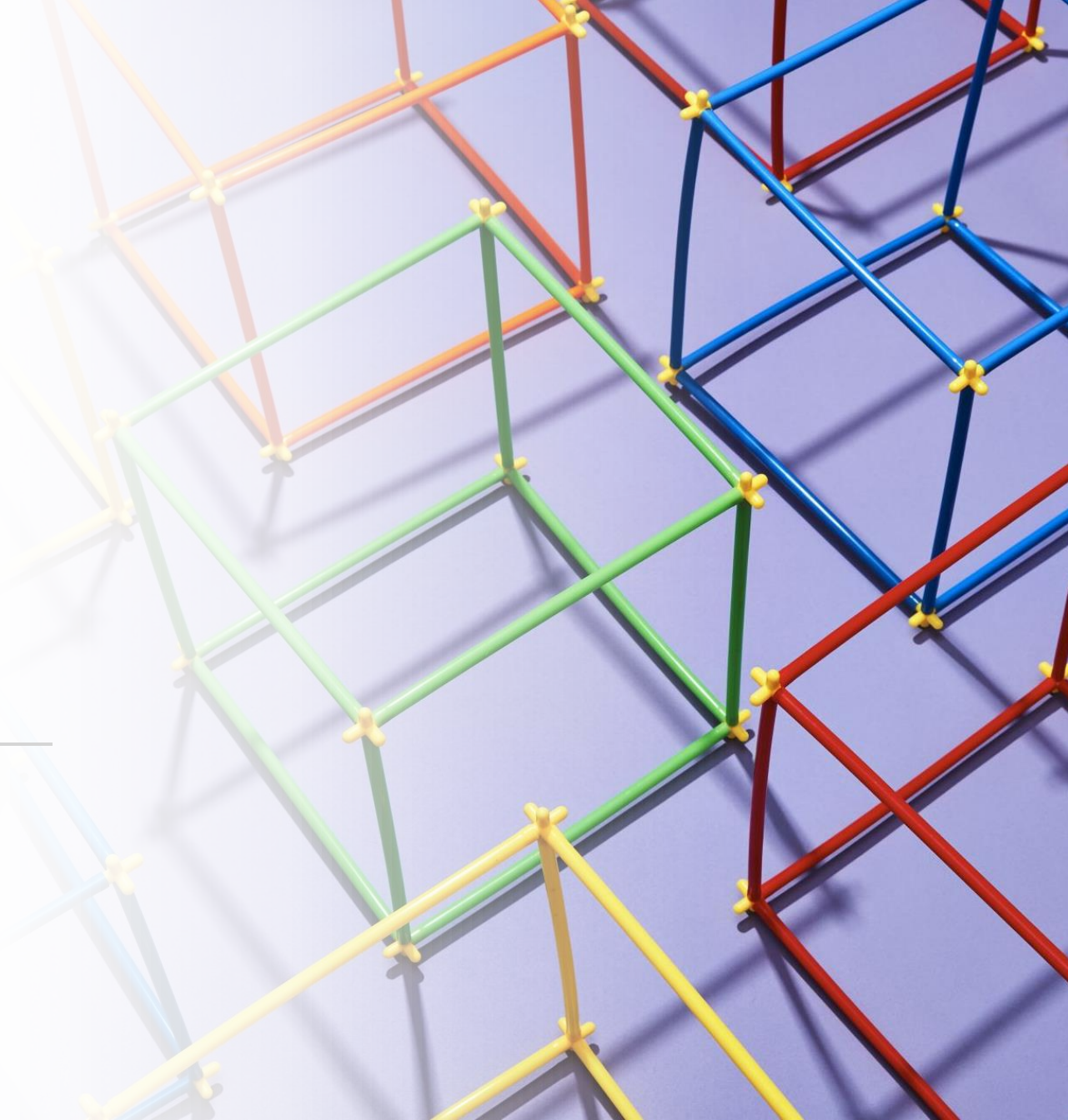
4. Entity Relationship (ER) Modeling

Database Design & Business Application Development



Learning Objectives

- After completing this class, you will be able to:
  - Identify the main characteristics of entity relationship components
  - Describe how relationships between entities are defined, refined, and incorporated into the database design process
  - See how ERD components affect database design and implementation
  - Understand that real-world database design often requires the reconciliation of conflicting goals

The Entity Relationship Model (ERM)

Forms the basis of an entity relationship diagram (ERD)

- Conceptual database as viewed by end user

Database's main components

- Entities
- Attributes
- Relationships

Entities

Object of interest to the end user

- Refers to the entity set and not to a single entity occurrence

ERM corresponds to a table—not to a row—in the relational environment

- ERM refers to a table row as an entity instance or entity occurrence

In Chen, Crow's Foot, and UML notations, an entity is represented by a rectangle that contains the entity's name

