

DATA MODELING WITH THE ENTITY-RELATIONSHIP MODEL

revised by 김태연

OBJECTIVES

- To understand the two-phase data modeling/database design process
- To understand the purpose of the data modeling process
- To understand entity-relationship (E-R) diagrams
- To be able to determine entities, attributes, and relationships
- To be able to create entity identifiers
- To be able to determine minimum and maximum cardinalities
- To understand and be able to use ID-dependent and other weak entities
- To understand and be able to use supertype/subtype entities

THE DATA MODEL

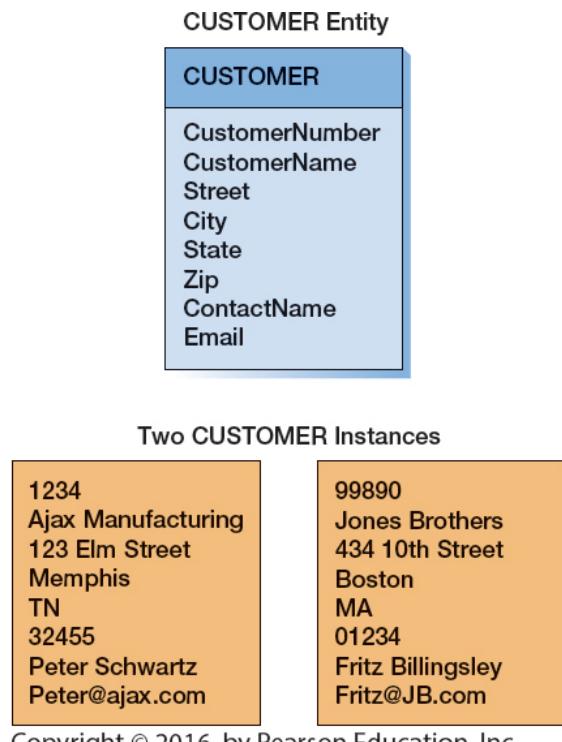
- A data model is a plan or blueprint for a database design.
- A data model is more generalized and abstract than a database design.
- It is easier to change a data model than it is to change a database design, so it is the appropriate place to work through conceptual database problems.
- Books on systems analysis and design often identify three design stages:
 - Conceptual design (conceptual schema)
 - Logical design (logical schema)
 - Physical design (physical schema)
- The data model we are discussing is equivalent to the conceptual design as defined in these books.

E-R MODEL

- Entity-Relationship model is a set of concepts and graphical symbols that can be used to create conceptual schemas.
- Versions:
 - Original E-R model—by Peter Chen (1976)
 - Extended E-R model—extensions to the Chen model (+**Subtype**)
 - Information Engineering (IE)—by James Martin (1990); uses **“crow’s foot” notation**, is easier to understand, and we will use it
 - IDEF1X—a national standard developed by the National Institute of Standards and Technology
 - Unified Modeling Language (UML)—by the Object Management Group; it supports object-oriented methodology

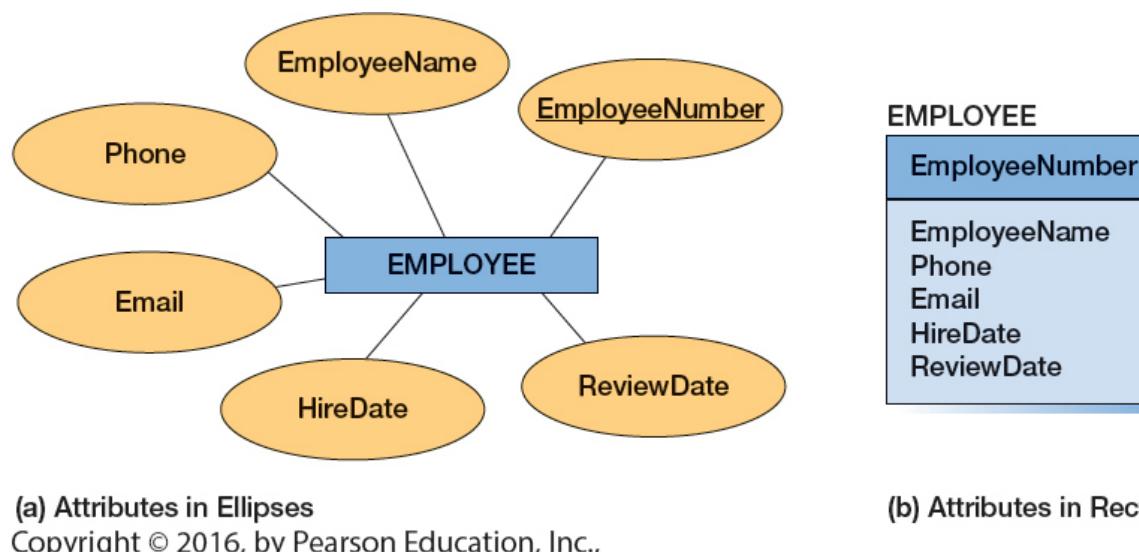
ENTITIES

- Something that can be identified and the users want to track:
 - Entity class—a collection of entities of a given type
 - Entity instance—the occurrence of a particular entity
- There are usually many instances of an entity in an entity class.



ATTRIBUTES

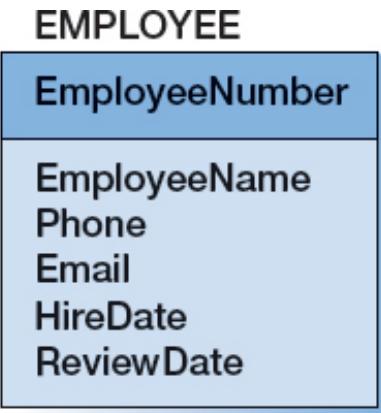
- Attributes describe an entity's characteristics.
- All entity instances of a given entity class have the same attributes, but vary in the values of those attributes.
- Originally shown in data models as ellipses.
- Data modeling products today commonly show attributes in rectangular form.



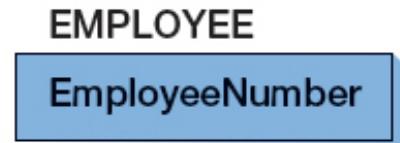
IDENTIFIERS

- Identifiers are attributes that name, or identify, entity instances.
- The identifier of an entity instance consists of one or more of the entity's attributes.
- Composite identifiers are identifiers that consist of two or more attributes.
- Identifiers in data models become keys in database designs.
 - Entities have identifiers.
 - Tables (or relations) have keys.

ENTITY ATTRIBUTE DISPLAY IN DATA MODELS



(a) Entity with All Attributes



(b) Entity with Identifier Attribute Only



(c) Entity with No Attributes

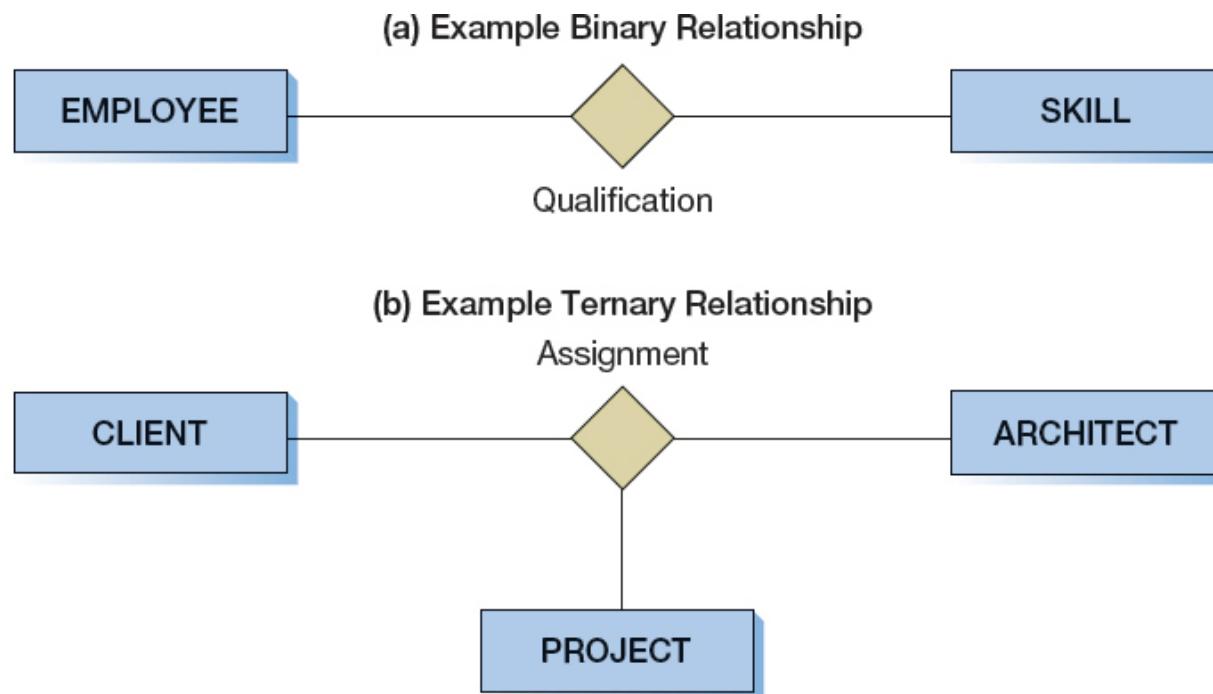
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RELATIONSHIPS

- Entities can be associated with one another in relationships:
 - Relationship classes: associations among entity classes
 - Relationship instances: associations among entity instances
- In the original E-R model, relationships could have attributes, but today this is no longer done.
- A relationship class can involve two or more entity classes.

