(ADVANCED) DATABASE SYSTEMS (DATABASE MANAGEMENTS)

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(2ND WEEK)

2. OUTLINE

2. Database Analysis

2.1 Modeling Data in the Organization

2.2 The Enhanced E-R Model

2.1 MODELING DATA IN THE ORGANIZATION

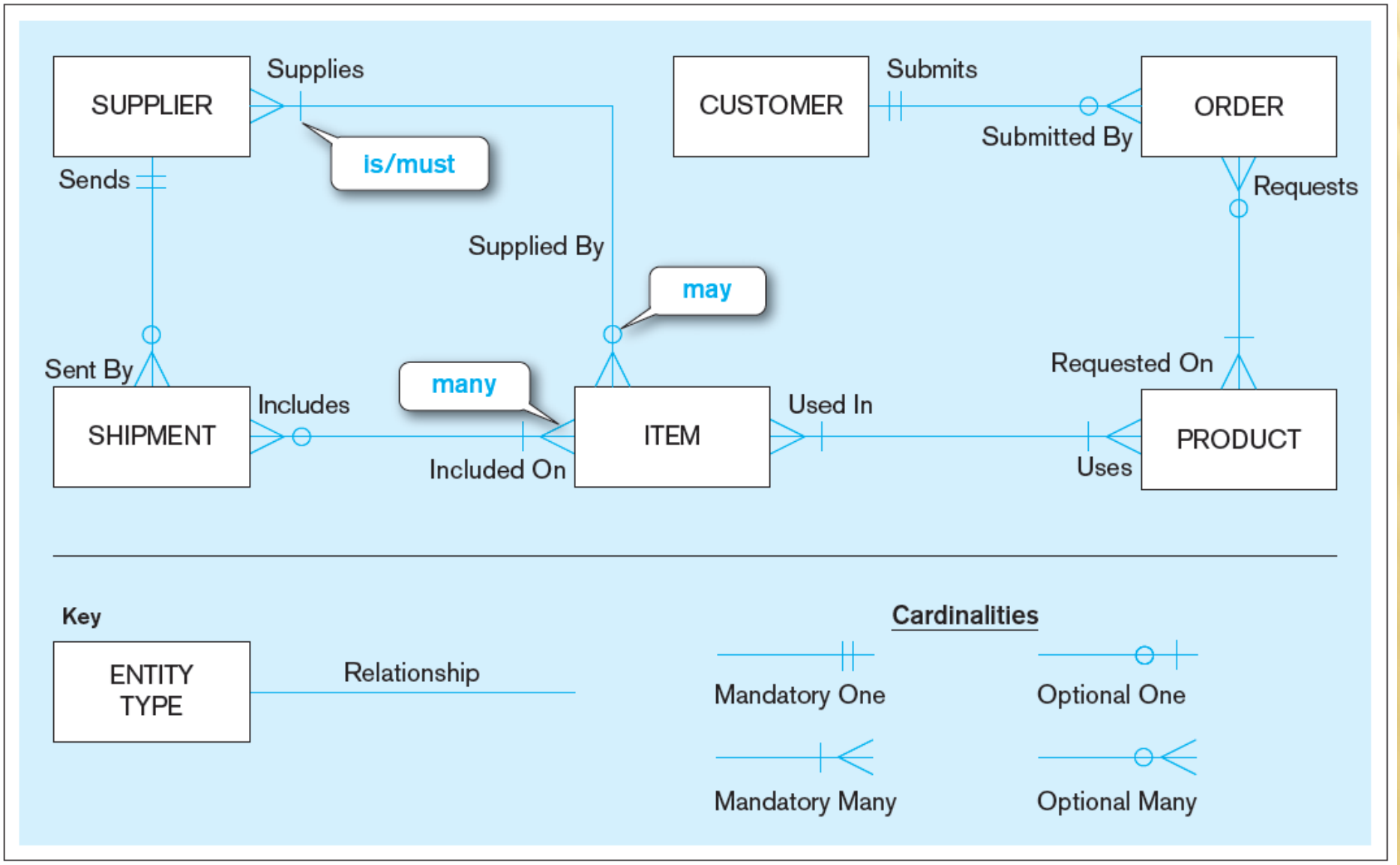
OBJECTIVES

- Define terms
- Understand importance of data modeling
- Write good names and definitions for entities, relationships, and attributes
- Distinguish unary, binary, and ternary relationships
- Model different types of attributes, entities, relationships, and cardinalities
- Draw E-R diagrams for common business situations
- Convert many-to-many relationships to associative entities
- Model time-dependent data using time stamps

E-R MODEL CONSTRUCTS

- Entities:
  - Entity instance–person, place, object, event, concept (often corresponds to a row in a table)
  - Entity Type–collection of entities (often corresponds to a table)
- Relationships:
  - Relationship instance–link between entities (corresponds to primary key-foreign key equivalencies in related tables)
  - Relationship type–category of relationship…link between entity types
- Attributes:
  - Properties or characteristics of an entity or relationship type (often corresponds to a field in a table)

Sample E-R Diagram

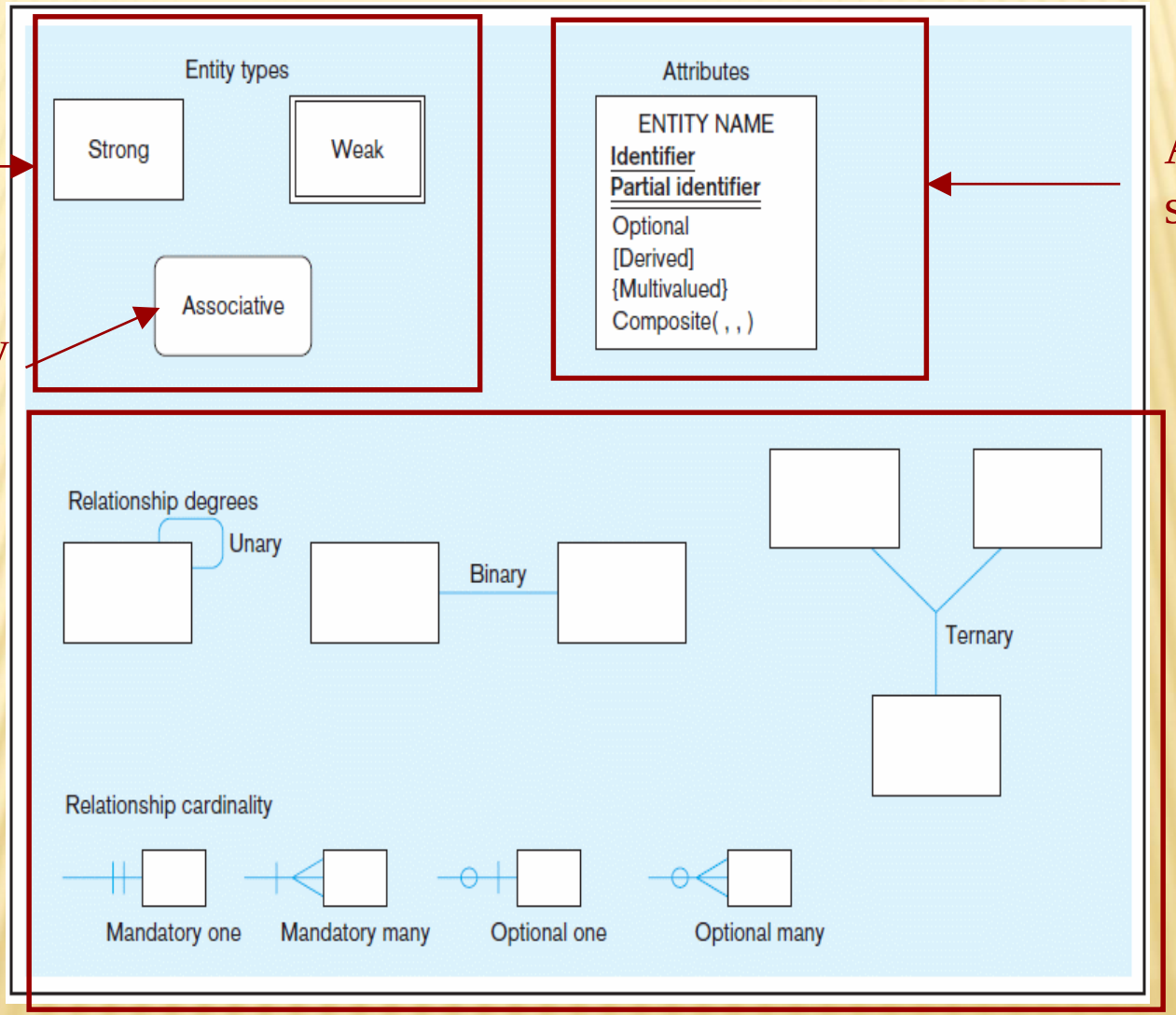


Basic E-R notation

Entity symbols

A special entity that is also a relationship

Relationship degrees specify number of entity types involved



Attribute symbols

Relationship symbols

Relationship cardinalities specify how many of each entity type is allowed

BUSINESS RULES

- Are statements that define or constrain some aspect of the business
- Are derived from policies, procedures, events, functions
- Assert business structure
- Control/influence business behavior
- Are expressed in terms familiar to end users
- Are automated through DBMS software

A GOOD BUSINESS RULE IS:

- 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, characteristics
- Meaningful and self-documenting
- Unique
- Readable
- Composed of words from an approved list
- Repeatable
- Written in standard syntax

DATA DEFINITIONS

- Explanation of a term or fact
  - Term–word or phrase with specific meaning
  - Fact–association between two or more terms
- Guidelines for good data definition
  - A concise description of essential data meaning
  - Gathered in conjunction with systems requirements
  - Accompanied by diagrams
  - Achieved by consensus, and iteratively refined

ENTITIES

- **Entity** – a person, a place, an object, an event, or a concept in the user environment about which the organization wishes to maintain data
- **Entity type** – a collection of entities that share common properties or characteristics
- **Entity instance** – A single occurrence of an entity type

