Chapter 4
Entity Relationship (ER) Modeling

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

Entity Relationship Model (ERM)

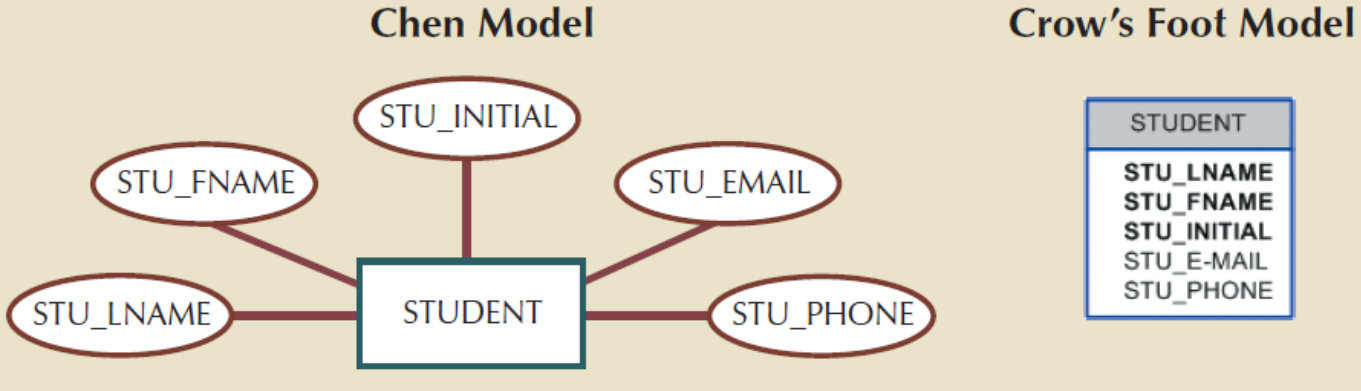
- Basis of an entity relationship diagram (ERD)
- ERD depicts the:
  - Conceptual database as viewed by end user
  - Database's main components
    - Entities
    - Attributes
    - Relationships
- Entity - Refers to the entity set and not to a single entity occurrence

Attributes

- 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

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

FIGURE 4.1 THE ATTRIBUTES OF THE STUDENT ENTITY: CHEN AND CROW' FOOT

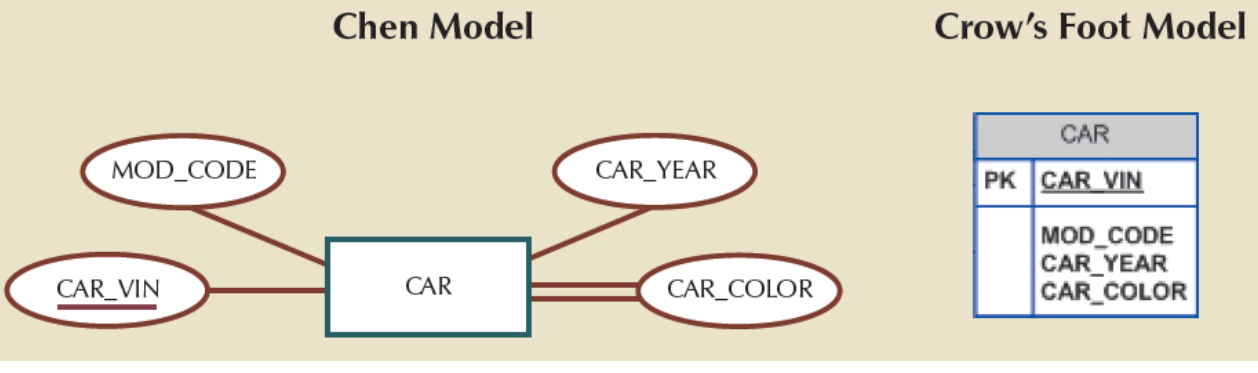


Attributes

- **Composite identifier**: Primary key composed of more than one attribute
- **Composite attribute**: Attribute that can be subdivided to yield additional attributes
- **Simple attribute**: Attribute that cannot be subdivided
- **Single-valued attribute**: Attribute that has only a single value
- **Multivalued attributes**: Attributes that have many values

Figure 4.3 - A Multivalued Attribute in an Entity

FIGURE 4.3 A MULTIVALUED ATTRIBUTE IN AN ENTITY



Attributes

- **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 4.4 – Splitting the Multivalued Attributes into New Attributes