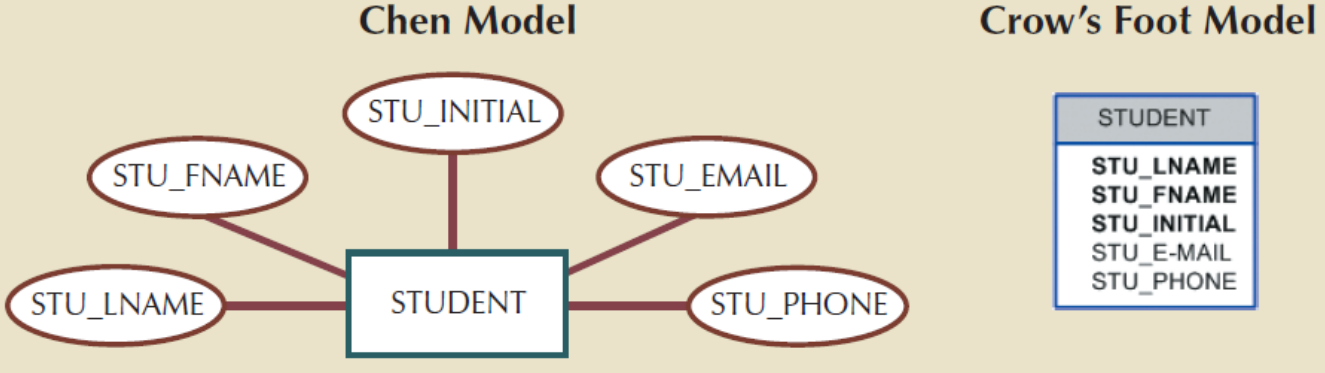
- The entity name, a noun, is usually written in all capital letters

Attributes (1 of 7)

- Characteristics of entities
  - Required attribute: must have a value and cannot be left empty
  - Optional attribute: does not require a value and can be left empty
  - Domain: set of possible values for a given attribute
  - Identifier: one or more attributes that uniquely identify each entity instance
  - 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

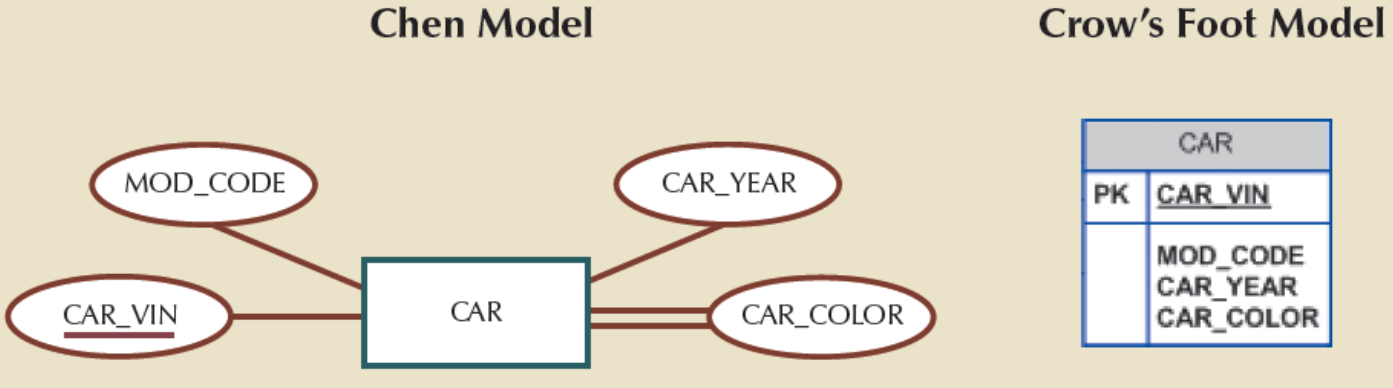
Attributes (2 of 7)

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



Attributes (3 of 7)

FIGURE 4.3 A MULTIVALUED ATTRIBUTE IN AN ENTITY

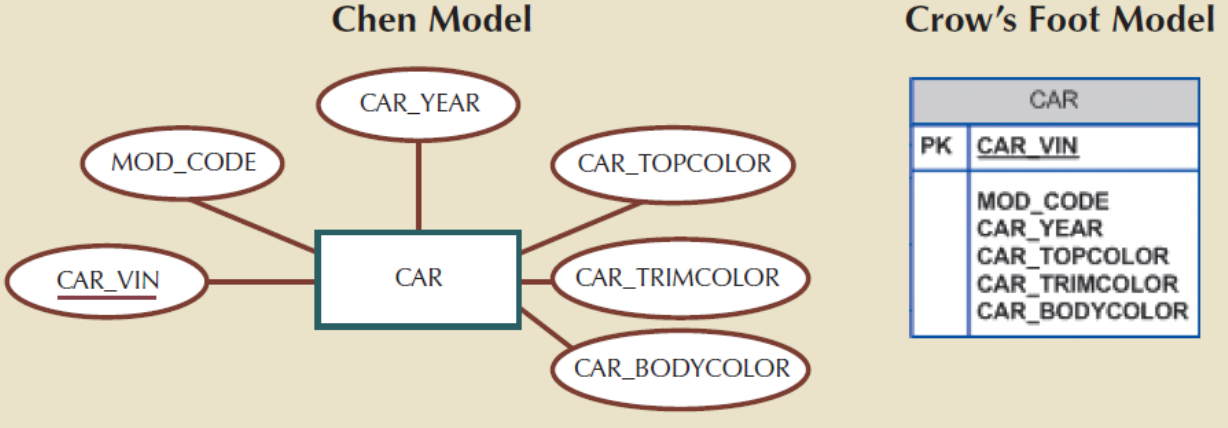


Attributes (4 of 7)

- Requirements of multivalued attributes
  - Create several new attributes, one for each component of the original multivalued attribute
  - Develop 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

