UTS:ENGINEERING AND INFORMATION TECHNOLOGY

UTS UNIVERSITY OF TECHNOLOGY, SYDNEY

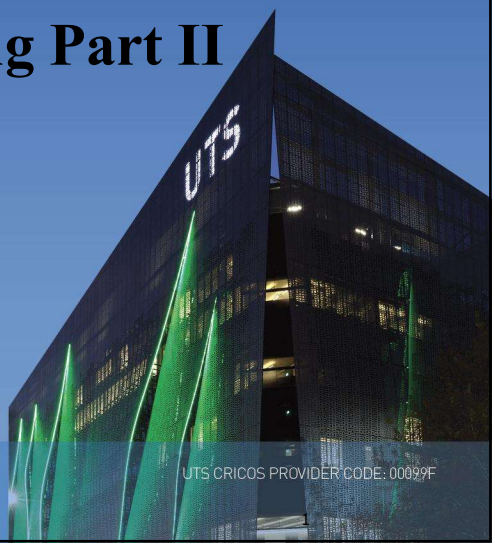
lecture 2: Data Modeling Part II

Modern Database Management

11th Edition, International Edition

Chapter 2: Modeling Data in the Organization

Jeffrey A. Hoffer, V. Ramesh, Heikki Topi



Innovation in practice

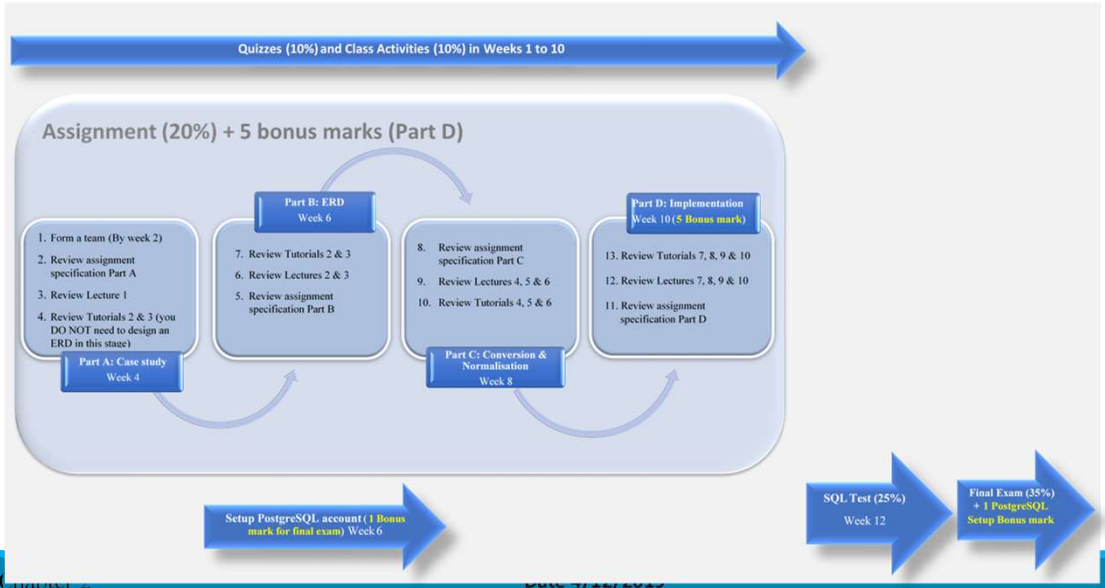
eng.uts.edu.au • it.uts.edu.au

Participations and Discussions

If you have any question and you don't want to share it now, send it to us via UTSOnline/Discussion Board.

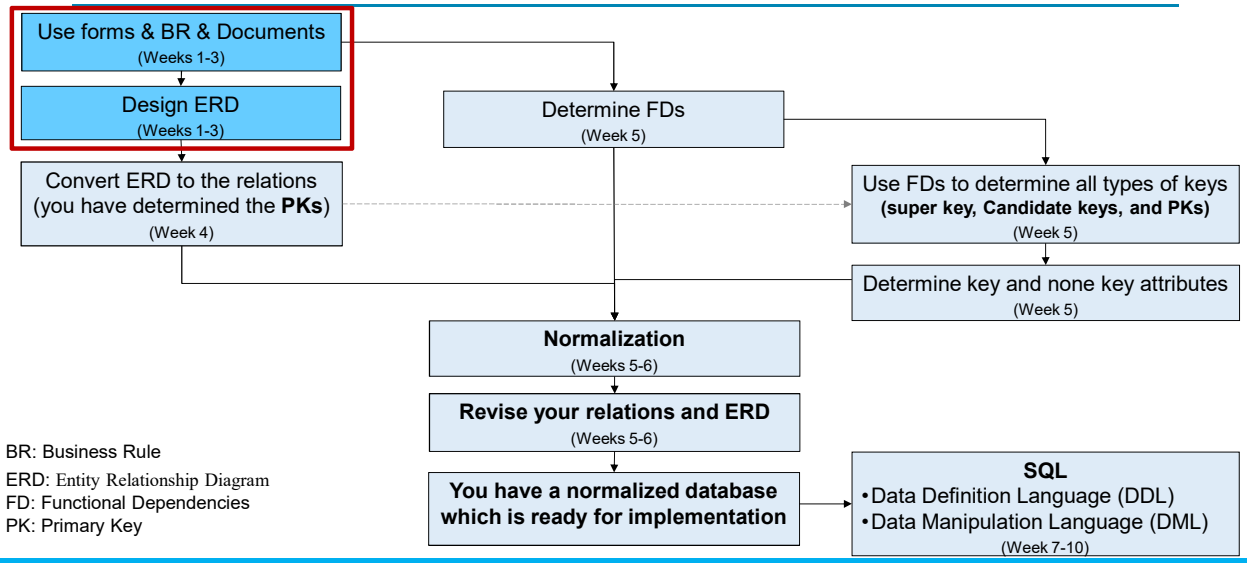
However, it is better to speak out ☺

Assessment Chart and Knowledge Guideline



3

Subject Flowchart



BR: Business Rule
ERD: Entity Relationship Diagram
FD: Functional Dependencies
PK: Primary Key

4

Subject Overview

- **Design Entity Relationship Diagram (ERD)**
  - Week 1: Data Modelling I (Conceptual Level)
  - Week 2: Data Modelling II (Conceptual Level)
  - Week 3: Data Modelling III (Conceptual Level)
  - Week 4: Convert ERD to Relations (Logical Level)
  - Week 5: Functional Dependencies
  - Week 5: Normalization I
  - Week 6: Normalization II
- **Data manipulation**
  - Week 7: Simple Query
  - Week 8: Multiple Table Queries
  - Week 9: Subquery
  - Week 10: Correlated Subquery

DF Learning Plan

Description: we will have collaborative lecture at the beginning of the class. You need to do some tasks during the lecture as part of your class activities. Then you will do a quiz of what you have learned, then the tutorial will start. you will work in groups during the class.