BINARY AND TERNARY RELATIONSHIP

- The degree of the relationship is the number of entity classes in the relationship:
 - Two entities have a binary relationship of degree two.
 - Three entities have a ternary relationship of degree three.



ENTITIES AND TABLES

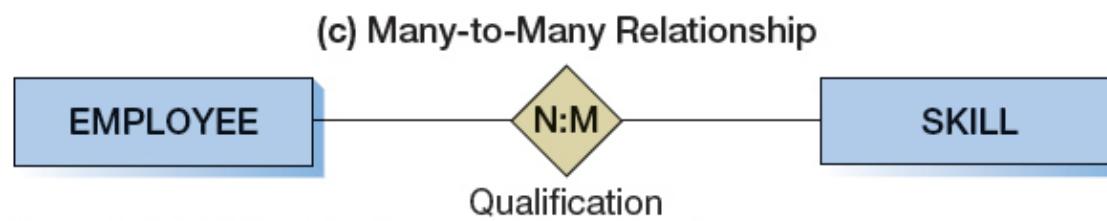
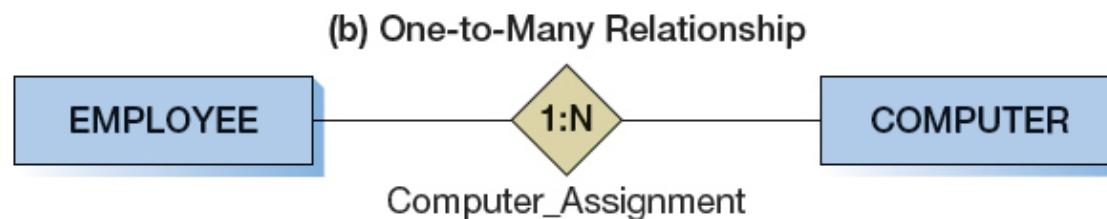
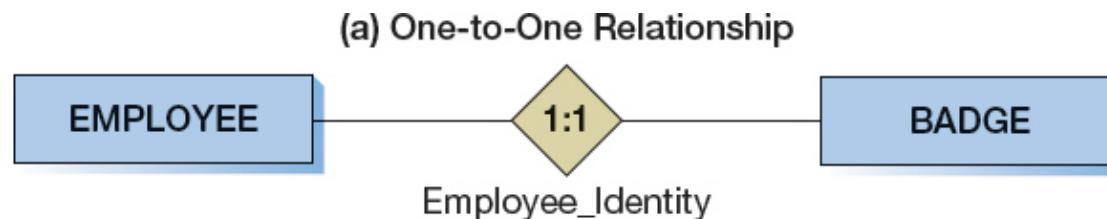
- The principle difference between an entity and a table (relation) is that you can express a relationship between entities without using foreign keys.
- This makes it easier to work with entities in the early design process where the very existence of entities and the relationships between them is uncertain.
- For example, you can say that a DEPARTMENT relates to many EMPLOYEEs before you know any of the attributes of either EMPLOYEE or DEPARTMENT.
- This characteristic enables you to work from the general to the specific.
- First, identify the entities, then think about relationships, and, finally, determine the attributes.

CARDINALITY

- Cardinality means “count,” and is expressed as a number.
- Maximum cardinality is the maximum number of entity instances that can participate in a relationship.
- Minimum cardinality is the minimum number of entity instances that must participate in a relationship.

MAXIMUM CARDINALITY

- Maximum cardinality is the maximum number of entity instances that can participate in a relationship.
- There are three types of maximum cardinality:



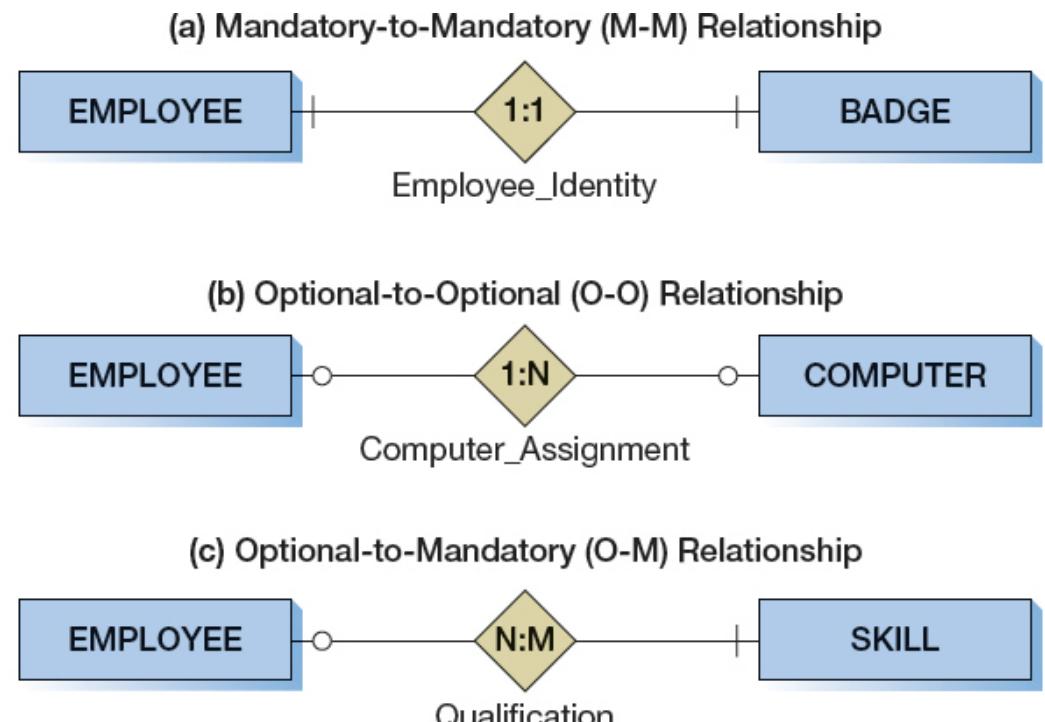
INTERPRETATION OF RELATIONSHIP

- The relationships we have been discussing are known as HAS-A relationships:
- Each entity instance has a relationship with another entity instance.
 - An EMPLOYEE has one or more COMPUTERS.
 - A COMPUTER has one assigned EMPLOYEE.
- In a one-to-many relationship:
 - The entity on the one side of the relationship is called the parent entity or just the parent.
 - The entity on the many side of the relationship is called the child entity or just the child.
 - An EMPLOYEE is the parent and a COMPUTER is the child:



MINIMUM CARDINALITY

- Minimum cardinality is the minimum number of entity instances that must participate in a relationship.
- Minimums are generally stated as either zero or one:
 - IF zero [0] THEN participation in the relationship by the entity is **optional**, and no entity instance must participate in the relationship.
 - IF one [1] THEN participation in the relationship by the entity is **mandatory**, and at least one entity instance must participate in the relationship.

