Existence Dependence

- An entity is said to be existence-dependent if it can exist in the database only when it is associated with another related entity occurrence. 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. For example, if an employee wants to claim one or more dependents for tax-withholding purposes, the relationship "EMPLOYEE claims DEPENDENT" would be appropriate.
- In that case, the DEPENDENT entity is clearly existence-dependent on the EMPLOYEE entity because it is impossible for the dependent to exist apart from the EMPLOYEE in the database.

Existence Dependence

- If an entity can exist apart from one or more related entities, it is said to be existence-independent. (Sometimes designers refer to such an entity as a strong or regular entity.)
- For example, suppose that the XYZ Corporation uses parts to produce its products. Further, suppose that some of those parts are produced in-house and other parts are bought from vendors. In that scenario, it is quite possible for a PART to exist independently from a VENDOR in the relationship "PART is supplied by VENDOR," because at least some of the parts are not supplied by a vendor. Therefore, PART is existence-independent from VENDOR.

Relationship Strength

- The concept of relationship strength is based on how the primary key of a related entity is defined. To implement a relationship, the primary key of one entity appears as a foreign key in the related entity. For example, the 1: relationship between VENDOR and PRODUCT, is implemented by using the VEND_CODE primary key in VENDOR as a foreign key in PRODUCT. There are times when the foreign key also is a primary key component in the related entity. For example, the CAR entity primary key (CAR_VIN) appears as both a primary key component and a foreign key in the CAR_COLOR entity. How various relationship strength decisions affect primary key arrangement in database design?

Weak (Non-identifying) Relationships

- A weak relationship, also known as a non-identifying relationship, exists if the PK of the related entity does not contain a PK component of the parent entity. By default, relationships are established by having the PK of the parent entity appear as an FK on the related entity. For example, suppose that the COURSE and CLASS entities are defined as:

COURSE(<u>CRS_CODE</u>, DEPT_CODE, CRS_DESCRIPTION, CRS_CREDIT)

CLASS(<u>CLASS_CODE</u>, CRS_CODE, CLASS_SECTION, CLASS_TIME, ROOM_CODE, PROF_NUM)

- In this case, a weak relationship exists between COURSE and CLASS because the CLASS_CODE is the CLASS entity's PK, while the CRS_CODE in CLASS is only an FK. In this example, the CLASS PK did not inherit the PK component from the COURSE entity.

- Figure 4.8 shows how the Crow's Foot notation depicts a weak relationship by placing a dashed relationship line between the entities. The tables shown below the ERD illustrate how such a relationship is implemented.

FIGURE 4.8 A weak (non-identifying) relationship between COURSE and CLASS

Table name: COURSE **Database name: Ch04_TinyCollege**

CRS_CODE	DEPT_CODE	CRS_DESCRIPTION	CRS_CREDIT
ACCT-211	ACCT	Accounting I	3
ACCT-212	ACCT	Accounting II	3
CIS-220	CIS	Intro. to Microcomputing	3
CIS-420	CIS	Database Design and Implementation	4
MATH-243	MATH	Mathematics for Managers	3
QM-261	CIS	Intro. to Statistics	3
QM-362	CIS	Statistical Applications	4

Table name: CLASS

CLASS_CODE	CRS_CODE	CLASS_SECTION	CLASS_TIME	ROOM_CODE	PROF_NUM
10012	ACCT-211	1	MWF 8:00-8:50 a.m.	BUS311	105
10013	ACCT-211	2	MWF 9:00-9:50 a.m.	BUS200	105
10014	ACCT-211	3	TTh 2:30-3:45 p.m.	BUS252	342
10015	ACCT-212	1	MWF 10:00-10:50 a.m.	BUS311	301
10016	ACCT-212	2	Th 6:00-8:40 p.m.	BUS252	301
10017	CIS-220	1	MWF 9:00-9:50 a.m.	KLR209	228
10018	CIS-220	2	MWF 9:00-9:50 a.m.	KLR211	114
10019	CIS-220	3	MWF 10:00-10:50 a.m.	KLR209	228
10020	CIS-420	1	W 6:00-8:40 p.m.	KLR209	162
10021	QM-261	1	MWF 8:00-8:50 a.m.	KLR200	114
10022	QM-261	2	TTh 1:00-2:15 p.m.	KLR200	114
10023	QM-362	1	MWF 11:00-11:50 a.m.	KLR200	162
10024	QM-362	2	TTh 2:30-3:45 p.m.	KLR200	162
10025	MATH-243	1	Th 6:00-8:40 p.m.	DRE155	325

Strong (Identifying) Relationships

- A strong relationship, also known as an identifying relationship, exists when the PK of the related entity contains a PK component of the parent entity.
- For example, the definitions of the COURSE and CLASS entities

COURSE(CRS_CODE, DEPT_CODE, CRS_DESCRIPTION, CRS_CREDIT)

CLASS(CRS_CODE, CLASS_SECTION, CLASS_TIME, ROOM_CODE, PROF_NUM)

- indicate that a strong relationship exists between COURSE and CLASS, because the CLASS entity's composite PK is composed of CRS_CODE + CLASS_SECTION. (Note that the CRS_CODE in CLASS is also the FK to the COURSE entity.) The Crow's Foot notation depicts the strong (identifying) relationship with a solid line between the entities.

Figure 4.9. Whether the relationship between COURSE and CLASS is strong or weak depends on how the CLASS entity's primary key is defined.