ENTITY TYPE AND ENTITY 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

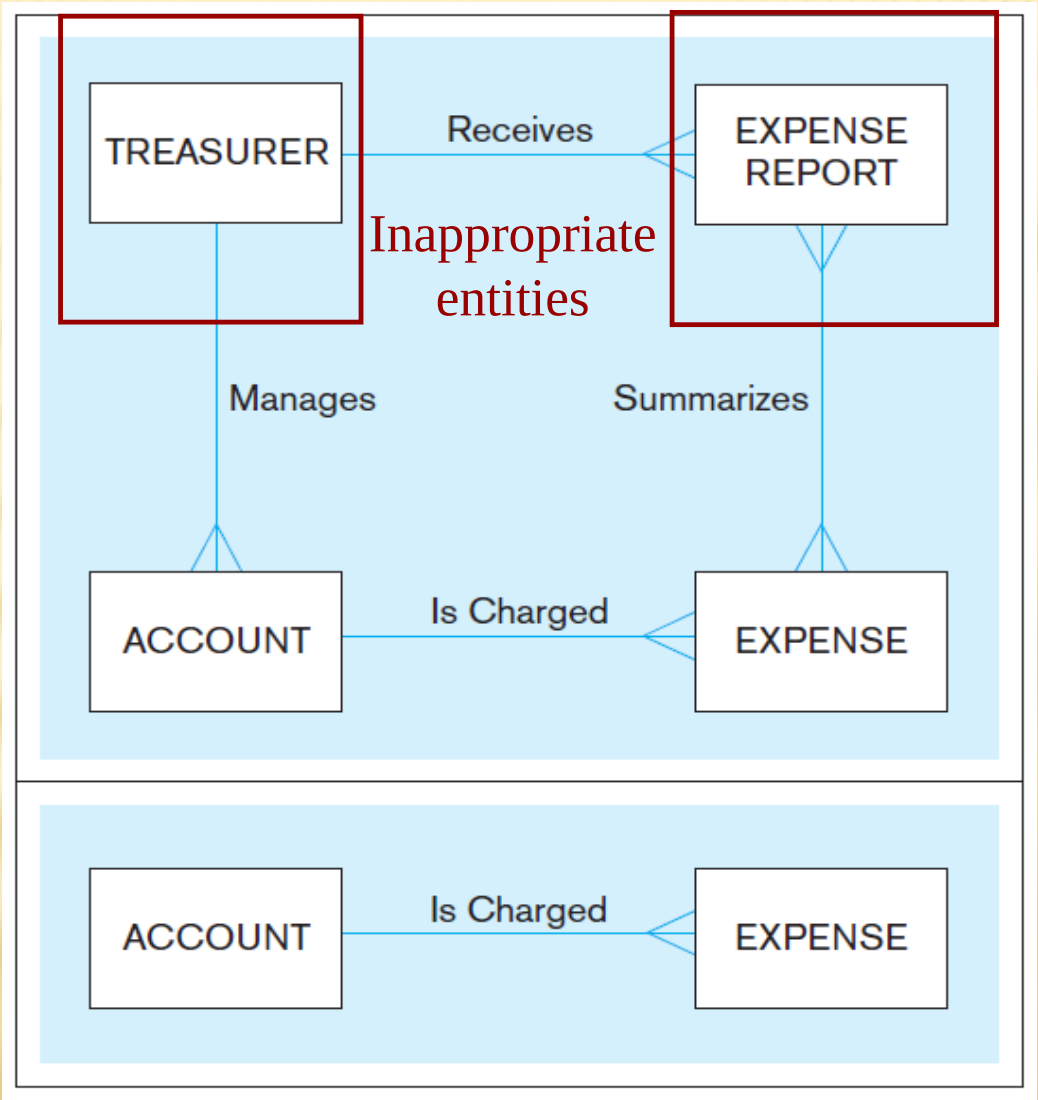
FIGURE 2-3 Entity type EMPLOYEE with two instances

AN ENTITY…

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

Example of inappropriate entities

System user



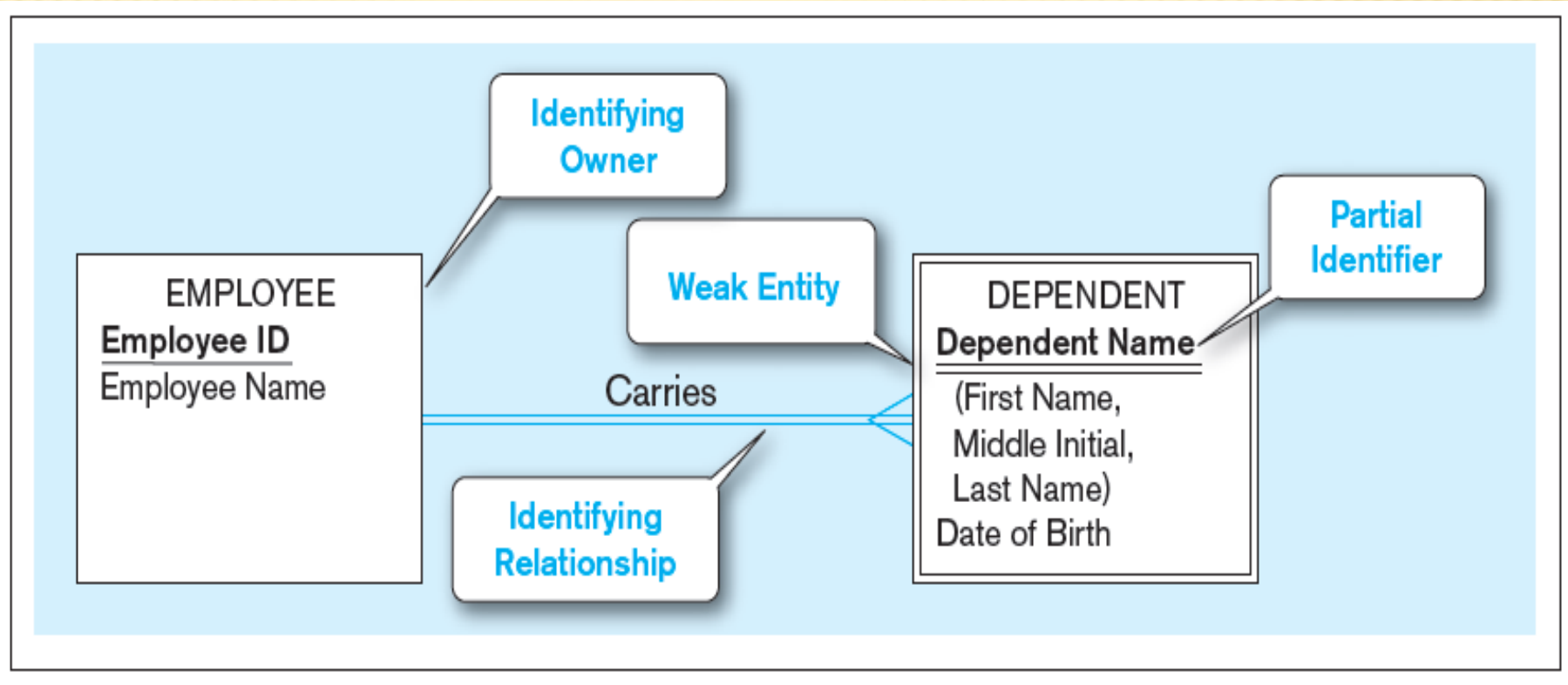
System output

Appropriate entities

STRONG VS. WEAK ENTITIES, AND IDENTIFYING RELATIONSHIPS

- Strong entity
  - exists independently of other types of entities
  - has its own unique identifier
    - identifier underlined with single line
- Weak entity
  - dependent on a strong entity (identifying owner)…cannot exist on its own
  - does not have a unique identifier (only a partial identifier)
  - entity box and partial identifier have double lines
- Identifying relationship
  - links strong entities to weak entities

Example of a weak identity and its identifying relationship



Strong entity

Weak entity

GUIDELINES FOR NAMING AND DEFINING ENTITIES

- Names:
  - Singular noun
  - Specific to organization
  - Concise, or abbreviation
  - For event entities, the result not the process
  - Name consistent for all diagrams
- Definitions:
  - “An X is…”
  - Describe unique characteristics of each instance
  - Explicit about what is and is not the entity
  - When an instance is created or destroyed
  - Changes to other entity types
  - History that should be kept

ATTRIBUTES

- Attribute–property or characteristic of an entity or relationship type
- Classifications of attributes:
  - Required versus Optional Attributes
  - Simple versus Composite Attribute
  - Single-Valued versus Multivalued 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

SIMPLE VS. COMPOSITE ATTRIBUTES

- **Composite attribute** – An attribute that has meaningful component parts (attributes)

