Unit 4: Entity Relationship Modelling

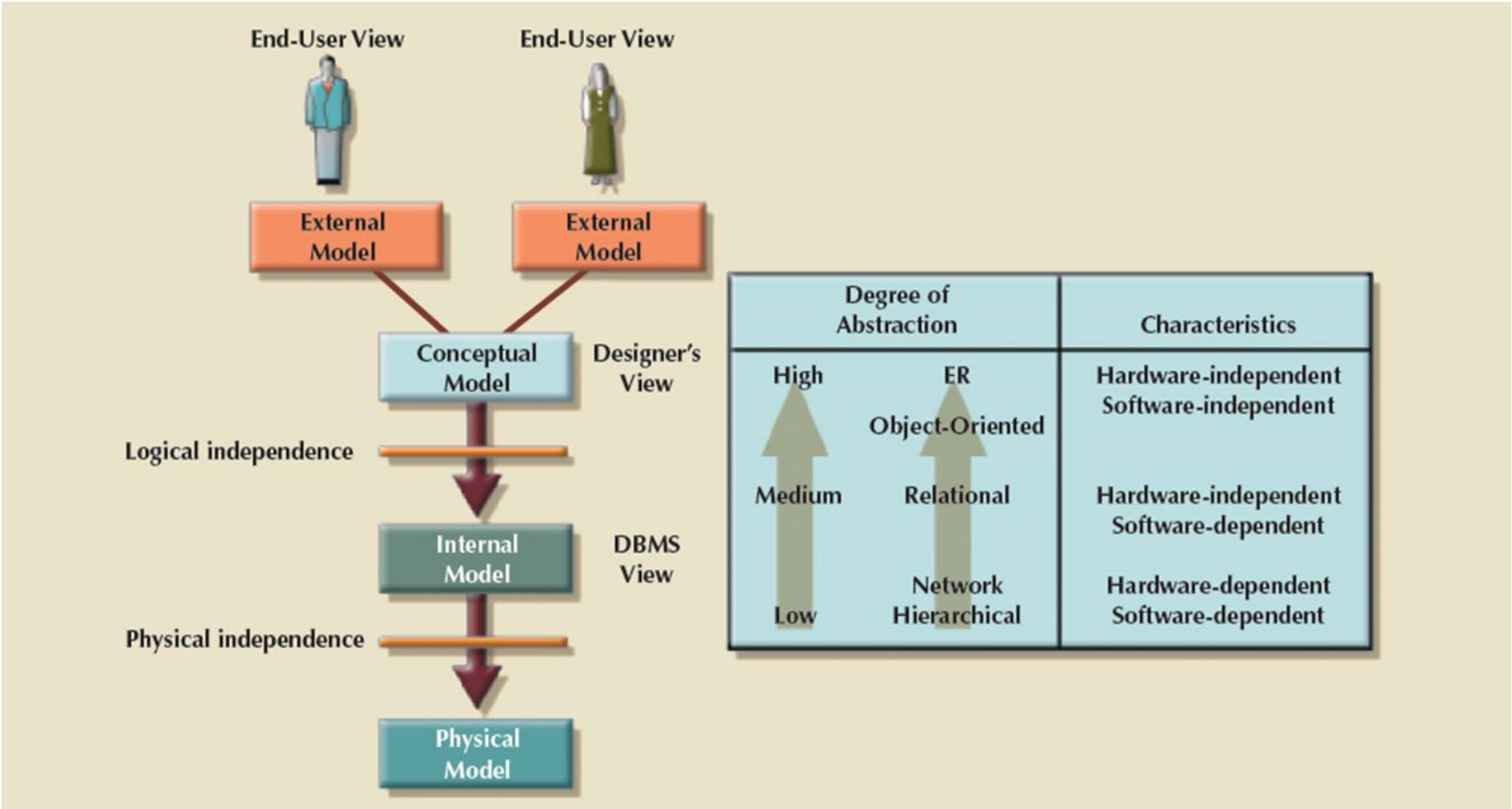
Learning Objectives

- In this chapter, you will learn:
  - The main characteristics of entity relationship components
  - How relationships between entities are defined, refined, and incorporated into the database design process
  - How ERD components affect database design and implementation
  - That real-world database design often requires the reconciliation of conflicting goals

Recap: Data Abstraction Models

Mention the 4 different Data Abstraction models

Recap - Data Abstraction Levels



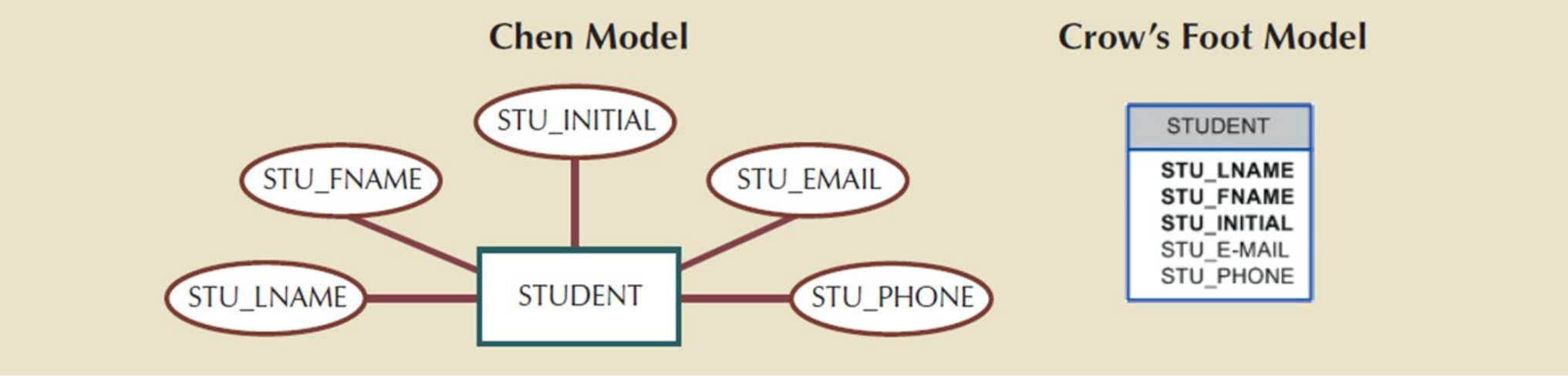
Entity Relationship Model (ERM)

- Basis of an entity relationship diagram (ERD)
- ERD depicts the:
  - Conceptual database as viewed by end user
  - Database's main components
    - Entities
    - Attributes
    - Relationships
- Entity - Refers to the entity set and not to a single entity occurrence

Attributes (1 of 3)