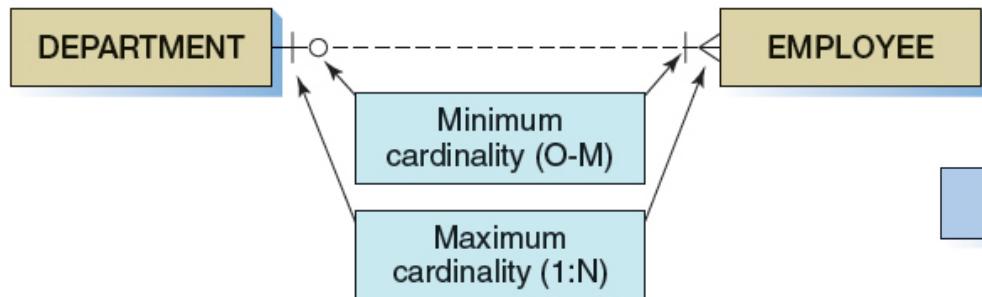


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DATA MODELING NOTATION: IE CROW'S FOOT 1:N & N:M

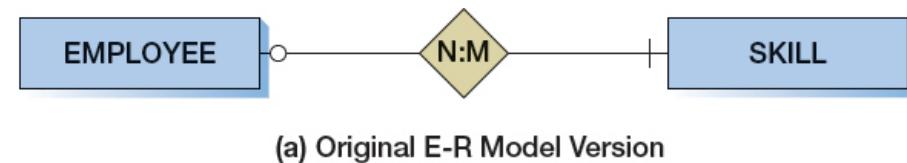


(a) Original E-R Model Version

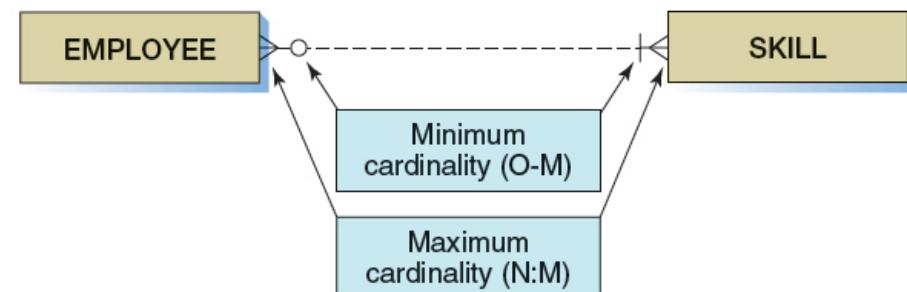


(b) Crow's Foot Version

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(a) Original E-R Model Version



(b) Crow's Foot Version

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- We will use the IE Crow's Foot model for E-R diagrams

STRONG & WEAK ENTITIES

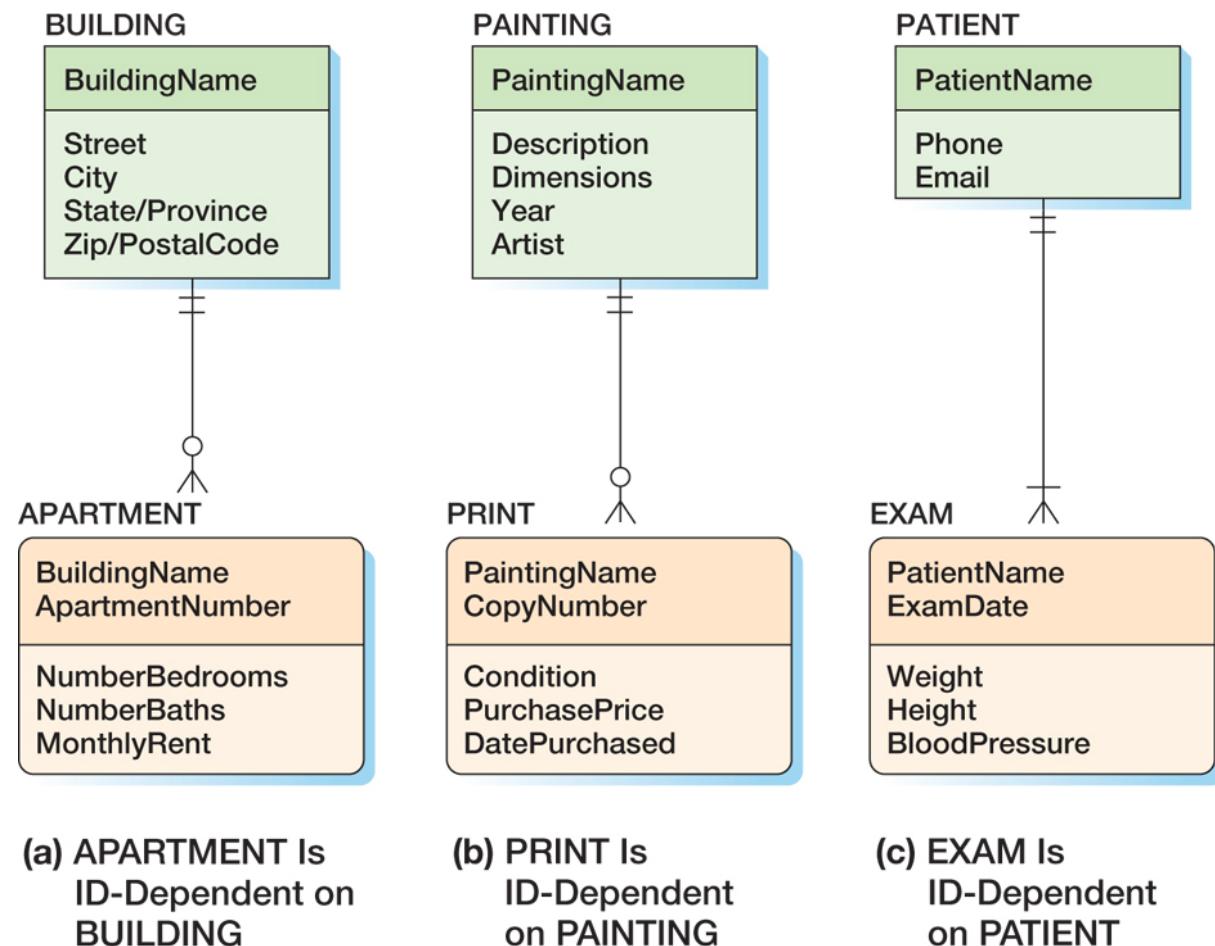
- A **strong entity** is an entity that represents something that can exist on its own.
 - For example, PERSON is a strong entity—we consider people to exist as individuals in their own right.
 - Similarly, AUTOMOBILE is a strong entity.
- A **weak entity** is defined as any entity whose existence depends on the presence of another entity.

ID-DEPENDENT ENTITIES

- An **ID-dependent entity** is an entity (child) whose identifier includes the identifier of another entity (parent).
- The minimum cardinality from the ID-dependent entity to **the parent is always one**.
- All ID-Dependent entities are considered as a **weak entity**.
- ID-dependent entities pose restrictions on the processing of the database that is constructed from them.
 - Namely, the row that represents the parent entity must be created before any ID-dependent child row can be created.
 - Further, when a parent row is deleted, all child rows must be deleted as well.
- We use an entity with **rounded corners** to represent the ID-dependent entity.
- We also use a **solid line** to represent the relationship between the ID-dependent entity and its parent, called an **identifying relationship**.

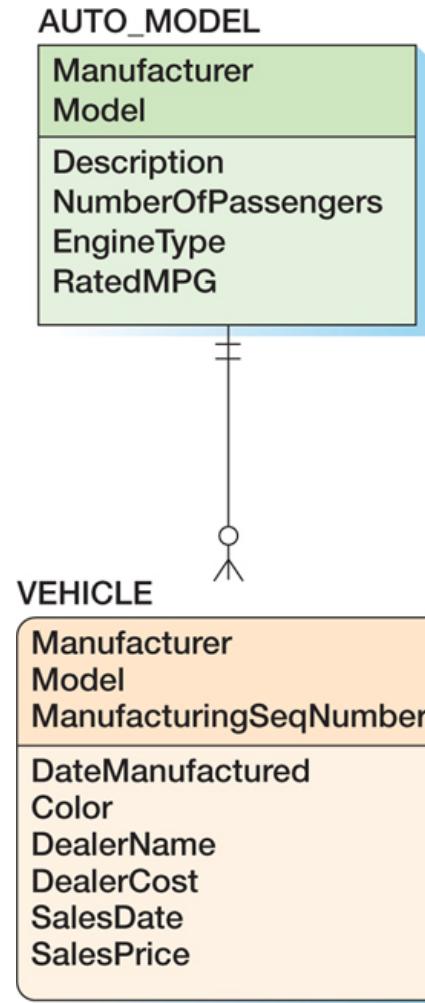
EXAMPLES OF ID-DEPENDENT ENTITIES

- The ID-dependent entity is a logical extension or subunit of the parent:
 - BUILDING : APARTMENT
 - PAINTING : PRINT
 - PATIENT : EXAM

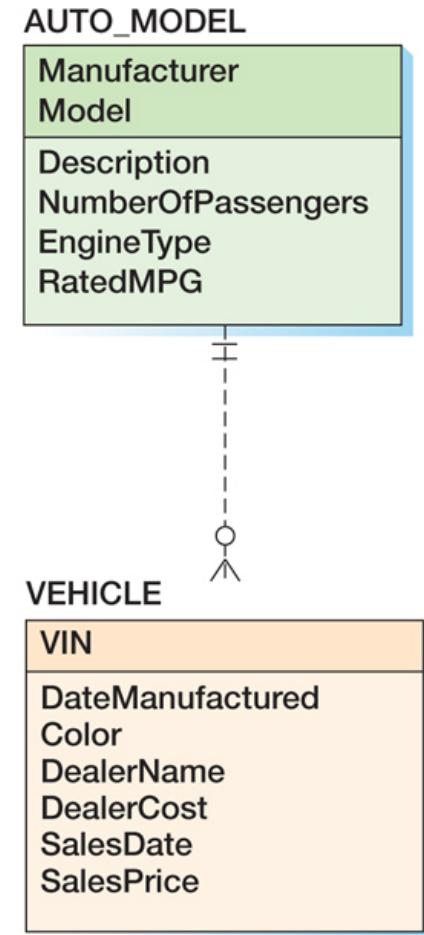


NON-ID-DEPENDENT ENTITIES

- An non-ID-dependent weak entities is the identifier of the parent does not appear in the identifier of the weak child entity.
- We will use a **nonidentifying relationship** with a note added to the data model indicating that the entity is weak.