The address is broken into component parts

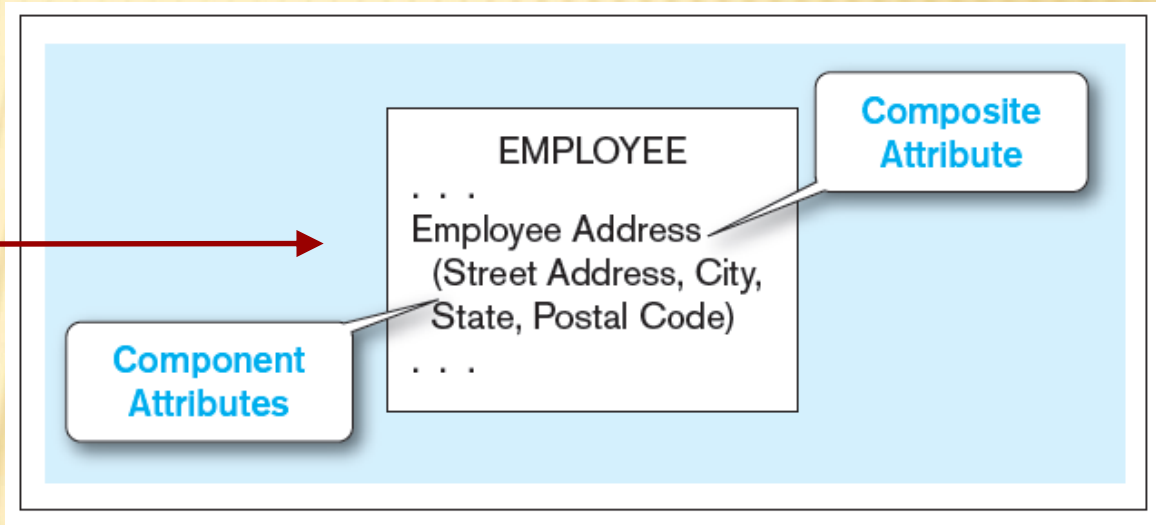


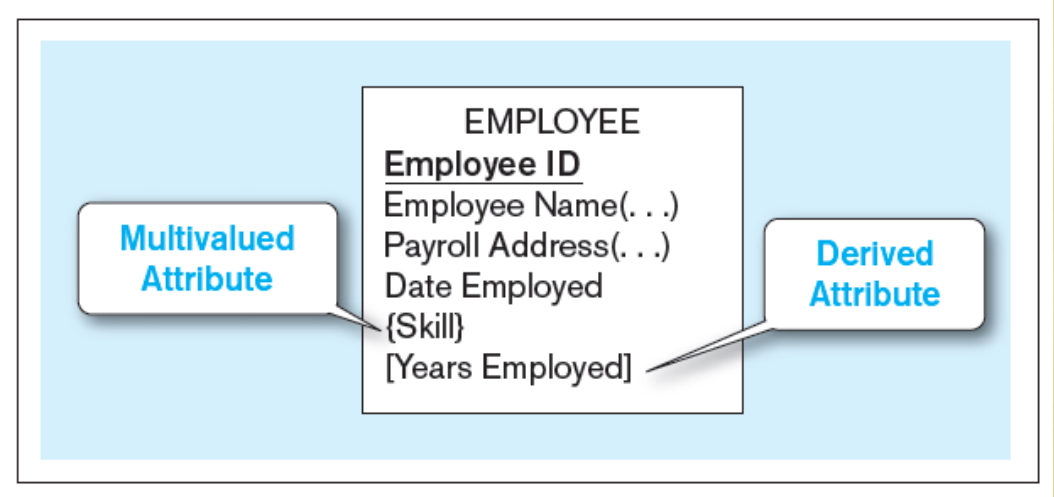
Figure 2-7 A **composite** attribute

MULTI-VALUED AND DERIVED ATTRIBUTES

Multivalued – may take on more than one value for a given entity (or relationship) instance

Derived – values can be calculated from related attribute values (not physically stored in the database)

Entity with **multivalued** attribute (Skill) and **derived** attribute (Years Employed)



Multivalued
an employee can have more than one skill

Derived
Calculated from date employed and current date

IDENTIFIERS (KEYS)

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

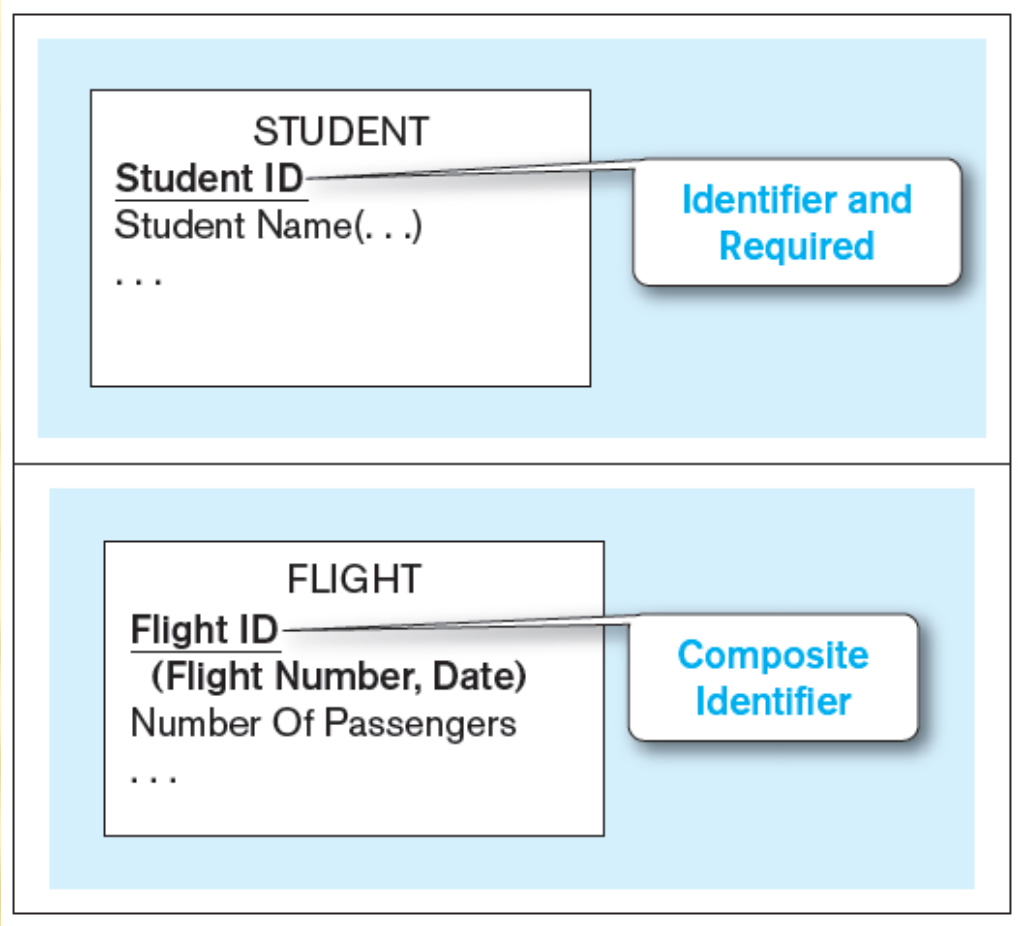
CRITERIA FOR IDENTIFIERS

- Choose Identifiers that
  - Will not change in value
  - Will not be null
- Avoid intelligent identifiers (e.g., containing locations or people that might change)
- Substitute new, simple keys for long, composite keys

Simple and composite identifier attributes

(a) Simple identifier attribute

(b) Composite identifier attribute



The identifier is boldfaced and underlined

NAMING ATTRIBUTES

- Name should be a singular noun or noun phrase
- Name should be unique
- Name should follow a standard format
  - e.g. **[Entity type name { [Qualifier] }] Class**
- Similar attributes of different entity types should use the same qualifiers and classes

DEFINING ATTRIBUTES

- State what the attribute is and possibly why it is important
- Make it clear what is and is not included in the attribute's value
- Include aliases in documentation
- State source of values
- State whether attribute value can change once set
- Specify required vs. optional
- State min and max number of occurrences allowed
- Indicate relationships with other attributes

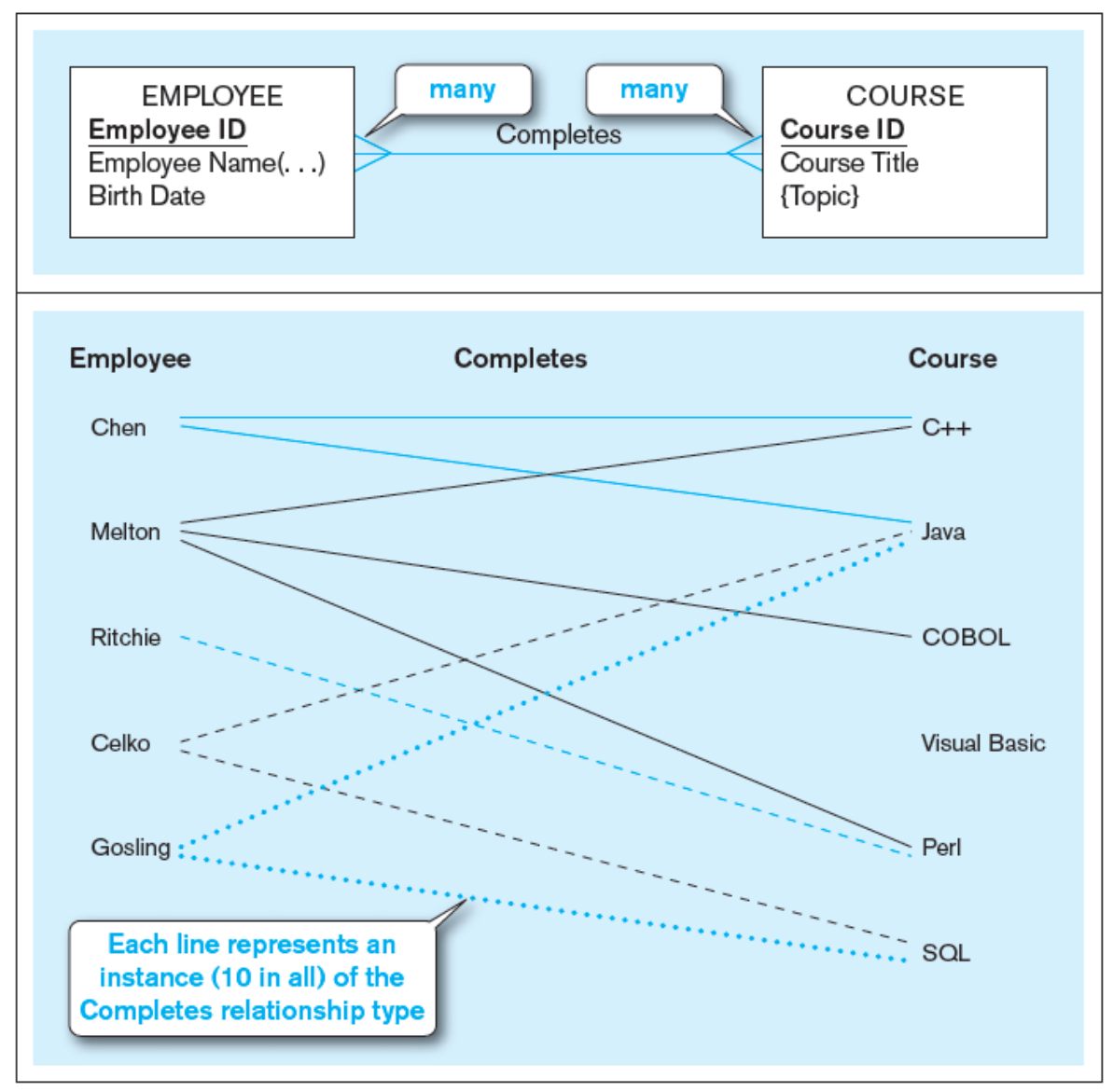
MODELING RELATIONSHIPS

- Relationship Types vs. Relationship Instances
  - The relationship type is modeled as lines between entity types…the instance is between specific entity instances
- Relationships can have attributes
  - These describe features pertaining to the association between the entities in the relationship
- Two entities can have more than one type of relationship between them (multiple relationships)
- Associative Entity–combination of relationship and entity

