



Chapter 2

Conceptual Modeling

Towards More Complex
Entity Relationship Diagrams



1

Objectives

- Model different types of attributes, entities, relationships, and cardinalities
 - Strong vs. Weak Entities
 - Relationships with Attributes
 - Unary and Ternary Relationships
 - Multiple Relationships
- Draw E-R diagrams for common business situations
- Convert M:M relationships to associative entities
- Model time-dependent data using time stamps

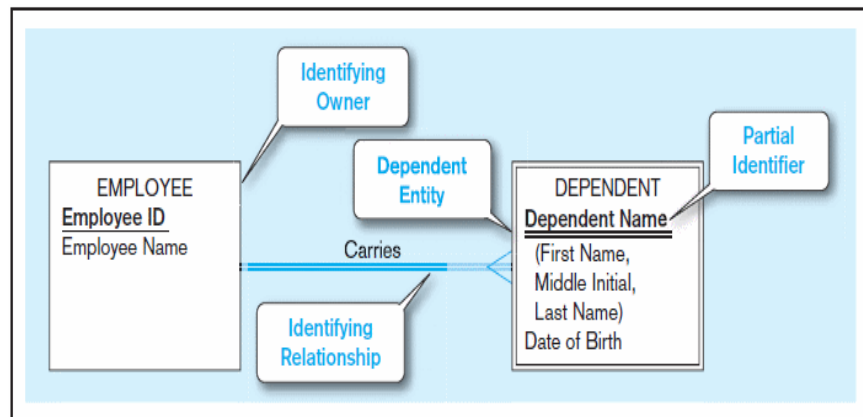
2

Strong vs. Weak Entities

- 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 ...cannot exist on its own
 - Does not have a unique identifier (only a partial identifier)
 - **Partial identifier underlined with double-line**
 - Entity box has double line
- Identifying relationship
 - links strong entities to weak entities

3

Figure 2-5 Example of a weak identity and its identifying relationship

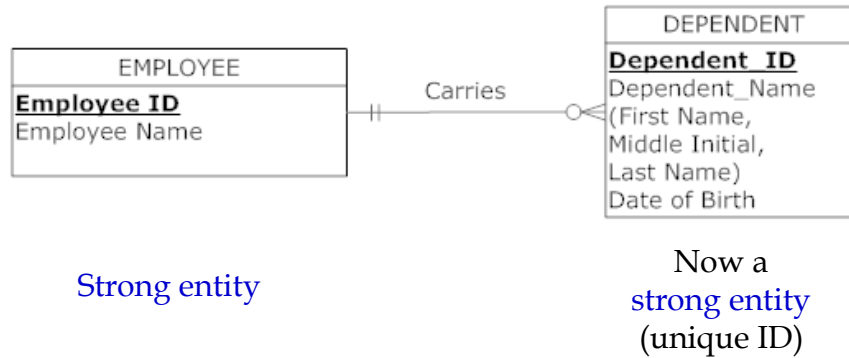


Strong entity

Weak entity

4

Weak Entity → Strong Entity



5

Practice: Course Sections

- Model the courses using two entities: **COURSE** and **SECTION**.
- Each course has a number and a title, and may have zero or more sections.
- Each section has a number and the term offered, which is composed of semester and year.

6

Practice: Weak Entities

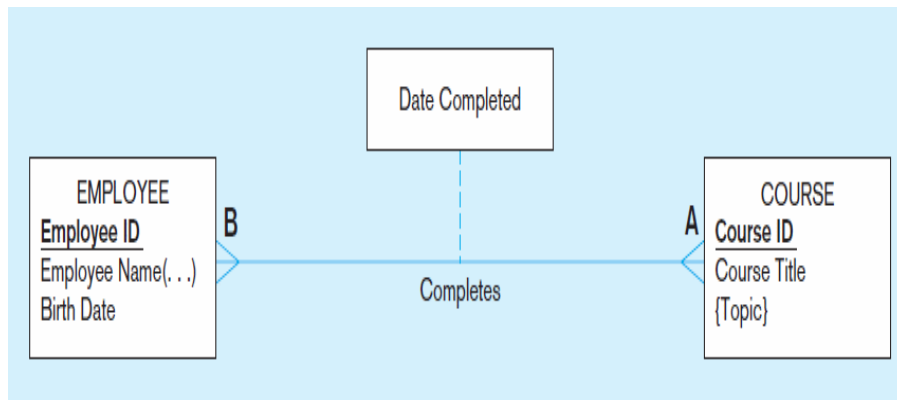
- Give another example of a weak entity type.

8

Relationships with Attributes

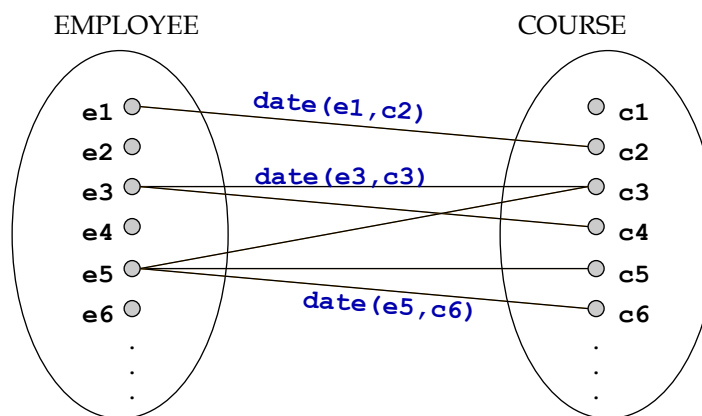
10

Figure 2-11a A binary relationship with an attribute
Attribute on a relationship (**Link Attribute/Associative**)



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

11



12

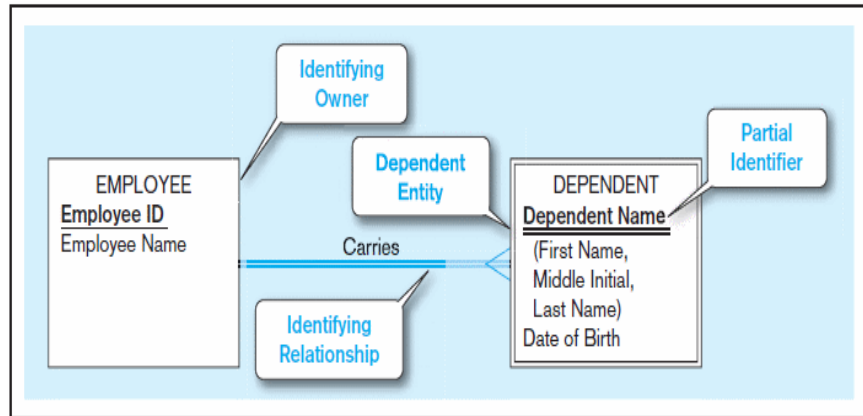
Practice: Relationships with Attributes

- #10, page 103. The figure below shows a grade report that is mailed to students at the end of each semester.

Prepare an ERD reflecting the data contained in the grade report. Assume that each course is taught by one instructor.

MILLENNIUM COLLEGE GRADE REPORT FALL SEMESTER 200X				
NAME:	Emily Williams	ID:	268300458	
CAMPUS ADDRESS:	208 Brooks Hall			
MAJOR:	Information Systems			
COURSE ID	TITLE	INSTRUCTOR NAME	INSTRUCTOR LOCATION	GRADE
IS 350	Database Mgt.	Codd	B104	A
IS 465	System Analysis	Parsons	B317	B

Example (revisited): Consider **DependentDate** (similar to CompletedDate) for when DEPENDENT begins to be carried by EMPLOYEE. Could you associate it with relationship Carries?