(a) ID-Dependent Entity



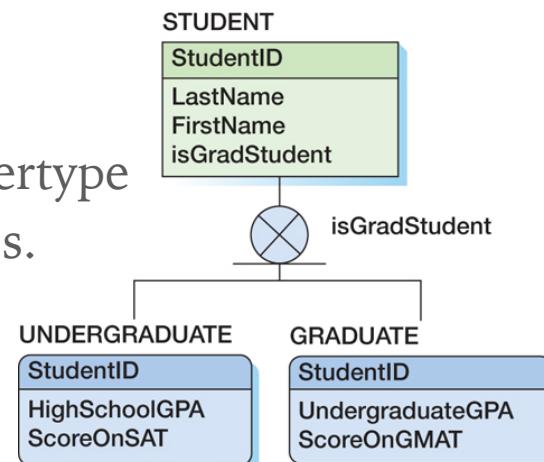
(b) Non-ID-Dependent Weak Entity

THE AMBIGUITY OF THE WEAK ENTITY

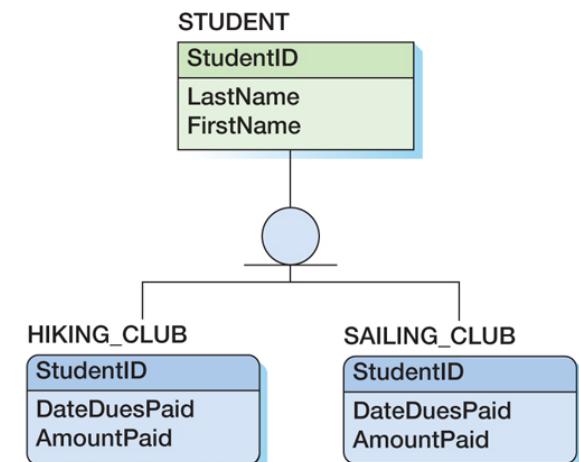
- The ambiguity is that in a strict sense, if a weak entity is defined as any entity whose presence in the database depends on another entity, then any entity that participates in a relationship having a minimum cardinality of one to a second entity is a weak entity.
- Thus, in an academic database, if a STUDENT must have an ADVISER, then STUDENT is a weak entity because a STUDENT entity cannot be stored without an ADVISER.
- A STUDENT is not physically dependent on an ADVISER (unlike an APARTMENT to a BUILDING), and a STUDENT is not logically dependent on an ADVISER.
- To avoid such situations, some people interpret the definition of weak entity more narrowly. They say that to be a weak entity an entity must logically depend on another entity.
- We agree with the latter approach.

SUBTYPE ENTITIES

- The extended E-R model introduced the concept of subtypes.
 - For example, Students may be classified as undergraduate or graduate students.
- A subtype entity is a special case of another entity called its supertype.
 - In this case, STUDENT is the supertype, and UNDERGRADUATE and GRADUATE are the subtypes.
- The most important (some would say the only) reason for creating subtypes in a data model is to avoid value-inappropriate nulls.
- If subtypes are exclusive, one supertype relates to at most one subtype.
- If subtypes are inclusive, one supertype can relate to one or more subtypes.

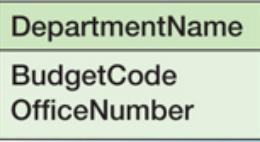
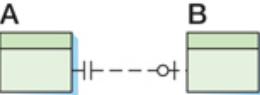
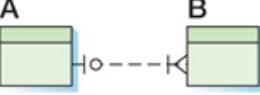
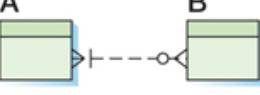
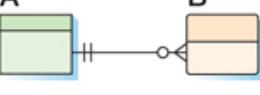
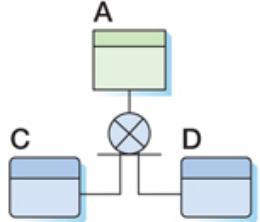
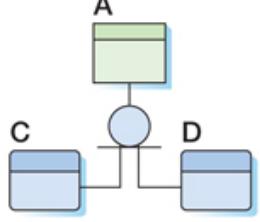


(a) Exclusive Subtypes with Discriminator



(b) Inclusive Subtypes

IE CROW'S FOOT SYMBOL SUMMARY

| | |
|--|--|
| DEPARTMENT  | DEPARTMENT entity; DepartmentName is identifier; BudgetCode and OfficeNumber are attributes. |
|  | 1:1, nonidentifying relationship. A relates to zero or one B; B relates to exactly one A. Identifier and attributes not shown. |
|  | 1:N, nonidentifying relationship. A relates to one or many Bs; B relates to zero or one A. Identifier and attributes not shown. |
|  | Many-to-many, nonidentifying relationship. A relates to zero or more Bs; B relates to one or more As. |
|  | 1:N identifying relationship. A relates to zero, one, or many Bs. B relates to exactly one A. Identifier and attributes not shown. For identifying relationships, the child must always relate to exactly one parent. The parent may relate to zero, one, many, or a combination of these minimum cardinalities. |
|  | A is supertype, C and D are exclusive subtypes. Discriminator not shown. Identifier and attributes not shown. |
|  | A is supertype, C and D are inclusive subtypes. Identifier and attributes not shown. |

STRONG ENTITY PATTERNS: 1:1 STRONG ENTITY RELATIONSHIPS

.....

(a) Club Membership Data Entry Form

Club Member Locker

| | |
|---------------|---------------------|
| Member Number | 1000 |
| Member Name | Jones |
| Phone | 123-456-7777 |
| Email | Jones@somewhere.com |
| Locker Number | 2100 |
| Locker Room | Mens |

Record: 1 of 4 No Filter Search

(b) Club Locker Report

CLUB LOCKERS

| Member Number | Member Name | Locker Number | Locker Room | Locker Size |
|---------------|-------------|---------------|-------------|-------------|
| 1000 | Jones | 2100 | Mens | Med |
| 2000 | Abernathy | 2200 | Womens | Large |
| 3000 | Wu | 2115 | Mens | Large |
| 4000 | Lai | 2217 | Womens | Small |

CLUB_MEMBER

MemberNumber
MemberName
Phone
Email

LOCKER

LockerNumber
LockerRoom
LockerSize

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STRONG ENTITY PATTERNS: 1:N STRONG ENTITY RELATIONSHIPS

.....

| Company Departments | | | |
|---------------------|---------------------|-------------|-----------|
| Company Name | Ajax Manufacturing | | |
| City | Sydney | | |
| Departments | Department Name | Budget Code | Mail Stop |
| | Accounting | A-100 | MS-100 |
| | Production | P-100 | MS-400 |
| | Information Systems | IS-200 | MS-417 |
| | Sales | S-1400 | MS-500 |
| * | | | |
| Record: | ◀◀ | 1 of 4 | ▶▶ |
| | ◀ | ▶ | ▶▶ |
| | No Filter | Search | |
| Record: | ◀◀ | 1 of 5 | ▶▶ |
| | ◀ | ▶ | ▶▶ |
| | No Filter | Search | |