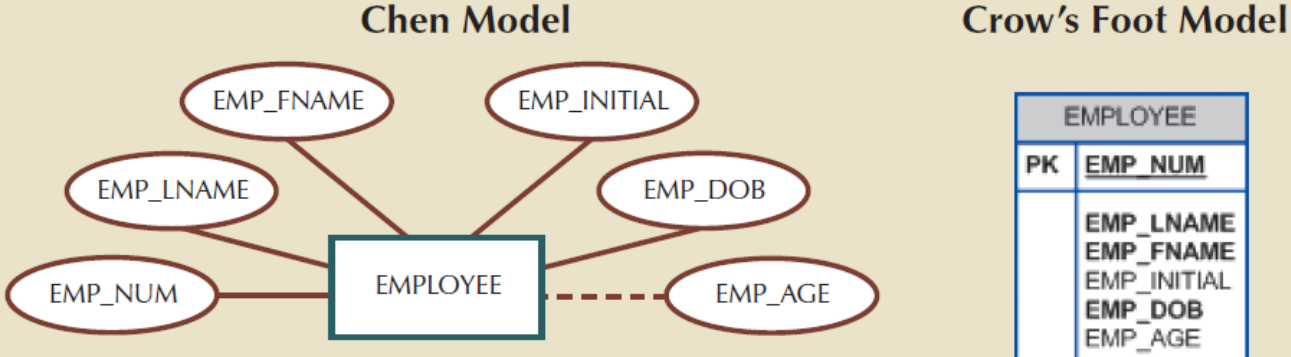
Attributes (5 of 7)

FIGURE 4.4 SPLITTING THE MULTIVALUED ATTRIBUTE INTO NEW ATTRIBUTES



Attributes (6 of 7)

FIGURE 4.6 DEPICTION OF A DERIVED ATTRIBUTE



Attributes (7 of 7)

Table 4.2	Advantages and Disadvantages of Storing Derived Attributes	
	Derived Attribute: Stored	**Derived Attribute: 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, Connectivity, and Cardinality

- Association between entities that always operate in both directions
  - Participants: entities that participate in a relationship
- Connectivity: describes the relationship classification
  - Include 1:1, 1:M, and M:N
- Cardinality: expresses the minimum and maximum number of entity occurrences associated with one occurrence of related entity
  - In the ERD, cardinality is indicated by placing the appropriate numbers beside the entities, using the format (x, y)

Existence Dependence

Existence dependence

- Entity exists in the database only when it is associated with another related entity occurrence

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

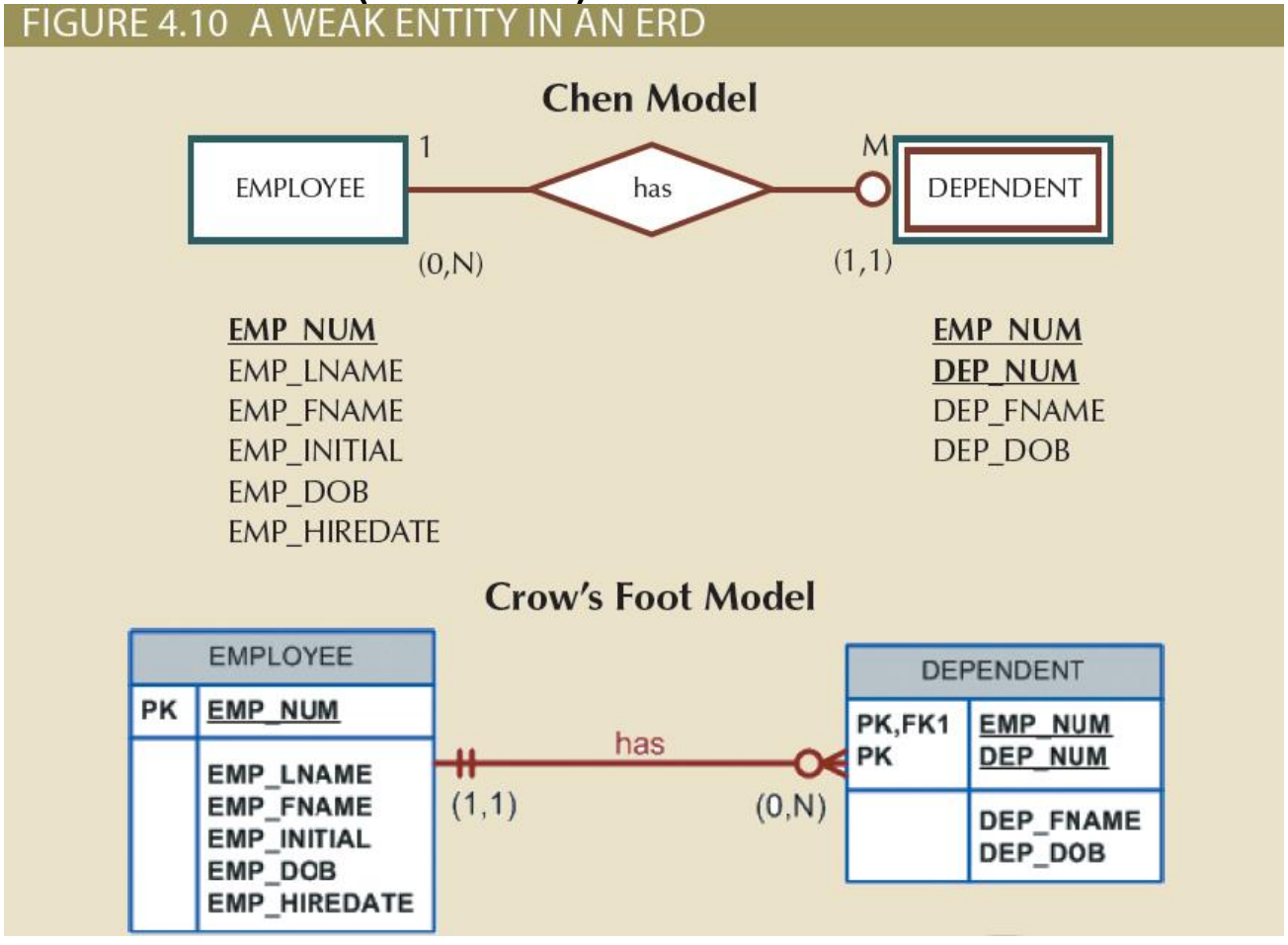
- Primary key of the related entity contains a primary key component of the parent entity