FIGURE 4.9 A strong (identifying) relationship between COURSE and CLASS

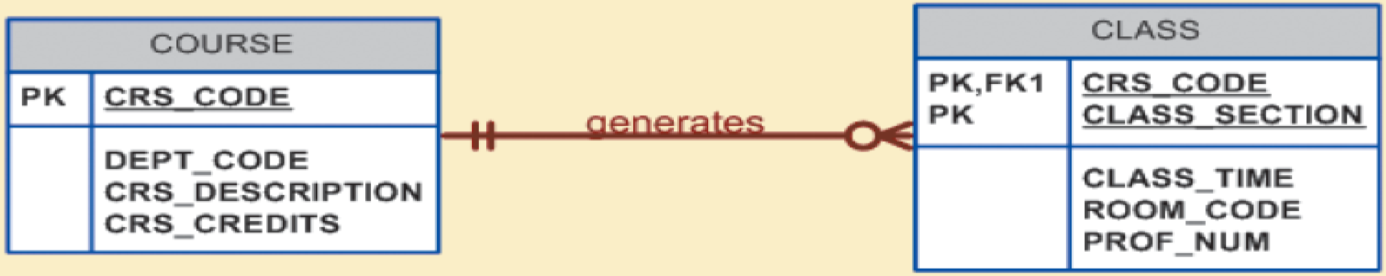


Table name: COURSE

Database name: Ch04_TinyCollege_Alt

CRS_CODE	DEPT_CODE	CRS_DESCRIPTION	CRS_CREDIT
ACCT-211	ACCT	Accounting I	3
ACCT-212	ACCT	Accounting II	3
CIS-220	CIS	Intro. to Microcomputing	3
CIS-420	CIS	Database Design and Implementation	4
MATH-243	MATH	Mathematics for Managers	3
QM-261	CIS	Intro. to Statistics	3
QM-362	CIS	Statistical Applications	4

Table name: CLASS

CRS_CODE	CLASS_SECTION	CLASS_TIME	ROOM_CODE	PROF_NUM
ACCT-211	1	MWF 8:00-8:50 a.m.	BUS311	105
ACCT-211	2	MWF 9:00-9:50 a.m.	BUS200	105
ACCT-211	3	TTh 2:30-3:45 p.m.	BUS252	342
ACCT-212	1	MWF 10:00-10:50 a.m.	BUS311	301
ACCT-212	2	Th 6:00-8:40 p.m.	BUS252	301
CIS-220	1	MWF 9:00-9:50 a.m.	KLR209	228
CIS-220	2	MWF 9:00-9:50 a.m.	KLR211	114
CIS-220	3	MWF 10:00-10:50 a.m.	KLR209	228
CIS-420	1	W 6:00-8:40 p.m.	KLR209	162
MATH-243	1	Th 6:00-8:40 p.m.	DRE155	325
QM-261	1	MWF 8:00-8:50 a.m.	KLR200	114
QM-261	2	TTh 1:00-2:15 p.m.	KLR200	114
QM-362	1	MWF 11:00-11:50 a.m.	KLR200	162
QM-362	2	TTh 2:30-3:45 p.m.	KLR200	162

Strong (Identifying) Relationships

- Keep in mind that the order in which the tables are created and loaded is very important. For example, in the "COURSE generates CLASS" relationship, the COURSE table must be created before the CLASS table. After all, it would not be acceptable to have the CLASS table's foreign key reference a COURSE table that did not yet exist.
- In fact, you must load the data of the "1" side first in a 1:M relationship to avoid the possibility of referential integrity errors, regardless of whether the relationships are weak or strong.

Strong (Identifying) Relationships

- As it is being examined in the Figure 4.9 what the O symbol next to the CLASS entity signifies? Discover this in the meaning of cardinality, Relationship Participation.
- Remember that the nature of the relationship is often determined by the database designer, who must use professional judgment to determine which relationship type and strength best suits

Weak Entities

A weak entity is one that meets two conditions:

1. The entity is existence-dependent; that is, it cannot exist without the entity with which it has a relationship.
2. The entity has a primary key that is partially or totally derived from the parent entity in the relationship.

- For example, a company insurance policy insures an employee and his/her dependents. For the purpose of describing an insurance policy, an EMPLOYEE might or might not have a DEPENDENT, but the DEPENDENT must be associated with an EMPLOYEE. Moreover, the DEPENDENT cannot exist without the EMPLOYEE; that is, a person cannot get insurance coverage as a dependent unless s(he) happens to be a dependent of an employee. DEPENDENT is the weak entity in the relationship "EMPLOYEE has DEPENDENT."

Weak Entities

- Note that the Chen notation identifies the weak entity by using a double-walled entity rectangle. The Crow's Foot notation generated by Visio Professional uses the relationship line and the PK/FK designation to indicate whether the related entity is weak. A strong (identifying) relationship indicates that the related entity is weak. Such a relationship means that both conditions for the weak entity definition have been met—the related entity is existence-dependent, and the PK of the related entity contains a PK component of the parent entity. (Some versions of the Crow's Foot ERD depict the weak entity by drawing a short line segment in each of the four corners of the weak entity box.)