Relationship types and instances

a) Relationship type (Completes)

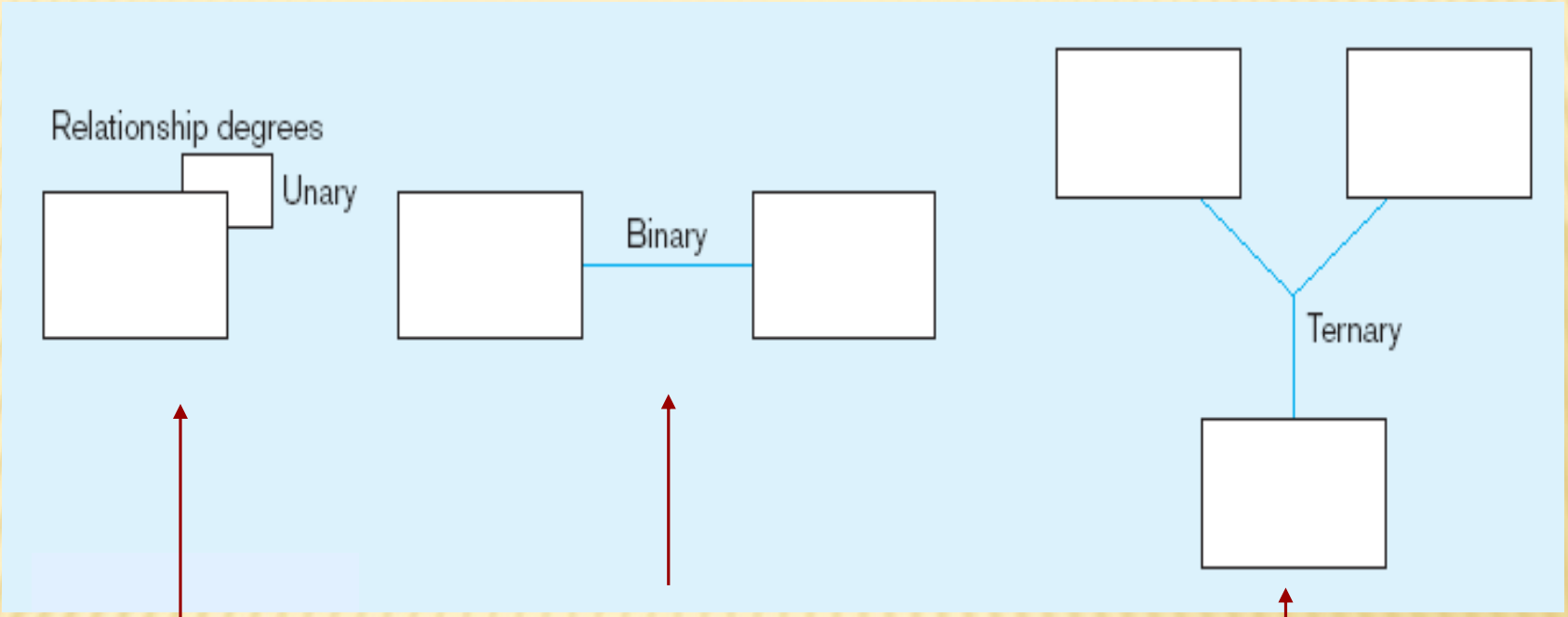
b) Relationship instances



DEGREE OF RELATIONSHIPS

- Degree of a relationship is the number of entity types that participate in it
  - Unary Relationship
  - Binary Relationship
  - Ternary Relationship

Degree of relationships



One entity related to another of the same entity type

Entities of two different types related to each other

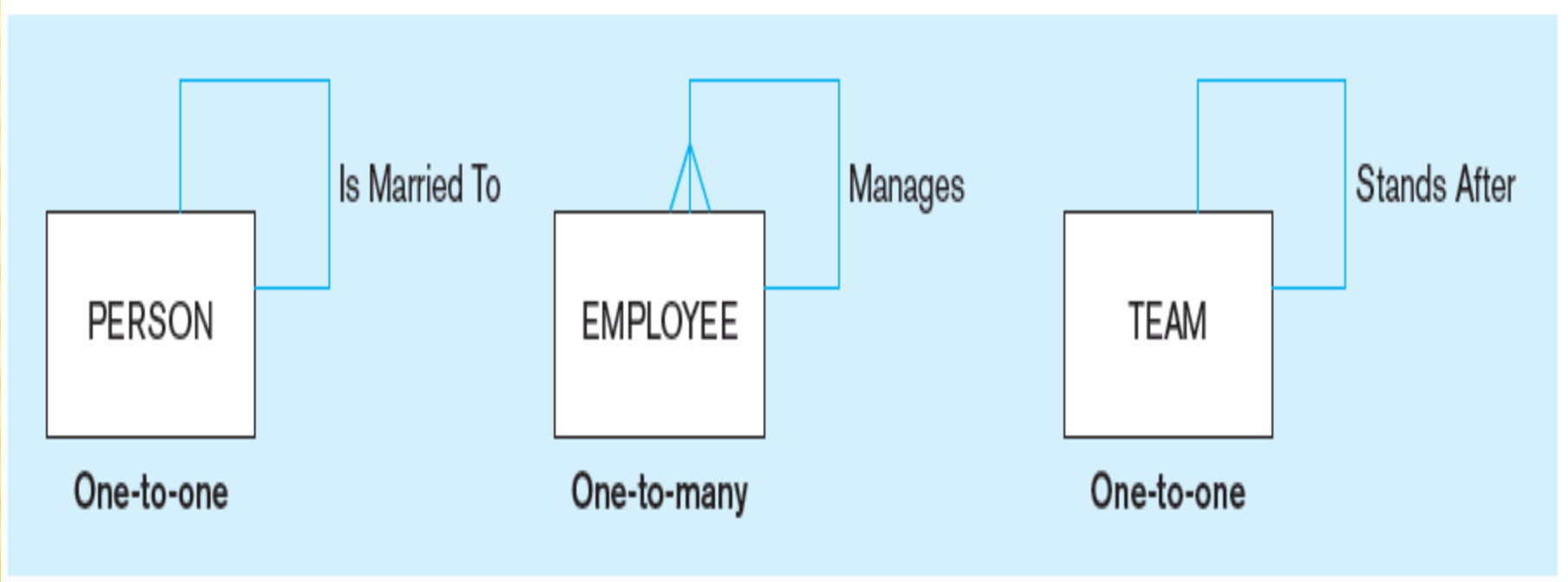
Entities of three different types related to each other

CARDINALITY OF RELATIONSHIPS

- One-to-One
  - Each entity in the relationship will have exactly one related entity
- One-to-Many
  - An entity on one side of the relationship can have many related entities, but an entity on the other side will have a maximum of one related entity
- Many-to-Many
  - Entities on both sides of the relationship can have many related entities on the other side

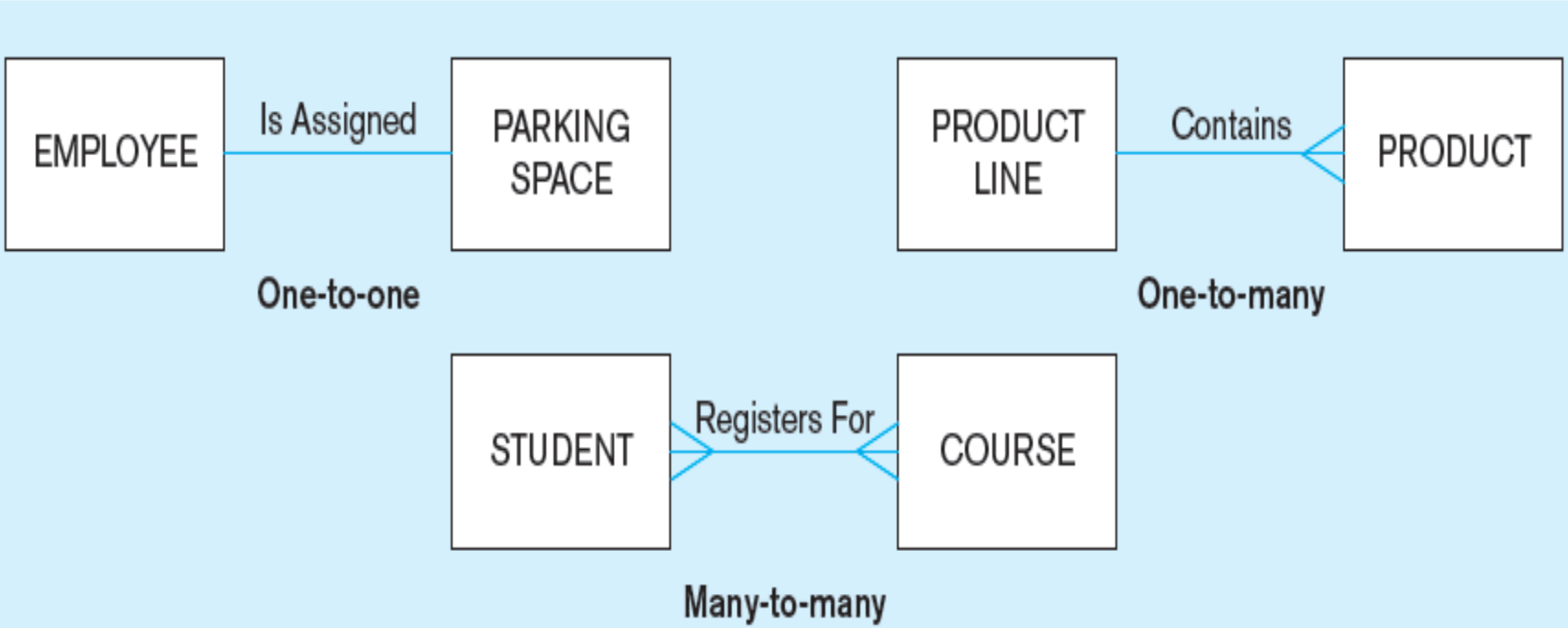
Examples of relationships of different degrees