Please be aware that the lecture slides with Blue title are designed for your self study.

Workshop Timetable:

Activity	Duration	Comments
Lecture	1 hour and 55 minutes	You will have 8 tasks to complete that need to take 30 minutes in total
Rest	10 minutes	Have fun and start to form your group if you wish to do group assignment (We will provide you a **Google Form** to register your team and team names soon)
Review		Please review the review questions after the class and ask your questions via UTSonline/Discussion board if you have any. The solution will be provided on this Friday midnight.
Tutorial	45 minutes	Have even more fun :D (read the case study in 5 minutes, then you have two tasks, and each needs to take 15 minutes to be completed plus 7 minutes for tutors to provide you the solution)
Quiz (Open Book)	5 minutes	On today's content. Quiz will be run before or after the tutorial. Do your best ;)
Leave the class	5 minutes	Don't forget to review what you have learn in this class, and check the information that is provided on **UTSOnline/Learning Material/Week 2**

Note: Week 2 has a longer lecture and a shorter tutorial, and Week 3 has a shorter lecture and a longer tutorial

Objectives

- ✓ Business Rules
- ✓ E-R Model Constructs:
  - ✓ Entities
  - ✓ Attributes / Identifiers (Keys)
  1. **Modeling Relationships:**
     - **1.1.** Relationship Types vs. Relationship Instances
     - **1.2.** Degree of Relationships
     - **1.3.** Cardinality of Relationships
     - **1.4.** Multiple Relationships Between Entities
     - **1.5. Associative Entity– Combination of Relationship and Entity**
     - **1.6.** Multivalued Attributes Can be Represented as Relationships
     - **1.7.** Relationships Can Have Attributes
     - **1.8. Weak and Strong Entities– Identifying Relationship**
  2. **Notations**
     - 2.1. Basic E-R Notation
     - 2.2. Crow's foot Notation

Review-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

Review-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 (often corresponds to a **table**)
- **Entity instance** – A single occurrence of an entity type (often corresponds to a **row** in a table)
- **Entity type** – a collection of entities that share common properties or characteristics … An entity type is a template for entity instances

Review-Attributes

- Attribute– property or characteristic of an entity or relationship type (often corresponds to a **field** in a table)
- Classifications of attributes:
  - Required versus Optional Attributes
  - Simple versus Composite Attribute
  - Single-Valued versus Multivalued Attribute
  - Stored versus Derived Attributes
  - Identifier Attributes

Class Activity 2.1 (1 minutes)

1. Which one of the following terms fit this definition?

"An attribute that may take on more than one value for a given entity instance."

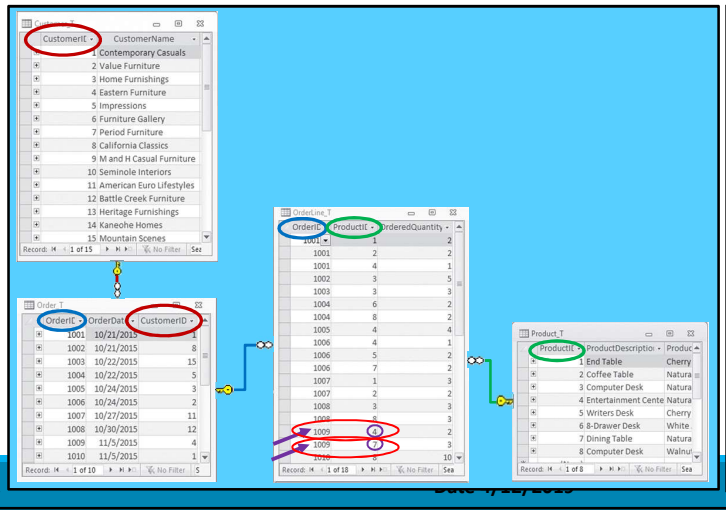
a. Multivalued attribute
b. Derived attribute
c. Cardinality constraint
d. Special attribute

Review-Attributes: 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 (or combination of attributes) that could be a key… satisfies the requirements for being an identifier

Review-Primary key/Foreign key

Business Rule: any order can be related to many products (related to OrderLine_T)



If two relations (tables) have a relationship, then the PK of the parent relation will be a FK in the dependent relation …

Question: What would be the FK in a relation (table) that need to have a relationship with OrderLine_T?

1. Relationships

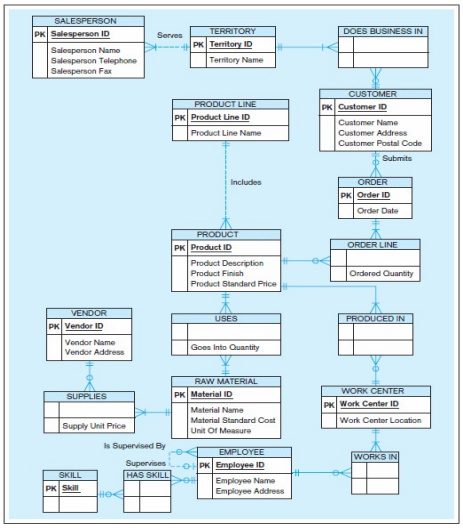
1. Relationship

- **Relationship instance:**

  link between entity instances ... (corresponds to **primary key-foreign key** equivalencies in related tables)

- **Relationship type:**

  Category/model of relationship … link between entity types



1. Relationship: Modeling Relationships

1.1. Relationship Types vs. Relationship Instances

1.2. Degree of Relationships

1.3. Cardinality of Relationships

1.4. Multiple Relationships Between Entities

1.5. Multivalued Attributes Can be Represented as Relationships

1.6. Relationships Can Have Attributes

1.7. Associative Entity– Combination of Relationship and Entity

1.8. Identifying Relationship – Weak and Strong Entities

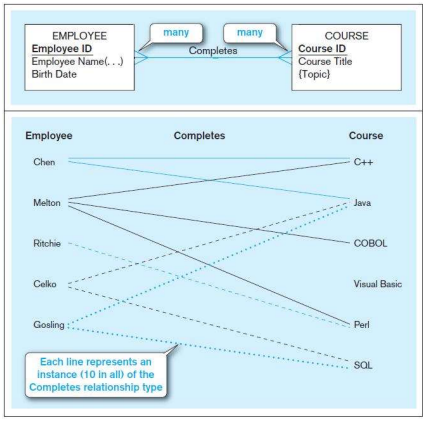
1.1. Relationship: Relationship types and instances (Figure 2-10)

a) The relationship type is **modeled** as lines between entity types

b) The relationship instance is between specific entity instances

a) Relationship type (Completes)