FIGURE 4.10 A weak entity in an ERD

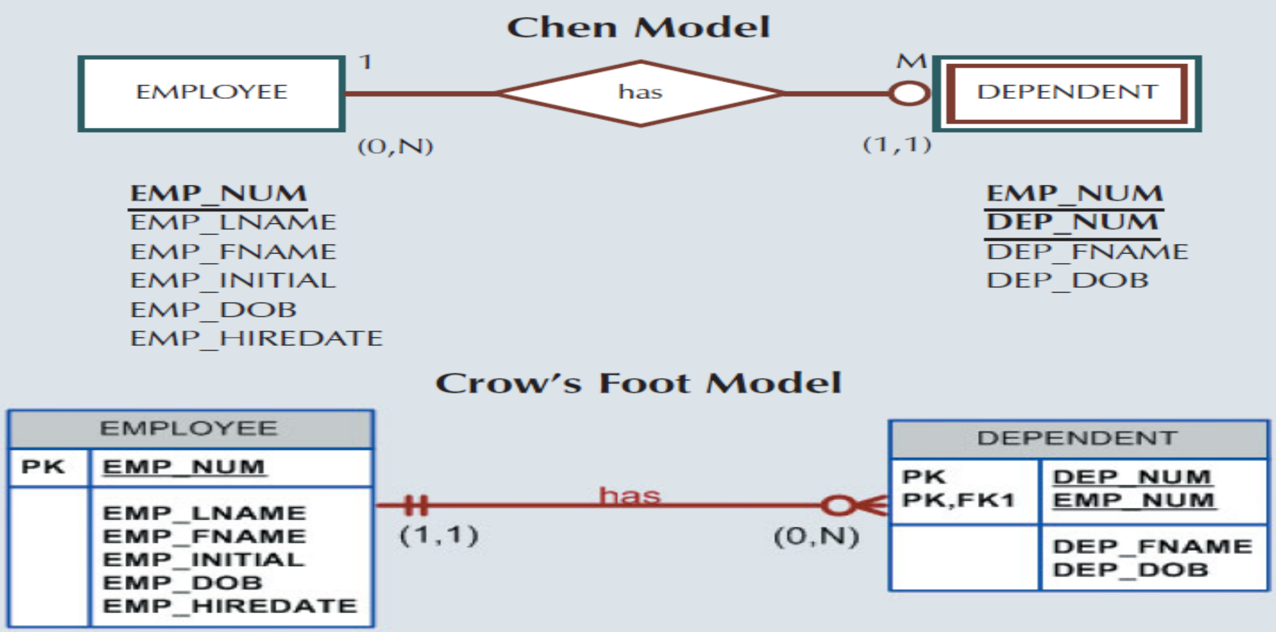


FIGURE 4.11 A weak entity in a strong relationship

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

Weak Entities

- Remember that the weak entity inherits part of its primary key from its strong counterpart. For example, at least part of the DEPENDENT entity's key shown in Figure was inherited from the EMPLOYEE entity:

EMPLOYEE (<u>EMP_NUM</u>, EMP_LNAME, EMP_FNAME, EMP_INITIAL, EMP_DOB, EMP_HIREDATE)
DEPENDENT (<u>EMP_NUM, DEP_NUM</u>, DEP_FNAME, DEP_DOB)

- Figure illustrates the implementation of the relationship between the weak entity (DEPENDENT) and its parent or strong counterpart (EMPLOYEE). Note that DEPENDENT's primary key is composed of two attributes, EMP_NUM and DEP_NUM, and that EMP_NUM was inherited from EMPLOYEE.

Weak Entities

- Keep in mind that the database designer usually determines whether an entity can be described as weak based on the business rules. An examination of the relationship between COURSE and CLASS in Figure might cause you to conclude that CLASS is a weak entity to COURSE. After all, in Figure, it seems clear that a CLASS cannot exist without a COURSE; so there is existence dependency. For example, a student cannot enroll in the Accounting I class ACCT-211, Section 3 (CLASS_CODE 10014) unless there is an ACCT_211 course. However, note that the CLASS table's primary key is CLASS_CODE, which is not derived from the COURSE parent entity. That is, CLASS may be represented by:

CLASS (<u>CLASS_CODE</u>, CRS_CODE, CLASS_SECTION, CLASS_TIME, ROOM_CODE, PROF_NUM)

Weak Entities

- The second weak entity requirement has not been met; therefore, by definition, the CLASS entity in Figure may not be classified as weak. On the other hand, if the CLASS entity's primary key had been defined as a composite key, composed of the combination CRS_CODE and CLASS_SECTION, CLASS could be represented by:

CLASS (<u>CRS_CODE, CLASS_SECTION</u>, CLASS_TIME, ROOM_CODE, PROF_NUM)

- In that case, the CLASS primary key is partially derived from COURSE because CRS_CODE is the COURSE table's primary key. Given this decision, CLASS is a weak entity by definition. (In Visio Professional Crow's Foot terms, the relationship between COURSE and CLASS is classified as strong, or identifying.) In any case, CLASS is always existence-dependent on COURSE, whether or not it is defined as weak.

Figure 4.9. Whether the relationship between COURSE and CLASS is strong or weak depends on how the CLASS entity's primary key is defined.

FIGURE 4.9 A strong (identifying) relationship between COURSE and CLASS

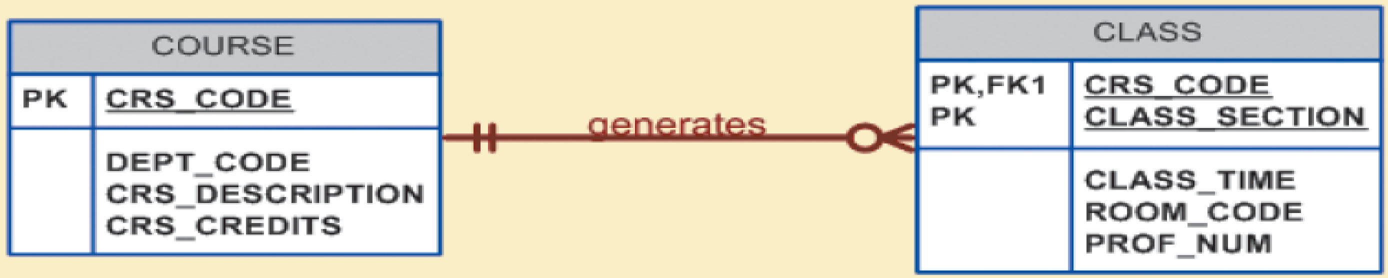


Table name: COURSE

Database name: Ch04_TinyCollege_Alt

CRS_CODE	DEPT_CODE	CRS_DESCRIPTION	CRS_CREDIT
ACCT-211	ACCT	Accounting I	3
ACCT-212	ACCT	Accounting II	3
CIS-220	CIS	Intro. to Microcomputing	3
CIS-420	CIS	Database Design and Implementation	4
MATH-243	MATH	Mathematics for Managers	3
QM-261	CIS	Intro. to Statistics	3
QM-362	CIS	Statistical Applications	4