Weak Entities (1 of 3)

Conditions of a weak entity	• 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

Weak Entities (2 of 3)

FIGURE 4.10 A WEAK ENTITY IN AN ERD



Weak Entities (3 of 3)

FIGURE 4.11 A WEAK ENTITY IN A STRONG RELATIONSHIP

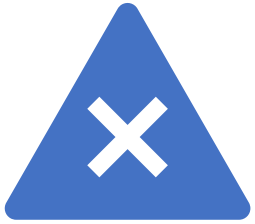
Table name: EMPLOYEE **Database name: Ch04_ShortCo**

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 (1 of 3)



Optional participation

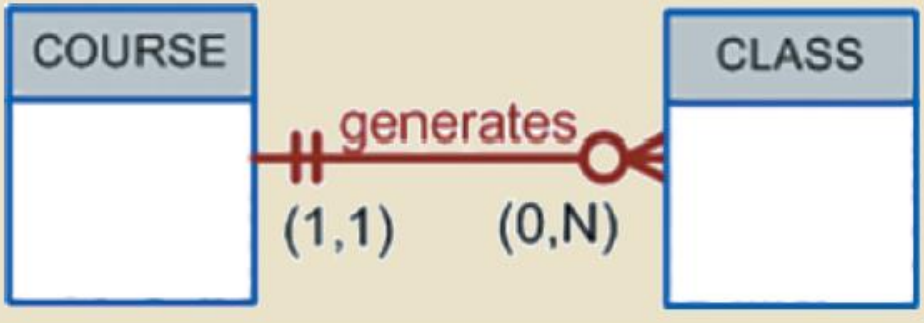
One entity occurrence does not require a corresponding entity occurrence in a particular relationship

Mandatory participation

One entity occurrence requires a corresponding entity occurrence in a particular relationship

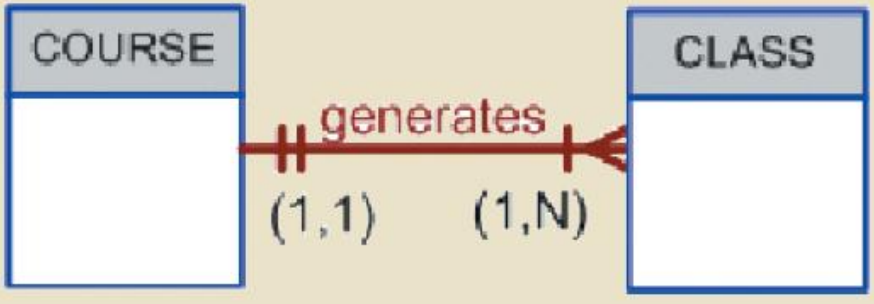
Relationship Participation (2 of 3)

FIGURE 4.13 CLASS IS OPTIONAL TO COURSE



Relationship Participation (3 of 3)

FIGURE 4.14 COURSE AND CLASS IN A MANDATORY RELATIONSHIP

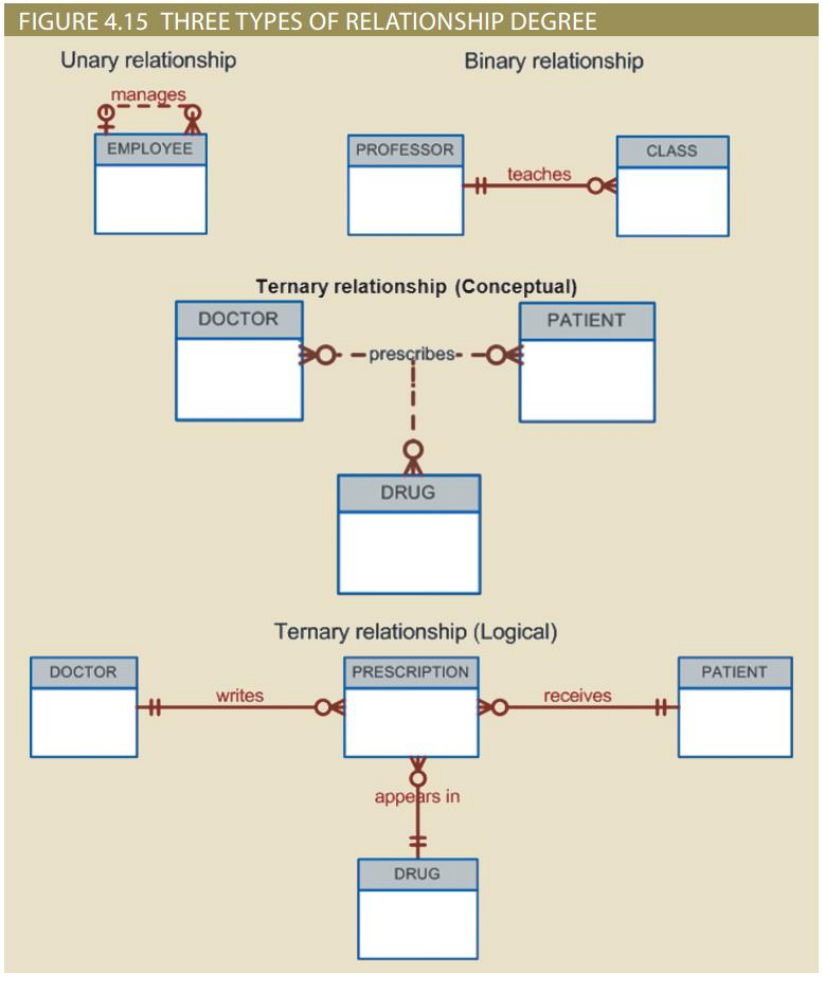


Relationship Degree (1 of 2)