FIGURE 4.4 SPLITTING THE MULTIVALUED ATTRIBUTE INTO NEW ATTRIBUTES

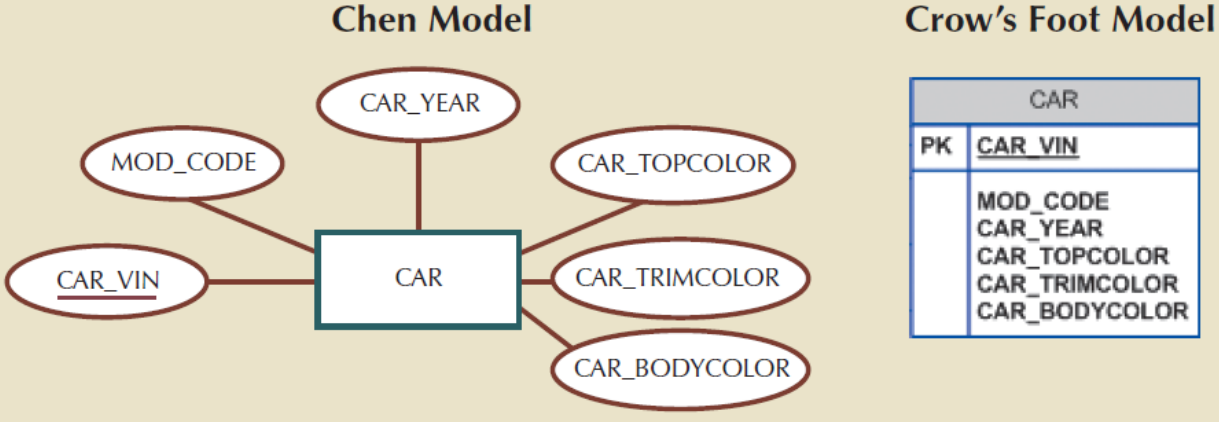


Figure 4.6 - Depiction of a Derived Attribute

FIGURE 4.6 DEPICTION OF A DERIVED ATTRIBUTE

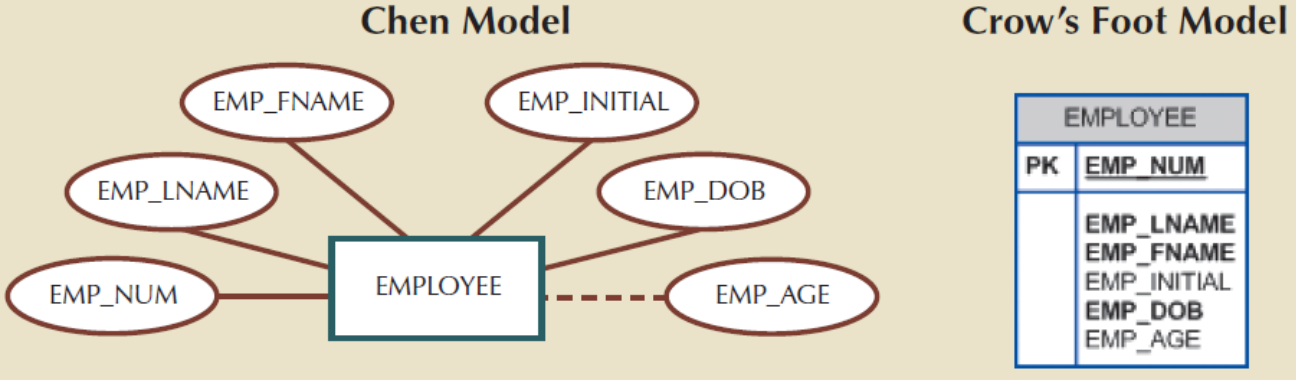


Table 4.2 - Advantages and Disadvantages of Storing Derived Attributes

TABLE 4.2

ADVANTAGES AND DISADVANTAGES OF STORING DERIVED ATTRIBUTES

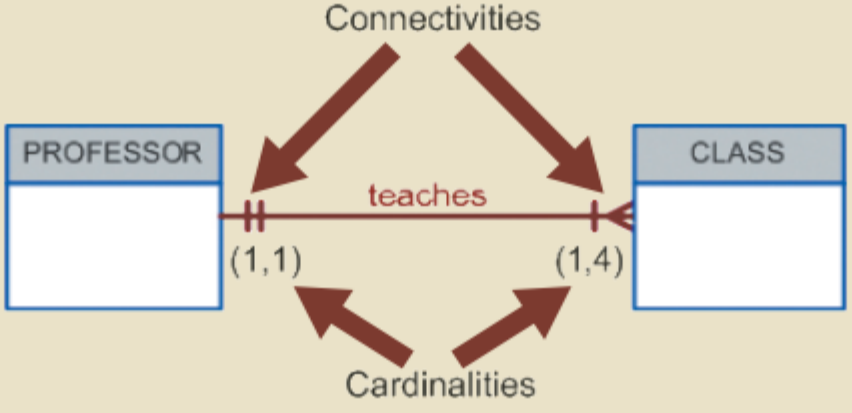
	DERIVED ATTRIBUTE	
	STORED	**NOT STORED**
Advantage	Saves CPU processing cycles Saves data access time Data value is readily available Can be used to keep track of historical data	Saves storage space Computation always yields current value
Disadvantage	Requires constant maintenance to ensure derived 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

Figure 4.7 - Connectivity and Cardinality in an ERD

FIGURE 4.7 CONNECTIVITY AND CARDINALITY IN AN ERD



Existence Dependence

Existence dependence	Existence independence
• Entity exists in the database only when it is associated with another related entity occurrence	• 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

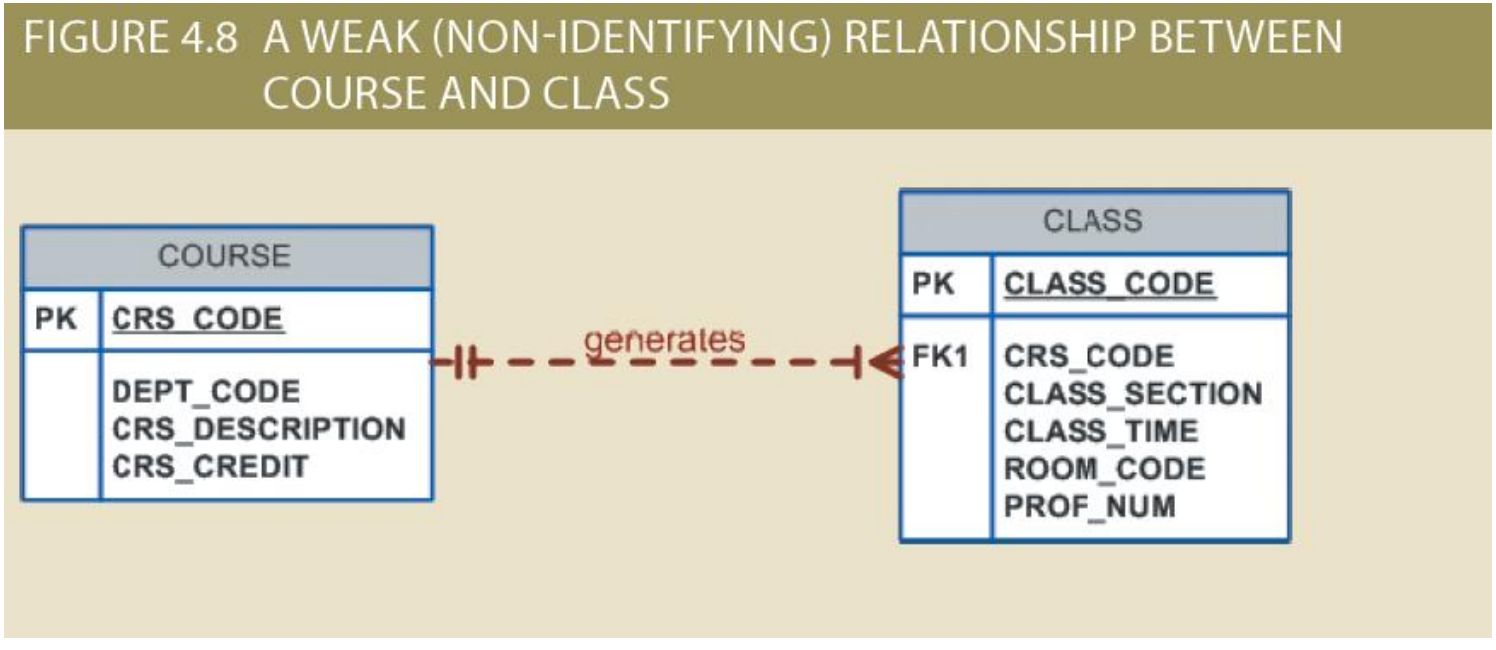
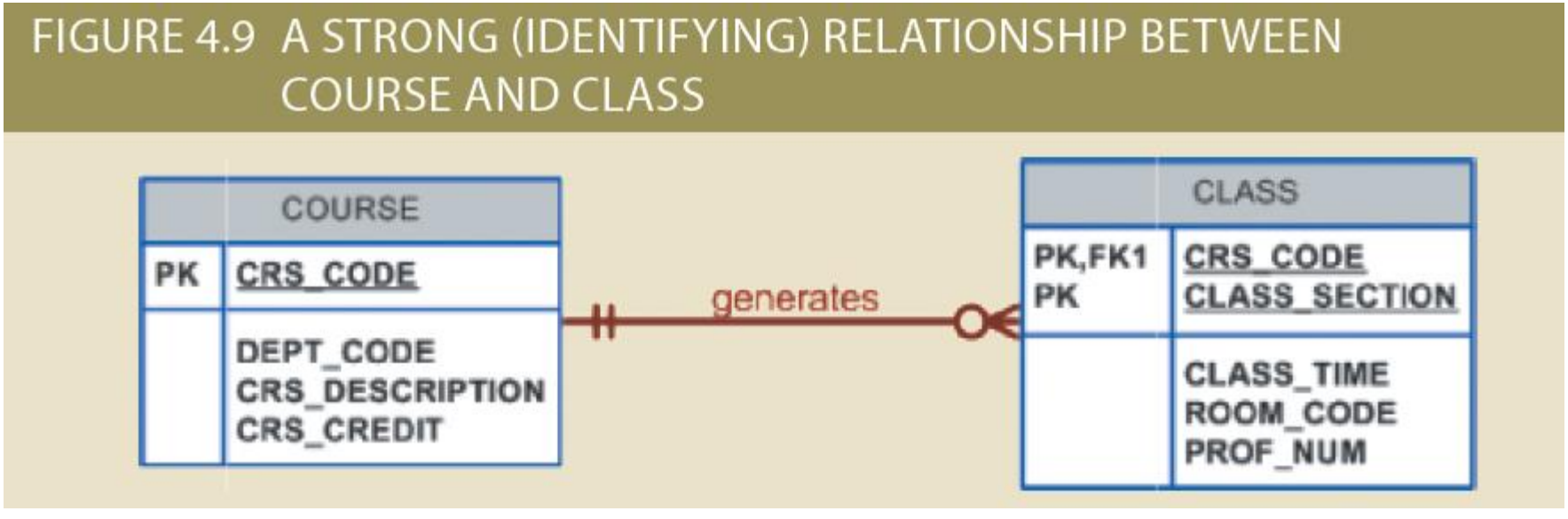