Table name: CLASS

CRS_CODE	CLASS_SECTION	CLASS_TIME	ROOM_CODE	PROF_NUM
ACCT-211	1	MWF 8:00-8:50 a.m.	BUS311	105
ACCT-211	2	MWF 9:00-9:50 a.m.	BUS200	105
ACCT-211	3	TTh 2:30-3:45 p.m.	BUS252	342
ACCT-212	1	MWF 10:00-10:50 a.m.	BUS311	301
ACCT-212	2	Th 6:00-8:40 p.m.	BUS252	301
CIS-220	1	MWF 9:00-9:50 a.m.	KLR209	228
CIS-220	2	MWF 9:00-9:50 a.m.	KLR211	114
CIS-220	3	MWF 10:00-10:50 a.m.	KLR209	228
CIS-420	1	W 6:00-8:40 p.m.	KLR209	162
MATH-243	1	Th 6:00-8:40 p.m.	DRE155	325
QM-261	1	MWF 8:00-8:50 a.m.	KLR200	114
QM-261	2	TTh 1:00-2:15 p.m.	KLR200	114
QM-362	1	MWF 11:00-11:50 a.m.	KLR200	162
QM-362	2	TTh 2:30-3:45 p.m.	KLR200	162

FIGURE 4.10 A weak entity in an ERD

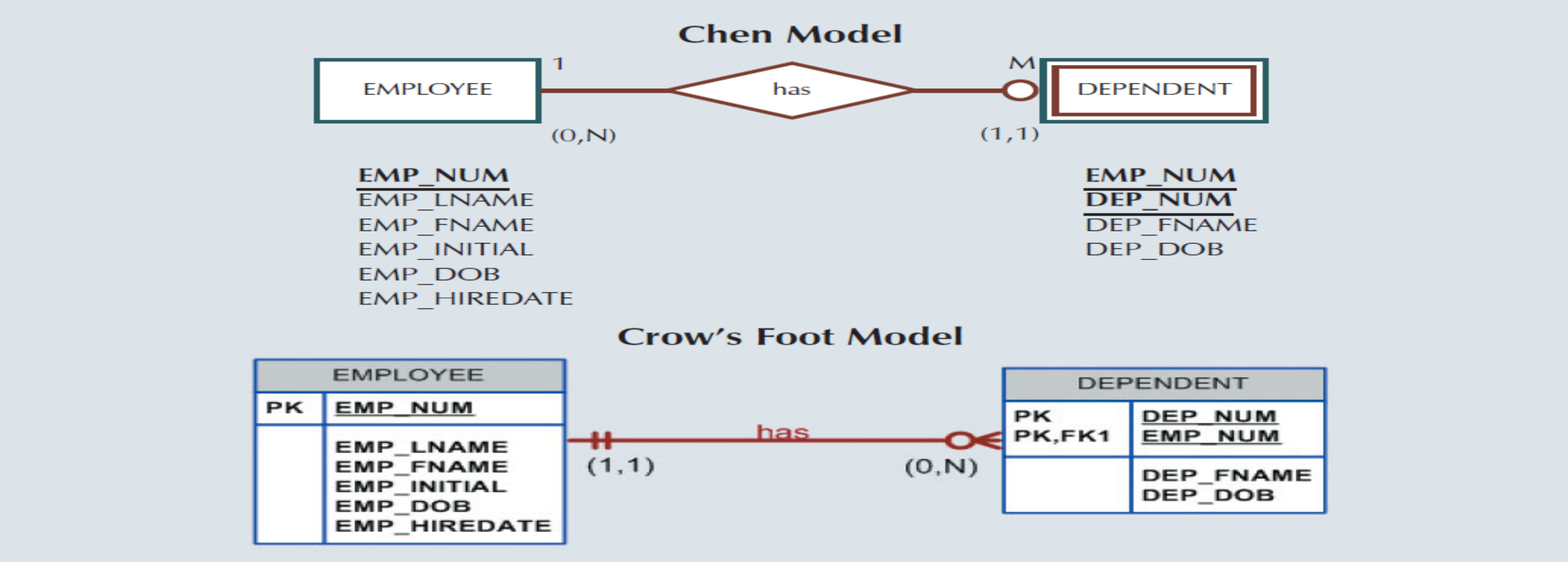


FIGURE 4.11 A weak entity in a strong relationship

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

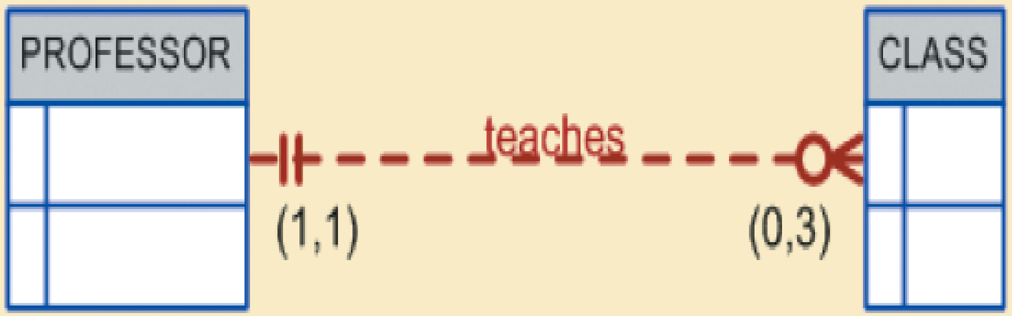
- Participation in an entity relationship is either optional or mandatory. Optional participation means that one entity occurrence does not require a corresponding entity occurrence in a particular relationship. For example, in the “COURSE generates CLASS” relationship, as noted that at least some courses do not generate a class.
- In other words, an entity occurrence (row) in the COURSE table does not necessarily require the existence of a corresponding entity occurrence in the CLASS table. (Remember that each entity is implemented as a table.) Therefore, the CLASS entity is considered to be optional to the COURSE entity.

Relationship Participation

- In Crow's Foot notation, an optional relationship between entities is shown by drawing a small circle (O) on the side of the optional entity, as illustrated in Figure. The existence of an optional entity indicates that the minimum cardinality is 0 for the optional entity. (The term optionality is used to label any condition in which one or more optional relationships exist.)