Strong entity

Weak entity

16

Review

- Strong entity
- Weak entity
- Relationship without attributes
- Relationship with attributes

17

Relevant Textbook Exercises

- Exercise #2 (f), page 102
- Exercise #17(a,g,h), pages 104-105
- Exercise #19, page 105
- Exercise #27, page #107

Associative Entities

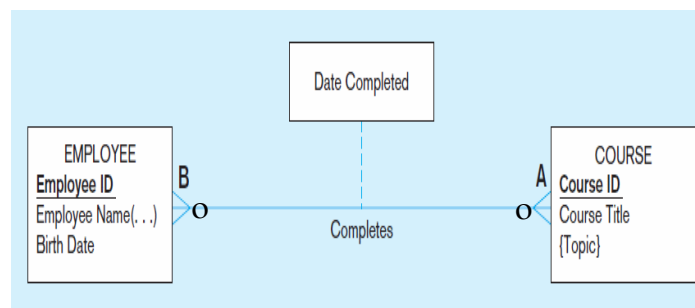
Associative Entities

- One of the hardest concepts in E-R modeling
- *An associative entity is a relationship transformed into an entity*
- Each *instance* of an associative entity represents an *instance* of the relationship
- Needed to represent ternary relationships, and for cases when we need to convert a relationship into an entity, to relate it to other entities.

20

Associative Entities - Example

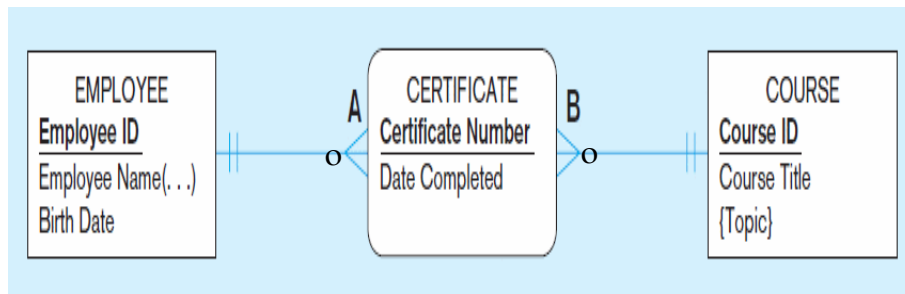
- Previous model: a database of courses taken by employees. For each employee we keep its SSN (identifier), name and birth date, and for each course we keep its id and title. We also keep the date the employee completed that course.



- Suppose that we also want to record information about the institutions issuing the certificates. **HOW???**

21

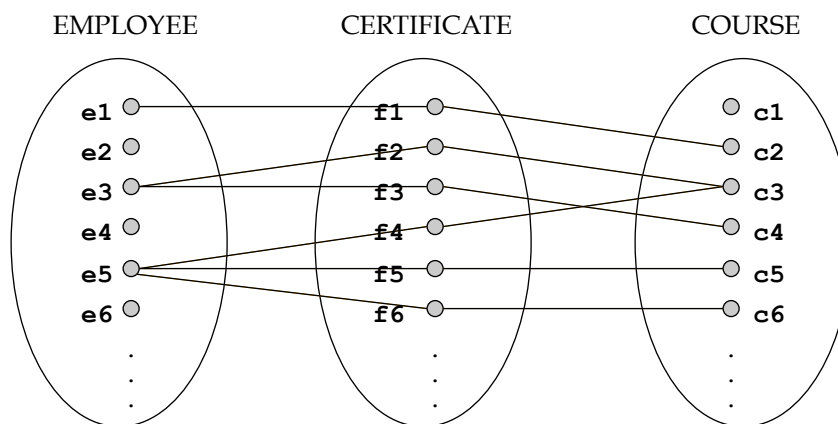
Figure 2-11b An associative entity (CERTIFICATE)



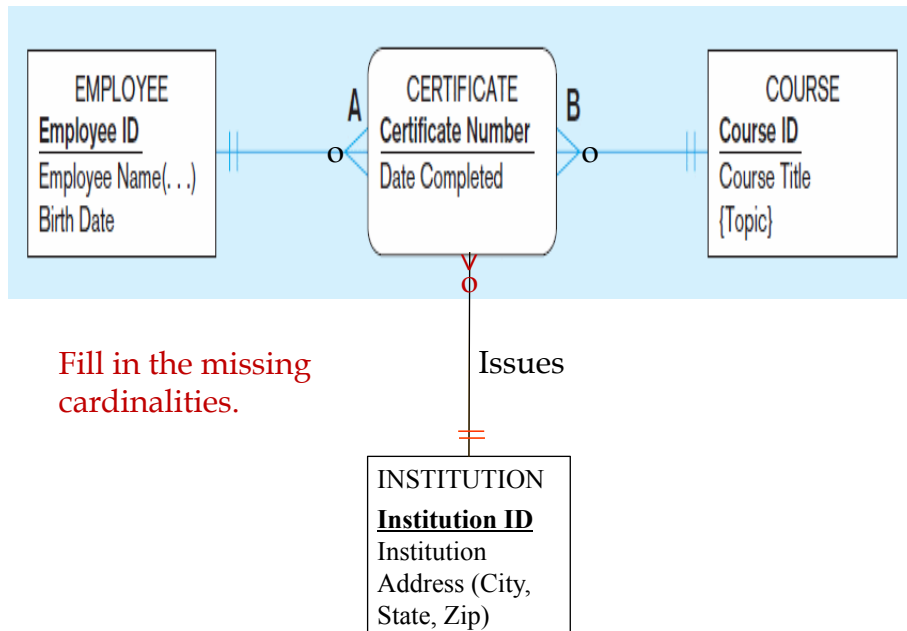
Associative entity is like a relationship with an attribute, but it is also considered to be an entity in its own right

Note that the many-to-many cardinality between entities in Figure 2-11a has been replaced by two one-to-many relationships with the associative entity

22



23



Fill in the missing cardinalities.