- Indicates the number of entities or participants associated with a relationship
  - Unary relationship: association is maintained within a single entity
  - Binary relationship: two entities are associated
  - Ternary relationship: three entities are associated
  - Recursive relationship: relationship exists within a single entity type

Relationship Degree (2 of 2)

FIGURE 4.15 THREE TYPES OF RELATIONSHIP DEGREE



Recursive Relationships (1 of 2)

Relationship can exist between occurrences of the same entity set

Naturally, such a condition is found within a unary relationship

- Common in manufacturing industries

One common pitfall when working with unary relationships is to confuse participation with referential integrity

Similar because they are both implemented through constraints on the same set of attributes

Recursive Relationships (2 of 2)

FIGURE 4.17 AN ER REPRESENTATION OF RECURSIVE RELATIONSHIPS

Associative (Composite) Entities (1 of 2)

Used to represent an M:N relationship between two or more entities

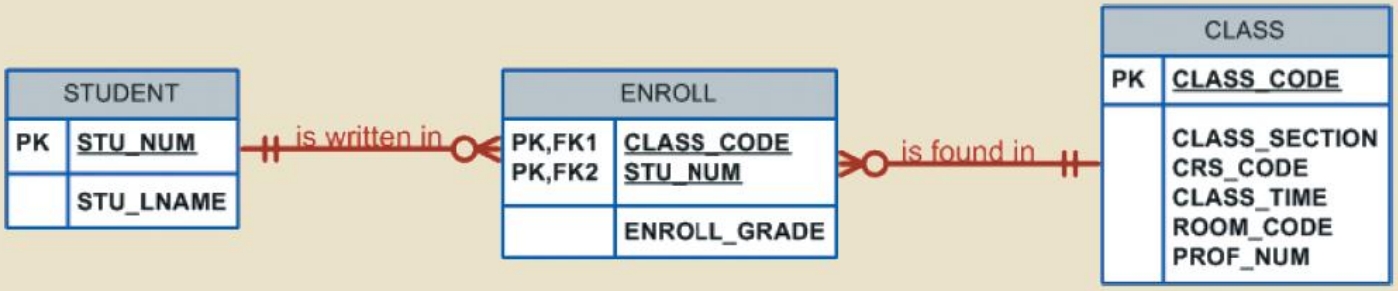
Has a 1:M relationship with the parent entities

- Composed of the primary key attributes of each parent entity

May also contain additional attributes that play no role in connective process

Associative (Composite) Entities (2 of 2)

FIGURE 4.25 A COMPOSITE ENTITY IN AN ERD

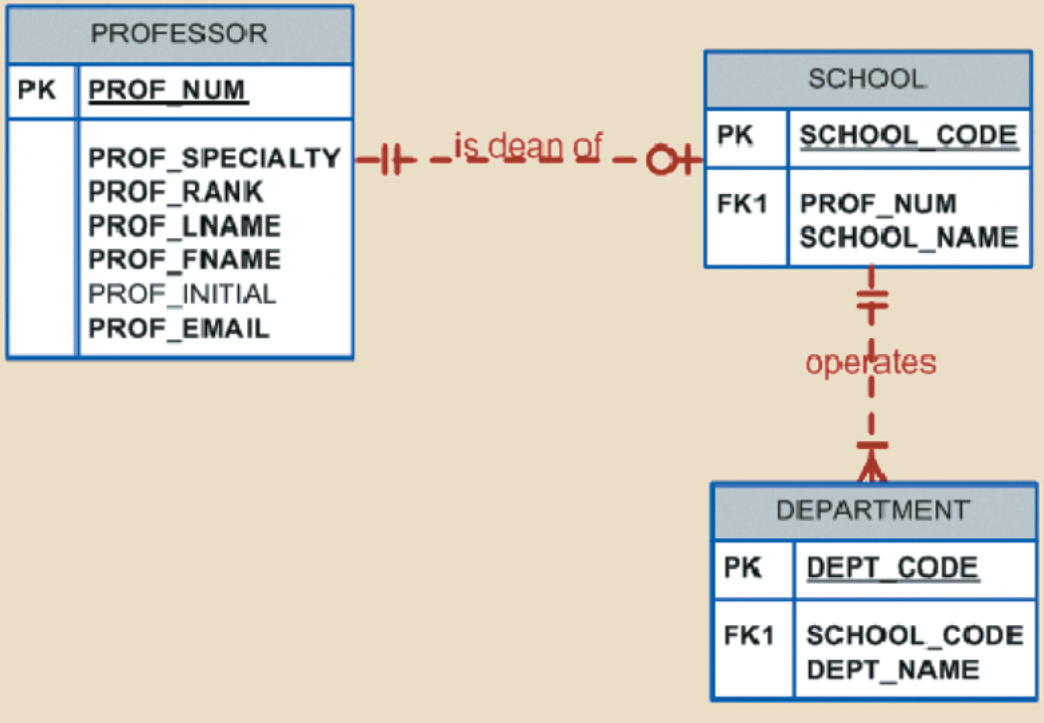


Developing an ER Diagram (1 of 11)

- Activities involved in building and ERD
  - 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