Relationship Participation

FIGURE 4.12 An optional CLASS entity in the relationship "PROFESSOR teaches CLASS"



Relationship Participation

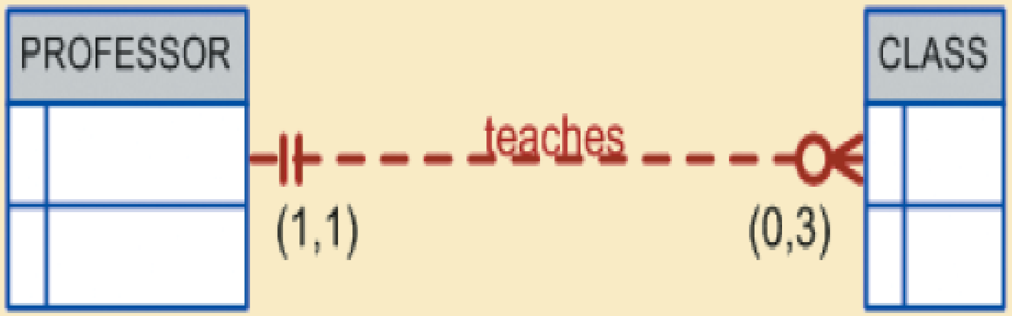
- Mandatory participation means that one entity occurrence requires a corresponding entity occurrence in a particular relationship. If no optionality symbol is depicted with the entity, the entity exists in a mandatory relationship with the related entity. The existence of a mandatory relationship indicates that the minimum cardinality is 1 for the mandatory entity.

Relationship Participation

- Because relationship participation turns out to be a very important component of the database design process, let's examine a few more scenarios. Suppose that Tiny College employs some professors who conduct research without teaching classes. If you examine the "PROFESSOR teaches CLASS" relationship, it is quite possible for a PROFESSOR not to teach a CLASS. Therefore, CLASS is optional to PROFESSOR. On the other hand, a CLASS must be taught by a PROFESSOR. Therefore, PROFESSOR is mandatory to CLASS. Note that the ERD model in Figure shows the cardinality next to CLASS to be (0,3), thus indicating that a professor may teach no classes at all or as many as three classes.

Relationship Participation

FIGURE 4.12 An optional CLASS entity in the relationship "PROFESSOR teaches CLASS"

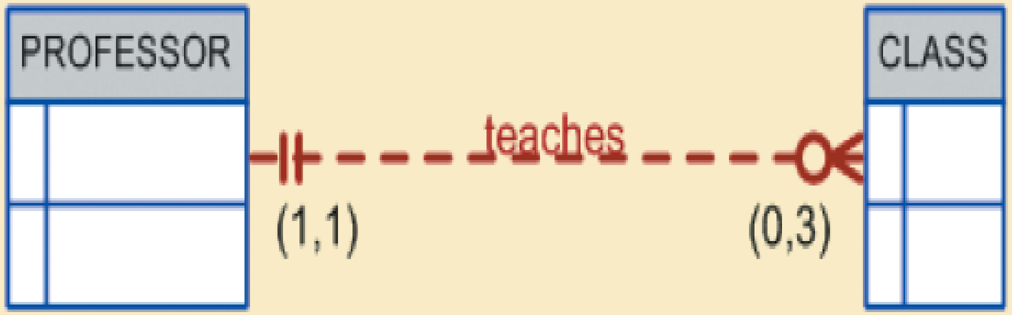


Relationship Participation

- And each CLASS table row will reference one and only one PROFESSOR row—assuming each class is taught by one and only one professor, represented by the (1,1) cardinality next to the PROFESSOR table.

Relationship Participation

FIGURE 4.12 An optional CLASS entity in the relationship "PROFESSOR teaches CLASS"



Relationship Participation

- Failure to understand the distinction between mandatory and optional participation in relationships might yield designs in which awkward (and unnecessary) temporary rows (entity instances) must be created just to accommodate the creation of required entities. Therefore, it is important that you clearly understand the concepts of mandatory and optional participation. It is also important to understand that the semantics of a problem might determine the type of participation in a relationship.

Relationship Participation

- For example, suppose that Tiny College offers several courses; each course has several classes. Note again the distinction between class and course in this discussion: a CLASS constitutes a specific offering (or section) of a COURSE. (Typically, courses are listed in the university's course catalog, while classes are listed in the class schedules that students use to register for their classes.)

Relationship Participation

- It is tempted to conclude that relationships are weak when they occur between entities in an optional relationship and that relationships are strong when they occur between entities in a mandatory relationship. However, this conclusion is not warranted. Keep in mind that relationship participation and relationship strength do not describe the same thing. A strong relationship can be encountered, when one entity is optional to another. For example, the relationship between EMPLOYEE and DEPENDENT is clearly a strong one, but DEPENDENT is clearly optional to EMPLOYEE. After all, you cannot require employees to have dependents. And it is just as possible for a weak relationship to be established when one entity is mandatory to another.

Relationship Participation

- The relationship strength depends on how the PK of the related entity is formulated, while the relationship participation depends on how the business rule is written. For example, the business rules “Each part must be supplied by a vendor” and “A part may or may not be supplied by a vendor” create different optionalities for the same entities! Failure to understand this distinction may lead to poor design decisions that cause major problems when table rows are inserted or deleted.

Relationship Participation

FIGURE 4.13 CLASS is optional to COURSE

FIGURE 4.14 COURSE and CLASS in a mandatory relationship

Relationship Participation

1. CLASS is optional. It is possible for the department to create the entity COURSE first and then create the CLASS entity after making the teaching assignments. In the real world, such a scenario is very likely; there may be courses for which sections (classes) have not yet been defined. In fact, some courses are taught only once a year and do not generate classes each semester.

Relationship Participation

2. CLASS is mandatory. This condition is created by the constraint that is imposed by the semantics of the statement "Each COURSE generates one or more CLASSes." In ER terms, each COURSE in the "generates" relationship must have at least one CLASS. Therefore, a CLASS must be created as the COURSE is created in order to comply with the semantics of the problem.