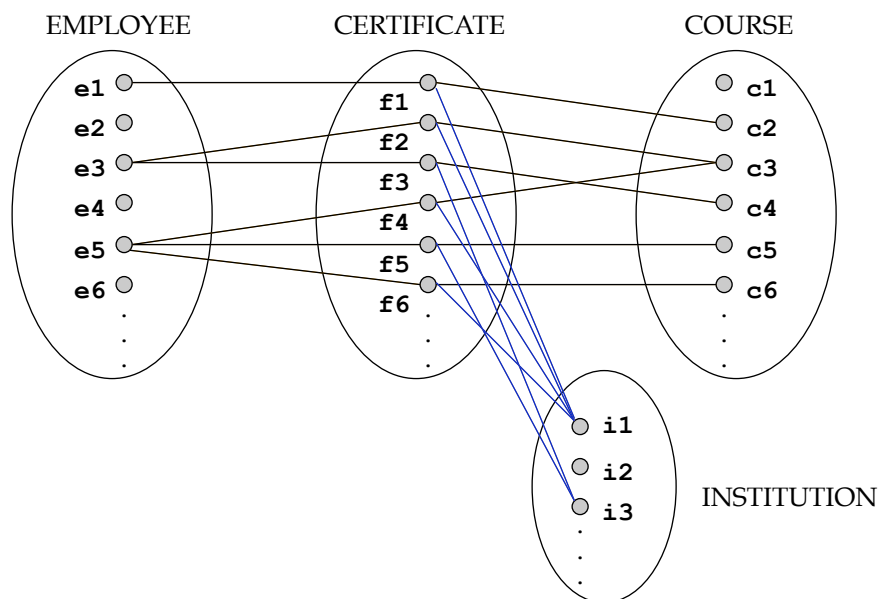
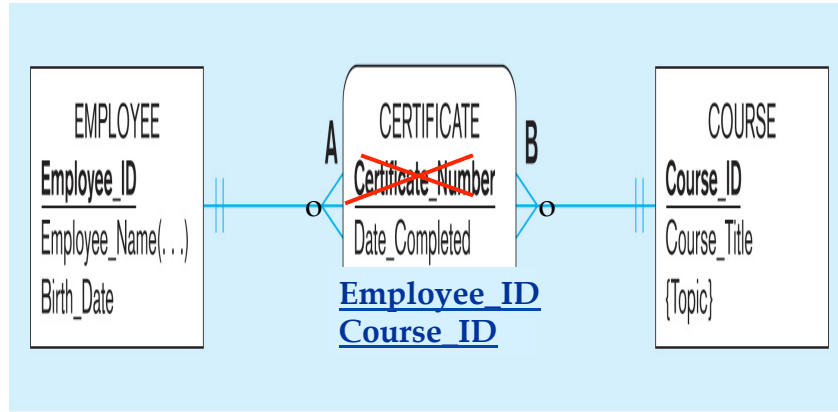


Fig. 2-11: (b) An associative entity (CERTIFICATE)



What is an alternative to assign the PK?

26

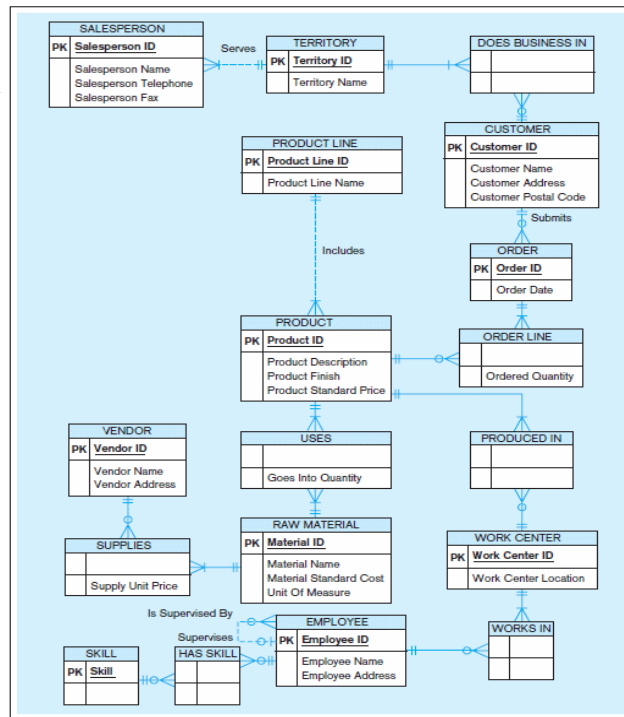
Associative Entities

- 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

27

Exercise 9, page 103

Visio does not explicitly show associative entities. Find them.



Ternary Relationships

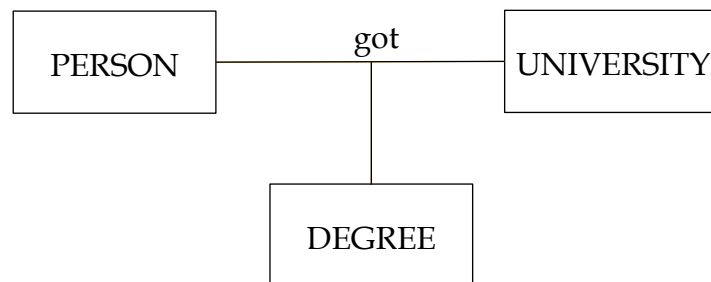
Ternary Relationships

- Relationships of degree 3
- Associates three entities *at the same time*
- Can't we just live with binary relationships?

31

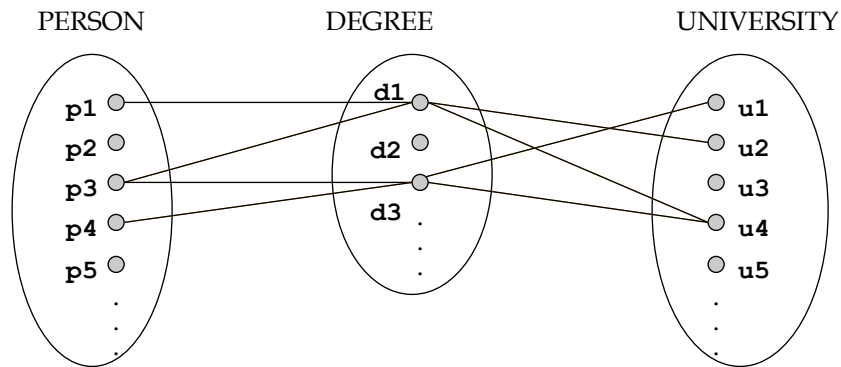
Ternary Relationship - Example

- Say we wanted to keep track of which Person got which Degrees from which University.



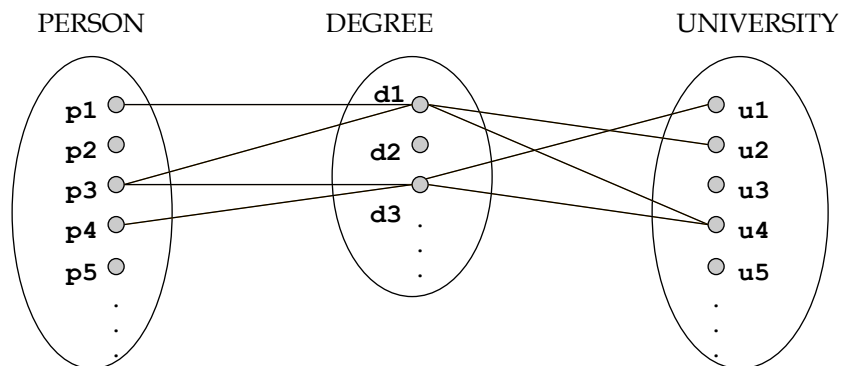
- Can this be modeled with binary relationships?

32



- Person p1 got degree d1 from university u2
- Person p3 got degree d1 from university u4
- Person p3 got degree d3 from university u4
- Person p4 got degree d3 from university u1

33

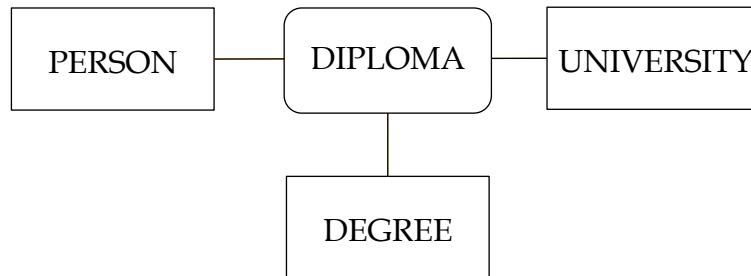


- p1 gets degree d1 from ... u2 or u4?
- p3 gets degree d1 from ... u2 or u4?