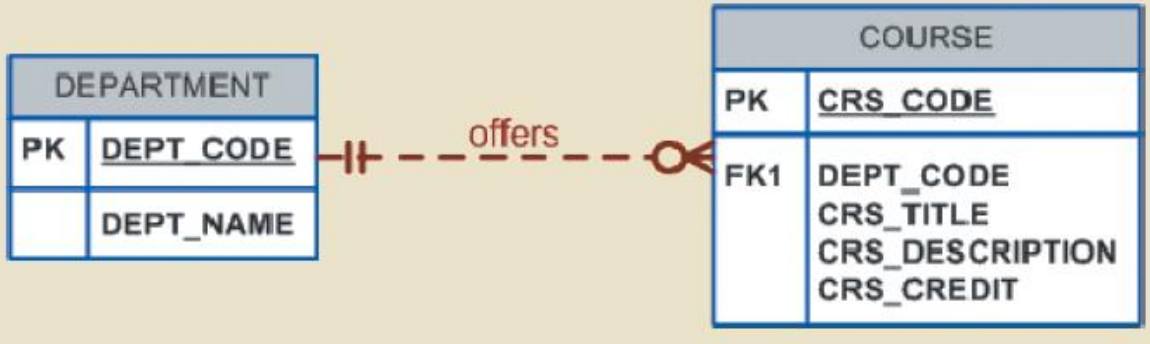
Developing an ER Diagram (2 of 11)

FIGURE 4.26 THE FIRST TINY COLLEGE ERD SEGMENT



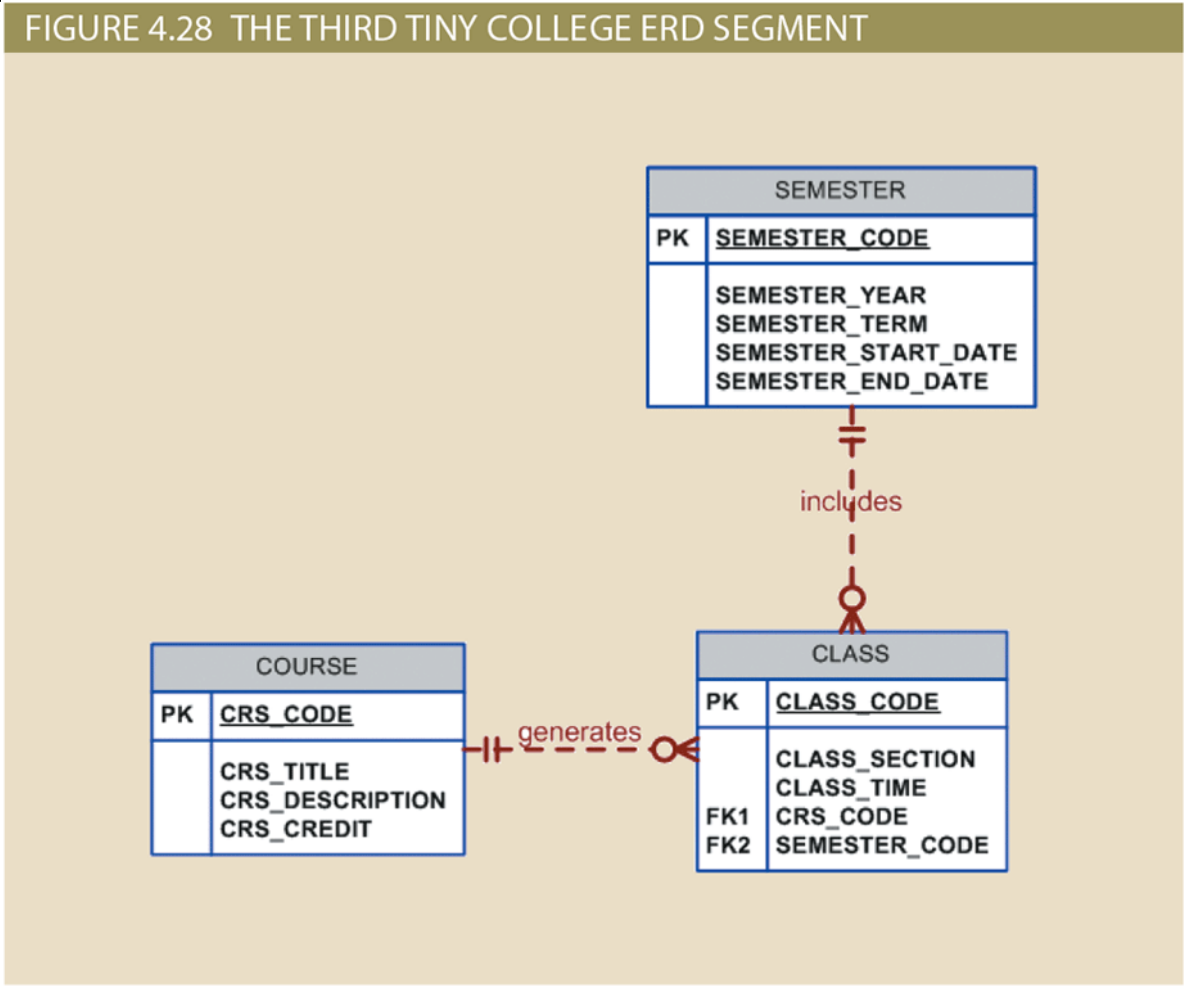
Developing an ER Diagram (3 of 11)