a) Unary relationships



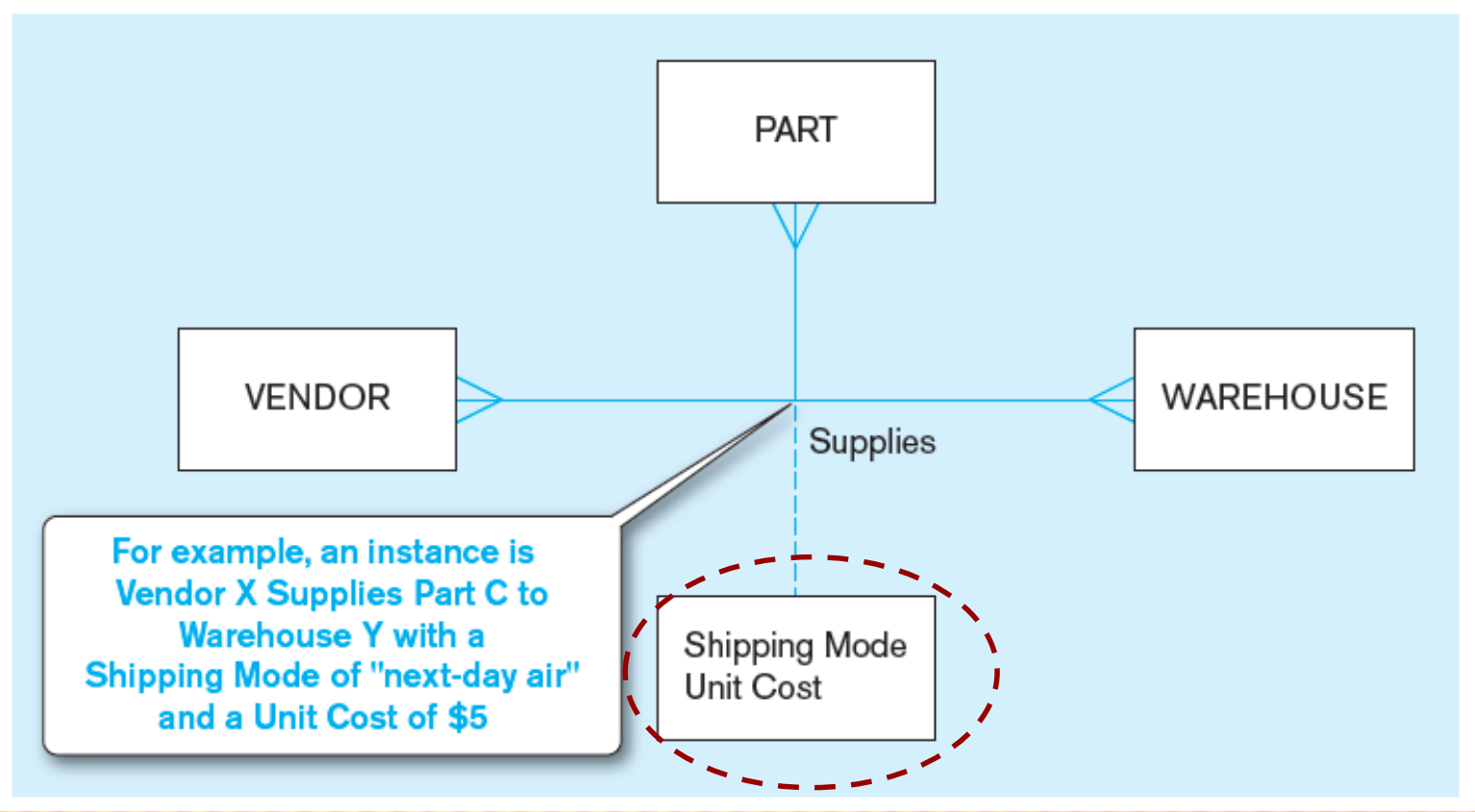
Examples of relationships of different degrees (cont.)

b) Binary relationships



Examples of relationships of different degrees (cont.)

c) Ternary relationship

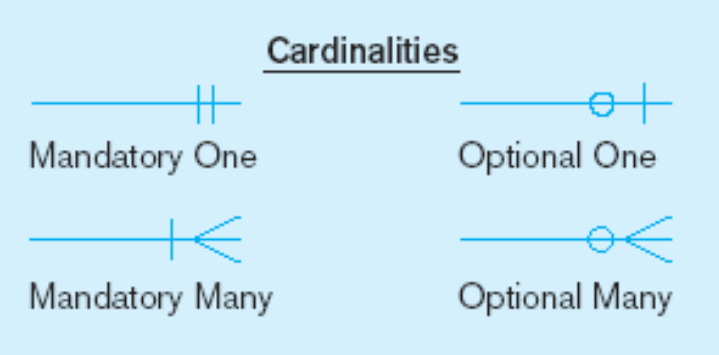


Note: a relationship can have attributes of its own

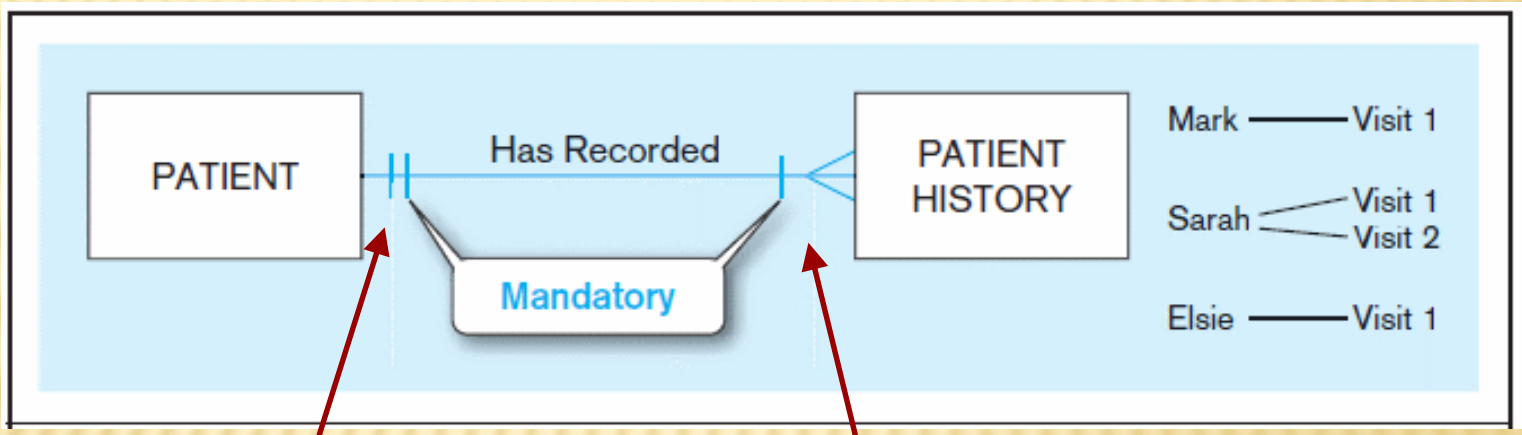
CARDINALITY CONSTRAINTS

- Cardinality Constraints—the number of instances of one entity that can or must be associated with each instance of another entity
- Minimum Cardinality
  - If zero, then optional
  - If one or more, then mandatory
- Maximum Cardinality
  - The maximum number

Examples of cardinality constraints



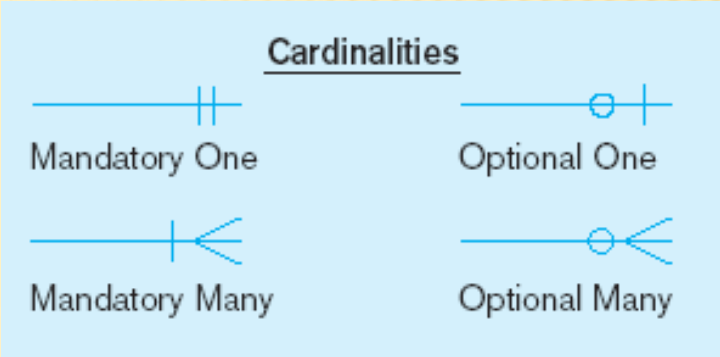
a) Mandatory cardinalities



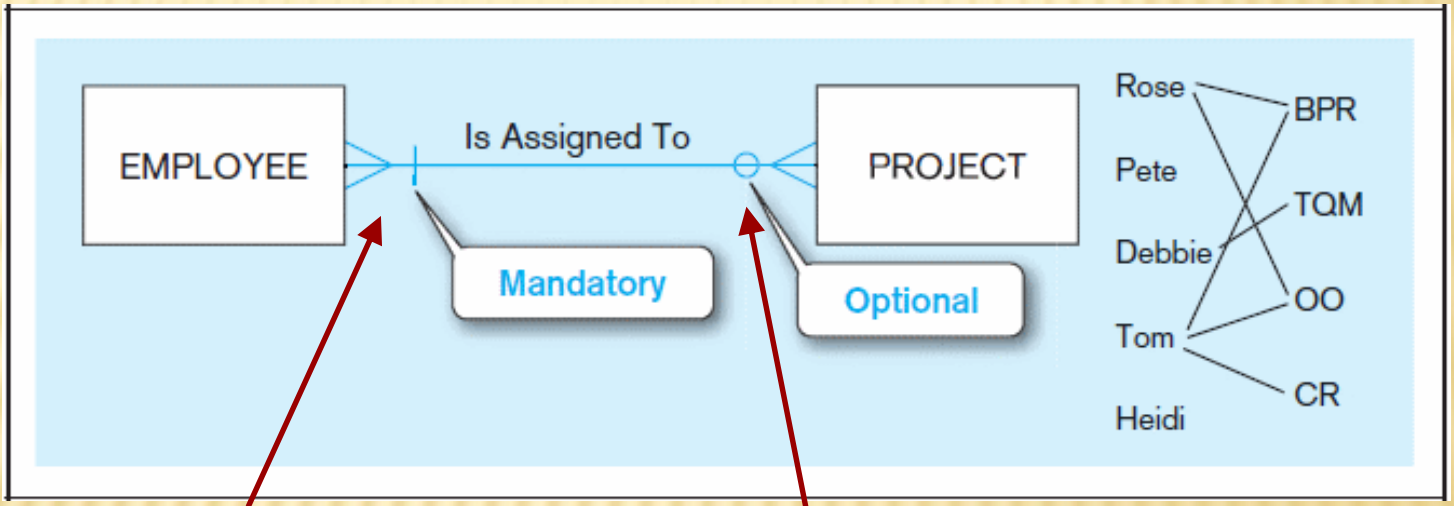
A patient history is recorded for one and only one patient

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

Examples of cardinality constraints (cont.)