34

Ternary Relationship - Example

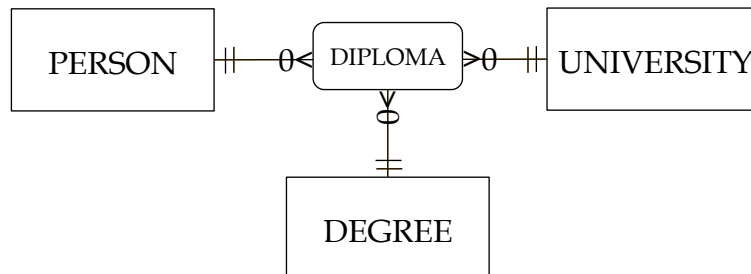
- Yes, with the help of an associative entity



- Ternary relationship “got” is now an associative entity, DIPLOMA. **Cardinality constraints?**

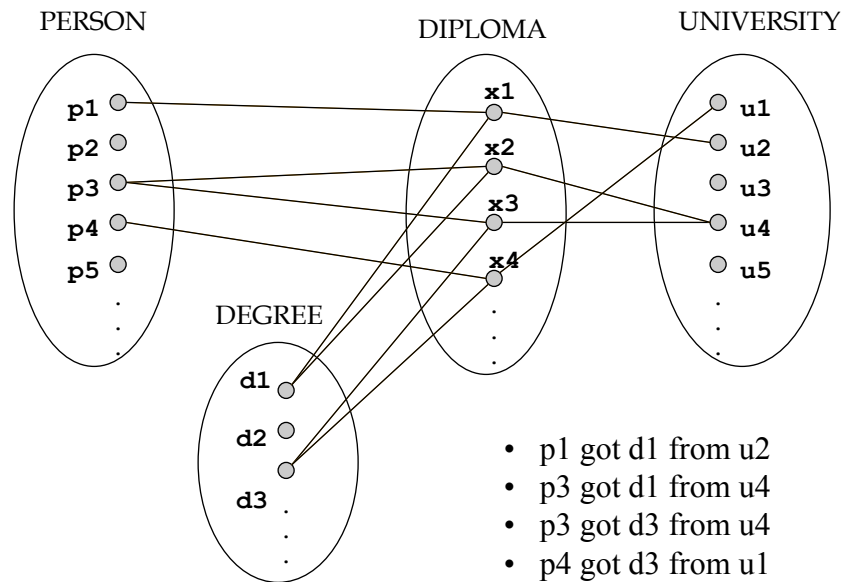
35

Example – Cardinalities Constraints



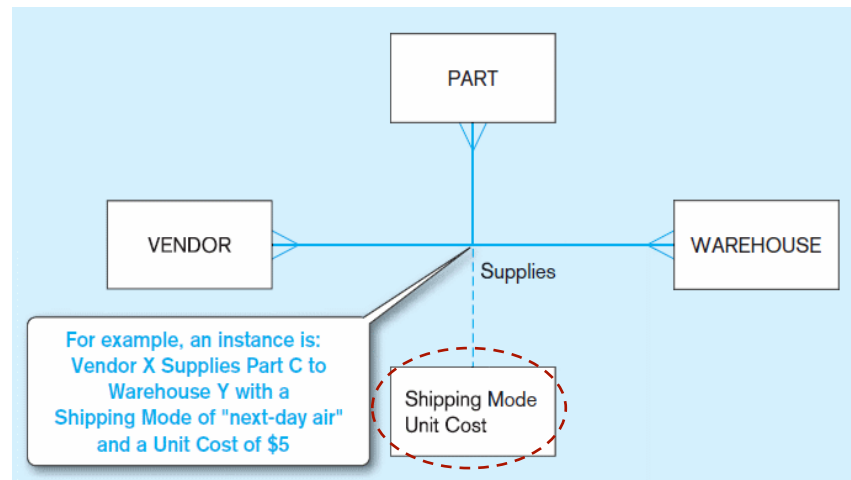
As a general rule, ternary relationships should be converted to associative entities.

36



37

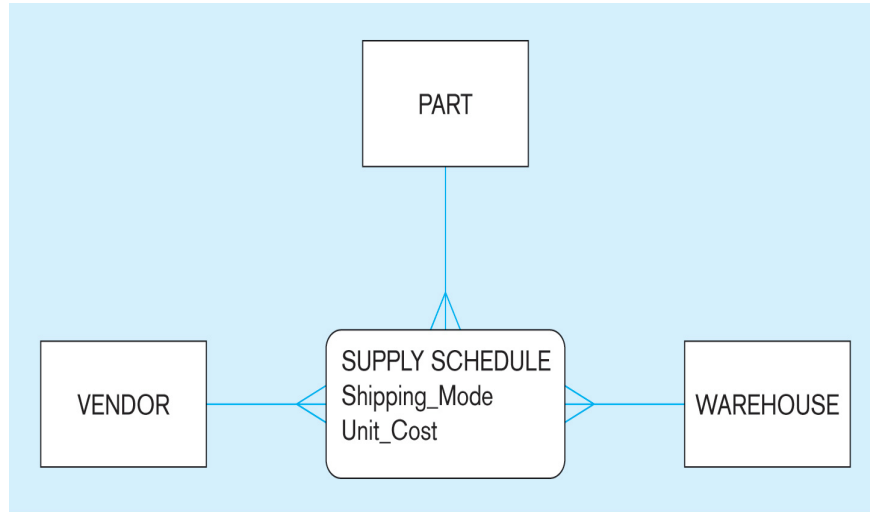
Figure 2-12 Example of a ternary relationship



Note: a relationship can have attributes of its own

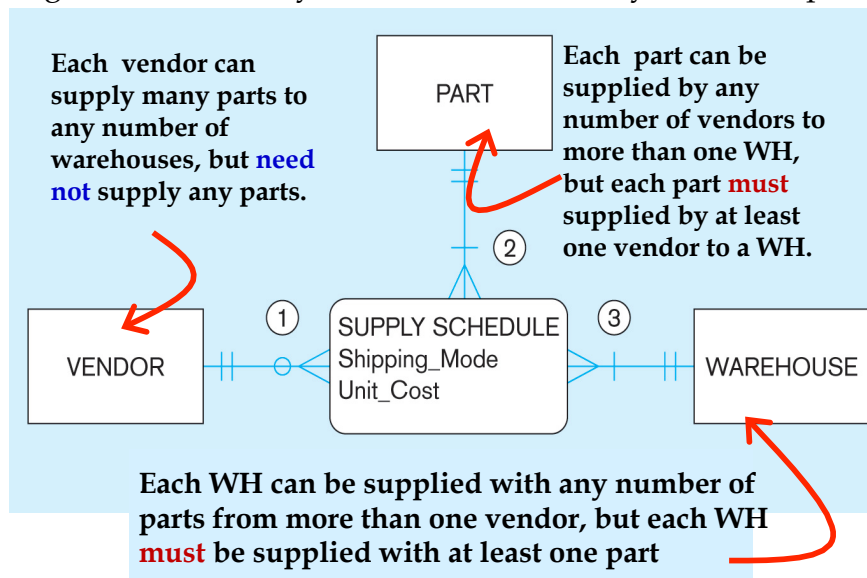
38

Fig. 2-14: Ternary relationships as an associative entity



39

Fig. 2-18: Cardinality constraints in a ternary relationship



40

Practice: Ternary Relationships

- Give another example of a ternary relationship.