FIGURE 4.27 THE SECOND TINY COLLEGE ERD SEGMENT



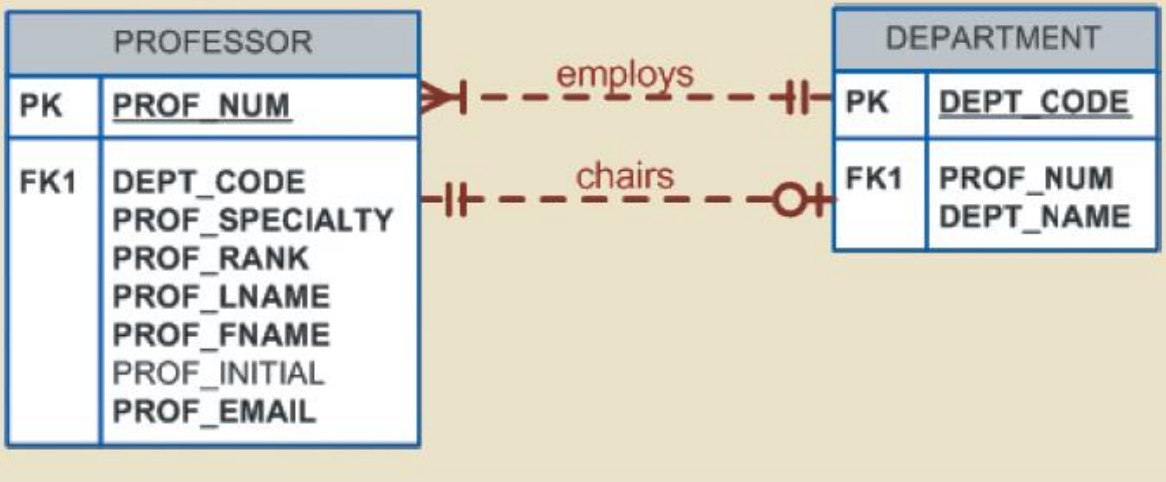
Developing an ER Diagram (4 of 11)

FIGURE 4.28 THE THIRD TINY COLLEGE ERD SEGMENT



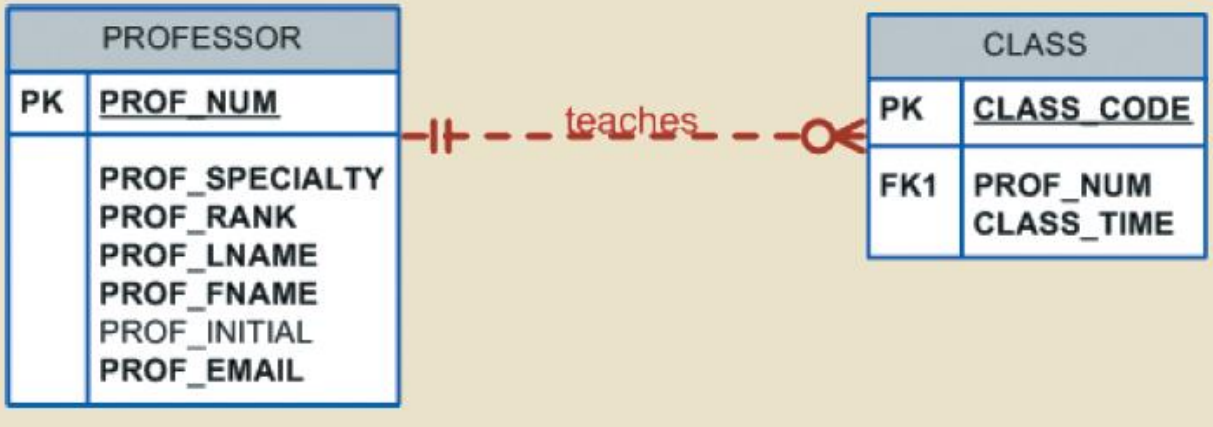
Developing an ER Diagram (5 of 11)

FIGURE 4.29 THE FOURTH TINY COLLEGE ERD SEGMENT



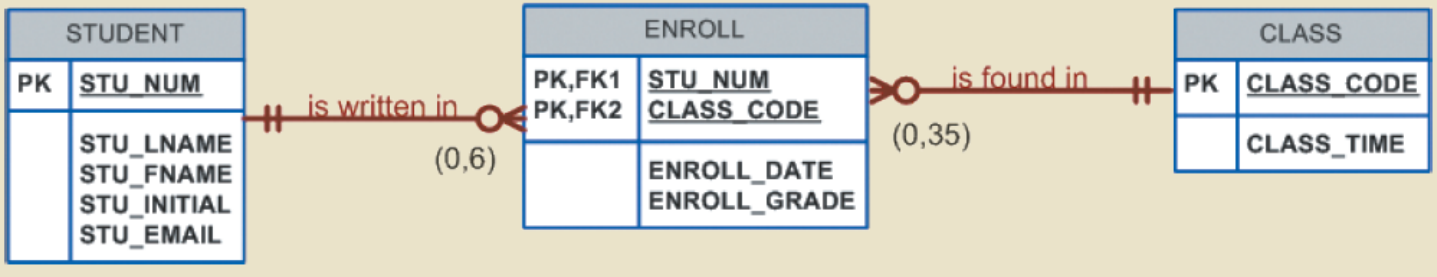
Developing an ER Diagram (6 of 11)