- Characteristics of entities
- **Required attribute**: Must have a value, cannot be left empty
- **Optional attribute**: Does not require a value, can be left empty
- Domain - Set of possible values for a given attribute
- **Identifiers**: One or more attributes that uniquely identify each entity instance (Primary Key)

Figure 4.1 - The Attributes of the Student Entity: Chen and Crow's Foot

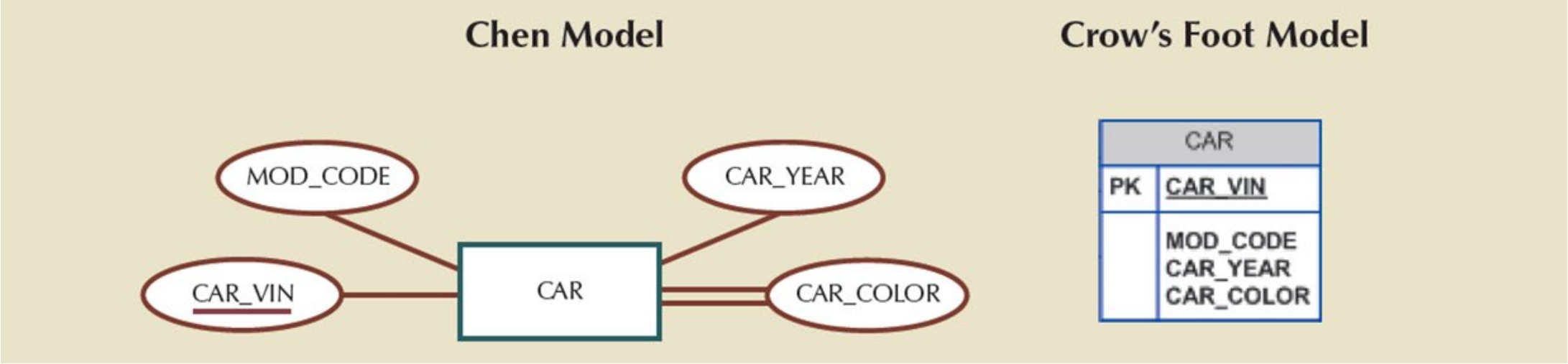


Required attributes are marked bold in Crow foot's model.

Attributes (2 of 3)

- **Composite identifier**: Primary key composed of more than one attribute
- **Composite attribute**: Attribute that can be subdivided to yield additional attributes
  - Address – Street, city, province, postal code
- **Simple attribute**: Attribute that cannot be subdivided
  - Age
- **Single-valued attribute**: Attribute that has only a single value e.g. ID
  - Single valued attribute is not necessarily a simple attribute
  - Different parts of the ID – first six digits represents the date of birth
- **Multivalued attributes**: Attributes that have many values for a single entity occurrence
  - Car colour – roof, body, trim
  - A person's college degrees

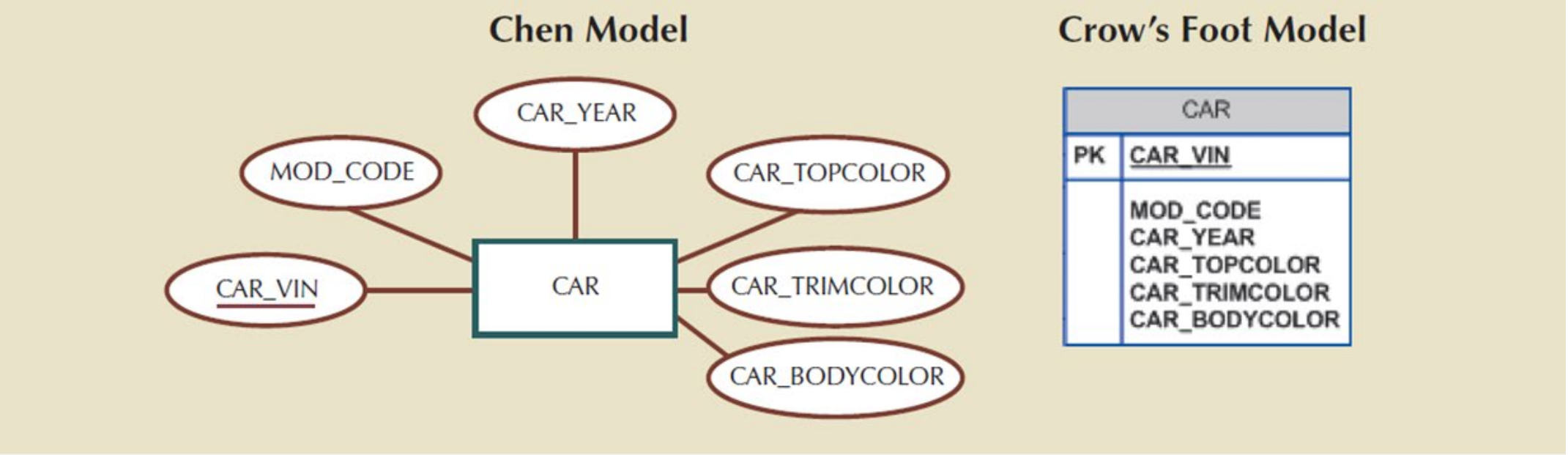
Figure 4.3 - A Multivalued Attribute in an Entity



Attributes (3 of 3)

- **Multivalued attributes**: Attributes that have many values and require creating:
  - Several new attributes, one for each component of the original multivalued attribute
  - A new entity composed of the original multivalued attribute's components
- **Derived attribute**: Attribute whose value is calculated from other attributes
  - Derived using an algorithm

First Approach – Splitting the Multivalued Attributes into New Attributes



It is only acceptable if every instance will have the same number of values for the multivalued attribute, and no instance will ever have more values.

Disadvantages

- Splitting the Multivalued Attributes into New Attributes
- Not scalable when different entity instances can have different number of attributes
  - An employee can have 4 degrees, with another having only one
    - Excessive NULLs
- Changes in operational requirements

Second Approach

FIGURE 4.5 A NEW ENTITY SET COMPOSED OF A MULTIVALUED ATTRIBUTE'S COMPONENTS

- This is the preferred approach.
- Need not change the table's structure

TABLE 4.1

COMPONENTS OF THE MULTIVALUED ATTRIBUTE

SECTION	COLOR
Top	White
Body	Blue
Trim	Gold
Interior	Blue

Attributes (3 of 3)

- **Multivalued attributes**: Attributes that have many values and require creating:
  - Several new attributes, one for each component of the original multivalued attribute
  - A new entity composed of the original multivalued attribute's components
- **Derived attribute**: Attribute whose value is calculated from other attributes
  - Derived using an algorithm