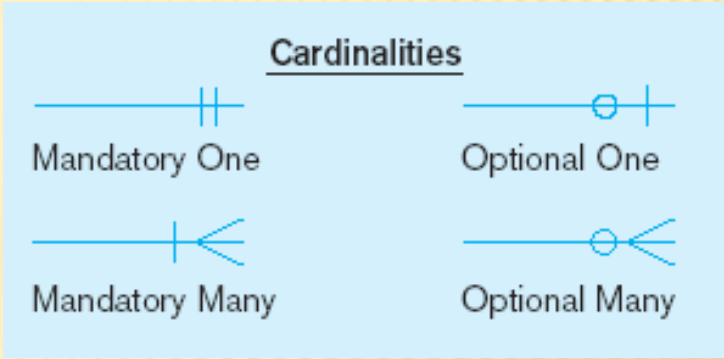
b) One optional, one mandatory



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

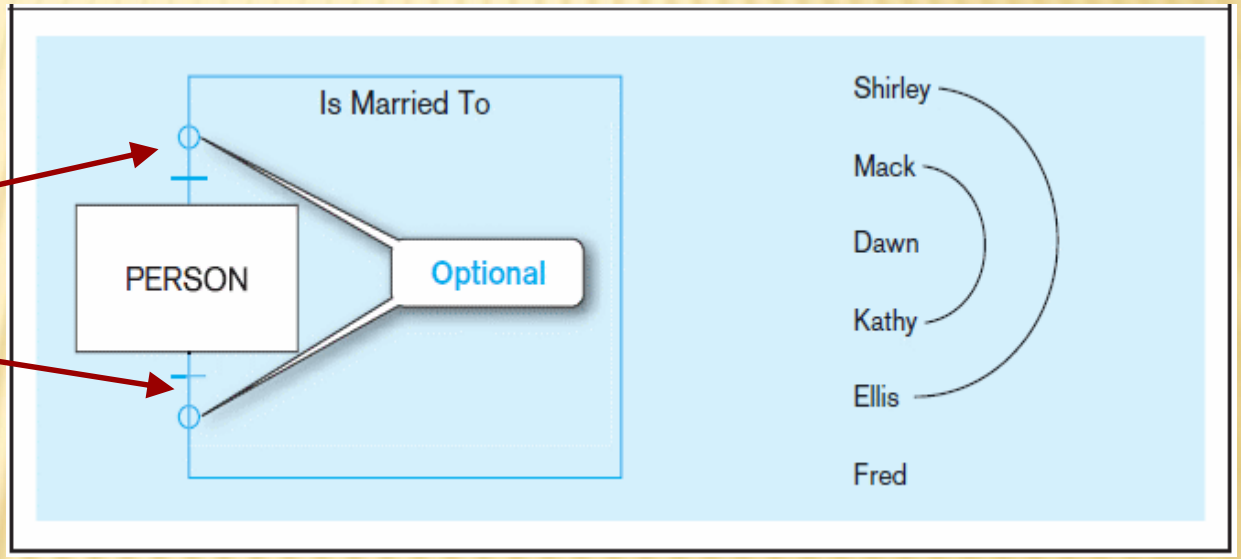
An employee can be assigned to any number of projects, or may not be assigned to any at all

Examples of cardinality constraints (cont.)