Practice: Ternary Relationships

Exercise #20, page #106.

- Each semester, each student must be assigned an adviser who counsels students about degree requirements and helps students register for classes.
- Each student must register for classes with the help of an adviser, but if the student's assigned adviser is not available, the student may register with any adviser.
- We must keep track of students, the assigned adviser for each, and the name of the adviser with whom the student registered for the current term.
- Represent this situation of students and advisers with an E- R diagram.

Relevant Textbook Exercises

- Exercise #17(b), page 104
- Exercise #23, page 106

47

Unary Relationships

48

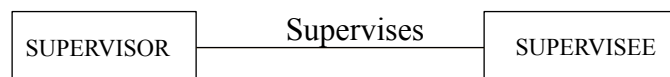
Unary Relationships

- Relationships of degree 1
- Also known as recursive relationships
- Two or more entities in the relationship are of the same type
- Example: we want to represent when an employee supervises another employee.

49

Example: Supervises

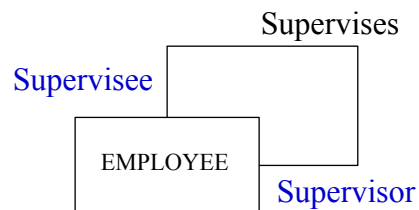
- Example: we want to represent when an employee supervises another employee.
- We could *start* with something like this:



50

Example: Supervises

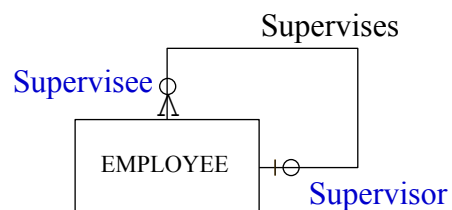
- But supervisors can have their own supervisors
- Both supervisor and supervisee are employees, so we need a recursive relationship, with **roles**



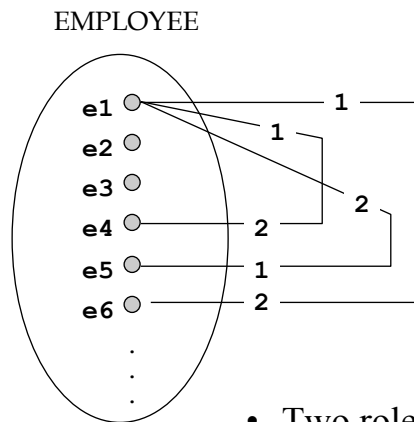
51

Example: Supervises

- And, of course, add cardinalities
- **Should always define roles** – even more important when cardinalities are different



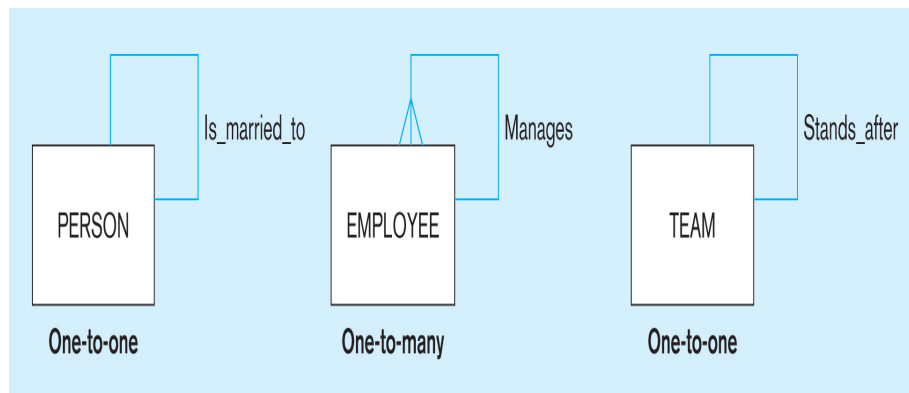
52



- Two roles:
supervisor (1) and supervisee (2)

53

Fig. 2-12 (a) Unary relationships



Practice: Add missing cardinalities.

54

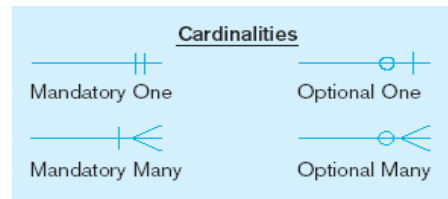
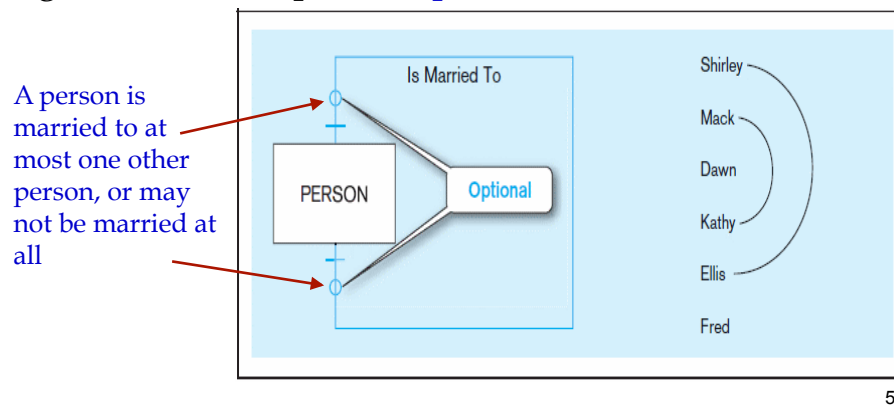
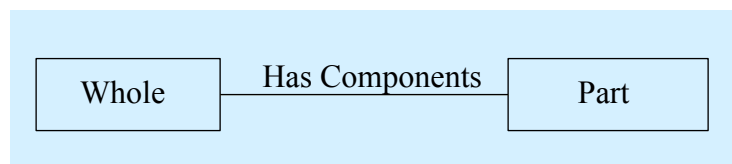


Figure 2-17 Examples of optional cardinalities

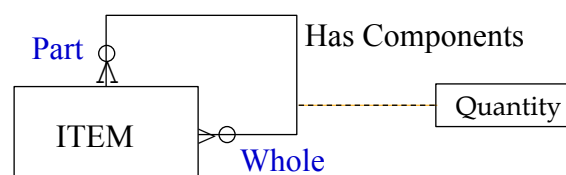


56

Example: Bill Of Materials

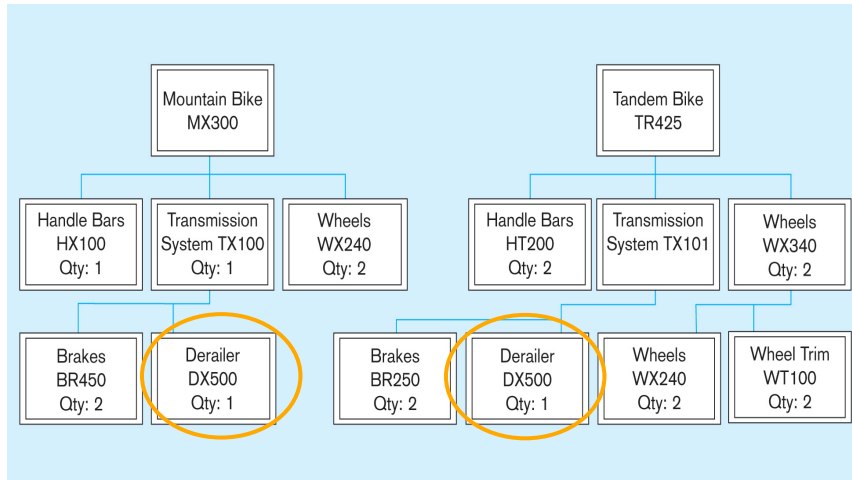


- Part-Whole is also a recursive relationship:



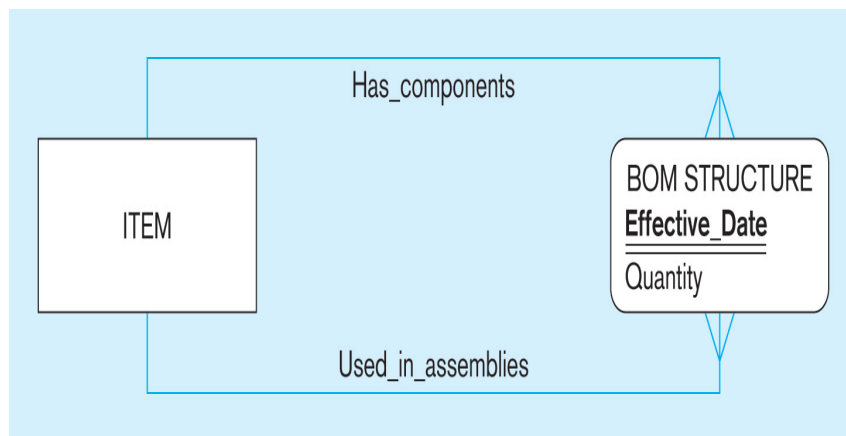
57

Fig. 2-13: Two ITEM bill-of-materials instances



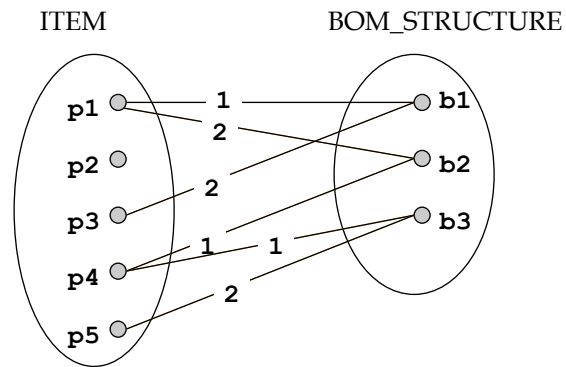
58

Fig. 2-13: An associative entity - bill of materials structure



This could just be a relationship with attributes...it's a judgment call

59



- Two roles:
part (1) and whole (2)

60

Practice: Unary Relationships

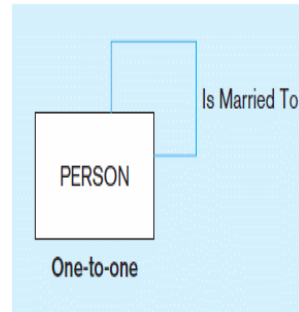
- Give another example of a unary relationship.

61

Practice: Unary Relationships

Draw an E/R diagram for the following variations:

1. All we need to know is who a person is currently married to, if any
2. We need to know who a person has ever been married to
3. Same as 2, but we also need to know the marriage date and dissolution date
4. Same as 3, but assume that same 2 people can remarry



Relevant Textbook Exercises

- Exercise #2(d, g), page 102

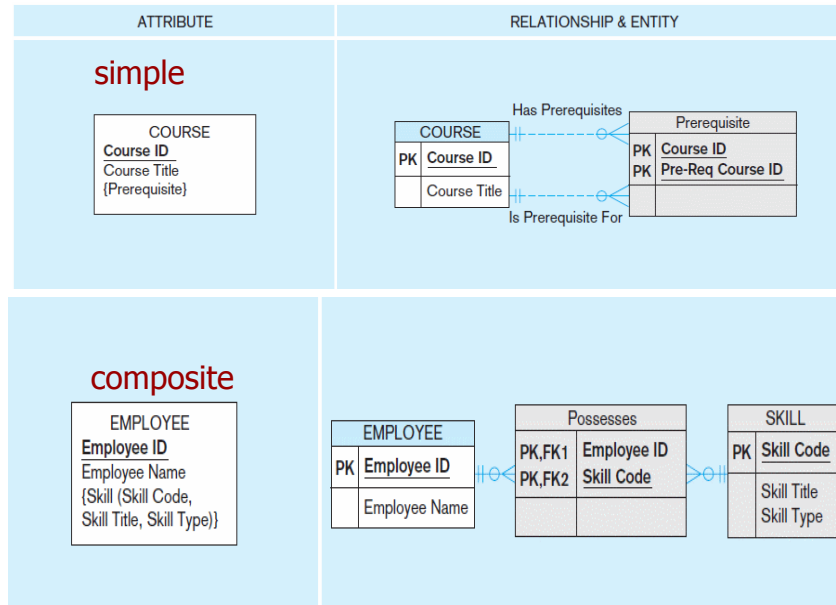
65

Attributes or Entity?

- Sometimes you will wonder whether to represent data as an attribute or an entity. This is a common dilemma.
- Let us look at a few situations.

66

Figure 2-15 Multivalued attributes can be represented as Relationships/Associative Entity



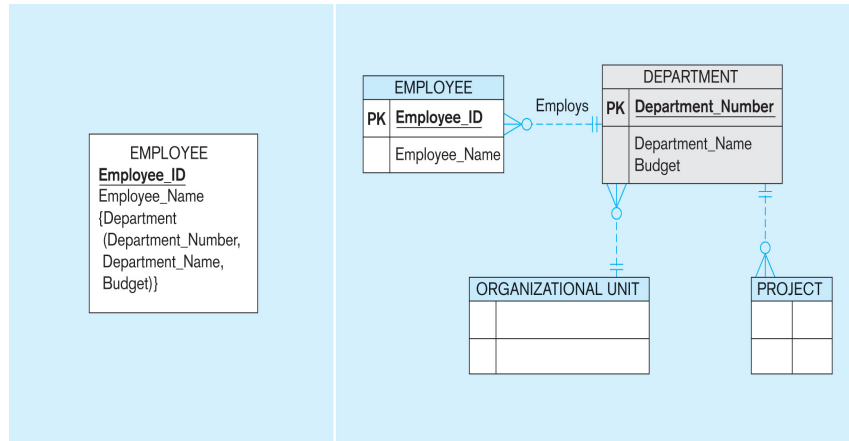
67

Attributes or Entity?