Figure 4.6 - Depiction of a Derived Attribute

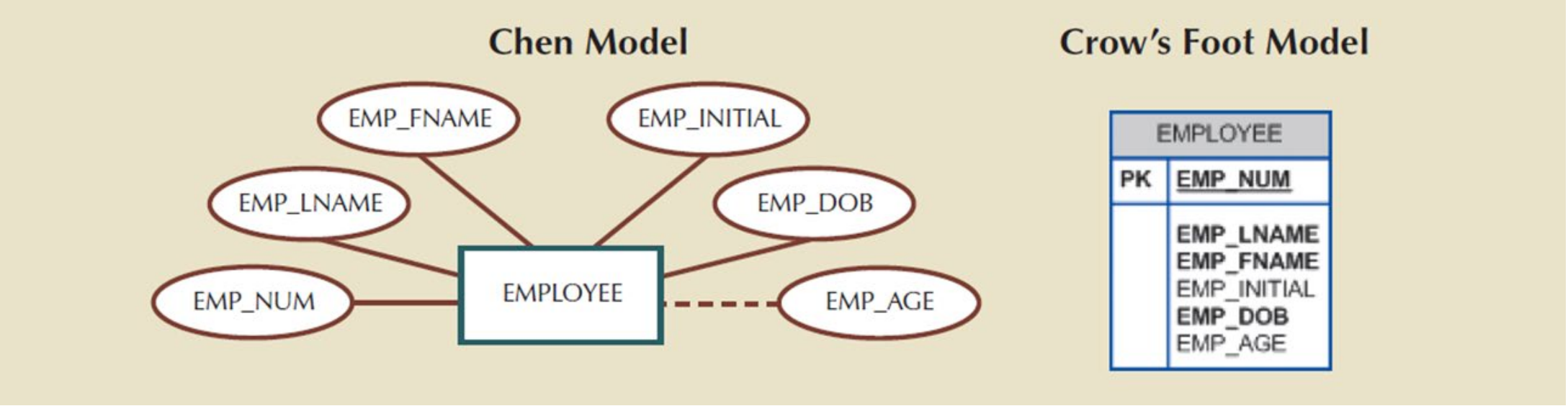


Table 4.2 - Advantages and Disadvantages of Storing Derived Attributes

	DERIVED ATTRIBUTE FOR STORED	DERIVED ATTRIBUTE FOR NOT STORED
Advantage	Saves CPU processing cycles Saves data access time Data value is readily available Can be used to keep track of historical data	Saves storage space Computation always yields current value
Disadvantage	Requires constant maintenance to ensure derived value is current, especially if any values used in the calculation change	Uses CPU processing cycles Increases data access time Adds coding complexity to queries

Relationships

- Association between entities that always operate in both directions
- **Participants**: Entities that participate in a relationship
- **Connectivity**: Describes the relationship classification
- **Cardinality**: Expresses the minimum and maximum number of entity occurrences associated with one occurrence of related entity

Relationships - 2

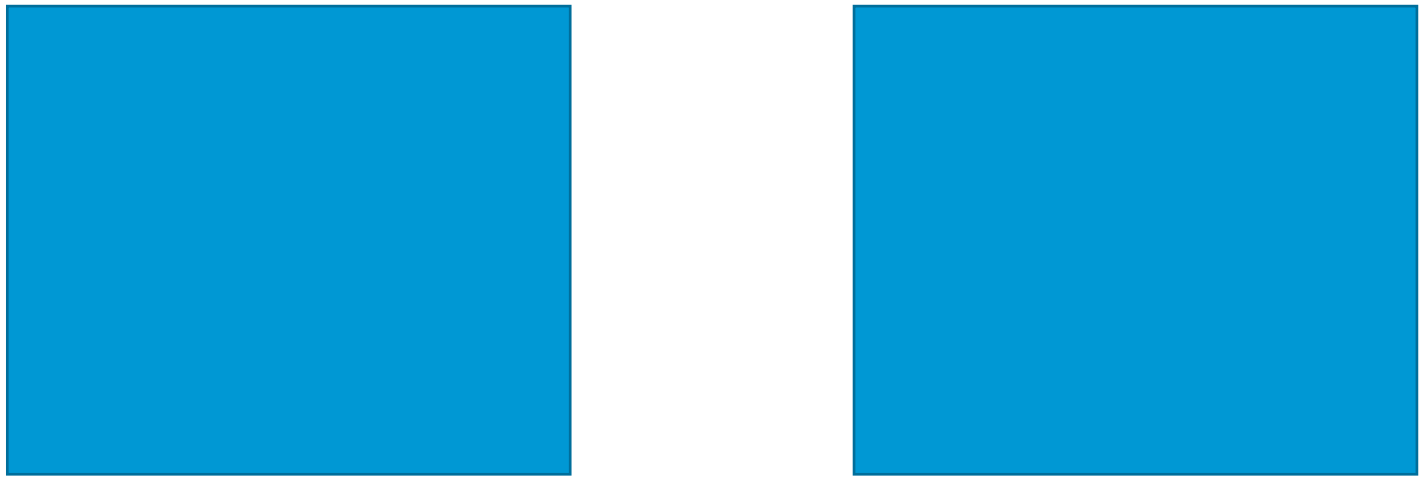
- Each relationship is identified by a name that describes the relationship.
- The relationship name is an active or passive verb; for
  - a STUDENT takes a CLASS,
  - a PROFESSOR teaches a CLASS,
  - a DEPARTMENT employs a PROFESSOR,
  - a DIVISION is managed by an EMPLOYEE,
  - an AIRCRAFT is flown by a CREW.