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COMPANY

CompanyName

City



DEPARTMENT

DepartmentName

BudgetCode

MailStop

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STRONG ENTITY PATTERNS: N:M STRONG ENTITY RELATIONSHIPS

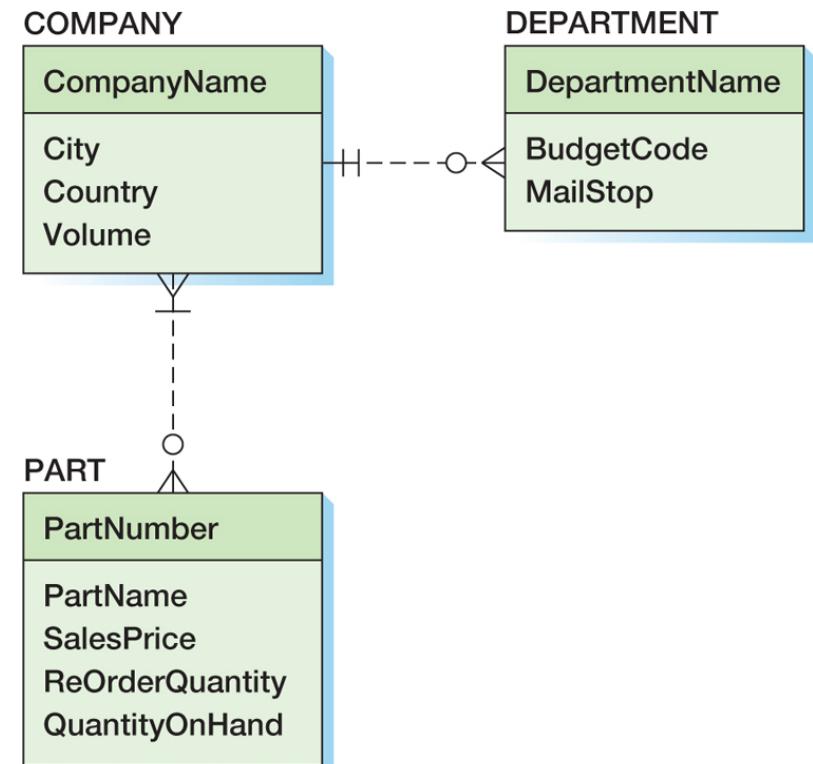
(a) Suppliers Form

| Suppliers | | | | | | | | | | | | | | | | | | | | | |
|---|--|------------|-----------------|----------------|-----------------|----------------|------|--------------|---------|-----|-----|------|---------------|------------|---|---|------|-----------------|---------|---|---|
| Company Name | Forrest Supplies | | | | | | | | | | | | | | | | | | | | |
| City | Denver | | | | | | | | | | | | | | | | | | | | |
| Country | US | | | | | | | | | | | | | | | | | | | | |
| Volume (USD) | \$177,990.00 | | | | | | | | | | | | | | | | | | | | |
| Parts | <table border="1"> <thead> <tr> <th>PartNumber</th> <th>PartName</th> <th>SalesPrice</th> <th>ReOrderQuantity</th> <th>QuantityOnHand</th> </tr> </thead> <tbody> <tr> <td>1000</td> <td>Cedar Shakes</td> <td>\$22.00</td> <td>100</td> <td>200</td> </tr> <tr> <td>2000</td> <td>Garage Heater</td> <td>\$1,750.00</td> <td>3</td> <td>4</td> </tr> <tr> <td>3000</td> <td>Utility Cabinet</td> <td>\$55.00</td> <td>7</td> <td>3</td> </tr> </tbody> </table> | PartNumber | PartName | SalesPrice | ReOrderQuantity | QuantityOnHand | 1000 | Cedar Shakes | \$22.00 | 100 | 200 | 2000 | Garage Heater | \$1,750.00 | 3 | 4 | 3000 | Utility Cabinet | \$55.00 | 7 | 3 |
| PartNumber | PartName | SalesPrice | ReOrderQuantity | QuantityOnHand | | | | | | | | | | | | | | | | | |
| 1000 | Cedar Shakes | \$22.00 | 100 | 200 | | | | | | | | | | | | | | | | | |
| 2000 | Garage Heater | \$1,750.00 | 3 | 4 | | | | | | | | | | | | | | | | | |
| 3000 | Utility Cabinet | \$55.00 | 7 | 3 | | | | | | | | | | | | | | | | | |
| Record: 1 of 3 < > << >> No Filter Search | | | | | | | | | | | | | | | | | | | | | |

(b) PART Report

| PART | | | | | | | |
|-------------|-----------------|-------------|-----|-----|--------------------|------------|-----------|
| Part Number | Part Name | Sales Price | ROQ | QOH | Company Name | City | Country |
| 1000 | Cedar Shakes | \$22.00 | 100 | 200 | Bristol Systems | Manchester | England |
| | | | | | ERS Systems | Vancouver | Canada |
| | | | | | Forrest Supplies | Denver | US |
| 2000 | Garage Heater | \$1,750.00 | 3 | 4 | Bristol Systems | Manchester | England |
| | | | | | ERS Systems | Vancouver | Canada |
| | | | | | Forrest Supplies | Denver | US |
| 3000 | Utility Cabinet | \$55.00 | 7 | 3 | Kyoto Importers | Kyoto | Japan |
| | | | | | Ajax Manufacturing | Sydney | Australia |
| | | | | | Forrest Supplies | Denver | US |

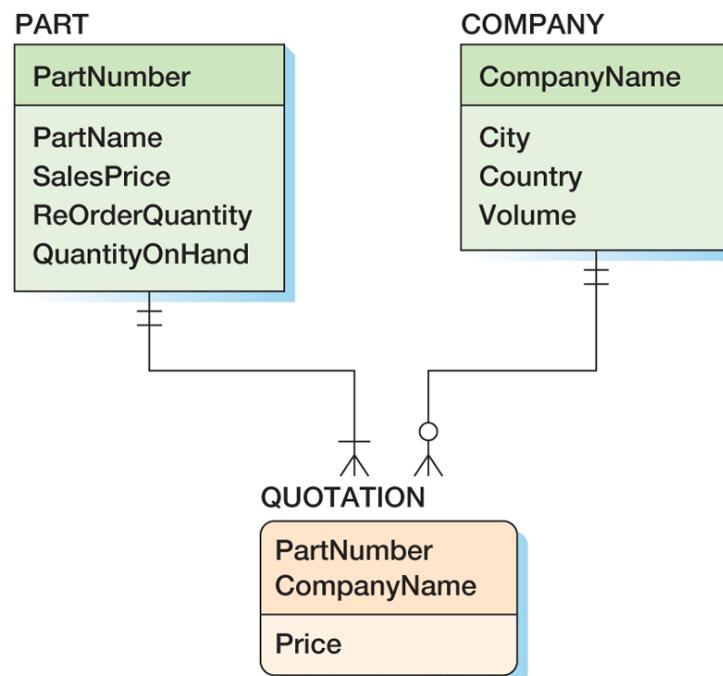
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ID-DEPENDENT RELATIONSHIPS: THE ASSOCIATION PATTERN

| PART QUOTATIONS | | | | | | | | | |
|-----------------|---------------|------------|-----|-----|------------------|------------|---------|------------|--|
| PartNumber | PartName | SalesPrice | ROQ | QOH | CompanyName | City | Country | Price | |
| 1000 | Cedar Shakes | \$22.00 | 100 | 200 | Bristol Systems | Manchester | England | \$14.00 | |
| | | | | | ERS Systems | Vancouver | Canada | \$12.50 | |
| | | | | | Forrest Supplies | Denver | US | \$15.50 | |
| 2000 | Garage Heater | \$1,750.00 | 3 | 4 | Bristol Systems | Manchester | England | \$950.00 | |
| | | | | | ERS Systems | Vancouver | Canada | \$875.00 | |
| | | | | | Forrest Supplies | Denver | US | \$915.00 | |
| | | | | | Kyoto Importers | Kyoto | Japan | \$1,100.00 | |



ID-DEPENDENT RELATIONSHIPS: THE MULTIVALUED ATTRIBUTE PATTERN

.....

Company

| | |
|--------------|---|
| Company Name | Ajax Manufacturing |
| City | Sydney |
| Country | Australia |
| Volume (USD) | \$187,500.00 |
| Phone | 1.100.334.8000 1.100.444.9988 800-123-4455 * |
| Contact | Alfred Jackson Lynda Swee * |

Record: 1 of 5

No Filter Search

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COMPANY

| |
|-------------|
| CompanyName |
| City |
| Country |
| Volume |

PHONE

| |
|-------------|
| CompanyName |
| PhoneNumber |

COMPANY

| |
|-------------|
| CompanyName |
| City |
| Country |
| Volume |

PHONE

| |
|-------------|
| CompanyName |
| PhoneNumber |

CONTACT

| |
|-------------|
| CompanyName |
| Contact |

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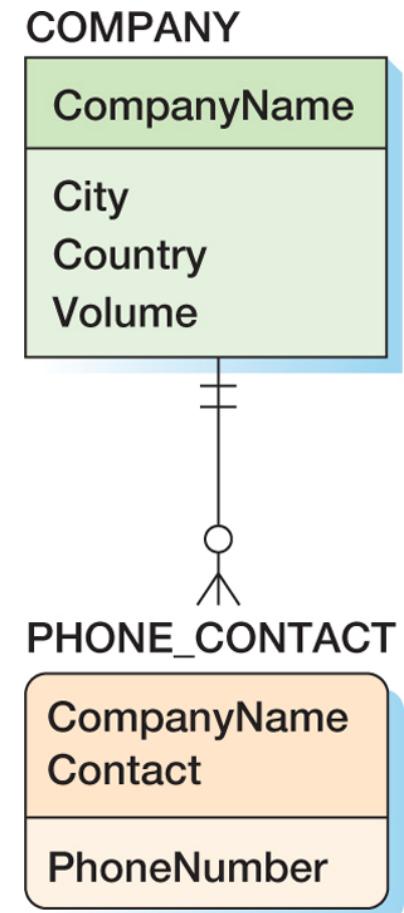
ID-DEPENDENT RELATIONSHIPS: COMPOSITE MULTIVALUED ATTRIBUTES