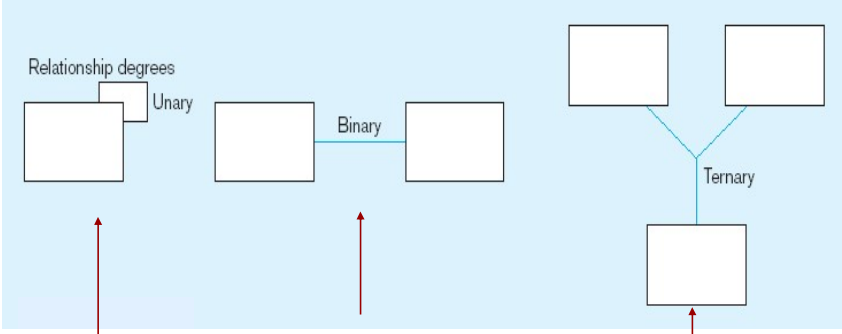
b) Relationship instances



1.2. Relationship: Degree of Relationships

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

1.2. Relationship: Degree of Relationships (Figure 2-2)



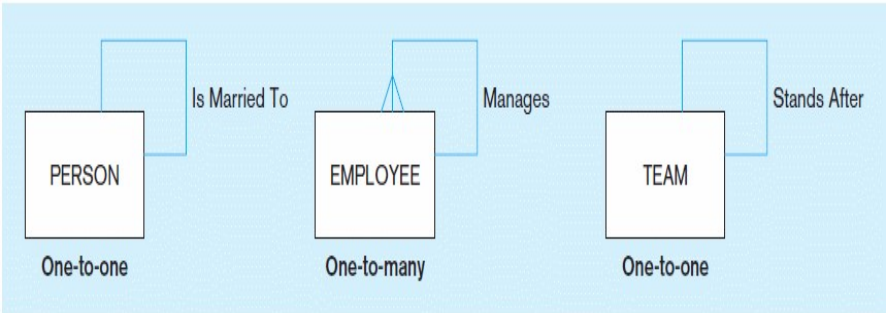
One entity related to another of the same entity type

Entities of two different types related to each other

Entities of three different types related to each other

1.2. Relationship: Examples of Relationships of Different Degrees (Figure 2-12)

a) Unary relationships

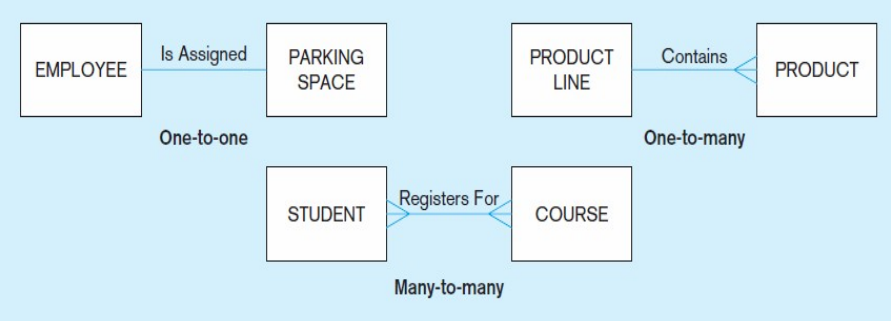


Employee

Employee ID	Employee Name	Employment Date	Manager ID
1234587	Jack	1/1/2011	3459087
3459087	Michael	5/2/2010	
2387468	Sara	5/8/2010	3459087
5745321	Fahimeh	9/2/2012	1234587
8743836	Ricky	5/11/2010	3459087

1.2. Relationship: Examples of Relationships of Different Degrees (Figure 2-12) (cont.)

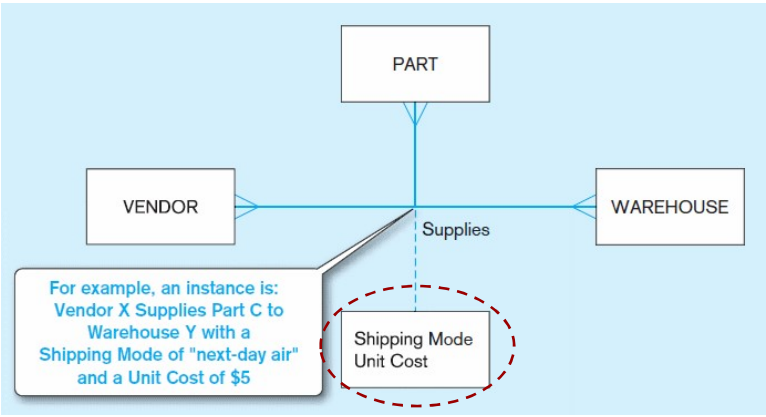
b) Binary relationships



21

1.2. Relationship: Examples of Relationships of Different Degrees (Figure 2-12) (cont.)

c) Ternary relationship

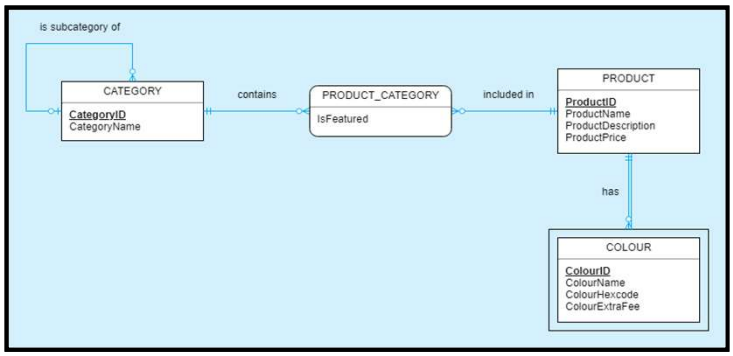


Note: a relationship can have attributes of its own

22

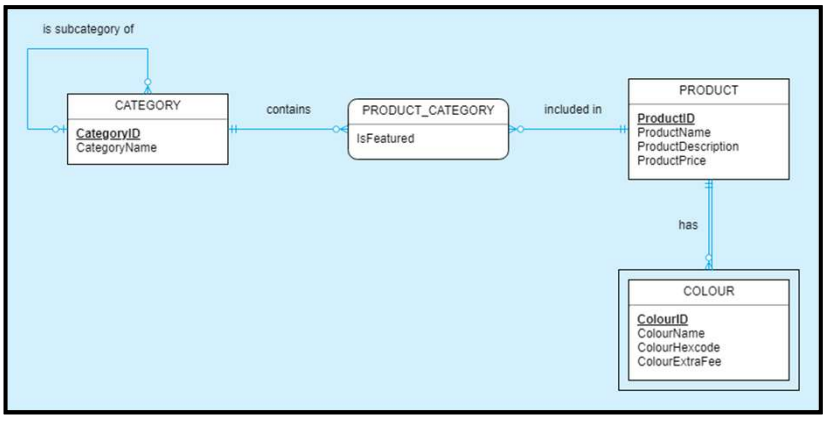
Clothing Shop Case study

A clothing store has a variety products which they sell online. To make things easier for customers to navigate the online store, the products are separated into categories with popular products being featured in each. Each product can come in different colours which each include additional fees.