Figure 4.9 - A Strong (Identifying) Relationship between COURSE and CLASS



Weak Entity

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

Figure 4.10 - A Weak Entity in an ERD

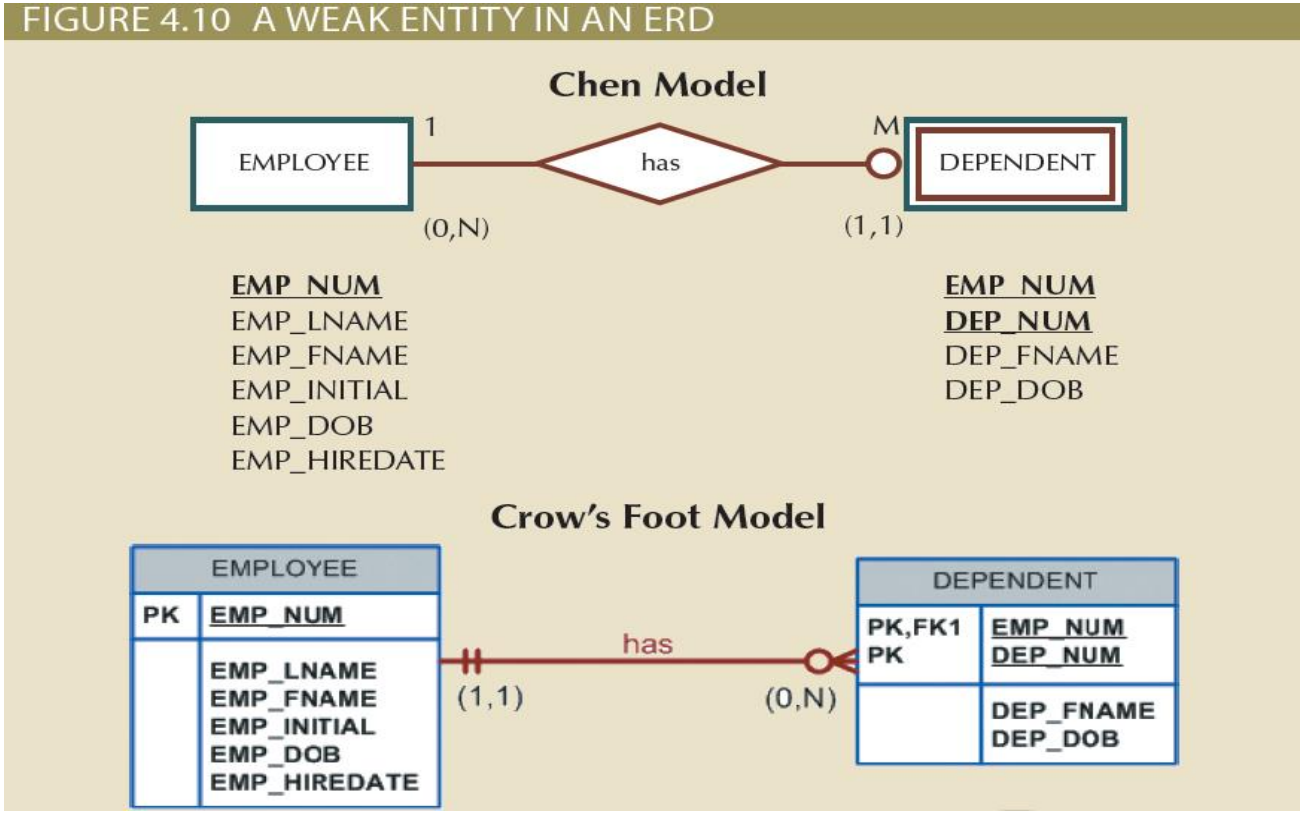


Figure 4.11 - A Weak Entity in a Strong Relationship

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

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 4.13 - CLASS is Optional to COURSE

FIGURE 4.13 CLASS IS OPTIONAL TO COURSE

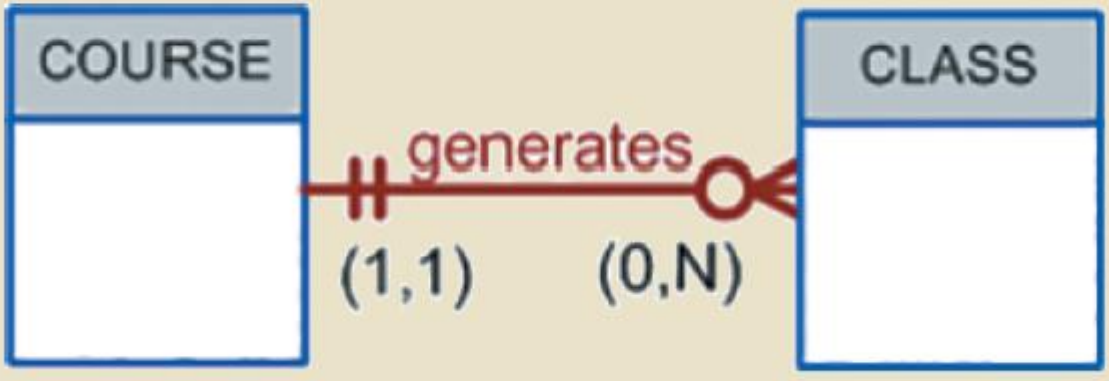
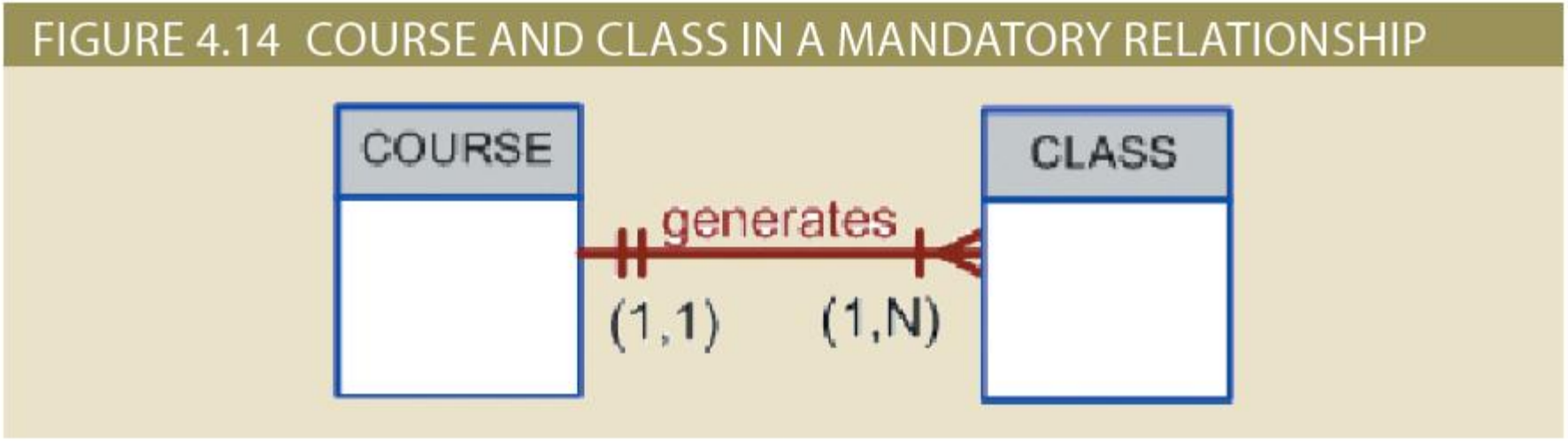