Company

| Company Name | Ajax Manufacturing | | | | | | | | | | | | |
|----------------|--|-------------|---------|----------------|--------|----------------|---------|--------------|-------|--------------|------|---|--|
| City | Sydney | | | | | | | | | | | | |
| Country | Australia | | | | | | | | | | | | |
| Volume (USD) | \$187,500.00 | | | | | | | | | | | | |
| Contact Phone | <table border="1"> <thead> <tr> <th>PhoneNumber</th> <th>Contact</th> </tr> </thead> <tbody> <tr> <td>1.100.334.8000</td> <td>Alfred</td> </tr> <tr> <td>1.100.444.9988</td> <td>Jackson</td> </tr> <tr> <td>800-123-4455</td> <td>Lynda</td> </tr> <tr> <td>800-123-4455</td> <td>Swee</td> </tr> <tr> <td>*</td> <td></td> </tr> </tbody> </table> | PhoneNumber | Contact | 1.100.334.8000 | Alfred | 1.100.444.9988 | Jackson | 800-123-4455 | Lynda | 800-123-4455 | Swee | * | |
| PhoneNumber | Contact | | | | | | | | | | | | |
| 1.100.334.8000 | Alfred | | | | | | | | | | | | |
| 1.100.444.9988 | Jackson | | | | | | | | | | | | |
| 800-123-4455 | Lynda | | | | | | | | | | | | |
| 800-123-4455 | Swee | | | | | | | | | | | | |
| * | | | | | | | | | | | | | |

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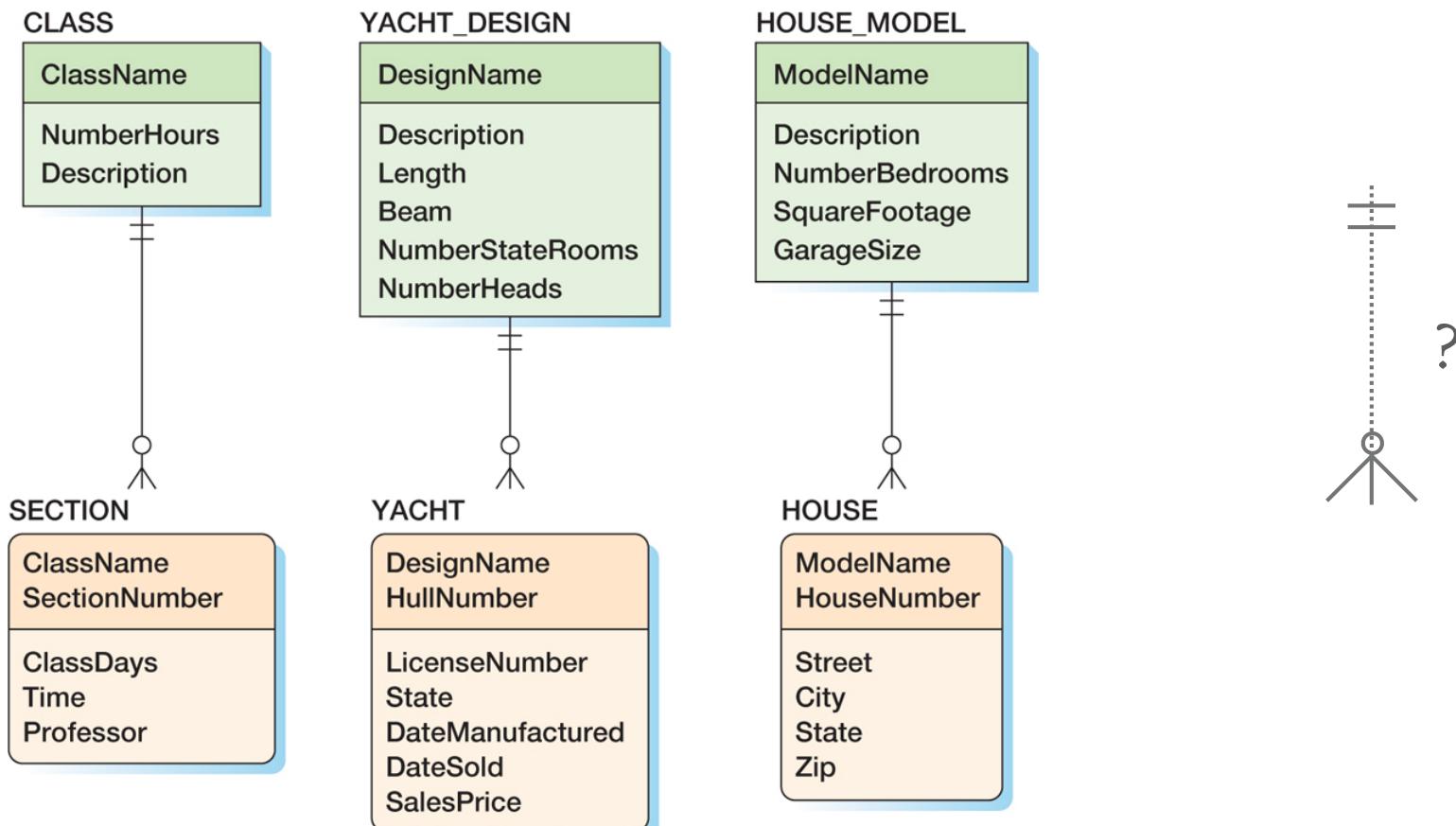
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ID-DEPENDENT RELATIONSHIPS: THE ARCHETYPE/INSTANCE PATTERN

- The archetype-instance pattern occurs when the ID-dependent child entity is the physical manifestation (instance) of an abstract or logical parent.



MIXED PATTERNS: THE LINE-ITEM PATTERN (1/2)

.....

Carbon River Furniture Sales Order Form

Carbon River Furniture Sales Order Form

| | | | |
|--------------------|-----------------|------------------|----------------|
| Sales Order Number | 2013003845 | Salesperson | Anne Dodsworth |
| Sales Order Date | 9/25/2013 | Salesperson Code | EN-01 |
| Customer Name | Kelly Welsch | | |
| Address | 1145 Elm Street | | |
| City | Carbon River | State | IL |
| Phone | 733-357-8462 | ZIP | 60662 |

Sales Order Line Items

| ItemNumber | Description | Quantity | UnitPrice | ExtendedPrice |
|------------|------------------|----------|------------|---------------|
| 92 | Desk Chair | 1 | \$650.00 | \$650.00 |
| 81 | Conference Table | 1 | \$7,750.00 | \$7,750.00 |
| 91 | Side Chair | 8 | \$485.00 | \$3,880.00 |
| 78 | Executive Desk | 1 | \$3,500.00 | \$3,500.00 |
| * | | | | |