Exercise

- Write down on your paper the three types of relationships that exist

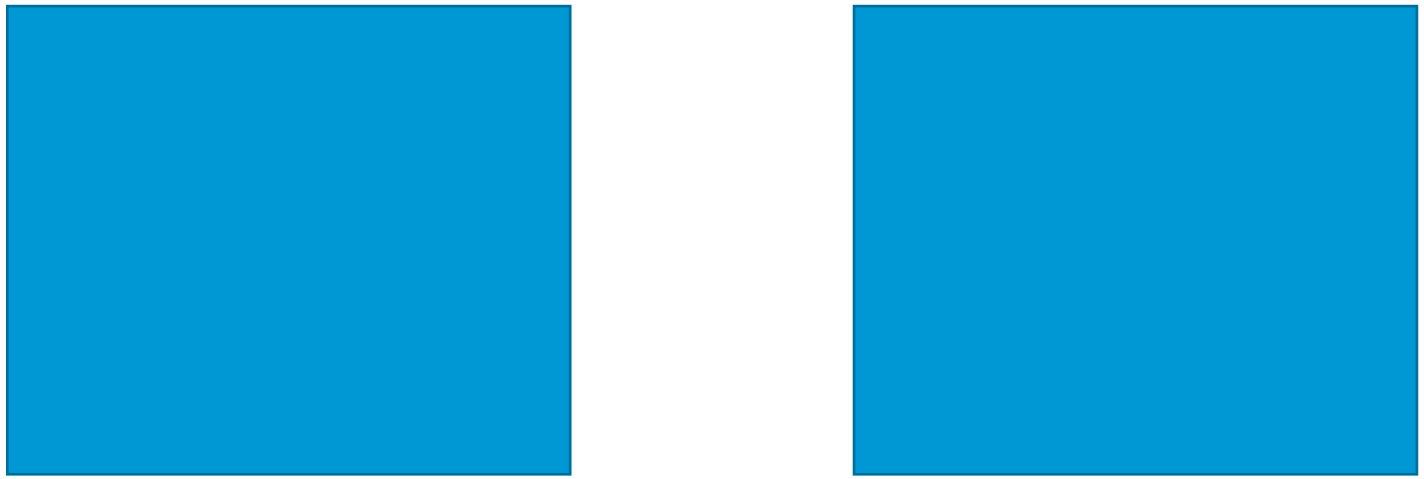
Exercise

- Using the Crow foot notation
- Draw two sets of boxes (entities)
- Draw the 1:1 notation on your paper



Exercise

- Using the Crow foot notation
- Draw two sets of boxes
- Draw the 1:M notation on your paper



Exercise

- Using the Crow foot notation
- Draw two sets of boxes
- Draw the M:N notation on your paper

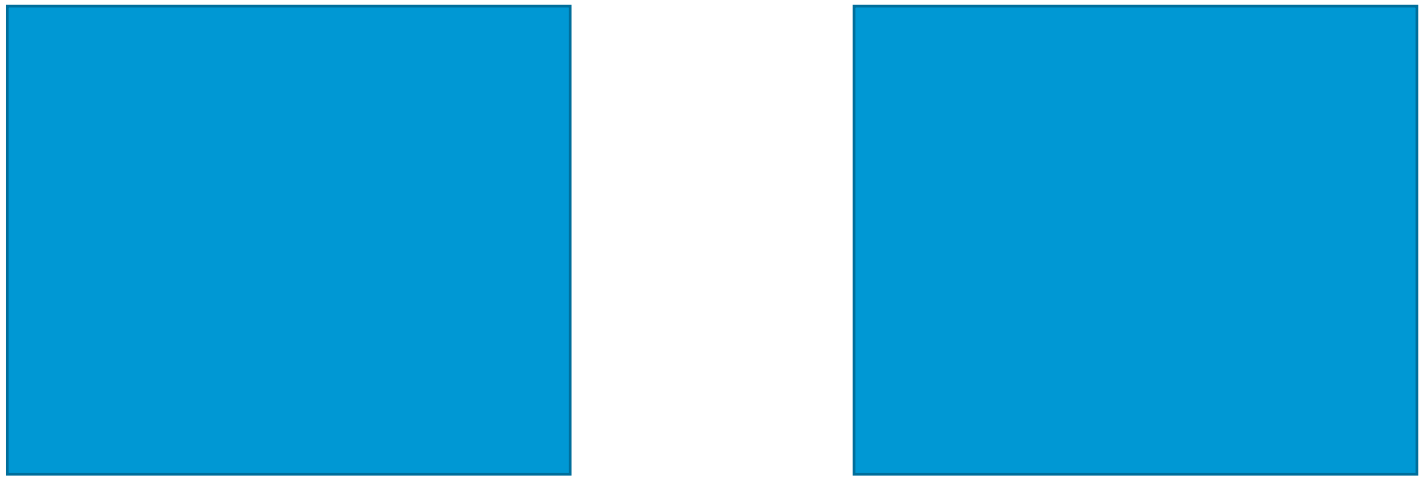
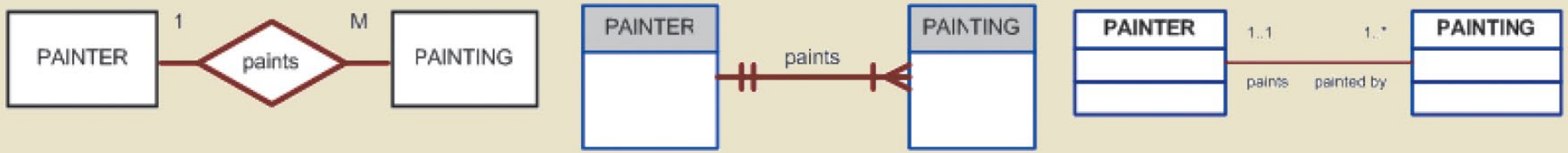


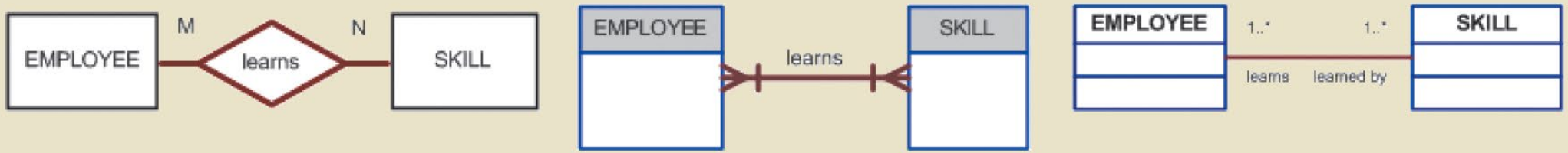
FIGURE 2.3 THE ER MODEL NOTATIONS

Chen Notation ***Crow's Foot Notation*** *UML Class Diagram Notation*

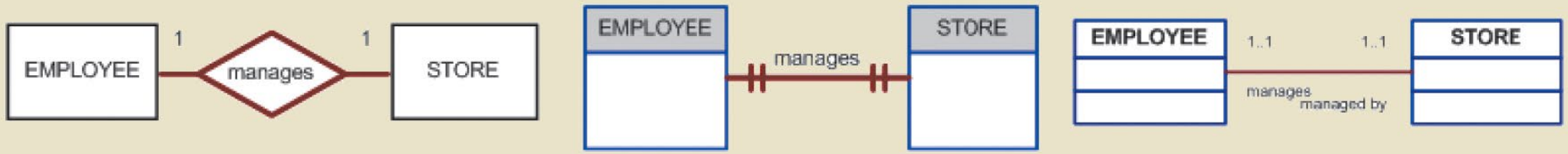
A One-to-Many (1:M) Relationship: a PAINTER can paint many PAINTINGs; each PAINTING is painted by one PAINTER.