Figure 4.14 - COURSE and CLASS in a Mandatory Relationship



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 - Three Types of Relationship Degree

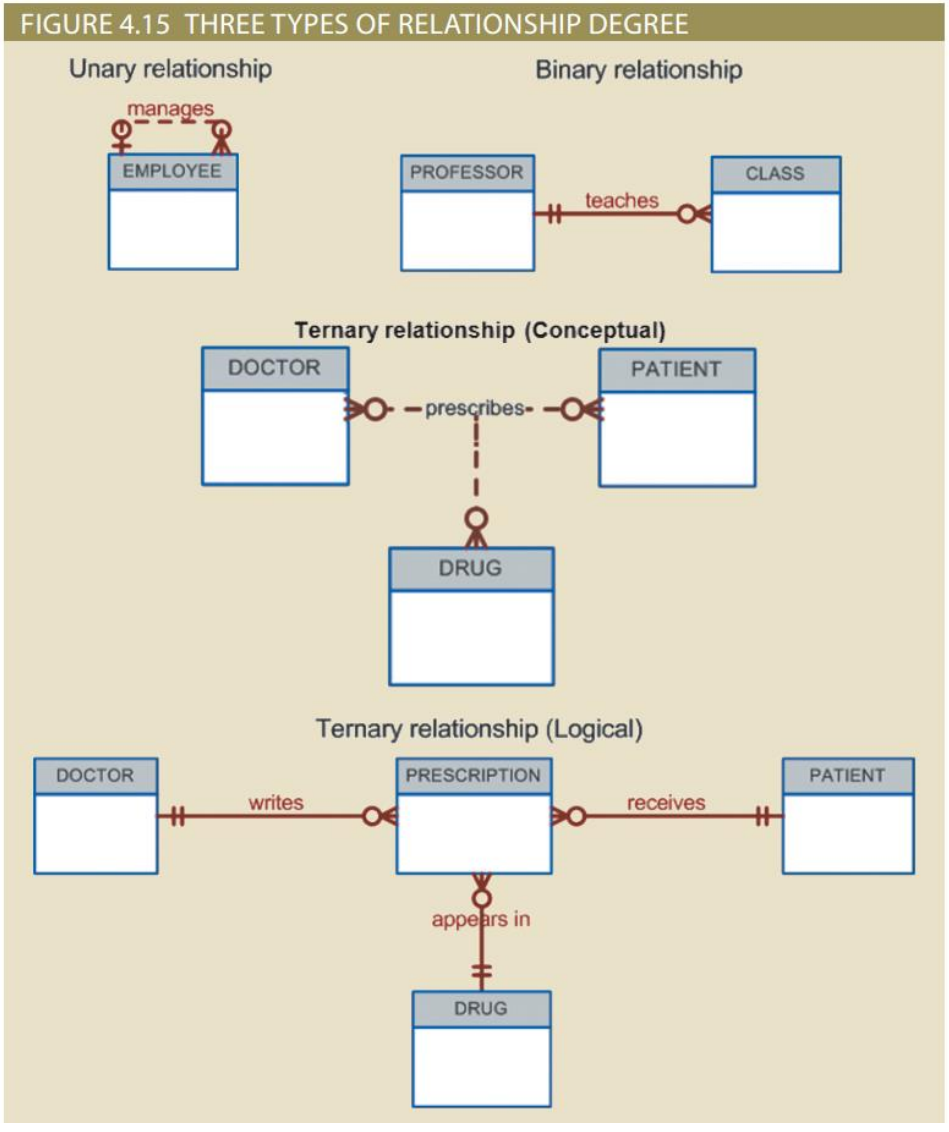
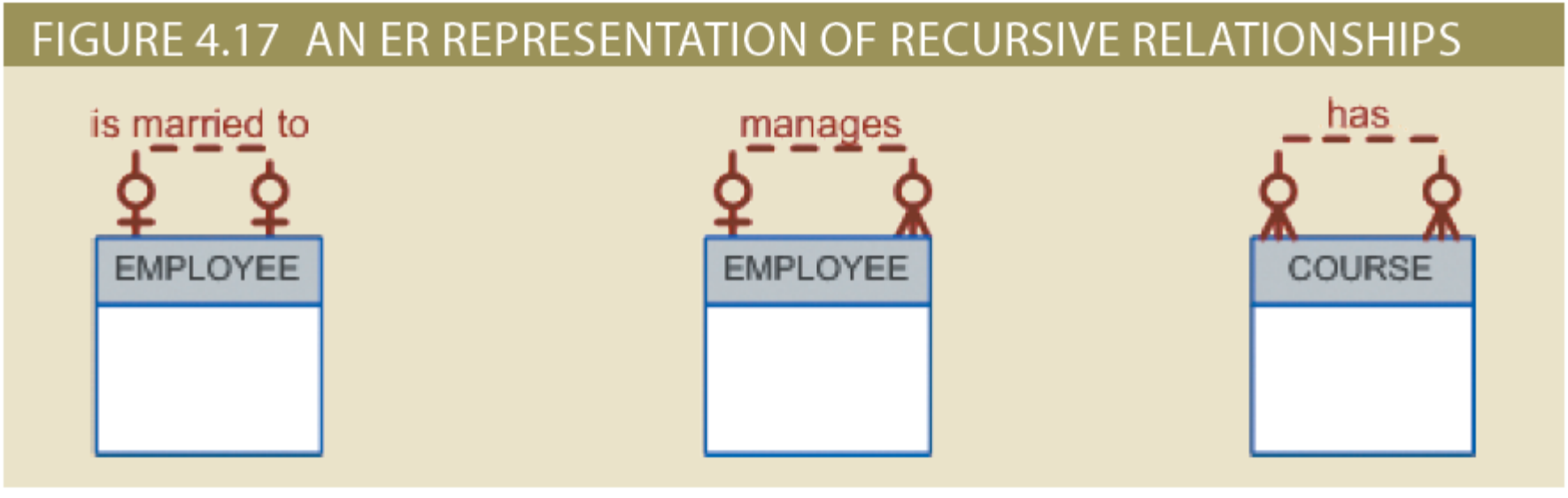