Record: 14 1 of 4 No Filter Search

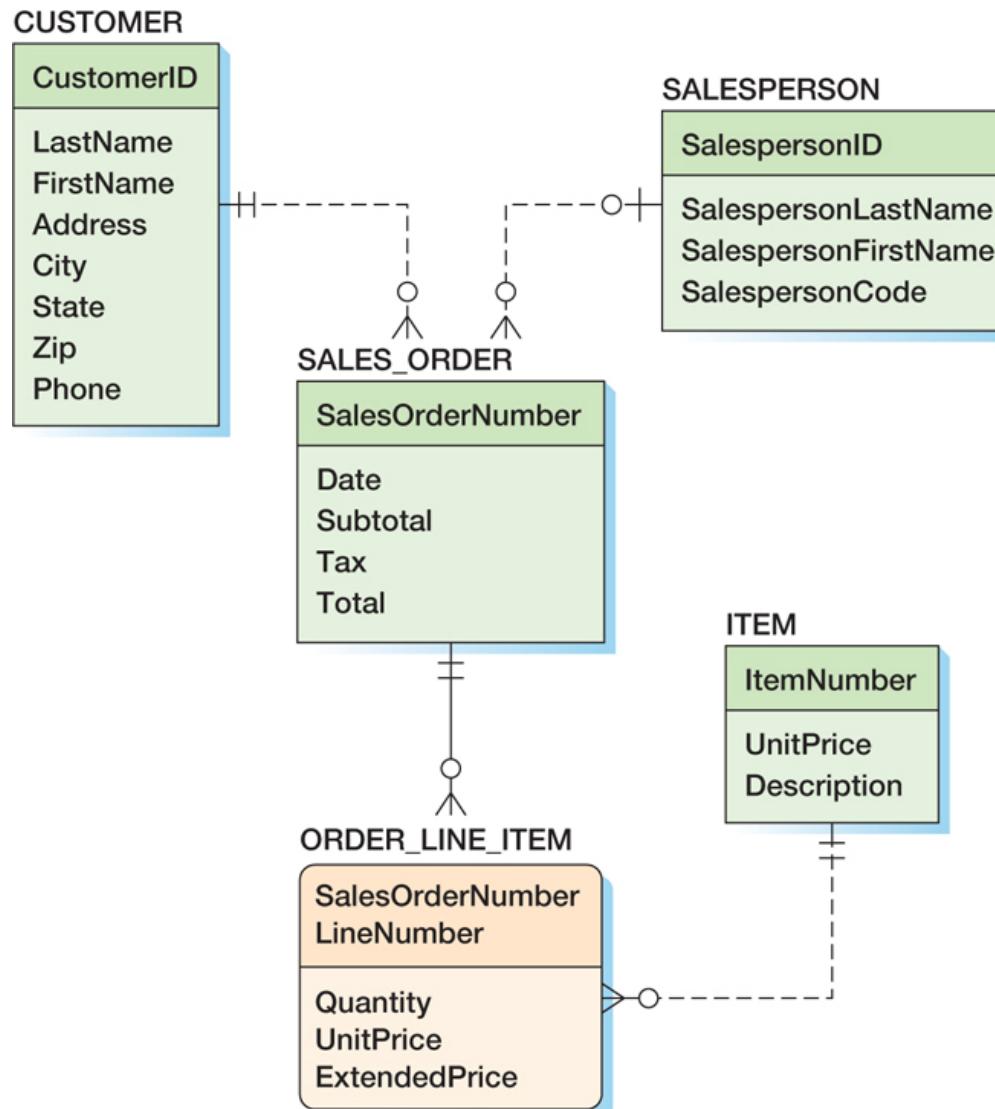
Subtotal: \$15,780.00

Tax: \$1,388.64

Total: \$17,168.64

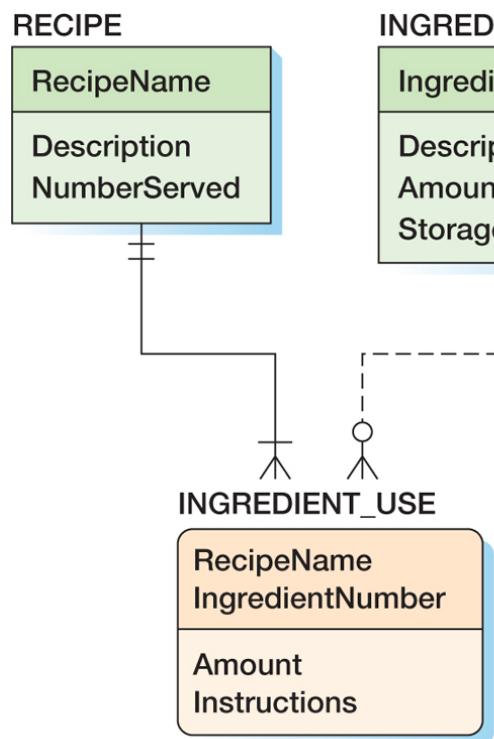
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MIXED PATTERNS: THE LINE-ITEM PATTERN (2/2)

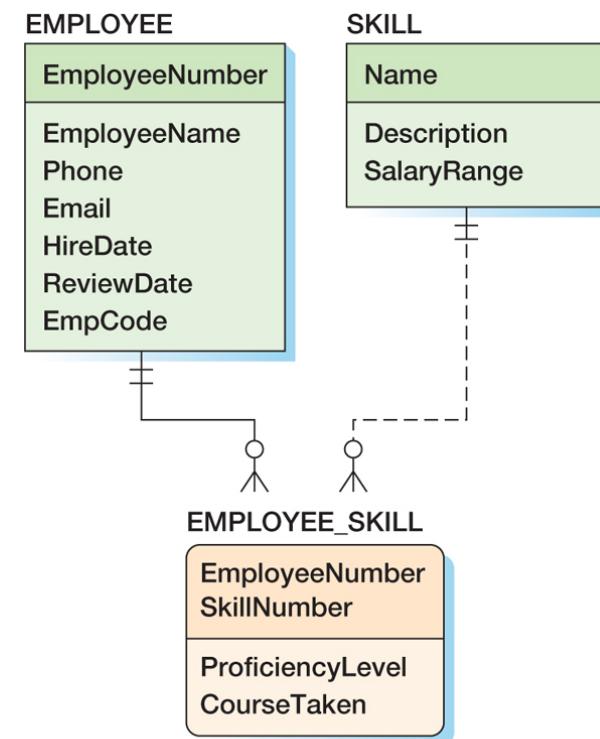


MIXED PATTERNS: OTHER MIXED PATTERNS

- Look for a mixed pattern where:
 - A strong entity has a multivalued composite group
 - One of the elements of the composite group is an identifier of another strong entity.



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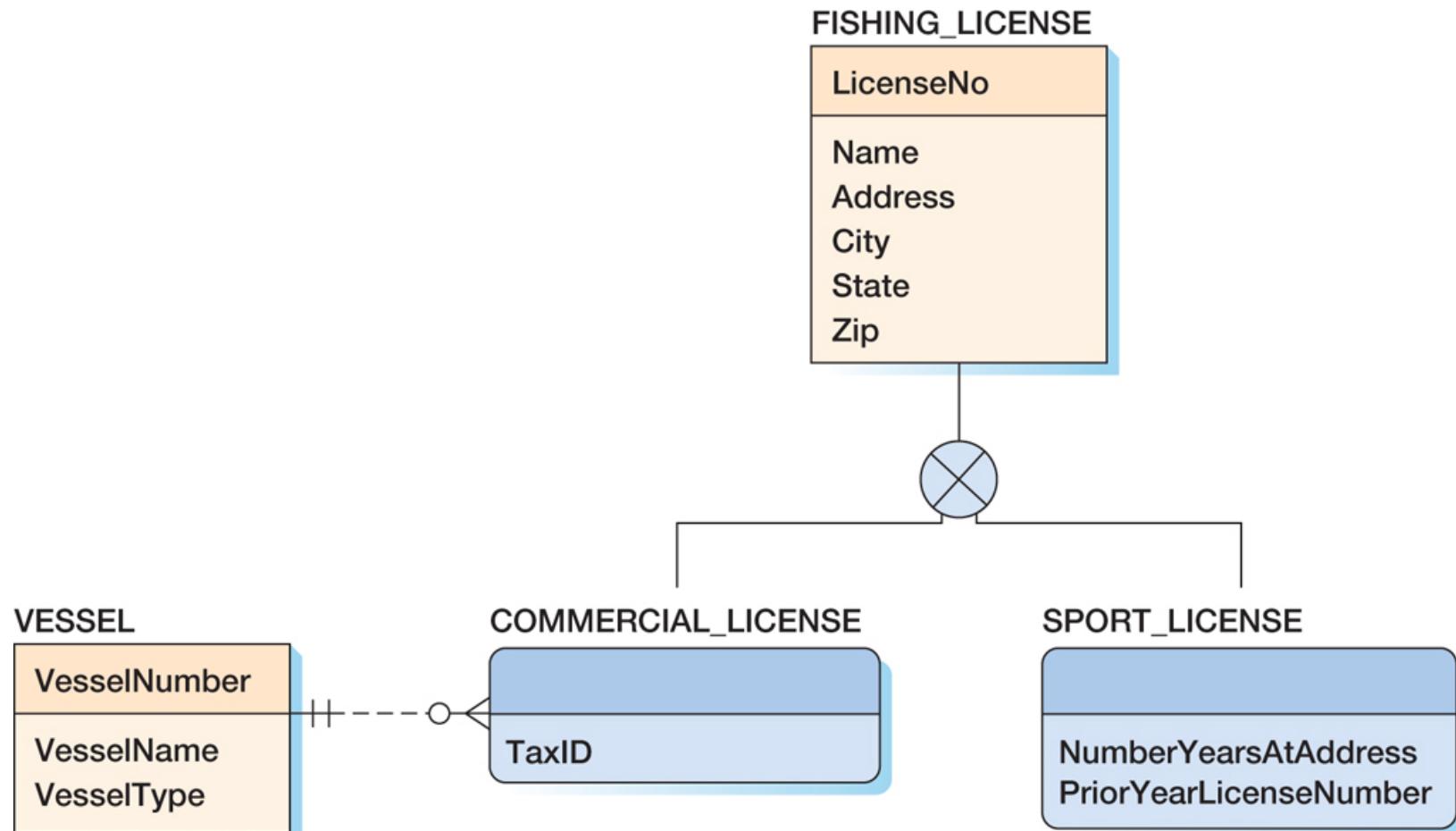
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MIXED PATTERNS: THE FOR-USE-BY PATTERN (1/2)