A Many-to-Many (M:N) Relationship: an EMPLOYEE can learn many SKILLs; each SKILL can be learned by many EMPLOYEEs.



A One-to-One (1:1) Relationship: an EMPLOYEE manages one STORE; each STORE is managed by one EMPLOYEE.



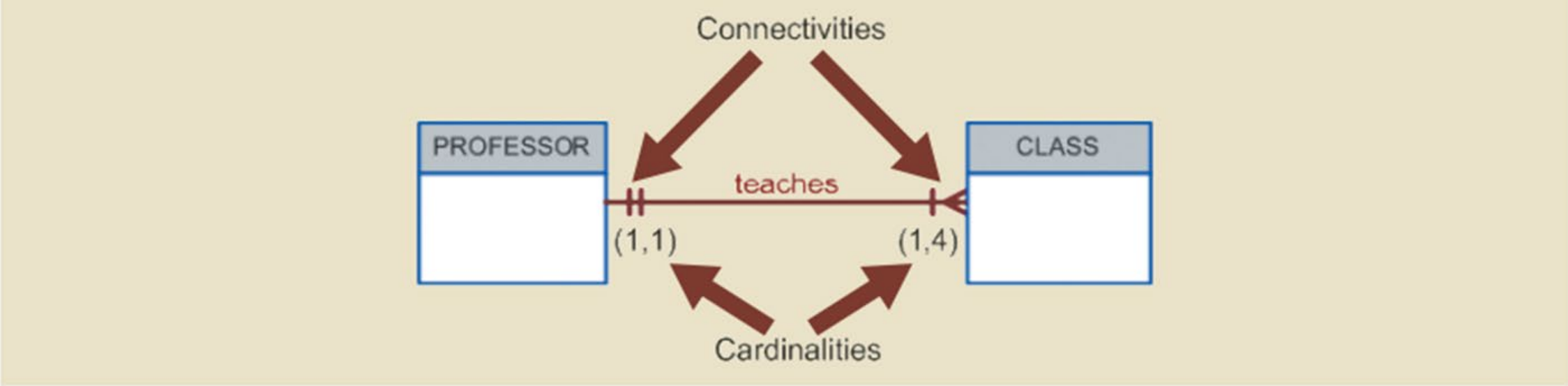
Determining Relationships

- Relationships between entities always operate in both directions.
- To define the relationship between the entities named CUSTOMER and INVOICE, you would specify that:
  - A CUSTOMER may generate many INVOICEs.
  - Each INVOICE is generated by one CUSTOMER.
  - 1 - M
- The relationship classification is difficult to establish if you know only one side of the relationship.
  - A DIVISION is managed by one EMPLOYEE.

Determining Relationships

- The relationship classification is difficult to establish if you know only one side of the relationship.
  - A DIVISION is managed by one EMPLOYEE.
  - “Can an employee manage more than one division?”
  - YES – 1:M
  - NO – 1:1
- Basically, you need to understand the business rules of the organization.
  - How do thinks work?

Figure 4.7 - Connectivity and Cardinality in an ERD



Existence Dependence

Existence dependence

- Entity exists in the database only when it is associated with another related entity occurrence
- Eg. A Dependent entity cannot exist without an Employee entity
- In implementation terms, an entity is existence-dependent if it has a mandatory foreign key—that is, a foreign key attribute that cannot be null.

Existence independence

- Entity exists apart from all of its related entities
- Referred to as a **strong entity** or **regular entity**

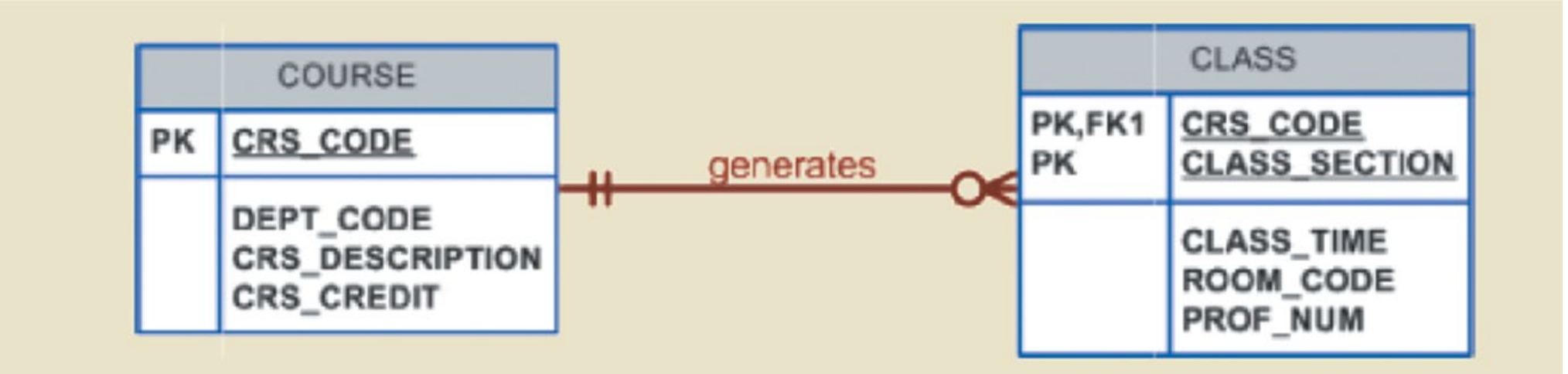
Relationship Strength

- **Weak (non-identifying) relationship**
  - Primary key of the related entity does not contain a primary key component of the parent entity
- **Strong (identifying) relationships**
  - Primary key of the related entity contains a primary key component of the parent entity

Figure 4.8 - A Weak (Non-Identifying) Relationship between COURSE and CLASS

Crow's Foot notation depicts a weak relationship by placing a dashed relationship line between the entities

Figure 4.9 - A Strong (Identifying) Relationship between COURSE and CLASS



Weak Entity

- Conditions
  - Existence-dependent
  - Has a primary key that is partially or totally derived from parent entity in the relationship (strong relationship)
- Database designer determines whether an entity is weak based on business rules