Figure 4.17 - An ER Representation of Recursive Relationships



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

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

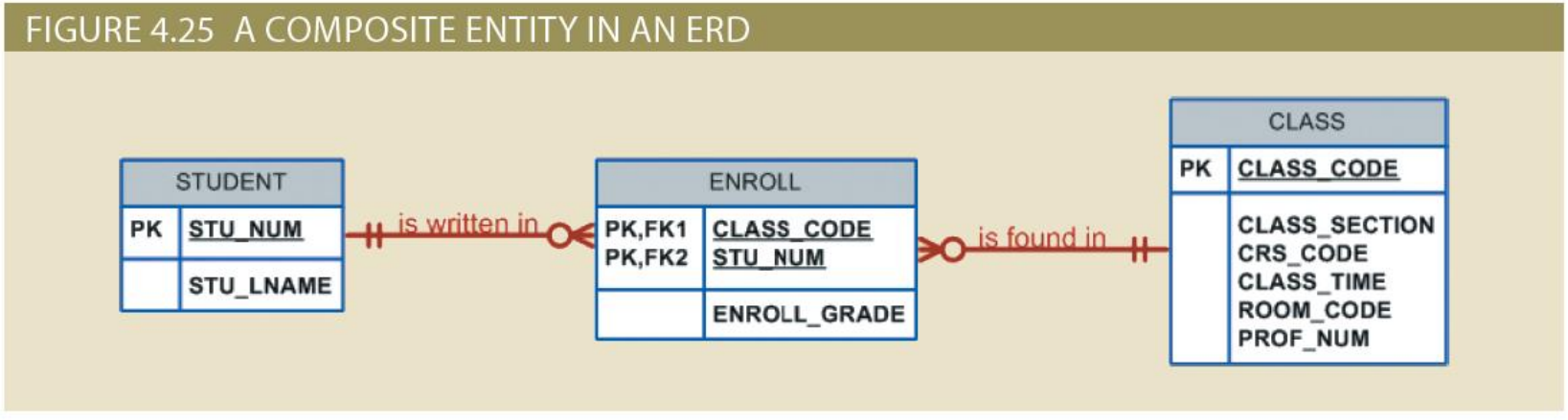
Table name: ENROLL

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



Developing an ER Diagram

- Create a detailed narrative of the organization's description of operations
- Identify business rules based on the descriptions
- Identify main entities and relationships from the business rules
- Develop the initial ERD
- Identify the attributes and primary keys that adequately describe entities
- Revise and review ERD