Relationship Participation

- Keep in mind the practical aspects of the scenario presented in Figure 4.14. Given the semantics of this relationship, the system should not accept a course that is not associated with at least one class section. Is such a rigid environment desirable from an operational point of view? For example, when a new COURSE is created, the database first updates the COURSE table, thereby inserting a COURSE entity that does not yet have a CLASS associated with it. Naturally, the apparent problem seems to be solved when CLASS entities are inserted into the corresponding CLASS table.

Relationship Participation

- However, because of the mandatory relationship, the system will be in temporary violation of the business rule constraint. For practical purposes, it would be desirable to classify the CLASS as optional in order to produce a more flexible design.
- Finally, as you examine the scenarios presented in Figures 4.13 and 4.14, keep in mind the role of the DBMS. To maintain data integrity, the DBMS must ensure that the "many" side (CLASS) is associated with a COURSE through the foreign key rules.

Relationship Participation

FIGURE 4.13 CLASS is optional to COURSE

FIGURE 4.14 COURSE and CLASS in a mandatory relationship

Relationship Participation

When you create a relationship in Visio, the default relationship will be mandatory on the "1" side and optional on the "many" side. Table 4.3 shows the various cardinalities that are supported by the Crow's Foot notation.

TABLE 4.3 Crow's Foot Symbols

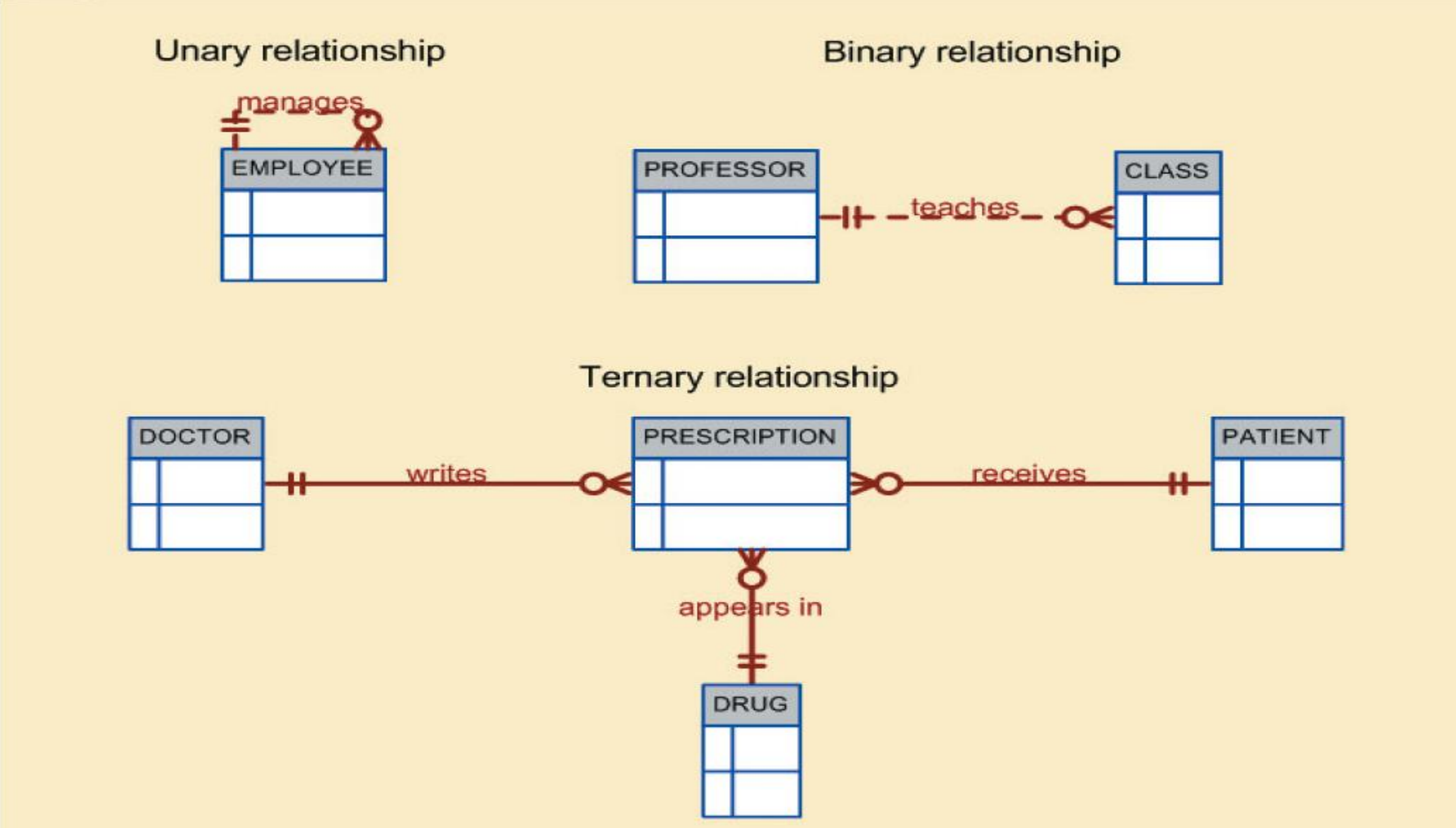
CROW'S FOOT SYMBOL	CARDINALITY	COMMENT
	(0,N)	Zero or many. Many side is optional.
	(1,N)	One or many. Many side is mandatory.
	(1,1)	One and only one. 1 side is mandatory.
	(0,1)	Zero or one. 1 side is optional.

Relationship Participation

Relationship Degree

- A relationship degree indicates the number of entities or participants associated with a relationship.
  - A unary relationship exists when an association is maintained within a single entity.
  - A binary relationship exists when two entities are associated.
  - A ternary relationship exists when three entities are associated.