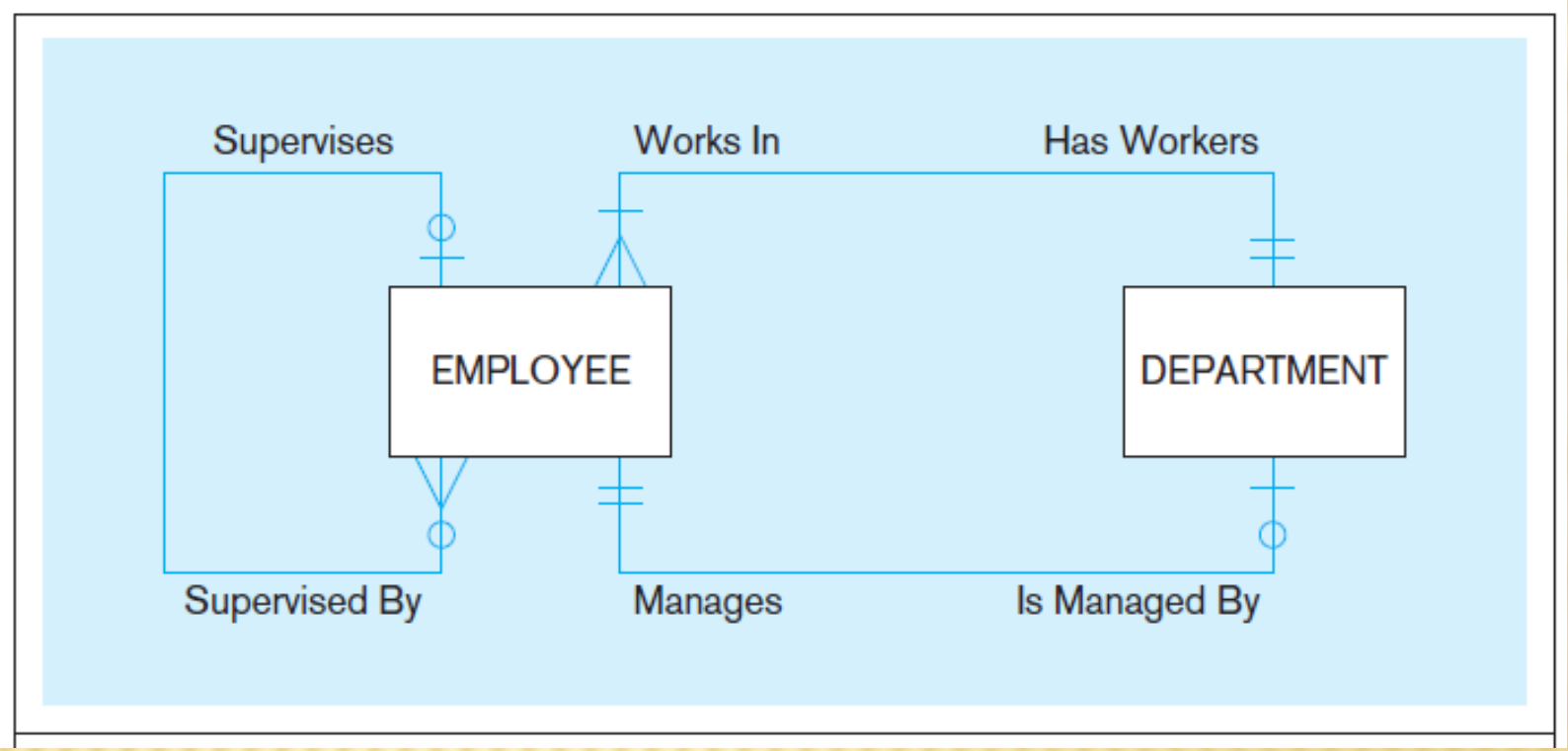
c) Optional cardinalities

A person is married to at most one other person, or may not be married at all



Examples of multiple relationships

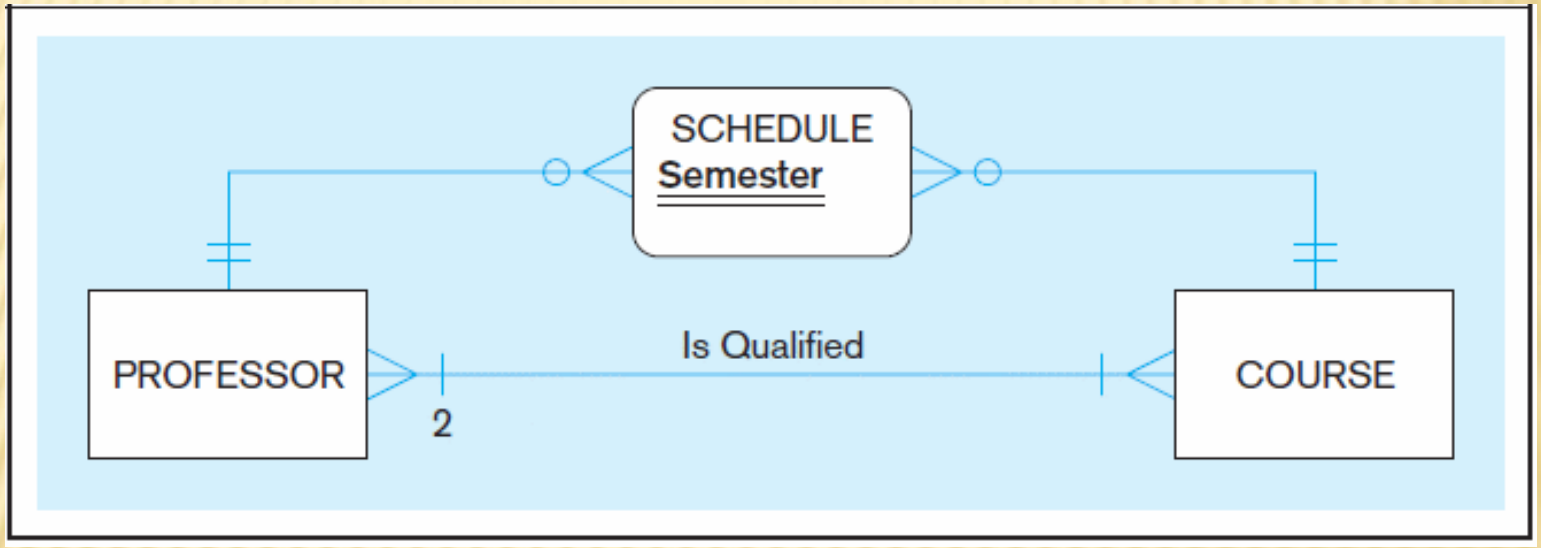
a) Employees and departments



Entities can be related to one another in more than one way

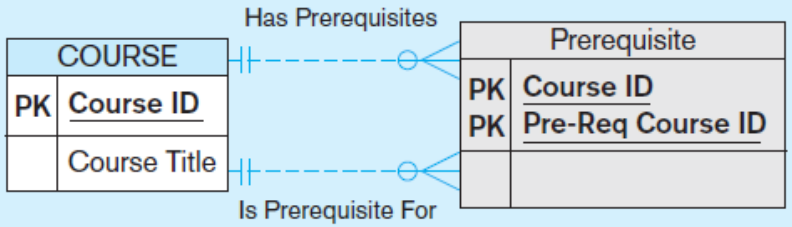
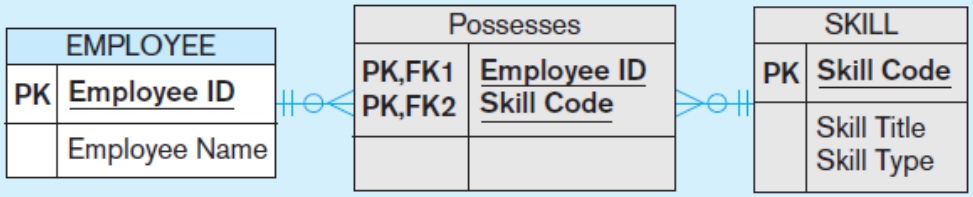
Examples of multiple relationships (cont.)

b) Professors and courses (fixed lower limit constraint)



Here, min cardinality constraint is 2. At least two professors must be qualified to teach each course. Each professor must be qualified to teach at least one course.

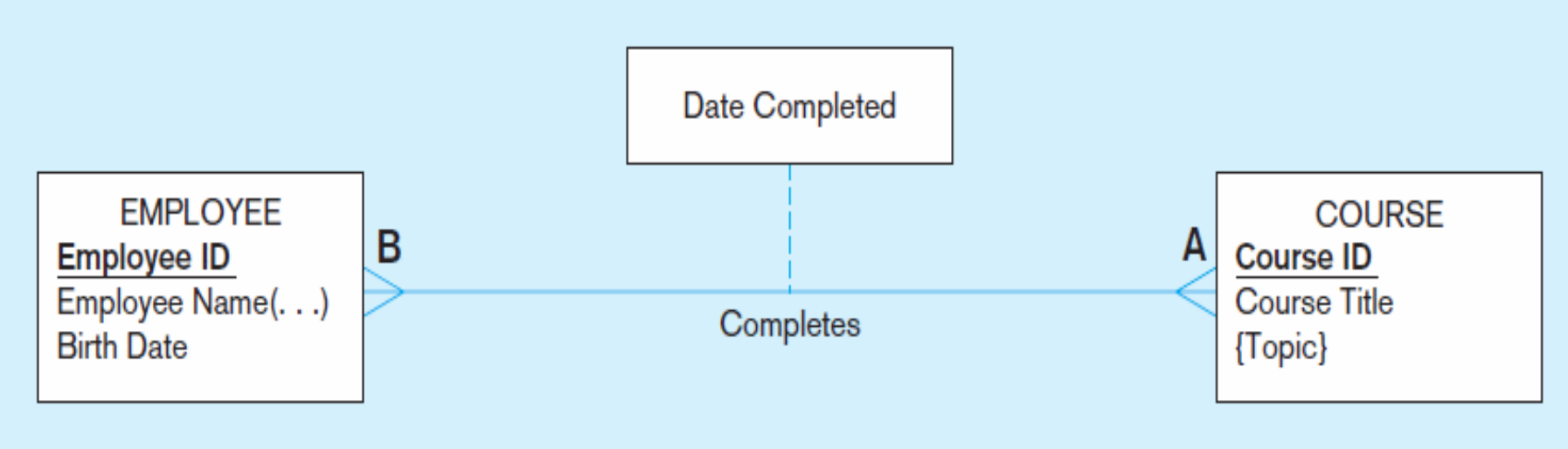
Multivalued attributes can be represented as relationships

ATTRIBUTE	RELATIONSHIP & ENTITY
COURSE **Course ID** Course Title {Prerequisite}	
simple	
EMPLOYEE **Employee ID** Employee Name {Skill (Skill Code, Skill Title, Skill Type)}	
composite	

ASSOCIATIVE ENTITIES

- An entity–has attributes
- A relationship–links entities together
- When should a *relationship with attributes* instead be an *associative entity*?
  - All relationships for the associative entity should be many
  - The associative entity could have meaning independent of the other entities
  - The associative entity preferably has a unique identifier, and should also have other attributes
  - The associative entity may participate in other relationships other than the entities of the associated relationship
  - Ternary relationships should be converted to associative entities

A binary relationship with an attribute



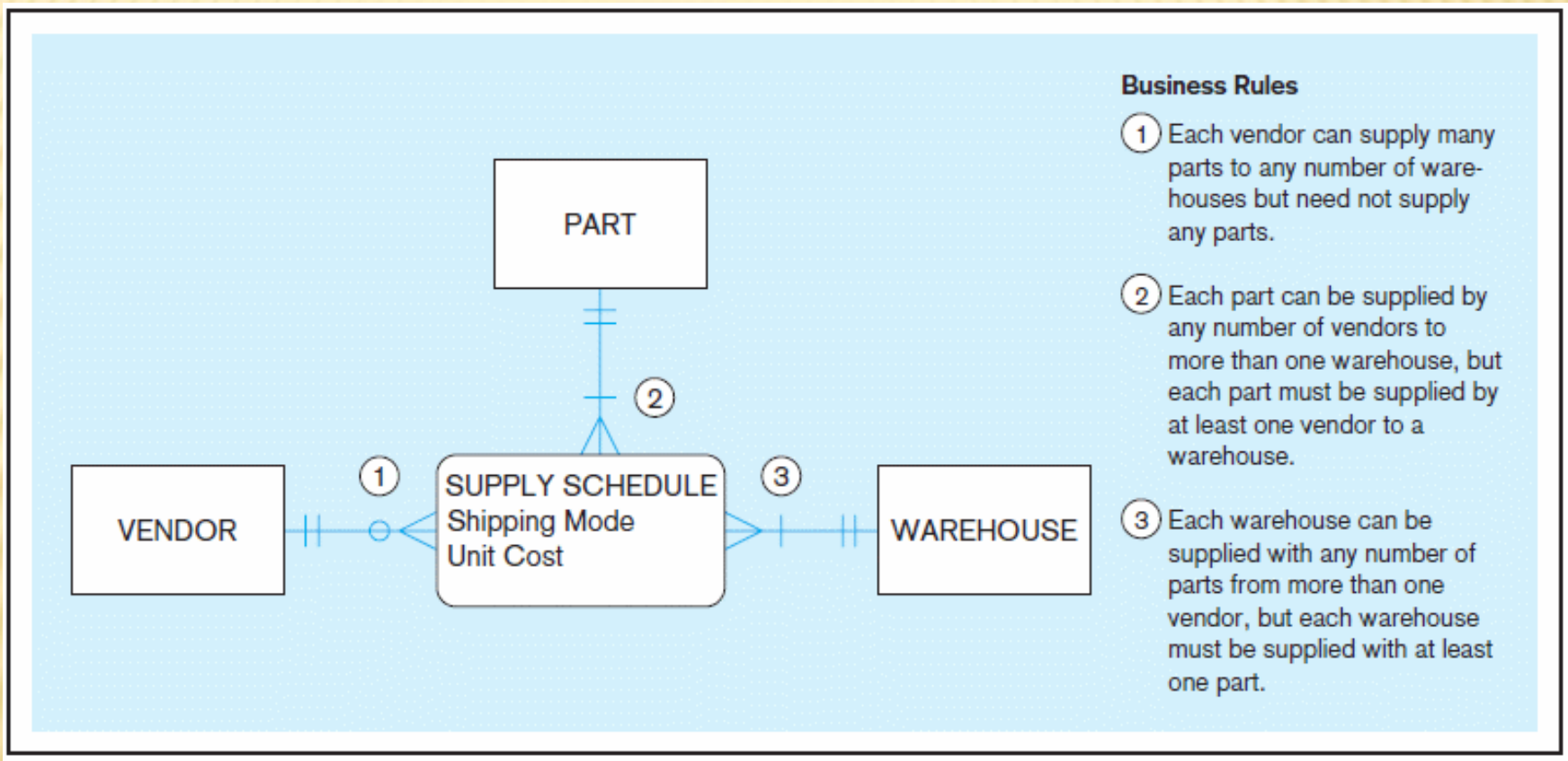
Here, the date completed attribute pertains specifically to the employee's completion of a course…it is an attribute of the *relationship.*

An associative entity (CERTIFICATE)