Figure 4.26 - The First Tiny College ERD Segment

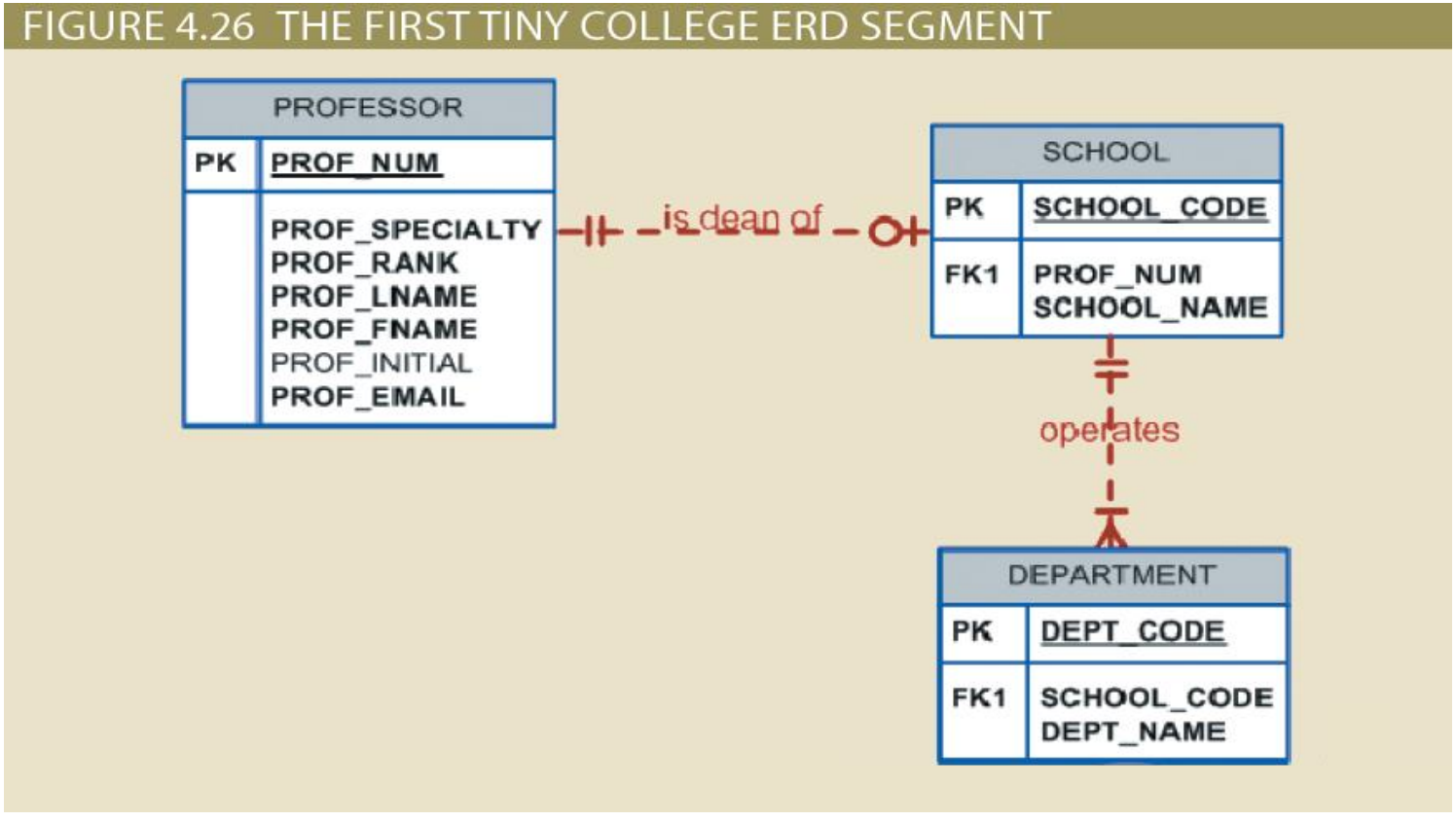


Figure 4.27 - The Second Tiny College ERD Segment

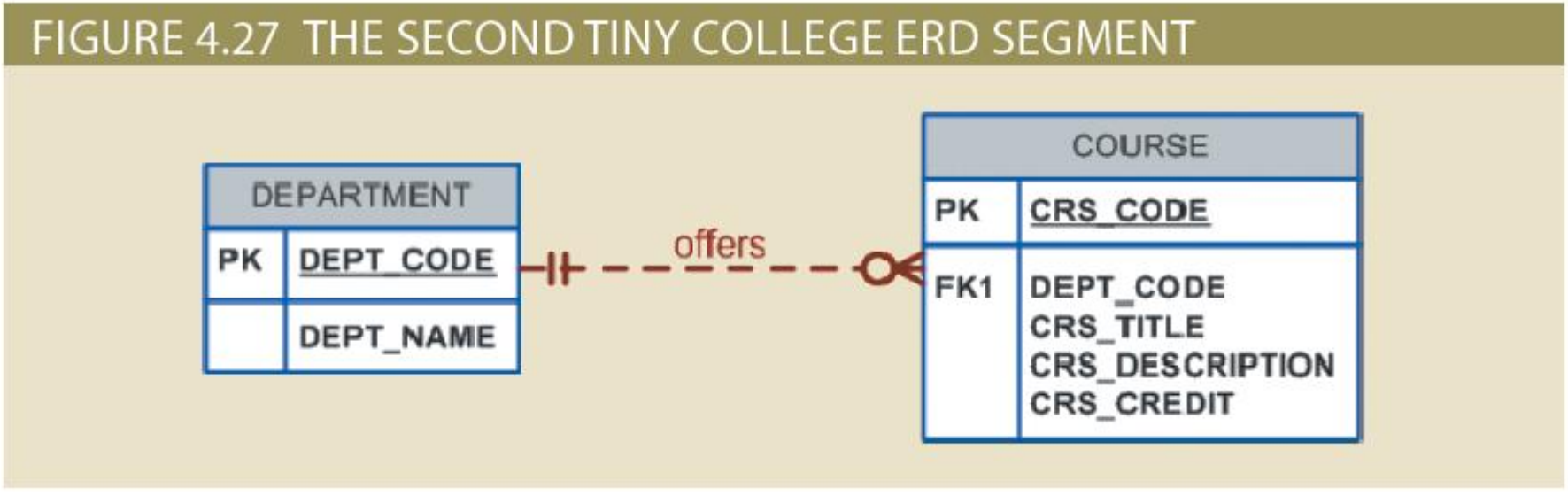


Figure 4.28 - The Third Tiny College ERD Segment

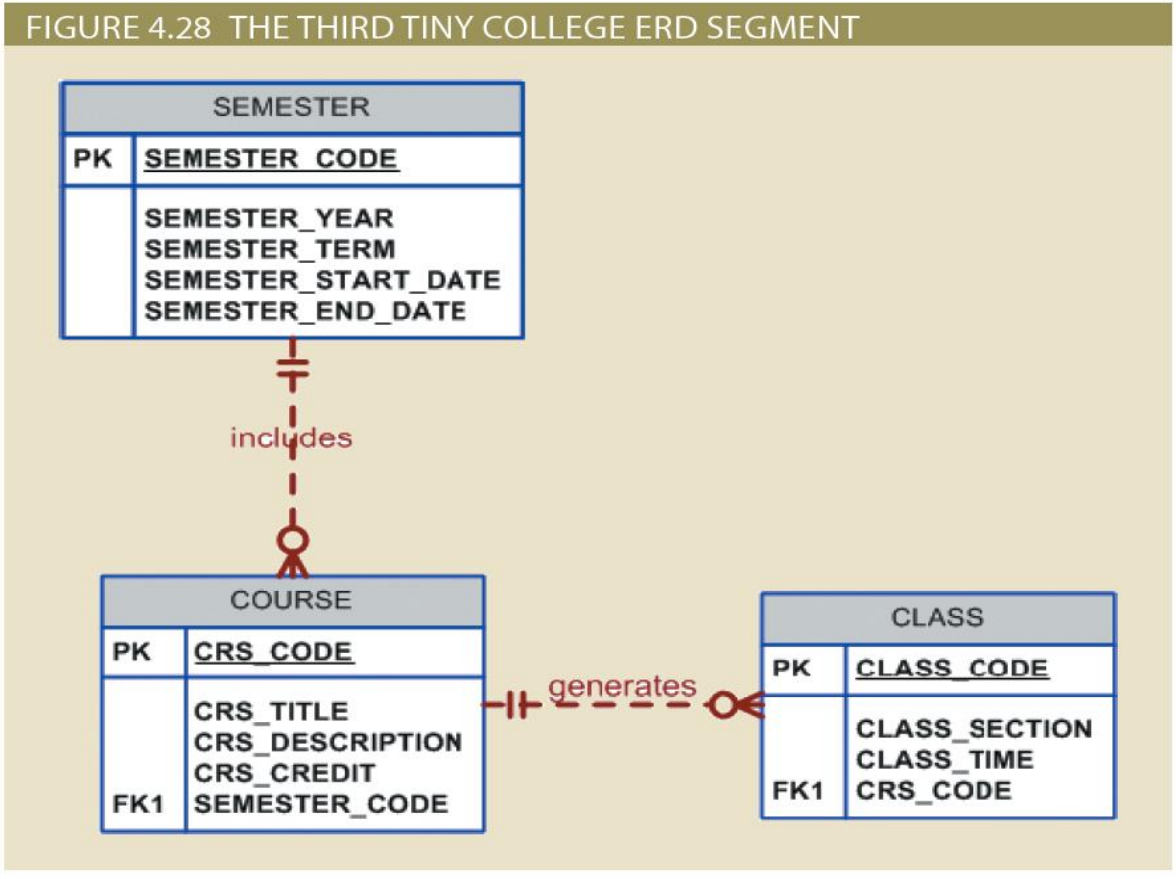


Figure 4.29 - The Fourth Tiny College ERD Segment

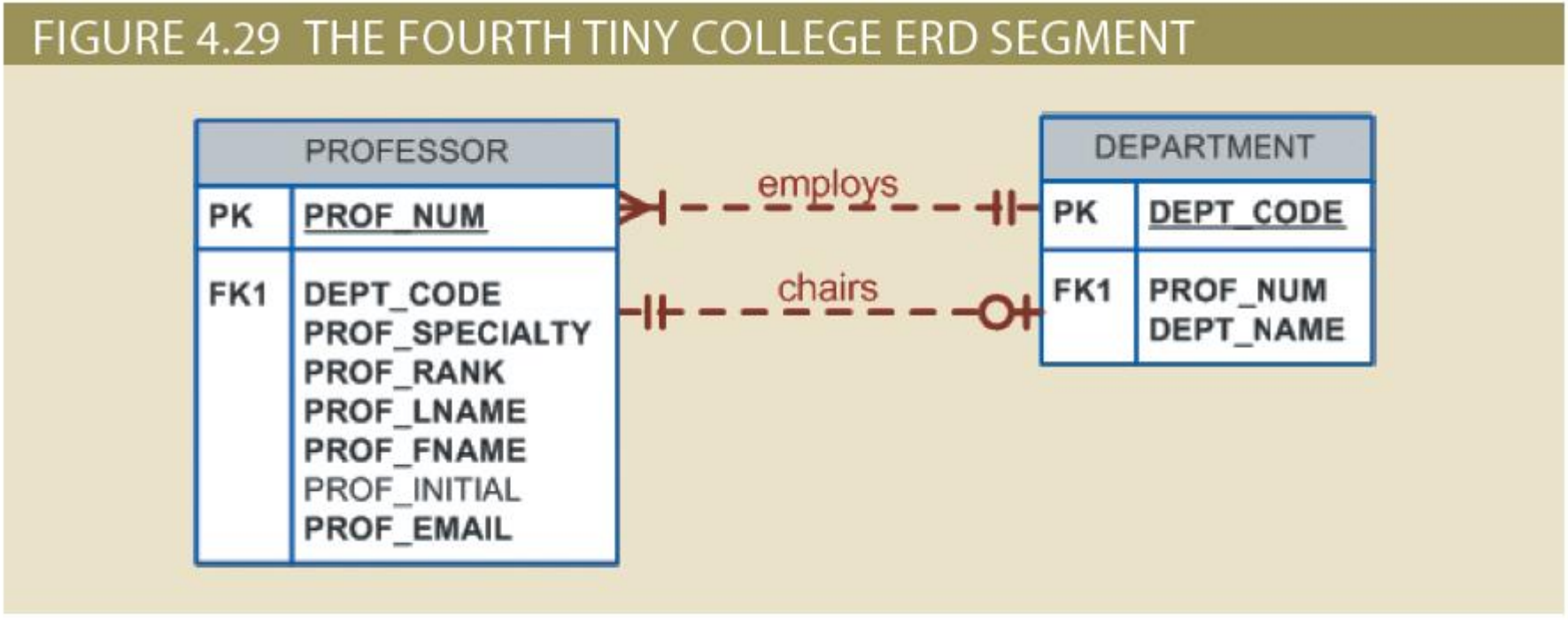


Figure 4.30 - The Fifth Tiny College ERD Segment

FIGURE 4.30 THE FIFTH TINY COLLEGE ERD SEGMENT

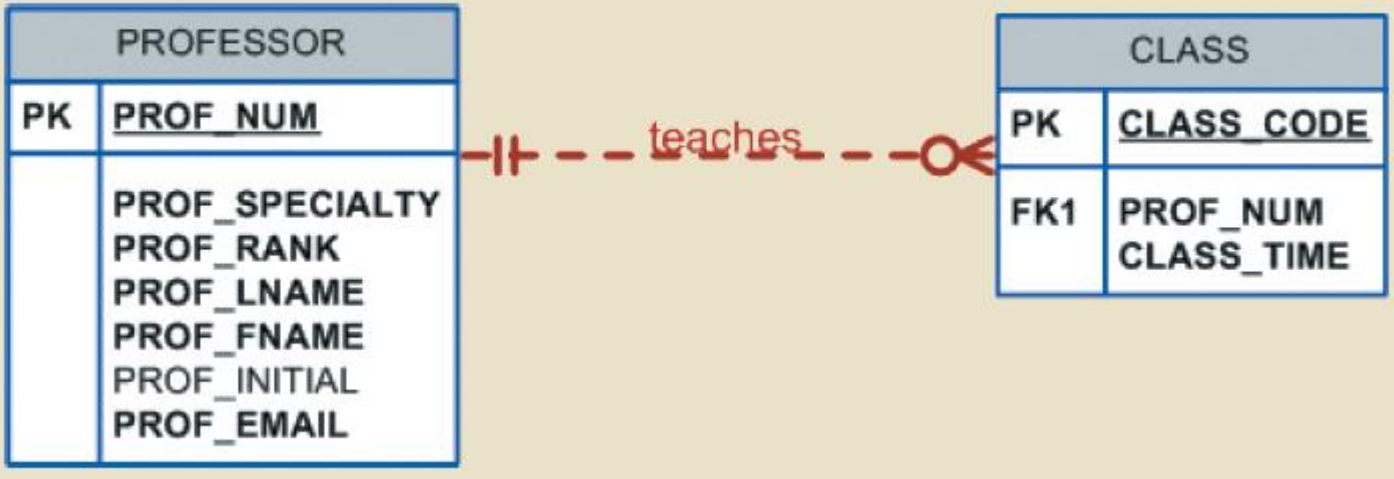


Figure 4.31 - The Sixth Tiny College ERD Segment

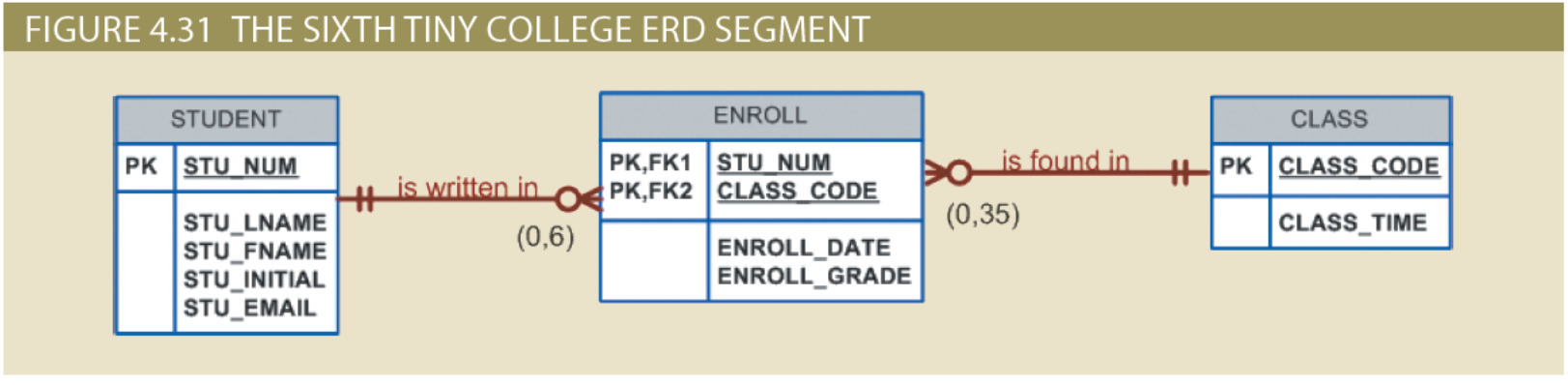


Figure 4.32 - The Seventh Tiny College ERD Segment

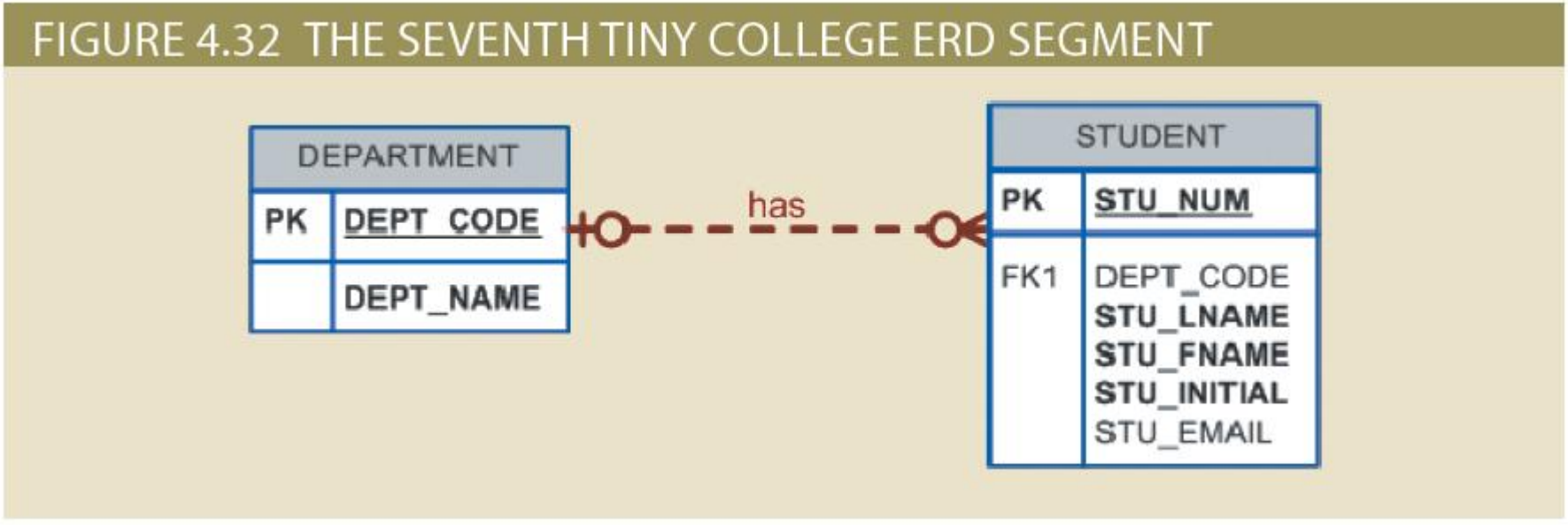


Figure 4.33 - The Eighth Tiny College ERD Segment

FIGURE 4.33 THE EIGHT TINY COLLEGE ERD SEGMENT

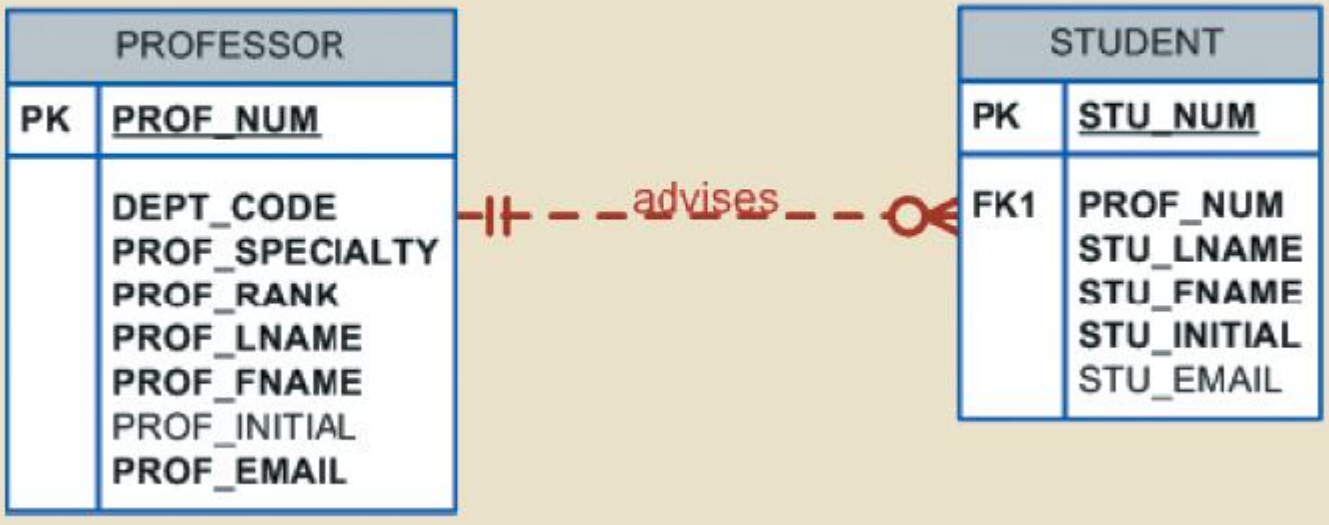


Figure 4.34 - The Ninth Tiny College ERD Segment

FIGURE 4.34 THE NINTH TINY COLLEGE ERD SEGMENT