Figure 4.10 - A Weak Entity in an ERD

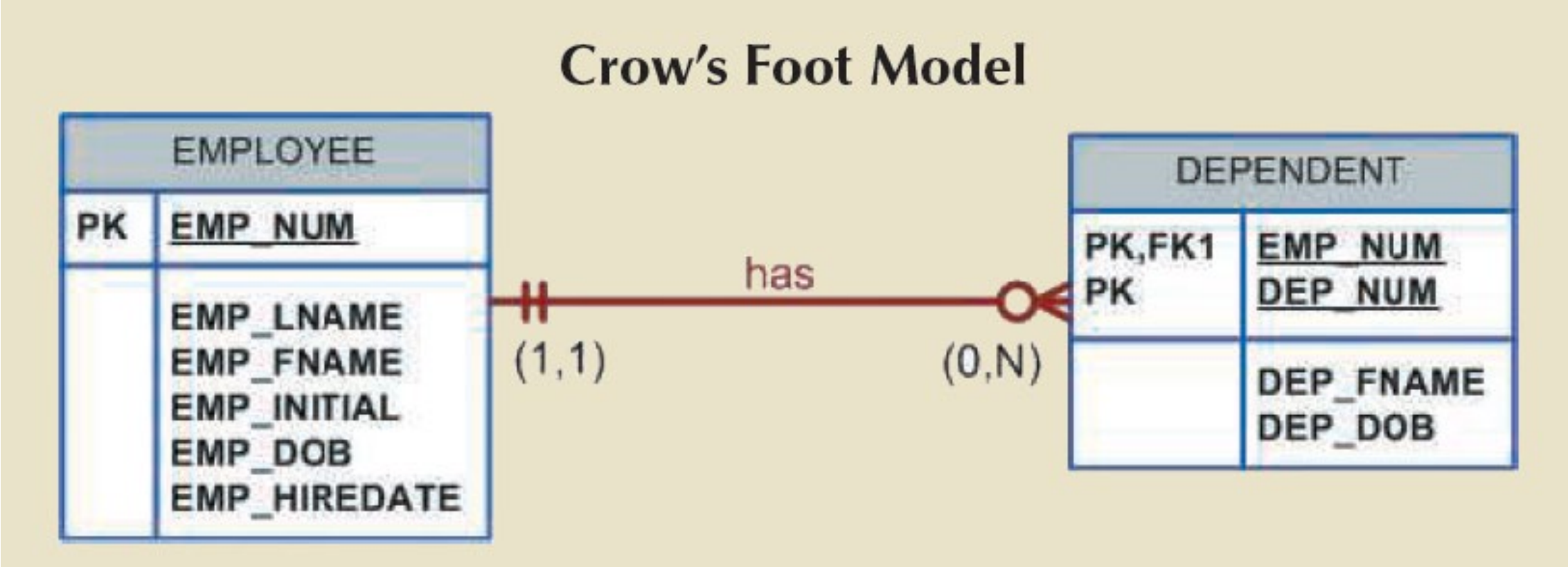


Figure 4.13 - CLASS is Optional to COURSE

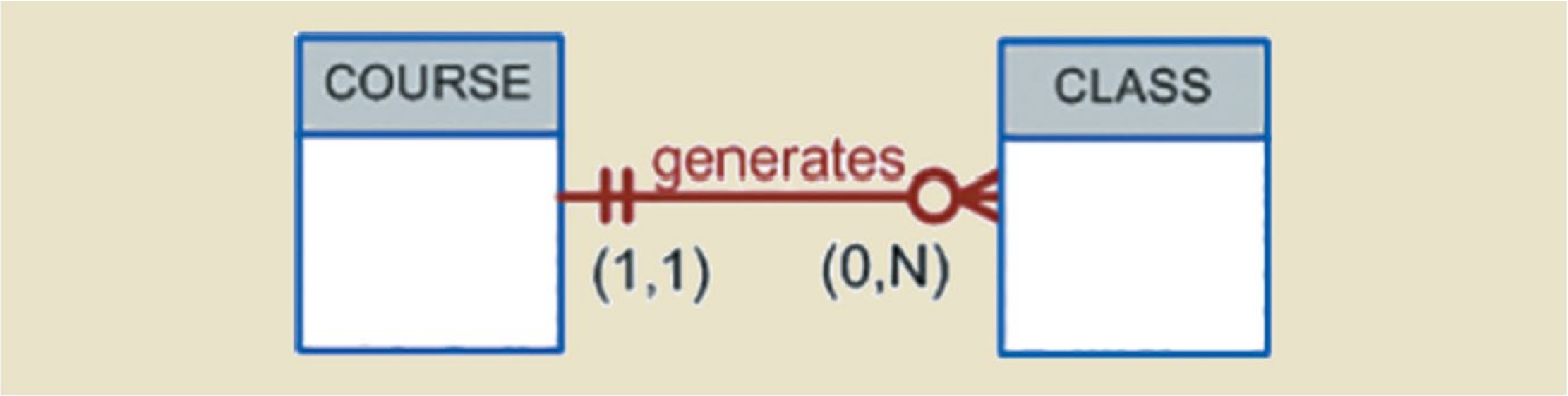


Figure 4.11 - A Weak Entity in a Strong Relationship

Table name: EMPLOYEE **Database name: Ch04_ShortCo**

EMP_NUM	EMP_LNAME	EMP_FNAME	EMP_INITIAL	EMP_DOB	EMP_HIREDATE
1001	Callifante	Jeanine	J	12-Mar-64	25-May-97
1002	Smithson	William	K	23-Nov-70	28-May-97
1003	Washington	Herman	H	15-Aug-68	28-May-97
1004	Chen	Lydia	B	23-Mar-74	15-Oct-98
1005	Johnson	Melanie		28-Sep-66	20-Dec-98
1006	Ortega	Jorge	G	12-Jul-79	05-Jan-02
1007	O'Donnell	Peter	D	10-Jun-71	23-Jun-02
1008	Brzenski	Barbara	A	12-Feb-70	01-Nov-03

Table name: DEPENDENT

EMP_NUM	DEP_NUM	DEP_FNAME	DEP_DOB
1001	1	Annelise	05-Dec-97
1001	2	Jorge	30-Sep-02
1003	1	Suzanne	25-Jan-04
1006	1	Carlos	25-May-01
1008	1	Michael	19-Feb-95
1008	2	George	27-Jun-98
1008	3	Katherine	18-Aug-03

Relationship Participation

- Optional participation
  - One entity occurrence does not require a corresponding entity occurrence in a particular relationship
- Mandatory participation
  - One entity occurrence requires a corresponding entity occurrence in a particular relationship

Table 4.3 - Crow's Foot Symbols

CROW'S FOOT SYMBOLS	CARDINALITY	COMMENT
	(0,N)	Zero or many; the "many" side is optional.
	(1,N)	One or many; the "many" side is mandatory.
	(1,1)	One and only one; the "1" side is mandatory.
	(0,1)	Zero or one; the "1" side is optional.