Class Activity 2.2 (3 minutes)

Determine the degree of relationships in the Clothing Shop ERD.



Solution: Degree of Relationships

1.3. Relationship: Cardinality of Relationships

➢One-to-One

- Each entity instance in the relationship will have exactly **one related entity instance.**

➢One-to-Many

- An entity instance on one side of the relationship can have **many related entity instances**, but an entity on the other side will have **a maximum of one related entity instance.**

➢Many-to-Many

- Entities on both sides of the relationship can have **many related entity instances** on the other side.

Class Activity 2.3 (4 minutes in total)

a. Provide an example for One-to-One relationship. (2 minutes)

Definition: Each entity instance in the relationship will have exactly **one related entity instance.**

Answer:

Class Activity 2.3

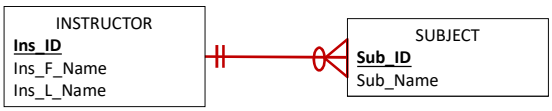
b. Provide an example for One-to-Many relationship. (1 minutes)

Definition: An entity instance on one side of the relationship can have **many related entity instances**, but an entity on the other side will have **a maximum of one related entity instance.**

Answer:

Discussion: Why in each one-to-many relationships, PK of the entity on one side is FK of the entity on the many side?

BR: One instructor **can** teach **many** subjects, but one subject **needs to** be taught by **one** instructor.



Store data using the following designs to show Fahimeh coordinates "database Fundamentals" and "Database Programming" subjects.

Correct choice of PK and FK.

PK — **Instructor**

Ins_ID	Ins_F_Name	Ins_L_Name
12548	Fahimeh	Ramezani
45476	Luke	Brown
14475	Jack	Cooper

Subject

Sub_ID	Sub_Name	Ins_ID
31271	Database fundamentals	
31253	Database Programming	
41114	Software Development Studio	

FK

incorrect choice of PK and FK.

Instructor

Ins_ID	Ins_F_Name	Ins_L_Name	Sub_ID
12548	Fahimeh	Ramezani	
45476	Luke	Brown	
14475	Jack	Cooper	

FK PK

Subject

Sub_ID	Sub_Name
31271	Database fundamentals
31253	Database Programming
41114	Software Development Studio

Class Activity 2.3

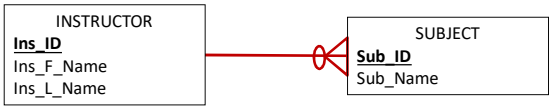
c. Provide an example for Many-to-Many relationship. (1 minutes)

Definition: Entities on both sides of the relationship can have **many related entity instances** on the other side.

Answer:

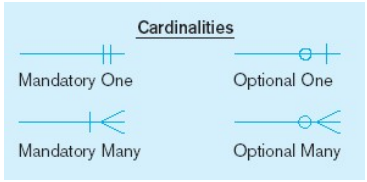
1.3. Relationship: Cardinality Constraints

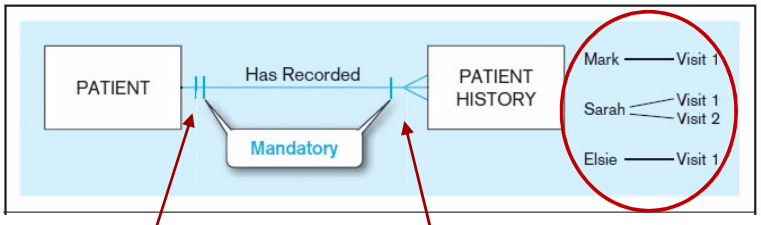
- **Cardinality Constraints**— the number of instances of one entity that **can** or **must** be associated with each instance of another entity
- **Minimum Cardinality**
  - If zero, then optional
  - If one or more, then mandatory
- **Maximum Cardinality**
  - The maximum number



1.3. Relationship: Examples of Cardinality Constraints (Figure 2-17)

a) Mandatory cardinalities



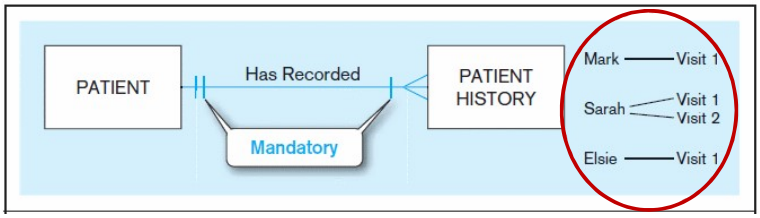


BR: A patient history is recorded for one and only one patient

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

1.3. Relationship: Examples of Cardinality Constraints (Figure 2-17)

a) Mandatory cardinalities



Patient

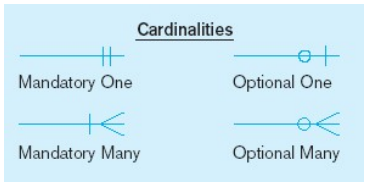
P_ID	P_F_Name	P_L_Name	...
123	Mark	Romanous	...
124	Sarah	Ramezani	...
125	Elsie	Cooper	...

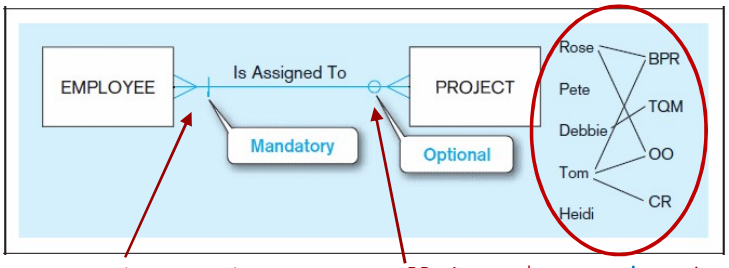
Patient-History

P_ID	P_Chart_ID	Doctor_ID	Nurse_ID	...
123	1	x	y	...
124	1	m	y	...
124	2	m	z	...
125	1	w	c	...