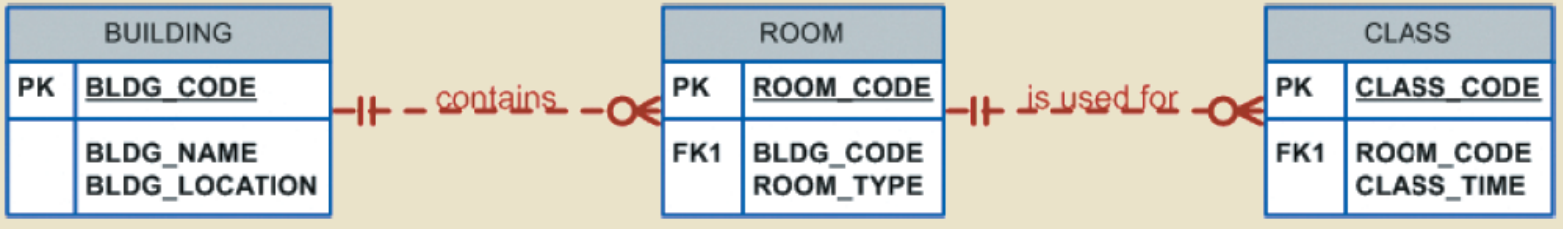


Table 4.4 - Components of the ERM

TABLE 4.4

COMPONENTS OF THE ERM

ENTITY	RELATIONSHIP	CONNECTIVITY	ENTITY
SCHOOL	operates	1:M	DEPARTMENT
DEPARTMENT	has	1:M	STUDENT
DEPARTMENT	employs	1:M	PROFESSOR
DEPARTMENT	offers	1:M	COURSE
COURSE	generates	1:M	CLASS
SEMESTER	includes	1:M	CLASS
PROFESSOR	is dean of	1:1	SCHOOL
PROFESSOR	chairs	1:1	DEPARTMENT
PROFESSOR	teaches	1:M	CLASS
PROFESSOR	advises	1:M	STUDENT
STUDENT	enrolls in	M:N	CLASS
BUILDING	contains	1:M	ROOM
ROOM	is used for	1:M	CLASS

Note: ENROLL is the composite entity that implements the M:N relationship "STUDENT enrolls in CLASS."

Database Design Challenges: Conflicting Goals

- Database design must conform to design standards
- Need for high processing speed may limit the number and complexity of logically desirable relationships
- Need for maximum information generation may lead to loss of clean design structures and high transaction speed