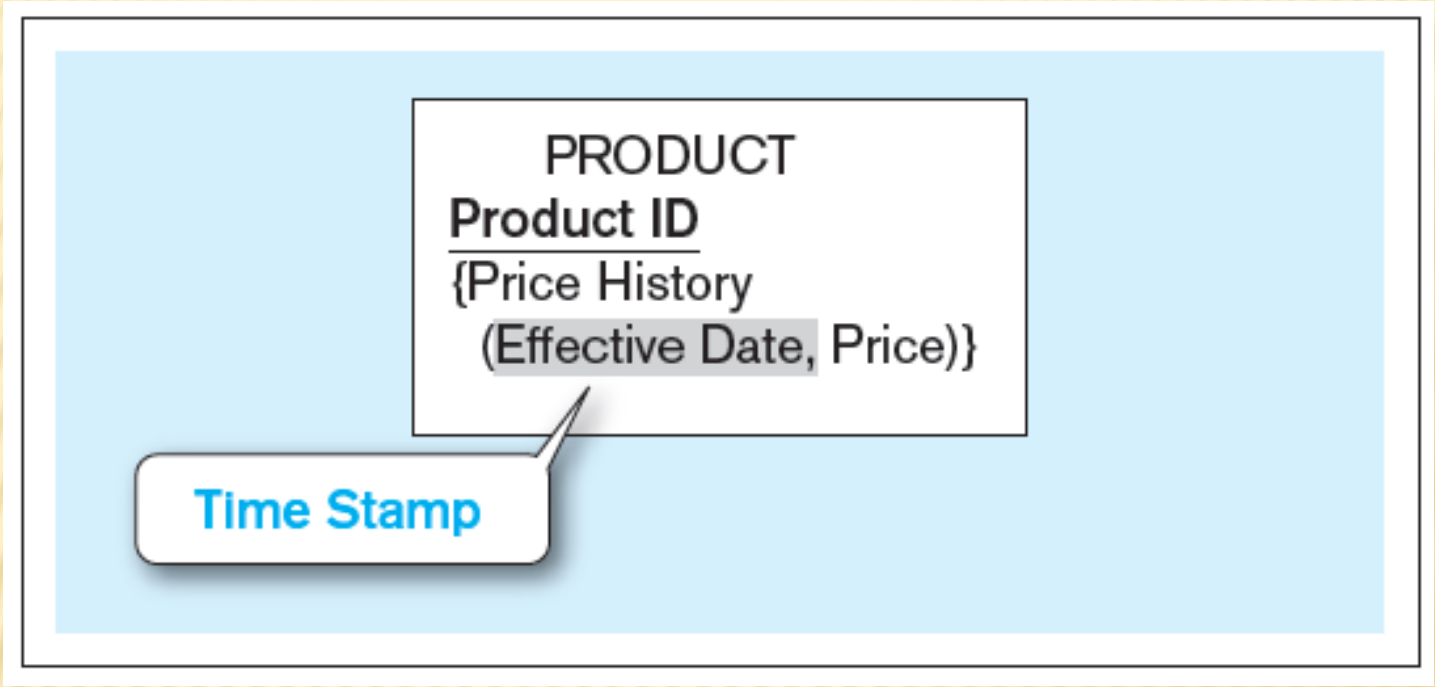
Associative entity is like a relationship with an attribute, but it is also considered to be an entity in its own right.

Note that the many-to-many cardinality between entities in Figure has been replaced by two one-to-many relationships with the associative entity.

Cardinality constraints in a ternary relationship



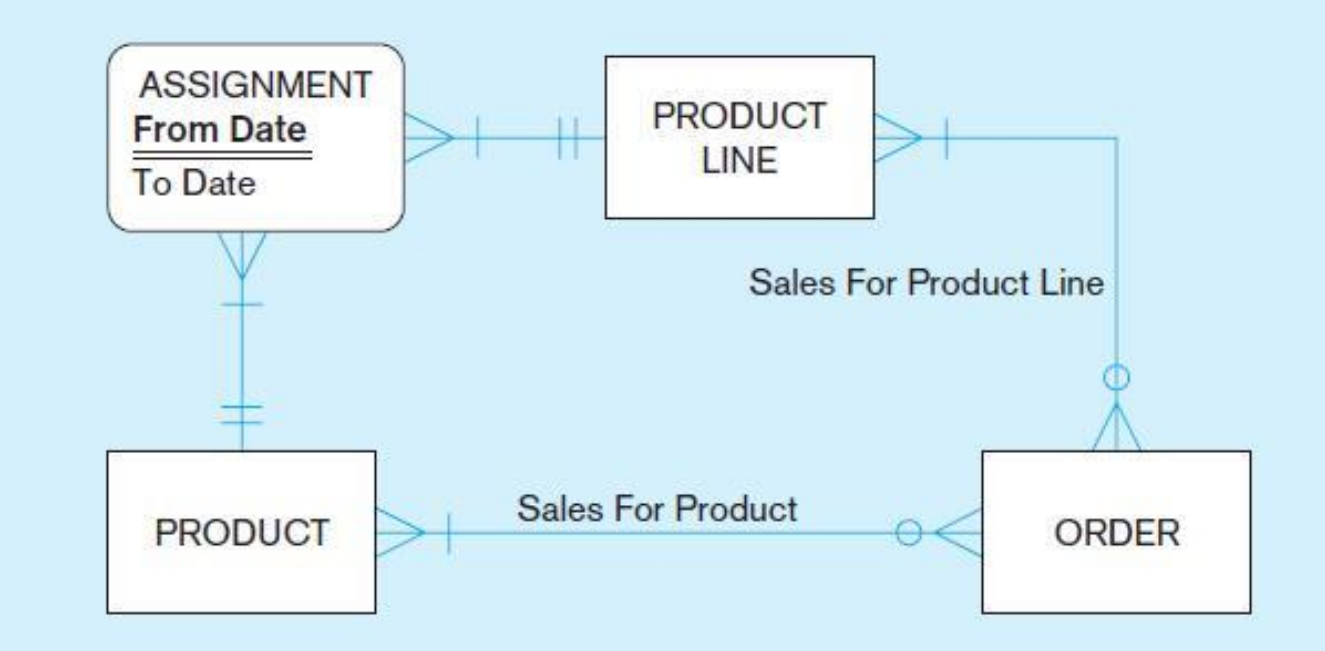
Simple example of time-stamping



Time stamp – a time value that is associated with a data value, often indicating when some event occurred that affected the data value

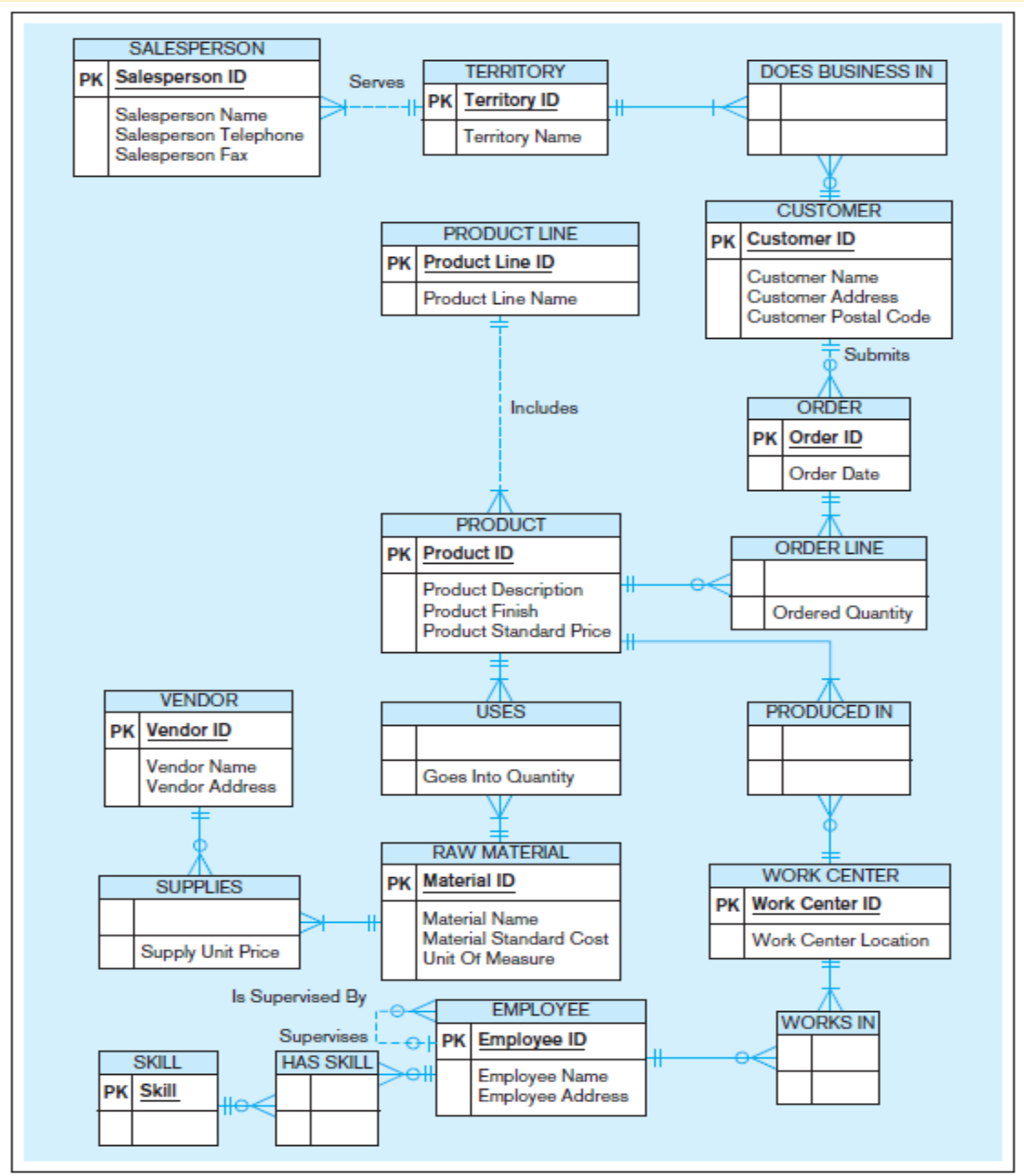
The Price History attribute is both multivalued *and* composite.

E-R diagram with associative entity for product assignment to product line over time



Modeling time-dependent data has become more important due to regulations such as HIPAA and Sarbanes-Oxley.

The Assignment associative entity shows the date range of a product's assignment to a particular product line.



Data model for Pine Valley Furniture Company in Microsoft Visio notation

Different modeling software tools may have different notation for the same constructs.