1.3. Relationship: Examples of Cardinality Constraints (Figure 2-17) (cont.)

b) One optional, one mandatory



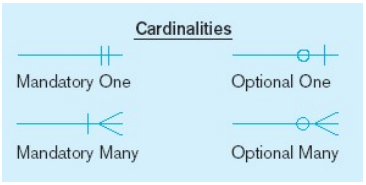


BR: A project must be assigned to at least one employee, and may be assigned to many

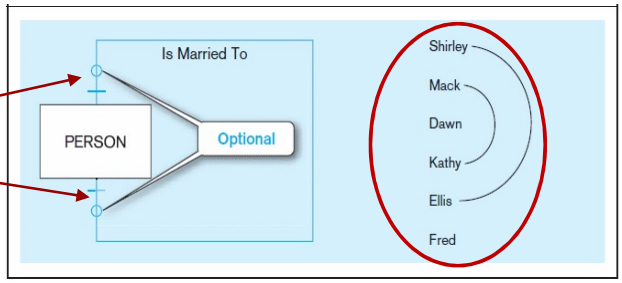
BR: An employee can be assigned to any number of projects, or may not be assigned to any at all

1.3. Relationship: Examples of Cardinality Constraints (Figure 2-17) (cont.)

c) Optional cardinalities

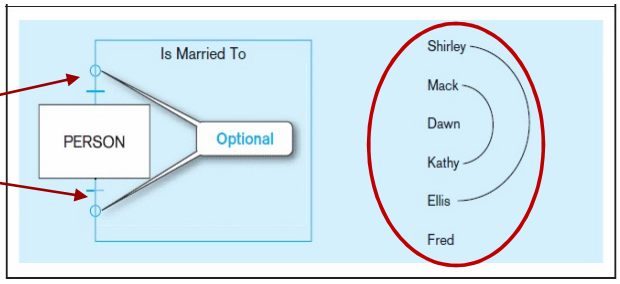


BR: A person is married to at most one other person, or may not be married at all

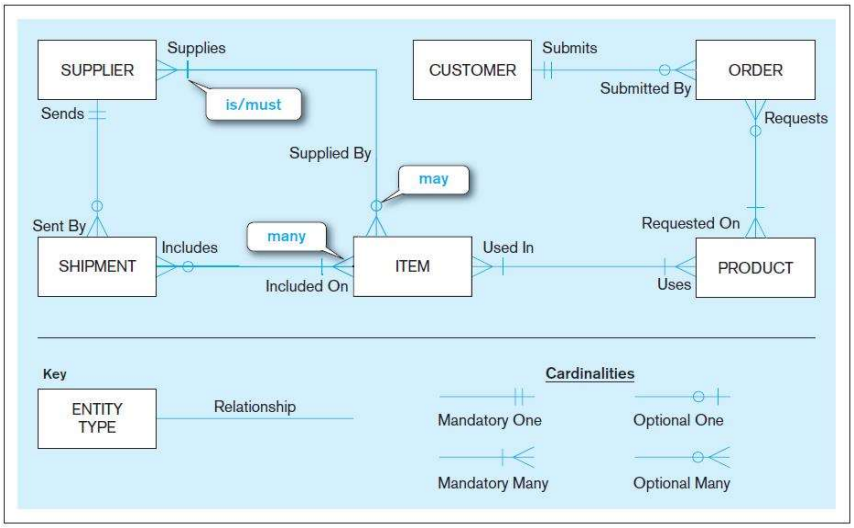


Class Activity 2.4: Draw the related table to this ERD (4 minutes)

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



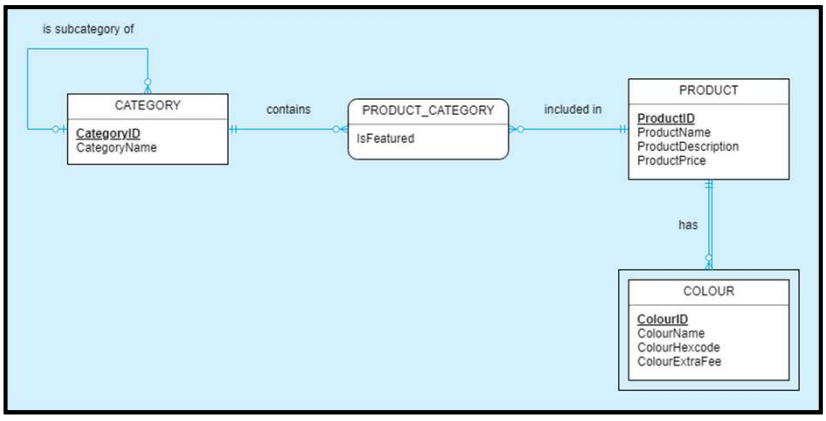
1.3. Relationship: Sample Entity Relationship Diagram (ERD) (Figure 2-1)



37

Class Activity 2.5 (4 minutes)

b. Determine the cardinalities in the Clothing Shop ERD.



38

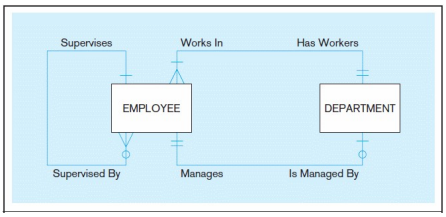
Solution- Cardinalities

1.4. Relationship: Multiple Relationships Between Entities

- Two entities can have more than one type of relationship between them (multiple relationships)

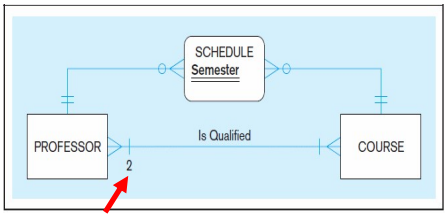
a) Figure 2-21: Employees and departments

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



b) Figure 2-21: Professors and courses (fixed lower limit constraint)

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

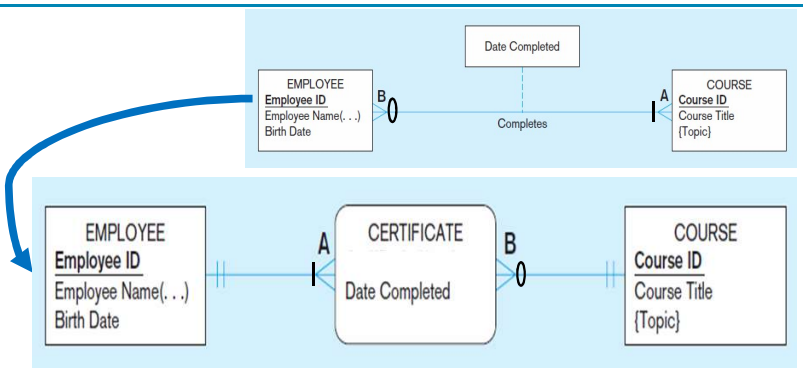


1.5. Associative Entities

1.5. Associative Entities

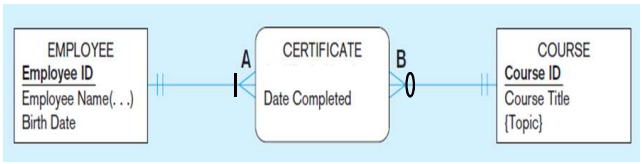
- An associative Entity is an entity– has attributes
- An associative Entity is a relationship– links entities together
- When should a **relationship with attributes** instead be an **associative entity**?
  - All relationships for the associative entity should be many
  - The associative entity could 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
  - Many-to-Many and Ternary relationships should be converted to associative entities

1.5. An associative entity (Figure 2-11b)



- An 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 the first figure has been replaced by two one-to-many relationships with the associative entity (CERTIFICATE).
- **Note** that we do not show FK's in the ERD of associative entity.