FIGURE 4.30 THE FIFTH TINY COLLEGE ERD SEGMENT



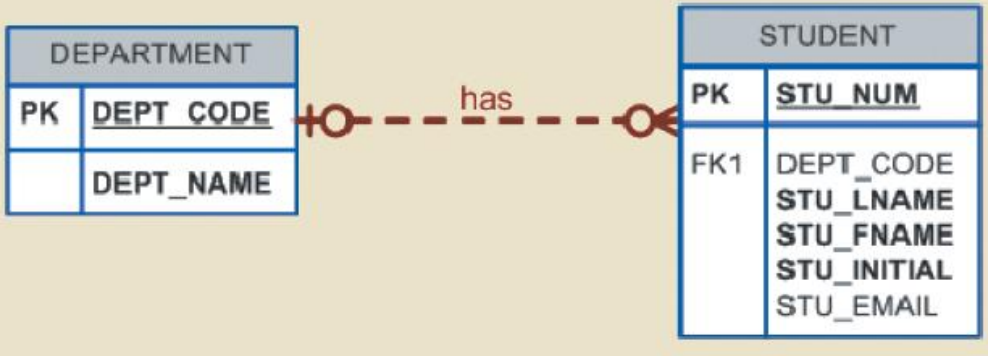
Developing an ER Diagram (7 of 11)

FIGURE 4.31 THE SIXTH TINY COLLEGE ERD SEGMENT



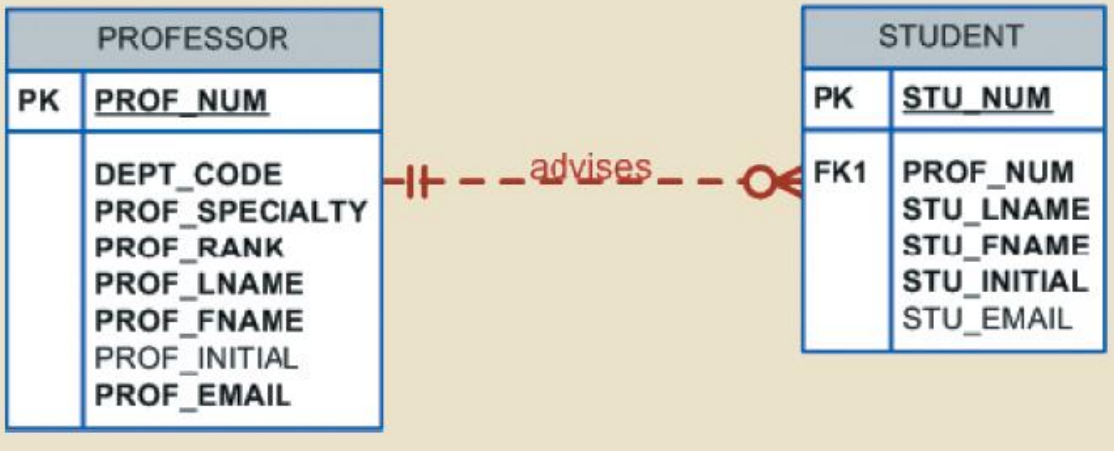
Developing an ER Diagram (8 of 11)

FIGURE 4.32 THE SEVENTH TINY COLLEGE ERD SEGMENT



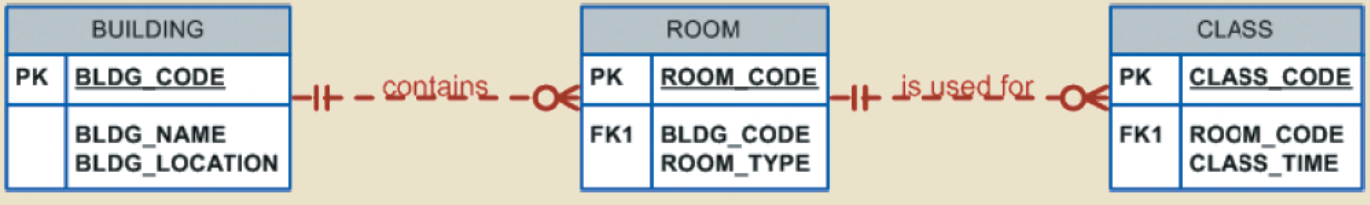
Developing an ER Diagram (9 of 11)

FIGURE 4.33 THE EIGHT TINY COLLEGE ERD SEGMENT



Developing an ER Diagram (10 of 11)

FIGURE 4.34 THE NINTH TINY COLLEGE ERD SEGMENT



Developing an ER Diagram (11 of 11)

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 (1 of 2)

- Database designers must often make design compromises that are triggered by conflicting goals
  - Database design must conform to design standards
  - High processing speed may limit the number and complexity of logically desirable relationships
  - Maximum information generation may lead to loss of clean design structures and high transaction speed

Database Design Challenges: Conflicting Goals (2 of 2)

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

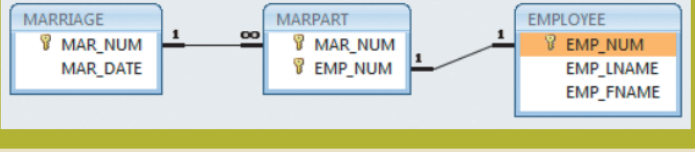
Table name: MARPART

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

Summary

- The ERM uses ERDs to represent the conceptual database as viewed by the end user
- Connectivity describes the relationship classification (1:1, 1:M, or M:N)
- In the ERM, an M:N relationship is valid at the conceptual level
- ERDs may be based on many different ERMs
- Unified Modeling Language (UML) class diagrams are used to represent the static data structures in a data model
- Database designers, no matter how well they can produce designs that conform to all applicable modeling conventions, are often forced to make design compromises

References

- Concepts of Database Management, 10th Edition | Lisa Friedrichsen, Lisa Ruffolo, Ellen Monk, Joy Starks, Philip Pratt, Mary Last | ISBN: 978- 0357422083 © 2020 | Publisher Course Technology – Cengage Learning
- Database Concepts, 9th Edition | David M. Kroenke, David Auer, David J. Auer, Scott L. Vandenberg, Robert C. Yoder | ISBN: 978- 0135188392 © 2020 | Publisher Pearson Education
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