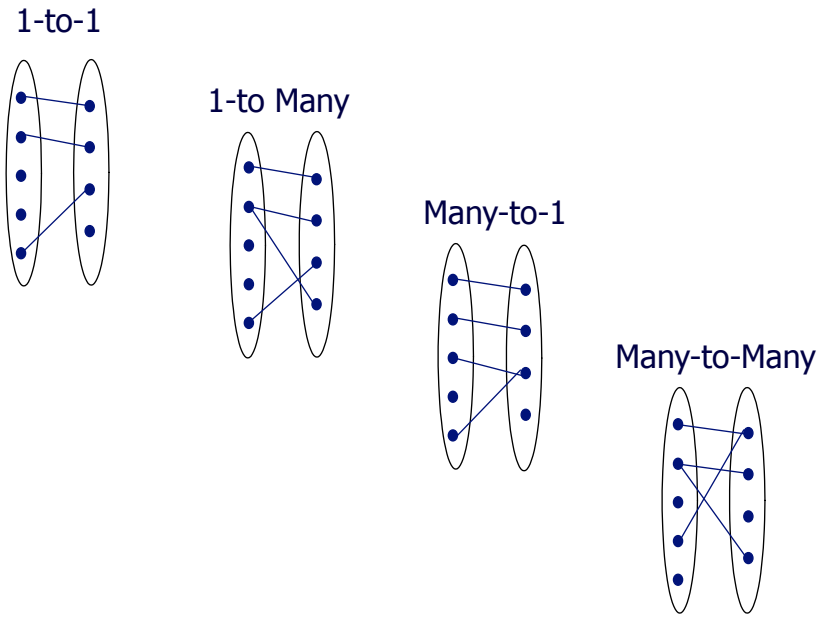
1. Mandatory one
2. Mandatory many
3. Optional one
4. Optional many



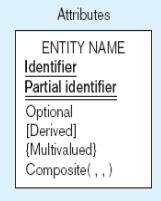
Maximum Cardinalities

- Looking at the MAXIMUM cardinality on BOTH sides, we classify relationships as:





Practice: Products

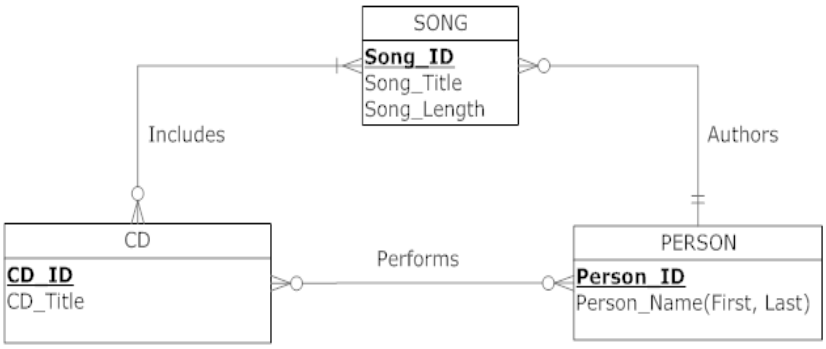


- We have two kinds of entities: Products and Categories.
- For each product we keep its identifier, name, price, wholesale price, and profit margin, which is calculated from the price and the wholesale price.
- For each category we keep its identifier and its name.
- Each product belongs to zero or more categories and each category can have zero or more products.

Practice : CD

- We have three entities: CD, PERSON and SONG.
  - A CD has a number, which is its identifier, and a title
  - A person has an ID and a name, divided into first, last
  - A song has an ID, a title and a length
  - We keep track of which person is a song's author. A person can author many songs and a song has exactly one author.
  - We keep track of which people perform on a CD. Zero or more people can perform on a CD, and people can perform on zero or more CDs.
  - We keep track of which songs are included on a CD. One or more songs are included on a CD, and a song is included in zero or more CDs.

Practice : CD



Review

- Conceptual modeling
- Business rules
- E-R Model
- Entity
- Entity Identifier
- Relationship
- Degree
- Cardinality
- One-to-Many Relationship

Relevant Textbook Exercises

- Exercise #1, page 101
- Exercise #2 (a, b, e, h), pages 101-102
- Exercise #17 (a, e, f, g), pages 105-106
- Exercise #19