1.5. PK of associative entity



PK

Employee

Employee ID	Employee Name	Birth Date
1234587	Jack	1/1/1960
3459087	Michael	5/2/1985

FK FK

Certificate

Employee ID	Course ID	Date Completed
1234587	C68	1/1/2017
3459087	A57	1/2/2016
3459087	C68	5/10/2016

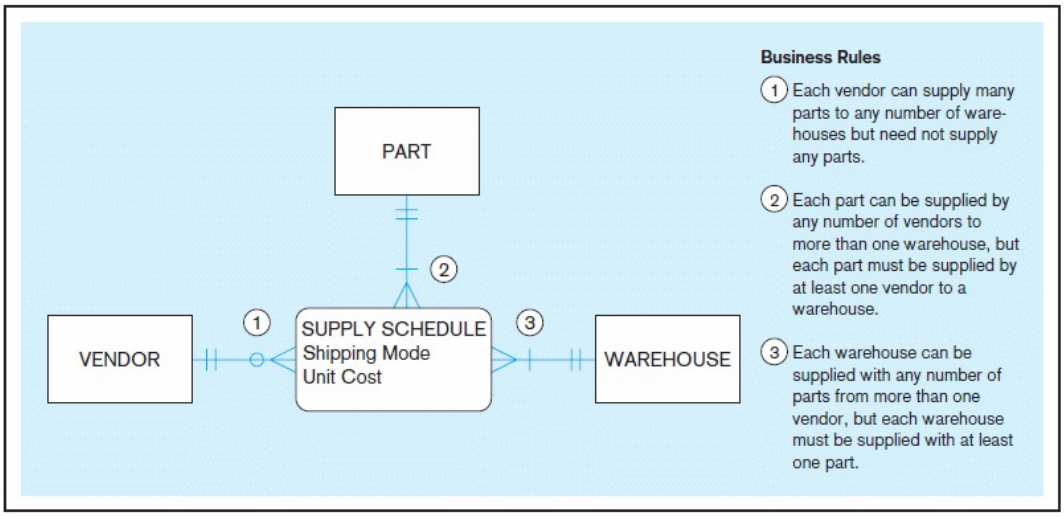
PK

Course

Course ID	Course Title	Topic
A57	Knowledge Management	....
C68	Project Management	....

Rule: in each one-to-many relationships, PK of the entity on one side is FK of the entity on the many side

1.5. Cardinality constraints in a ternary relationship (Figure 2-18)



Class Activity 2.6 (2 minutes)

Which one of the following is the definition of associative entity?

a. The relationship between a weak entity type and its owner (parent) entity.

b. An attribute whose values can be calculated from another attribute values.

c. An association between (or among) entity types.

d. An entity type that associates the instances of related entity types and contains attributes that represent the relationship between those entity instances.

Class Activity 2.7 (10 minutes)

Consider a book rental system in a store. When a customer borrows or returns a book, the shop-keeper needs to mark down the transaction or update the corresponding record on the transaction book. Any customer can borrow many books for many times.

a. Create a list of business rules. (2 minutes)

b. Draw an ERD for this book rental system while: (3 minutes)
   - Identifying the type of relationship between the entities.
   - Identifying the cardinalities of the relationships.
   - Designing some attributes for each entity.

c. Determine the degree of a relationship in your ERD (Unary, Binary, or Ternary Relationship) (1 minutes)

d. Draw the correspond table to each entity with some sample data that shows how the data of each table are related to the data of the other tables by considering their PK and FK(s). Each table should have at least 3 rows of data. (4 minutes)

Solution to Class Activity 2.7

a. Create a list of business rules.

b. Draw an ERD for this book rental system while Identifying the type of relationship, the cardinalities, and some attributes for each entity.

Solution to Class Activity 2.7 (cont.)

c. Determine the degree of a relationship in your ERD (Unary, Binary, or Ternary Relationship)

d. Draw the correspond table to each entity with some sample data that shows how the data of each table are related to the data of the other tables by considering their PK and FK(s). Each table should have at least 3 rows of data.

1.6. Relationship: Multivalued attributes can be represented as relationships.

1.6. Relationship: Multivalued attributes can be represented as relationships.

BR: Each employee can have many skills.

NOTE: This is not a good design!

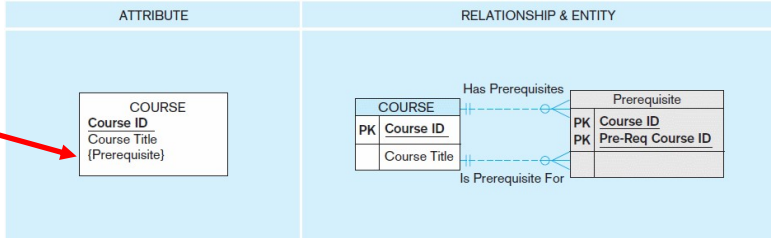
EMPLOYEE
Employee_ID
Employee_F_Name
Employee_L_Name
{Skills (Skill Code, Skill Title, Skill Type)}

Employee_ID	Employee_F_Name	Employee_L_Name	Skills
1123	Sara	Brown	C++, Java
1456	Jake	Cooper	C#, Java, Python
7892	Fahimeh	Ramezani	Python, C++
8764	Ricky	Romanous	C++, C#

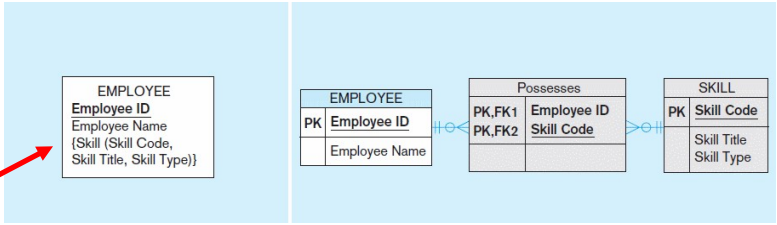
We cannot have more than one value in each cell of a table.