- So when SHOULD an attribute be linked to an entity type via a relationship?
 - Attribute refers to a concept in the data model
 - Multiple entity instances share the same attribute
- Example on next page

68

Fig. 2-15: Using relationships and entities to link related attributes
(c) Composite attribute of data shared with other entity types



69

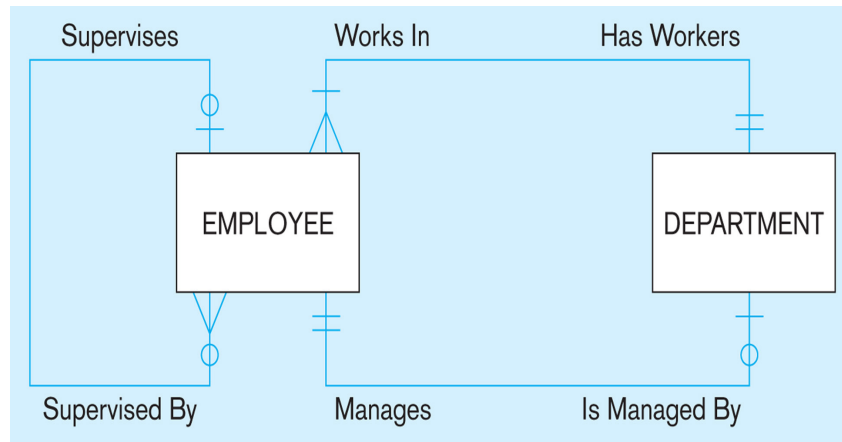
Multiple Relationships

- More than one relationship between the same entity types (Fig. 2-21)

70

Fig. 2-21: Examples of multiple relationships

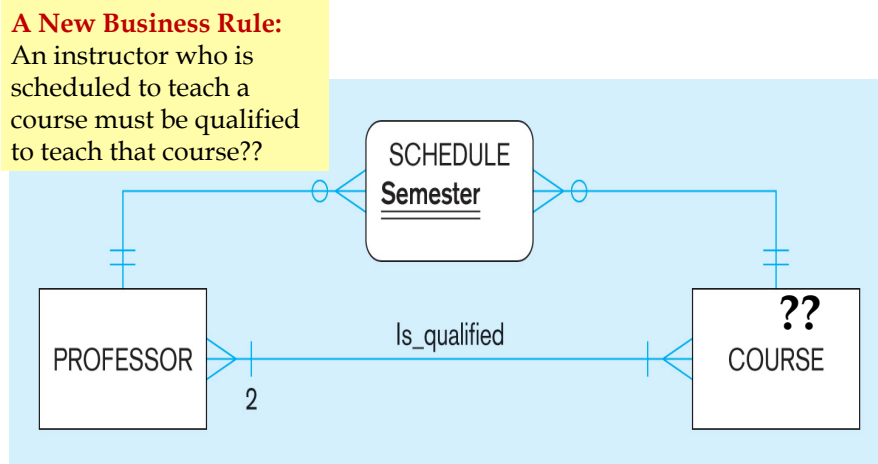
(a) Employees and departments



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

71

Fig. 2-21: (b) Professors and courses (fixed upon constraint)



Here, minimum cardinality constraint is 2, what's for?

At least two professors must be qualified to teach each course.
Each professor must be qualified to teach at least one course.

72

Practice: Multiple Relationships

- Exercise #17(d), page #104.

A hospital has a large number of registered physicians. Attributes of PHYSICIAN include Physician ID (the identifier) and Specialty. Patients are admitted to the hospital by physicians. Attributes of PATIENT include Patient ID (the identifier) and Patient Name. Any patient who is admitted must have exactly one admitting physician. A physician may optionally admit any number of patients. Once admitted, a given patient must be treated by at least one physician. A particular physician may treat any number of patients, or may not treat any patients. Whenever a patient is treated by a physician, the hospital wishes to record the details of the treatment (Treatment Detail). Components of Treatment Detail include Date, Time, and Results.

Does your ERD allow for the same patient to be admitted by different physicians over time? How would you include on the ERD the need to represent the date on which a patient is admitted for each time they are admitted?

Practice: Multiple Relationships

- Exercise #17(i), page #105.

Each publisher has a unique name; a mailing address and telephone number are also kept on each publisher. A publisher publishes one or more books; a book is published by exactly one publisher. A book is identified by its ISBN, and other attributes are title, price, and number of pages. Each book is written by one or more authors; an author writes one or more books, potentially for different publishers. Each author is uniquely described by an author ID, and we know each author's name and address. Each author is paid a certain royalty rate on each book he or she authors, which potentially varies for each book and for each author. An author receives a separate royalty check for each book he or she writes. Each check is identified by its check number, and we also keep track of the date and amount of each check.

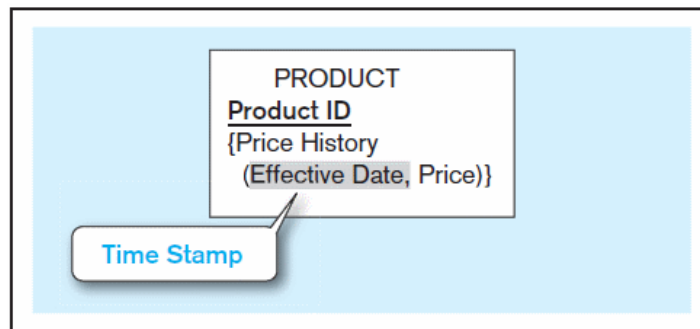
Relevant Textbook Exercises

- Exercises #13, #15, page 103
- Exercise #22, page 106
- Exercises #25, #26, #28, page 107
- Exercise #29, page 108

79

Modeling Time-Dependent Data

Figure 2-19. Simple example of time-stamping



This attribute is both
multivalued *and* composite.

80

Fig. 2-20: (a) E-R diagram **not** recognizing product *reassignment*

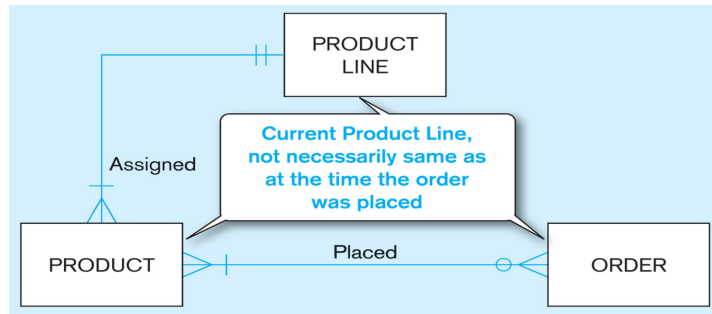
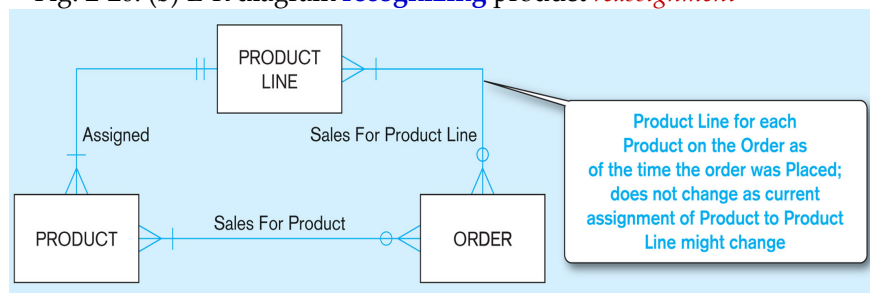
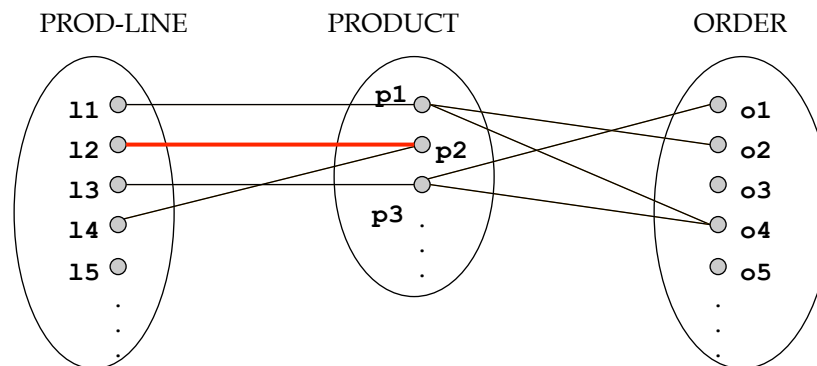