FIGURE 4.15 Three types of relationship degree



- A DOCTOR writes one or more PRESCRIPTIONs.
- A PATIENT may receive one or more PRESCRIPTIONs.
- A DRUG may appear in one or more PRESCRIPTIONs. (To simplify this example, assume that the business rule states that each prescription contains only one drug. In short, if a doctor prescribes more than one drug, a separate prescription must be written for each drug.)

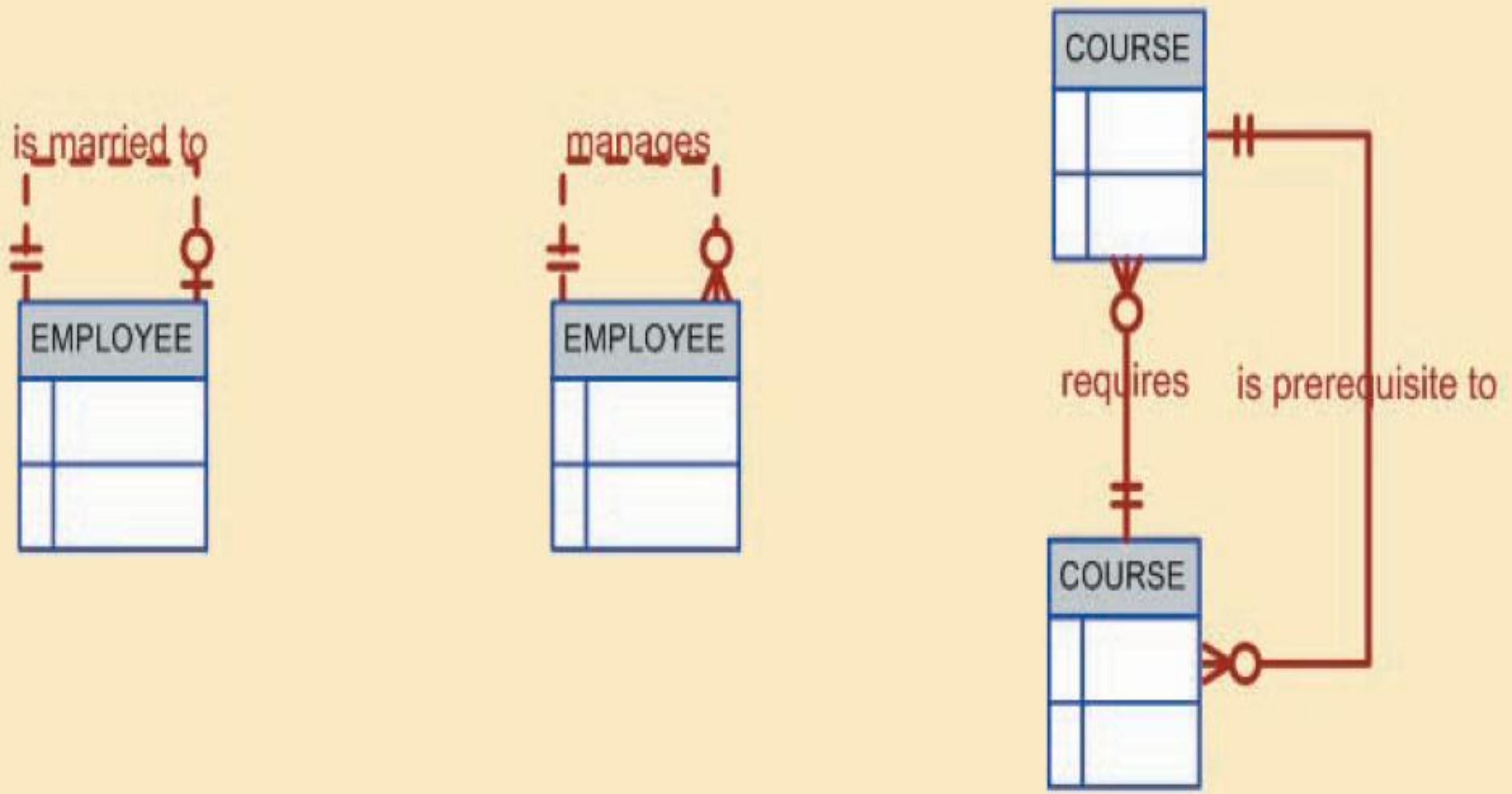
Relationship Participation

Recursive Relationships

- As was previously mentioned, a recursive relationship is one in which a relationship can exist between occurrences of the same entity set. (Naturally, such a condition is found within a unary relationship.)
- For example, a 1:M unary relationship can be expressed by "an EMPLOYEE may manage many EMPLOYEEs, and each EMPLOYEE is managed by one EMPLOYEE."
- COURSE may be a prerequisite to many other COURSEs, and each COURSE may have many other COURSEs as prerequisites

Relationship Participation

FIGURE 4.17 An ER representation of recursive relationships



Relationship Participation

Associative (Composite) Entities

- In the original ERM described by Chen, relationships do not contain attributes. The relational model generally requires the use of 1:M relationships. (Also, recall that the 1:1 relationship has its place, but it should be used with caution and proper justification.) If M:N relationships are encountered, you must create a bridge between the entities that display such relationships. The associative entity is used to implement a M:M relationship between two or more entities. This associative entity (also known as a composite or bridge entity) is composed of the primary keys of each of the entities to be connected.

Relationship Participation

- An example of such a bridge is shown in Figure 4.23. The Crow's Foot notation does not identify the composite entity as such. Instead, the composite entity is identified by the solid relationship line between the parent and child entities, thereby indicating the presence of a strong (identifying) relationship.