1.6. Relationship: Multivalued attributes can be represented as relationships (Figure 2-15a and 2-15b)

Prerequisite is a simple multivalued attribute



Skill is a composite Multivalued attribute



Employee_ID	Employee_F_Name	Employee_L_Name	Skills
1123	Sara	Brown	C++, Java
1456	Jake	Cooper	C#, Java, Python
7892	Fahimeh	Ramezani	Python, C++
8764	Ricky	Romanous	C++, C#

Employee_ID	Employee_F_Name	Employee_L_Name
1123	Sara	Brown
1456	Jake	Cooper
7892	Fahimeh	Ramezani
8764	Ricky	Romanous

Employee_ID	Skill_Code	Date_Completed
1123	B86	1/1/2004
1123	A23	2/4/2007

Skill_Code	Skill_title	Skill_Type
A23	Java	PL
B86	C++	PL
C55	C#	PL
C45	Python	PL

1.7. Relationship: Relationships Can Have Attributes

1.7. Relationship: Relationships Can Have Attributes

- Attributes of a relationship describe features pertaining to the association between the entities in the relationship

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

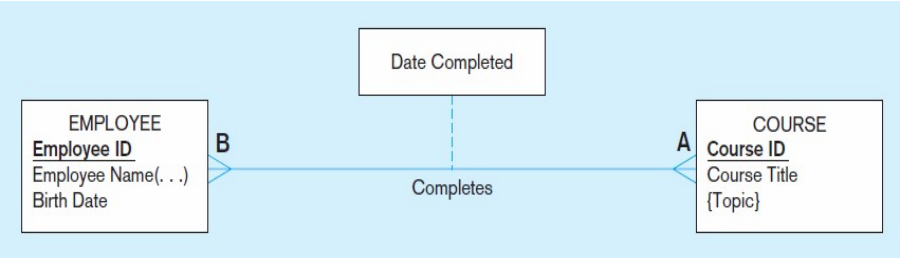
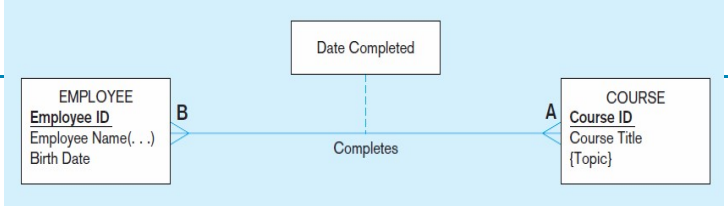


Figure 2-11a A binary relationship with an attribute

55



Employee_ID	Employee_F_Name	Employee_L_Name	....
1123	Sara	Brown	
1456	Jake	Cooper	
7892	Fahimeh	Ramezani	
8764	Ricky	Romanous	

Employee_ID	Course_ID	Date_Completed
1123	B86	1/1/2004
1123	A23	2/4/2007

Course_ID	Course_Title
A23	Java
B86	C++
C55	C#
C45	Python

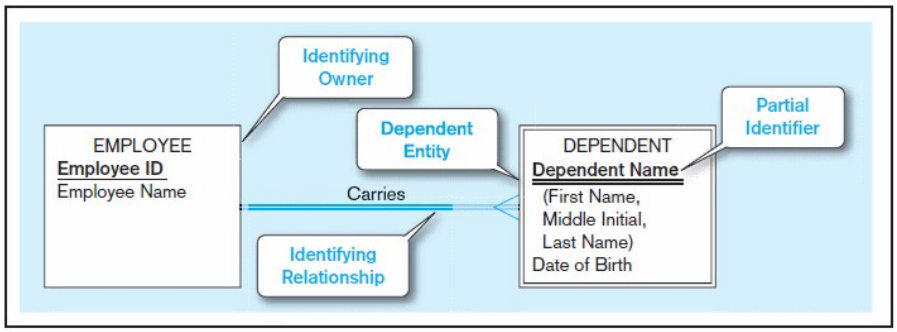
56

1.8. Identifying Relationships: Strong vs. Weak Entities

1.8. Identifying Relationships: Strong vs. Weak Entities

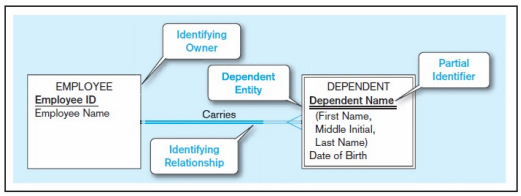
- **Strong entity**
  - exists independently of other types of entities
  - has its own unique identifier
    - identifier underlined with single line
- **Weak entity**
  - dependent on a strong entity (identifying owner)…cannot exist on its own
  - does not have a unique identifier (only a **partial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

1.8. Figure 2-5 Example of a weak identity and its identifying relationship (using ER Notation)



Strong entity Weak entity

1.8. PK of weak entity



PK of the weak entity (Dependent)

PK FK

Employee

Employee ID	Employee Name	Birth Date
1234587	Jack	1/1/1960
3459087	Michael	5/2/1985

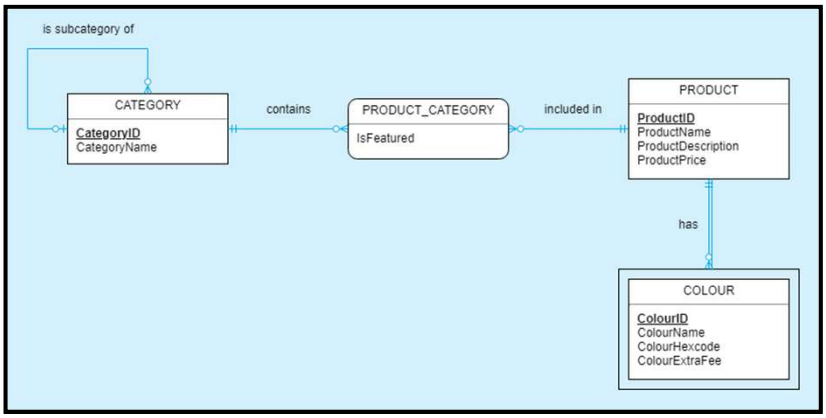
Dependent

Employee ID	Dependent Name	Date of Birth
1234587	John Harris	1/3/2004
1234587	Jennifer Harris	5/7/2006
3459087	John Harris	1/1/2015

Important Rule:
In each one-to-many relationships, PK of the entity on one side is FK of the entity on the many side

Class Activity 2.8 (2 minutes)

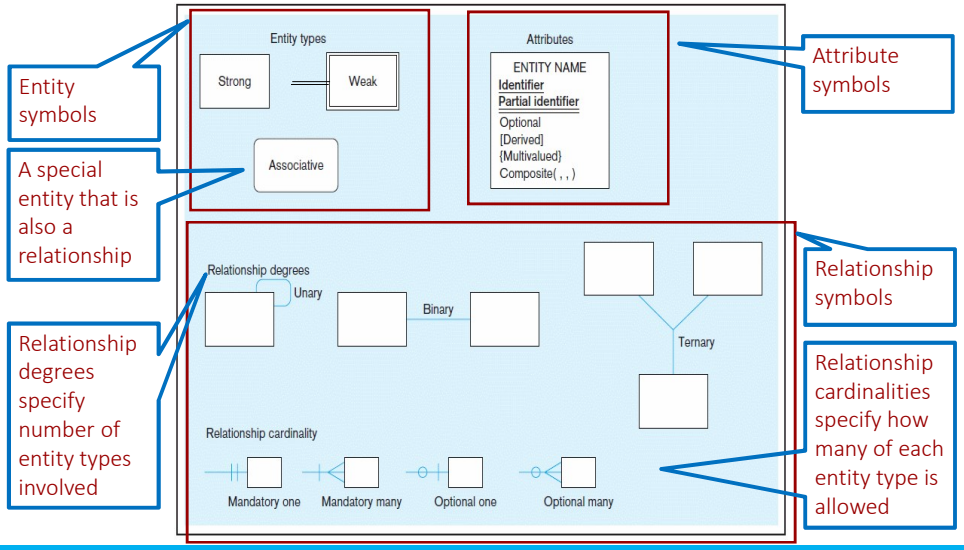
Determine the entity types in the Clothing Shop ERD.