.....

| | | |
|--|--------|---|
| Resident Fishing License 2013 Season <i>State of Washington</i> | | License No: 03-1123432 |
| Name: | | |
| Street: | | |
| City: | State: | Zip: |
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| For Use by Commercial Fishers Only | | For Use by Sport Fishers Only |
| Vessel Number: | | Number Years at This Address: |
| Vessel Name: | | Prior Year License Number: |
| Vessel Type: | | |
| Tax ID: | | |

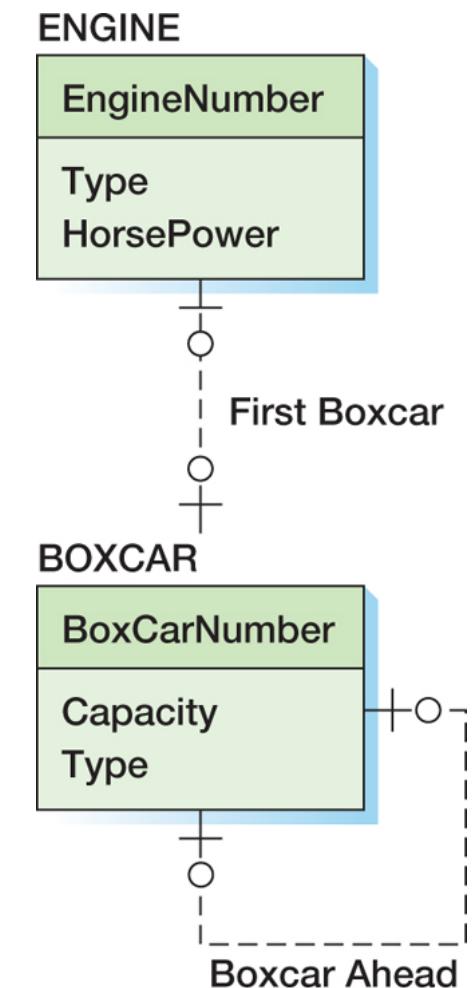
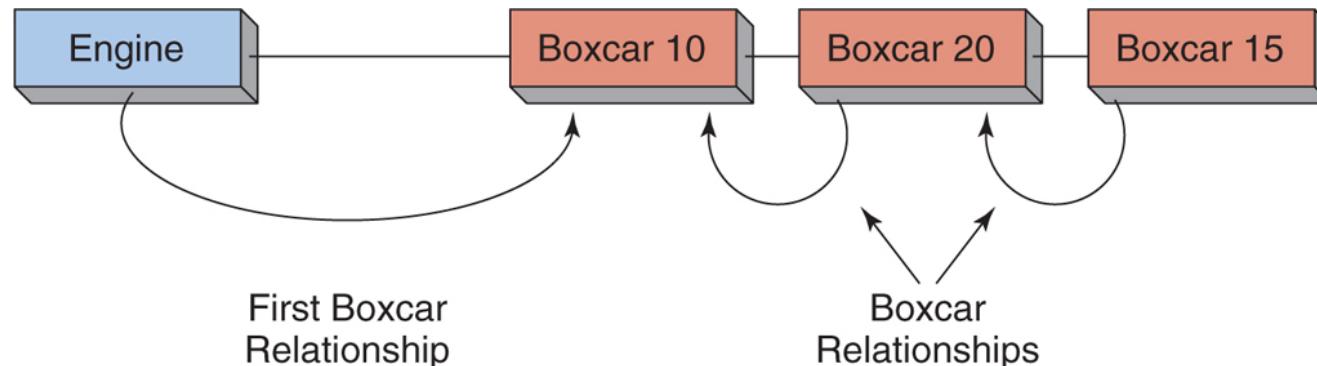
MIXED PATTERNS: THE FOR-USE-BY PATTERN (2/2)



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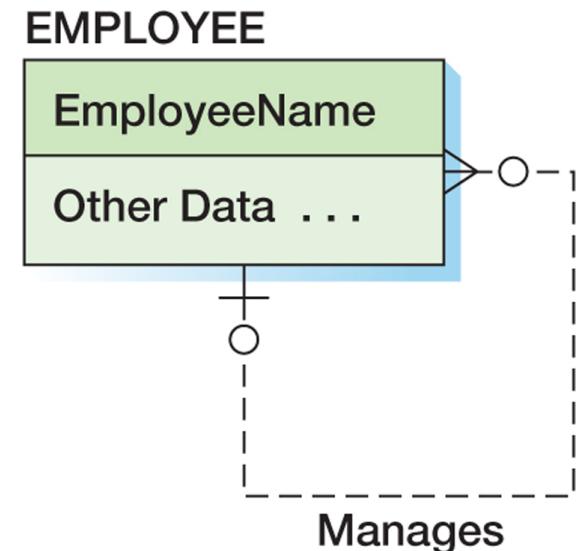
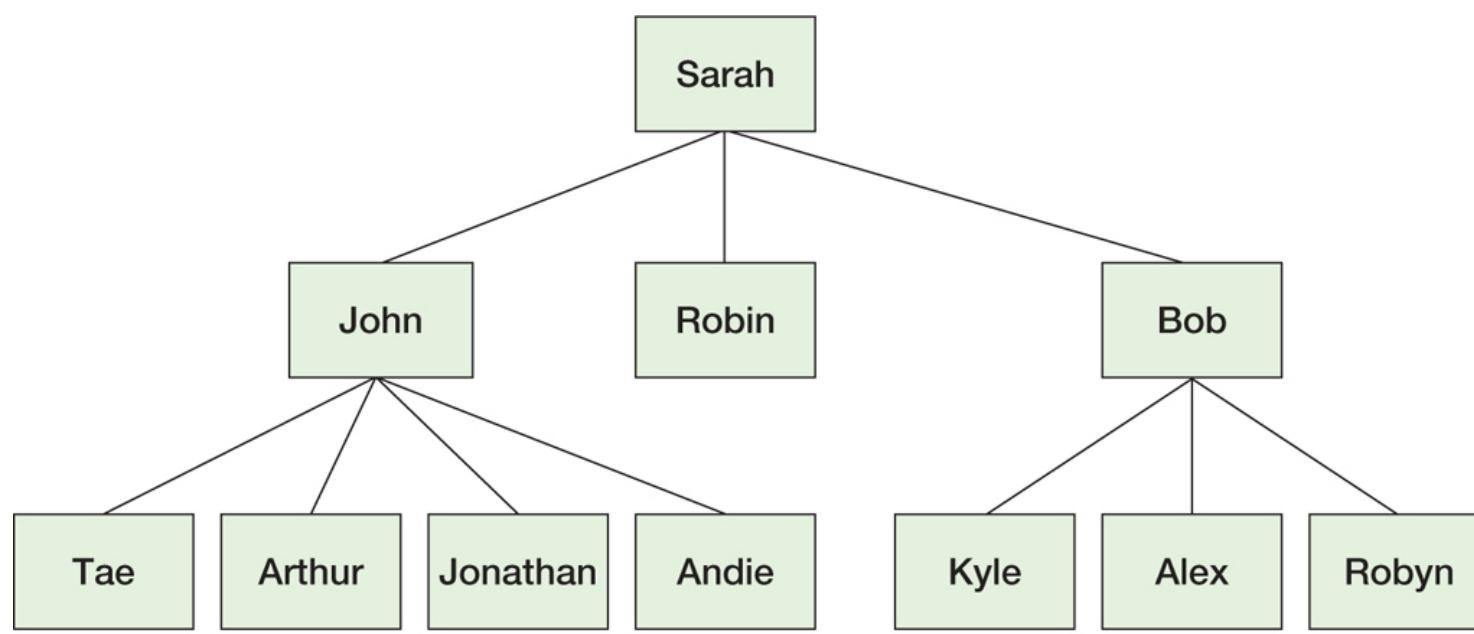
RECURSIVE PATTERNS: 1:1 RECURSIVE RELATIONSHIP

- A recursive relationship occurs when an entity has a relationship to itself.



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RECURSIVE PATTERNS: 1:N RECURSIVE RELATIONSHIP



RECURSIVE PATTERNS: N:M RECURSIVE RELATIONSHIP