Relationship Participation

FIGURE 4.25 A composite entity in an ERD

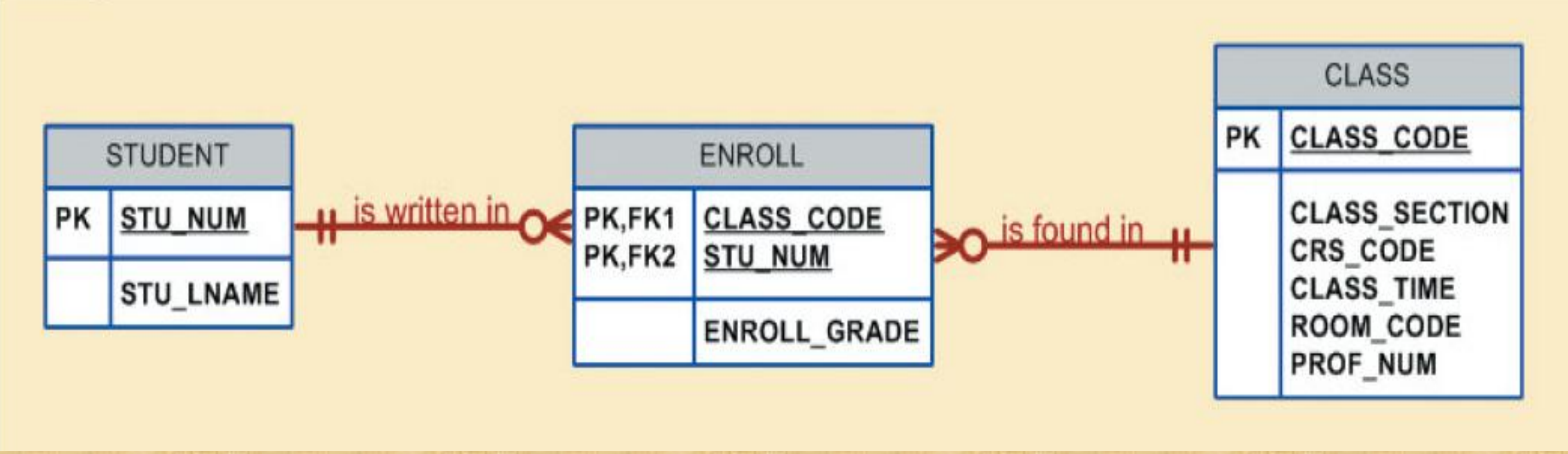
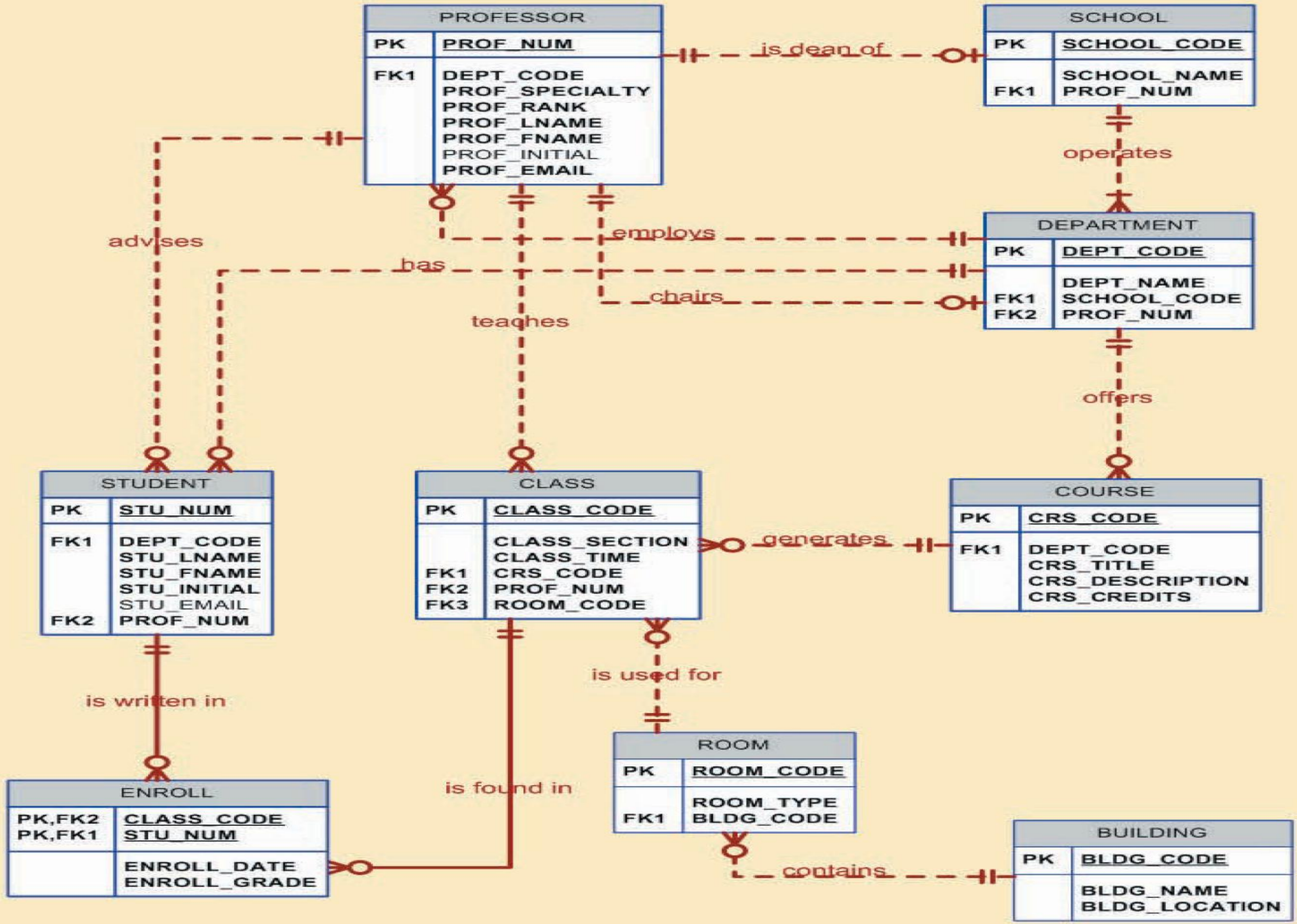


FIGURE 4.35 The completed Tiny College ERD



End of Lecture

Any Questions... ?