Figure 4.14 - COURSE and CLASS in a Mandatory Relationship

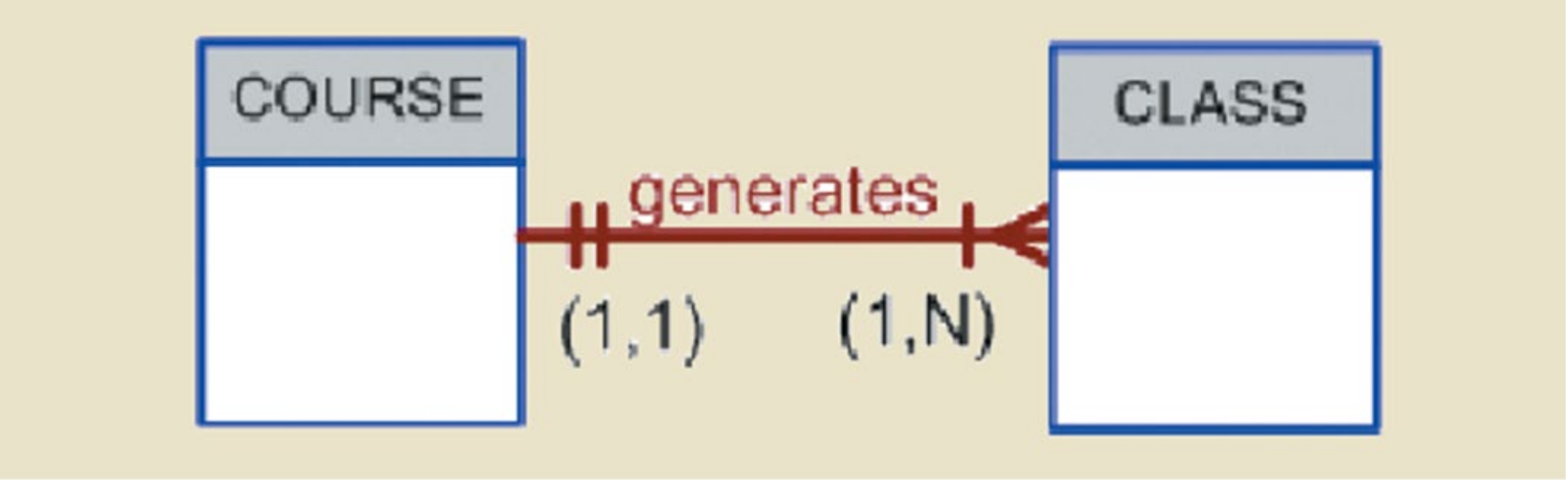


FIGURE 4.12 AN OPTIONAL CLASS ENTITY IN THE RELATIONSHIP "PROFESSOR TEACHES CLASS"

Relationship Degree

- Indicates the number of entities or participants associated with a relationship
- **Unary relationship**: Association is maintained within a single entity
  - **Recursive relationship**: Relationship exists between occurrences of the same entity set
- **Binary relationship**: Two entities are associated
- **Ternary relationship**: Three entities are associated

Figure 4.15 p Degree

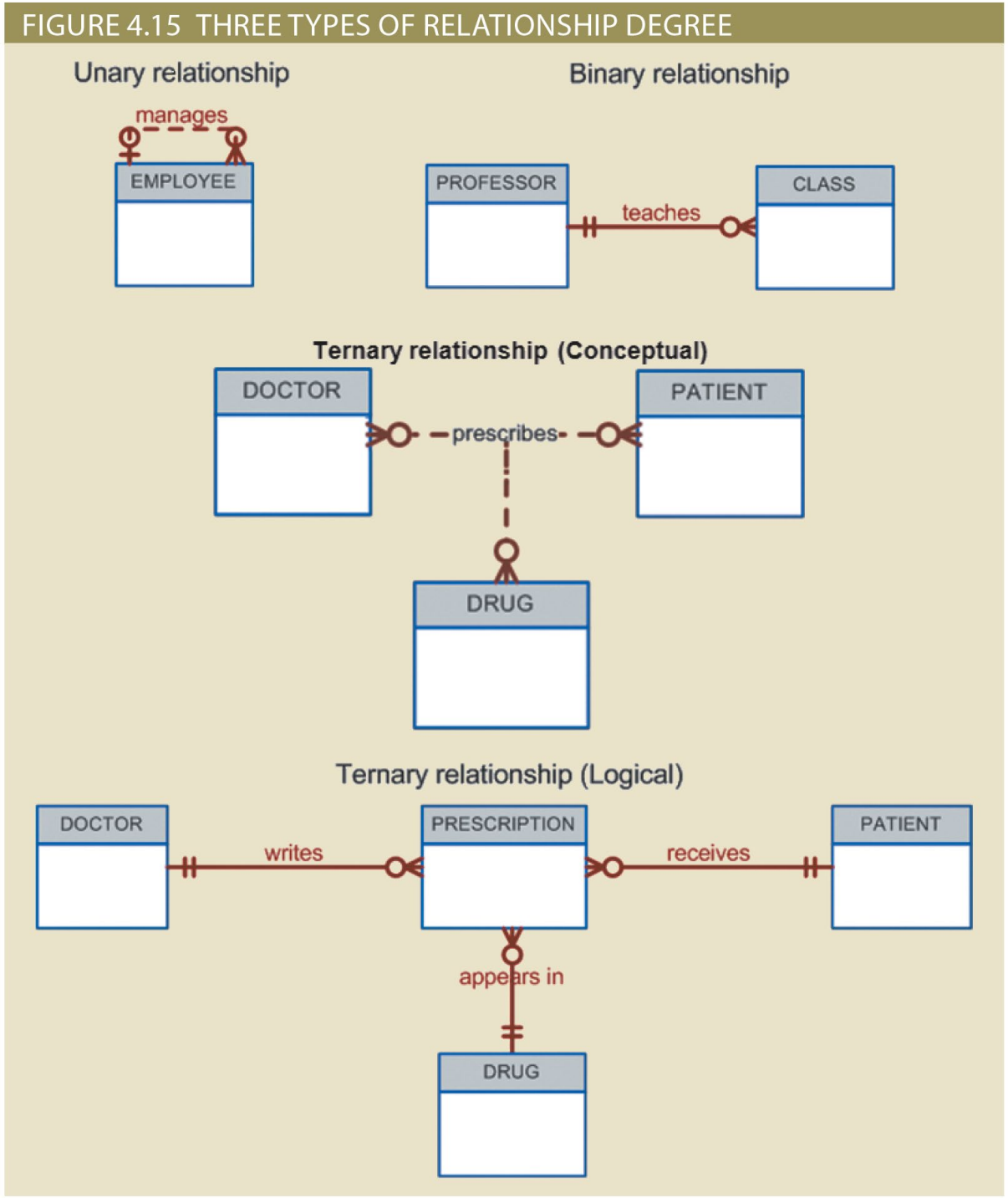


FIGURE 4.16 THE IMPLEMENTATION OF A TERNARY RELATIONSHIP

Database name: Ch04_Clinic

Table name: DRUG

DRUG_CODE	DRUG_NAME	DRUG_PRICE
AF15	Afgapan-15	25.00
AF25	Afgapan-25	35.00
DRO	Droalene Chloride	111.89
DRZ	Druzocholar Cryptolene	18.99
KO15	Koliabar Oxyhexalene	65.75
OLE	Oleander-Drizapan	123.95
TRYP	Tryptolac Heptadimetric	79.45