Fig. 2-20: (b) E-R diagram **recognizing** product *reassignment*



81

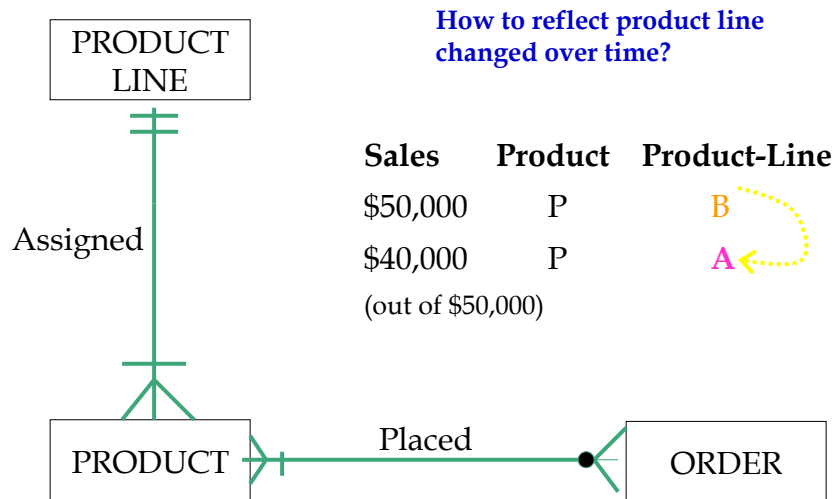


- **Reassignment**

82

Fig. 2-20: (a) E-R diagram **not** recognizing product *reassignment*

In the middle of year, due to a reorganization of the sales function some products are reassigned to different product lines

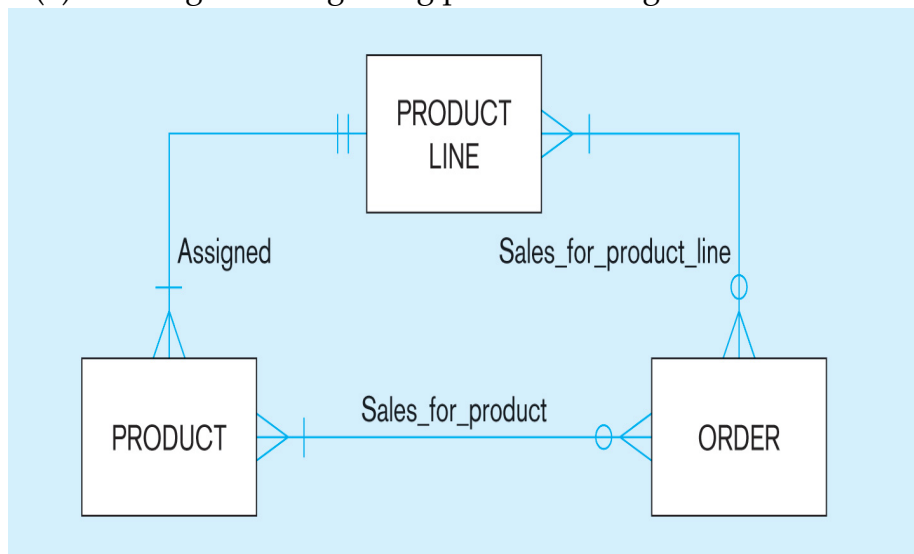


83

Fig. 2-20: Pine Valley Furniture product database

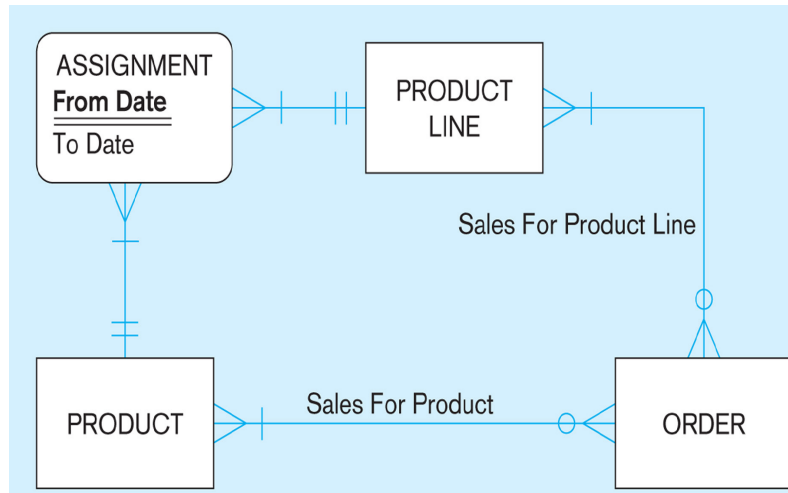
Solution: adding a new relationship of "Sales_for_product_line"

(b) E-R diagram recognizing product reassignment



84

Fig. 2-20: Pine Valley Furniture product database
 (c) E-R diagram with associative entity for product assignment to product line *over time*

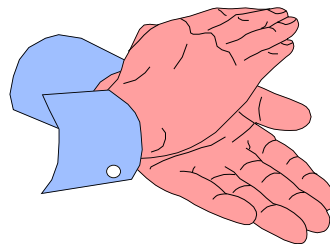


85

The Entity Relationship (E-R) Model

Congratulations !!

You have just learned
 one of the most
 important modeling
 concept (**E-R**) for
 developing the data
 base systems.



86

Recognizing Different ERD Notations

87

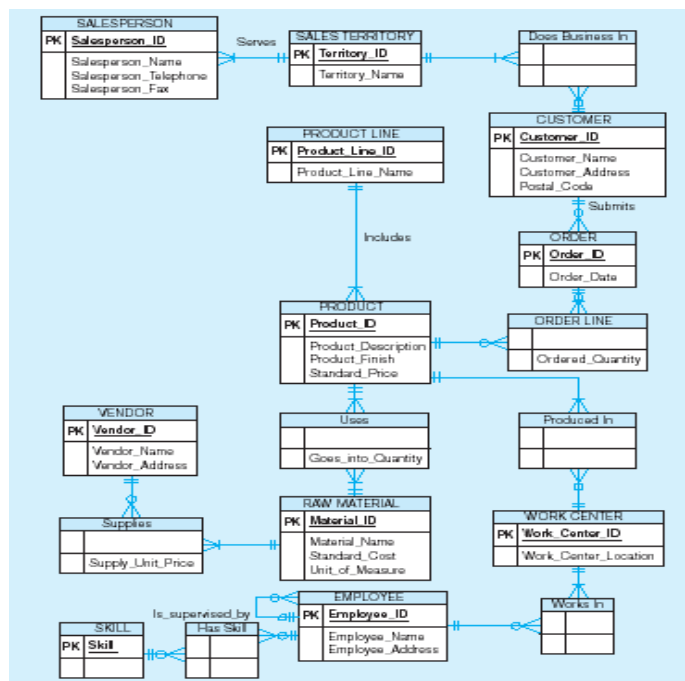


Fig. 2-22:
Microsoft Visio
Notation for
Pine Valley
Furniture
E-R diagram

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

88

Fig. 2-22: E-R diagram for Pine Valley Furniture Company