Figure 4.38 - Various Implementations of the 1:1 Recursive Relationship

FIGURE 4.38 VARIOUS IMPLEMENTATIONS OF THE 1:1 RECURSIVE RELATIONSHIP

Table name: EMPLOYEE_V1 — **Database name: Ch04_PartCo**

EMP_NUM	EMP_LNAME	EMP_FNAME	EMP_SPOUSE
345	Ramirez	James	347
346	Jones	Anne	349
347	Ramirez	Louise	345
348	Delaney	Robert	
349	Shapiro	Anton	346

First implementation

Table name: EMPLOYEE

EMP_NUM	EMP_LNAME	EMP_FNAME
345	Ramirez	James
346	Jones	Anne
347	Ramirez	Louise
348	Delaney	Robert
349	Shapiro	Anton

Table name: MARRIED_V1

EMP_NUM	EMP_SPOUSE
345	347
346	349
347	345
349	346

Second implementation

Table name: MARRIAGE

MAR_NUM	MAR_DATE
1	04-Mar-03
2	02-Feb-99

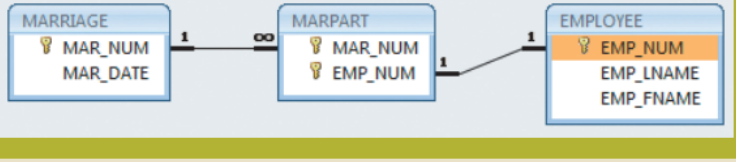
Table name: MARPART

MAR_NUM	EMP_NUM
1	345
1	347
2	346
2	349

Table name: EMPLOYEE

EMP_NUM	EMP_LNAME	EMP_FNAME
345	Ramirez	James
346	Jones	Anne
347	Ramirez	Louise
348	Delaney	Robert
349	Shapiro	Anton

The relational diagram for the third implementation



Third implementation