Solution- Entity Types

2. Notations

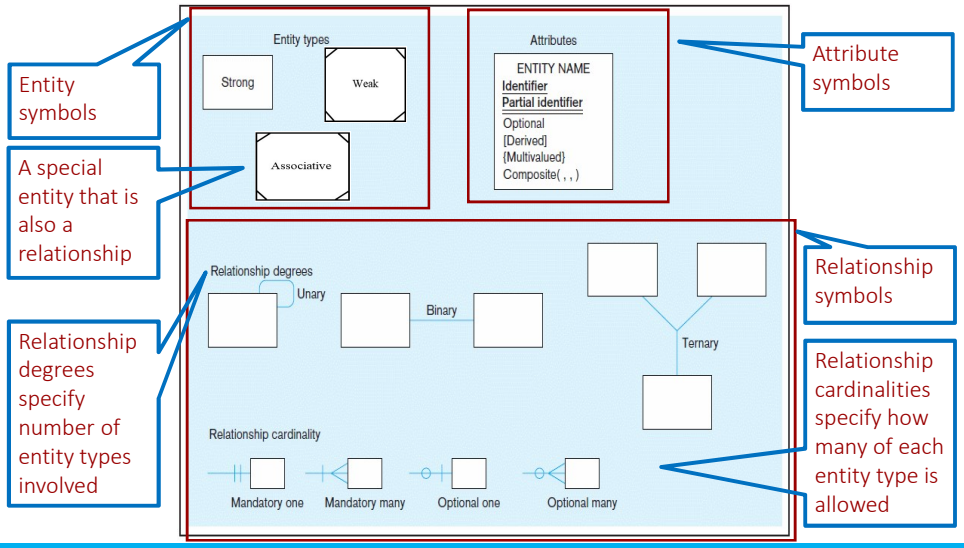
2.1. Basic Entity Relationship (ER) Notation (Figure 2-2)



2.1. Basic ER Notation: Lines

- **Double Line:**
  - Between Weak and Strong entities
- **Solid Line:**
  - Between other entities

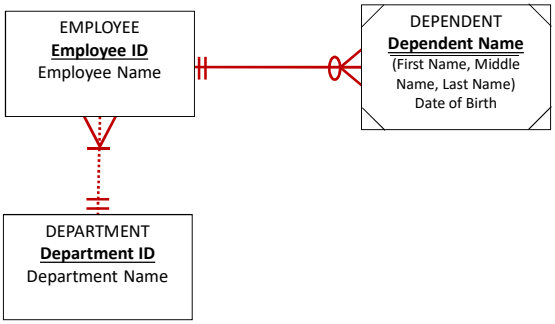
2.2. Crow's foot Notation



2.2. Crow's foot Notation: Lines

- **Solid Line:**
  - Between Associative and its related regular entities
  - Between Weak and Strong entities

- **Dotted Line:**
  - Between Regular entities



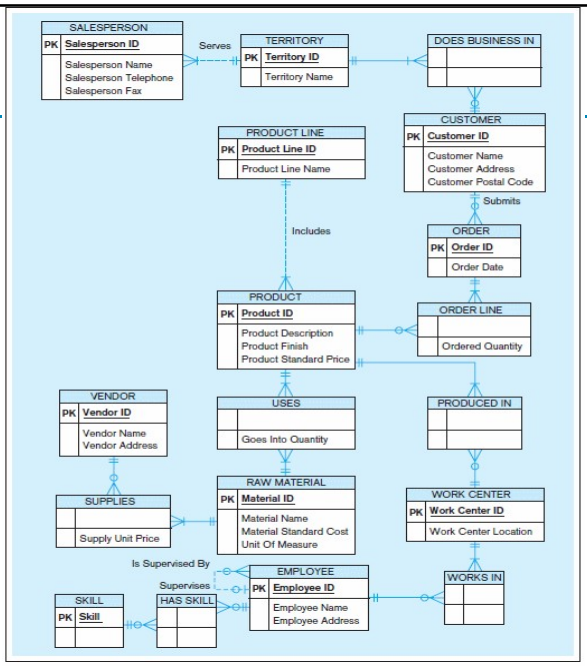


Figure 2-22
Data model for Pine Valley Furniture Company in Microsoft Visio notation

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

Note: Please be aware that you are not allowed to use Visio notation in your assignment as this notation doesn't have a clear notation for weak and associative entities.

Summary

- ✓ Define terms
- ✓ Understand importance of data modeling
- ✓ 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
- ✓ Distinguish weak and strong entities (Identifying Relationship)
- ✓ Notations

Next Lecture…

1. **Supertype/Subtype Relationships**
2. **Relationships and Subtypes**
3. **Generalization and Specialization**
4. **Constraints in Supertype/Subtype Relationships**
   - 4.1. Completeness Constraints
   - 4.2. Disjointness Constraints
   - 4.3. Subtype Discriminator

Message from previous students ☺
Angelo Athanasiou (DF Grade HD)

- **Why read the test book:**
  The modern database management textbook covers everything more in-depth than the lectures and will greatly help with understanding any areas that are unclear, the textbook is also available from the UTS library so students don't have to pay to access it. Older editions of the textbook can also be obtained for free and contain the same relevant information.

- **What to learn:**
  Learn how a relational database uses relations, cardinality, etc. because if you don't understand those concepts early on the subject won't be as clear as it progresses.

  Learn how SQL statements affect a database and what they do, as it is important to understand **how they work** instead of just understanding what they do, such as knowing why a certain output is given instead of just knowing what to do to get a certain output.

- **To aid with the transition from ERD to SQL,**
  Microsoft Access can be used to understand how things work as you can view the ERD, as well as use SQL to gain output. What I like about using Microsoft access to help people visualize is because you can use QbE to compare how a query would be undertaken in SQL.
  Links: How to use the Query By Example (QBE) grid | lynda.com tutorial:
  https://www.youtube.com/watch?v=X9vyzpdUWHs