Table name: PATIENT

PAT_NUM	PAT_TITLE	PAT_LNAME	PAT_FNAME	PAT_INITIAL	PAT_DOB	PAT_AREACODE	PAT_PHONE
100	Mr.	Kolmycz	George	D	15-Jun-1942	615	324-5456
101	Ms.	Lewis	Rhonda	G	19-Mar-2005	615	324-4472
102	Mr.	Vandam	Rhett		14-Nov-1958	901	675-8993
103	Ms.	Jones	Anne	M	16-Oct-1974	615	898-3456
104	Mr.	Lange	John	P	08-Nov-1971	901	504-4430
105	Mr.	Williams	Robert	D	14-Mar-1975	615	890-3220
106	Mrs.	Smith	Jeanine	K	12-Feb-2003	615	324-7883
107	Mr.	Diante	Jorge	D	21-Aug-1974	615	890-4567
108	Mr.	Wiesenbach	Paul	R	14-Feb-1966	615	897-4358
109	Mr.	Smith	George	K	18-Jun-1961	901	504-3339
110	Mrs.	Genkazi	Leighla	W	19-May-1970	901	569-0093
111	Mr.	Washington	Rupert	E	03-Jan-1966	615	890-4925
112	Mr.	Johnson	Edward	E	14-May-1961	615	898-4387
113	Ms.	Smythe	Melanie	P	15-Sep-1970	615	324-9006
114	Ms.	Brandon	Marie	G	02-Nov-1932	901	882-0845
115	Mrs.	Saranda	Hermine	R	25-Jul-1972	615	324-5505
116	Mr.	Smith	George	A	08-Nov-1965	615	890-2984

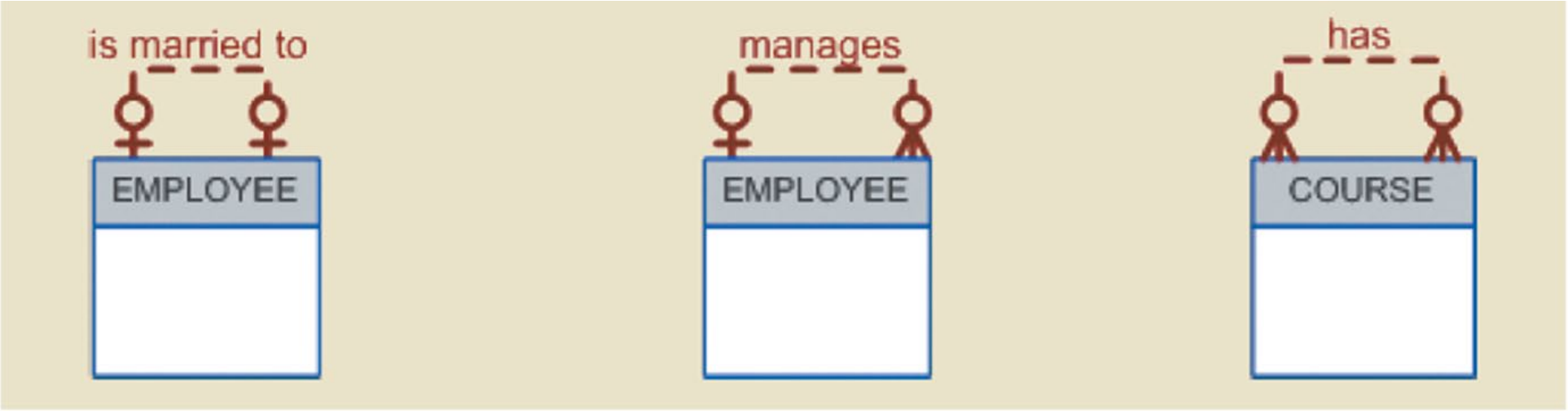
Table name: DOCTOR

DOC_ID	DOC_LNAME	DOC_FNAME	DOC_INITIAL	DOC_SPECIALTY
29827	Sanchez	Julio	J	Dermatology
32445	Jorgensen	Annelise	G	Neurology
33456	Korenski	Anatoly	A	Urology
33989	LeGrande	George		Pediatrics
34409	Washington	Dennis	F	Orthopaedics
36221	McPherson	Katye	H	Dermatology
36712	Dreifag	Herman	G	Psychiatry
38995	Minh	Tran		Neurology
40004	Chin	Ming	D	Orthopaedics
40028	Feinstein	Denise	L	Gynecology

Table name: PRESCRIPTION

DOC_ID	PAT_NUM	DRUG_CODE	PRES_DOSAGE	PRES_DATE
32445	102	DRZ	2 tablets every four hours -- 50 tablets total	12-Nov-16
32445	113	OLE	1 teaspoon with each meal -- 250 ml total	14-Nov-16
34409	101	KO15	1 tablet every six hours -- 30 tablets total	14-Nov-16
36221	109	DRO	2 tablets with every meal -- 60 tablets total	14-Nov-16
38995	107	KO15	1 tablet every six hours -- 30 tablets total	14-Nov-16

Figure 4.17 - An ER Representation of Recursive Relationships



Associative (Composite) Entities

- Used to represent an M:N relationship between two or more entities
- Is in a 1:M relationship with the parent entities
  - Composed of the primary key attributes of each parent entity
- May also contain additional attributes that play no role in connective process

Figure 4.23 - Converting the M:N Relationship into Two 1:M Relationships

Table name: STUDENT

Database name: Ch04_CollegeTry

STU_NUM	STU_LNAME
321452	Bowser
324257	Smithson

Table name: ENROLL

CLASS_CODE	STU_NUM	ENROLL_GRADE
10014	321452	C
10014	324257	B
10018	321452	A
10018	324257	B
10021	321452	C
10021	324257	C

Table name: CLASS

CLASS_CODE	CRS_CODE	CLASS_SECTION	CLASS_TIME	ROOM_CODE	PROF_NUM
10014	ACCT-211	3	TTh 2:30-3:45 p.m.	BUS252	342
10018	CIS-220	2	MWF 9:00-9:50 a.m.	KLR211	114
10021	QM-261	1	MWF 8:00-8:50 a.m.	KLR200	114

Figure 4.25 - A Composite Entity in an ERD