

ER Modeling Part 1

Lecture 3

Learning Outcomes

- In this chapter, students will learn:
 - the characteristics of entity relationship
 - constructing an ERD

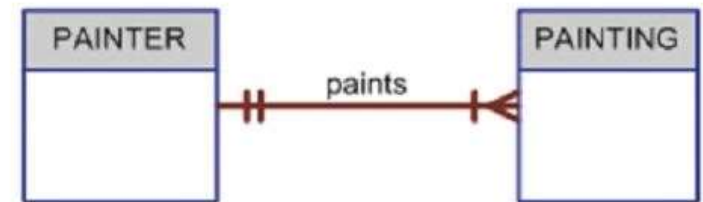
The Entity-Relationship Diagram (ERD)

- ERD represents actual design blueprint of a relational DB

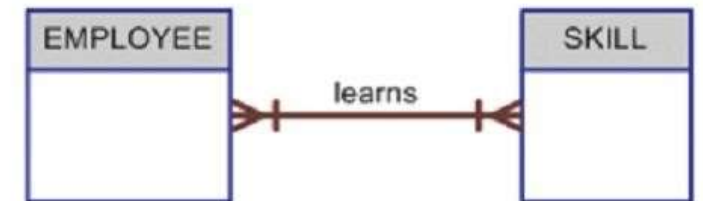
Chen Notation

Crow's Foot 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.



The Entity-Relationship Diagram (ERD)

- ERDs depict database's main components:
 - *Entities*
 - *Attributes*
 - *Relationships*



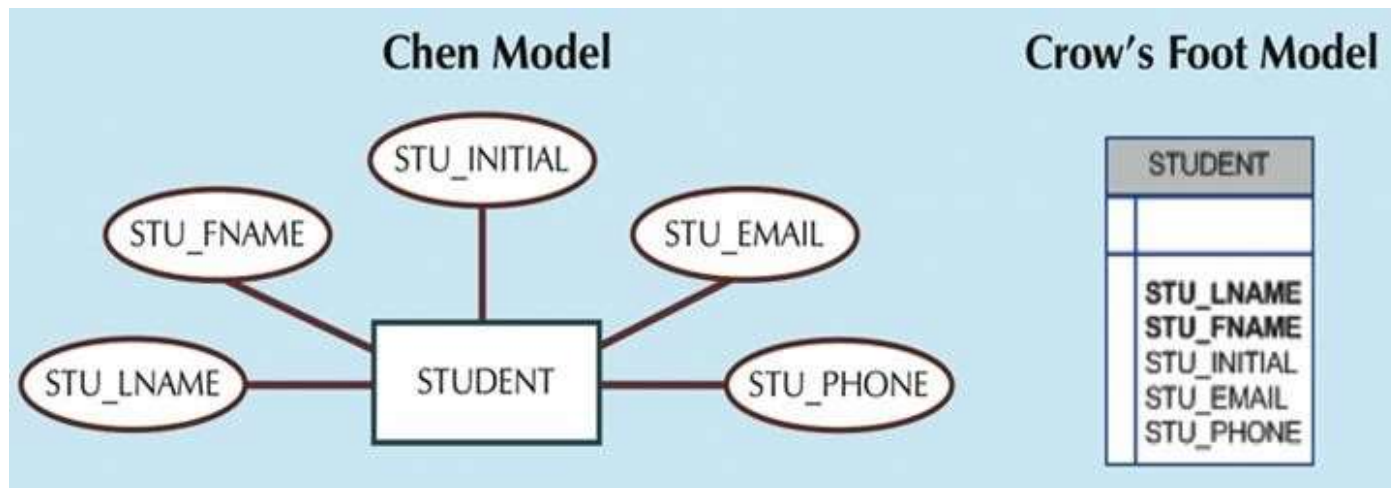
This course follows
Crow's foot diagram

Entities

- **Entity**: is a *person*, *place*, *thing*, *concept* or *event* for which data can be stored.
- **Entity instance** (or occurrence): a row in the table
- In Chen and Crow's Foot models, entity is represented by rectangle with entity's name
- Entity name, a noun, written in **CAPITAL** letters

Attributes

- Characteristics of entities
- **Chen** notation: attributes represented by ovals connected to entity rectangle with a line
- **Crow's Foot** notation: attributes written in attribute box below entity rectangle

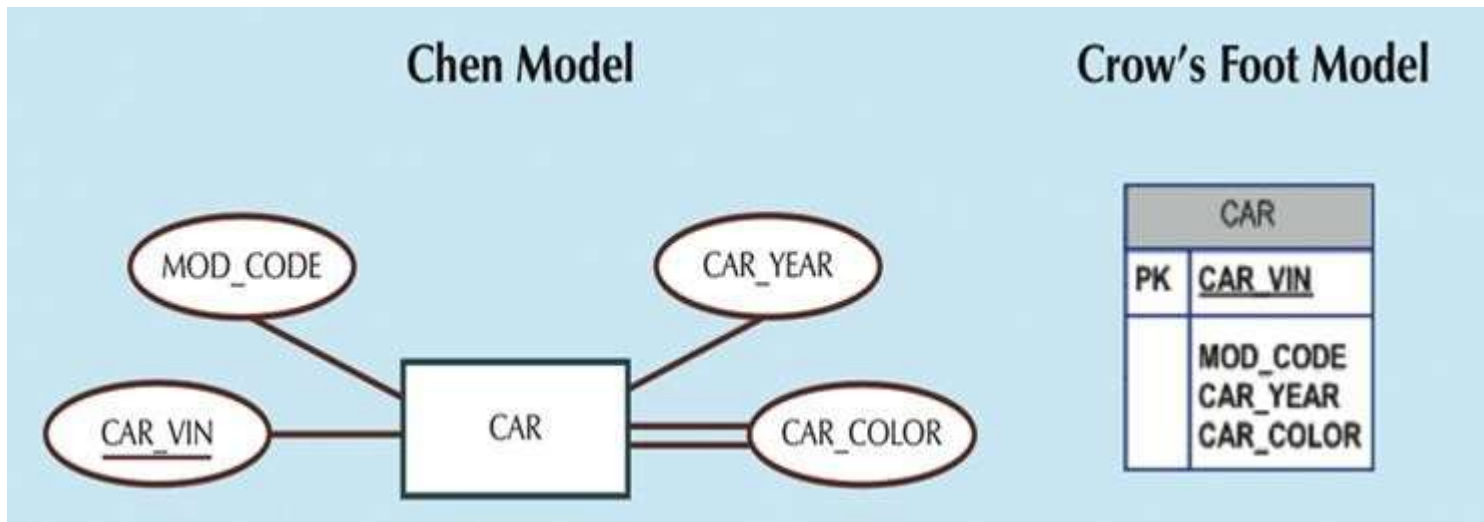


Attributes (cont'd.)

- Required attribute: must have a value
- Optional attribute: may be left empty
- **Domain**: set of possible values for an attribute (e.g., gender - Female or Male)
- **Composite attribute**: an attribute that can be further subdivided to yield additional attributes (e.g., address - street, city, state, zip code)
- **Simple attribute**: an attribute that cannot be subdivided (e.g., age, gender)

Attributes (cont'd.)

- **Single-value attribute**: attribute that can have only a single value at a particular instance of time (e.g., stuID)
- **Multivalued attributes**: attribute that can have many values (e.g., car's color - colors for roof, body, etc.)



Attributes (cont'd.)

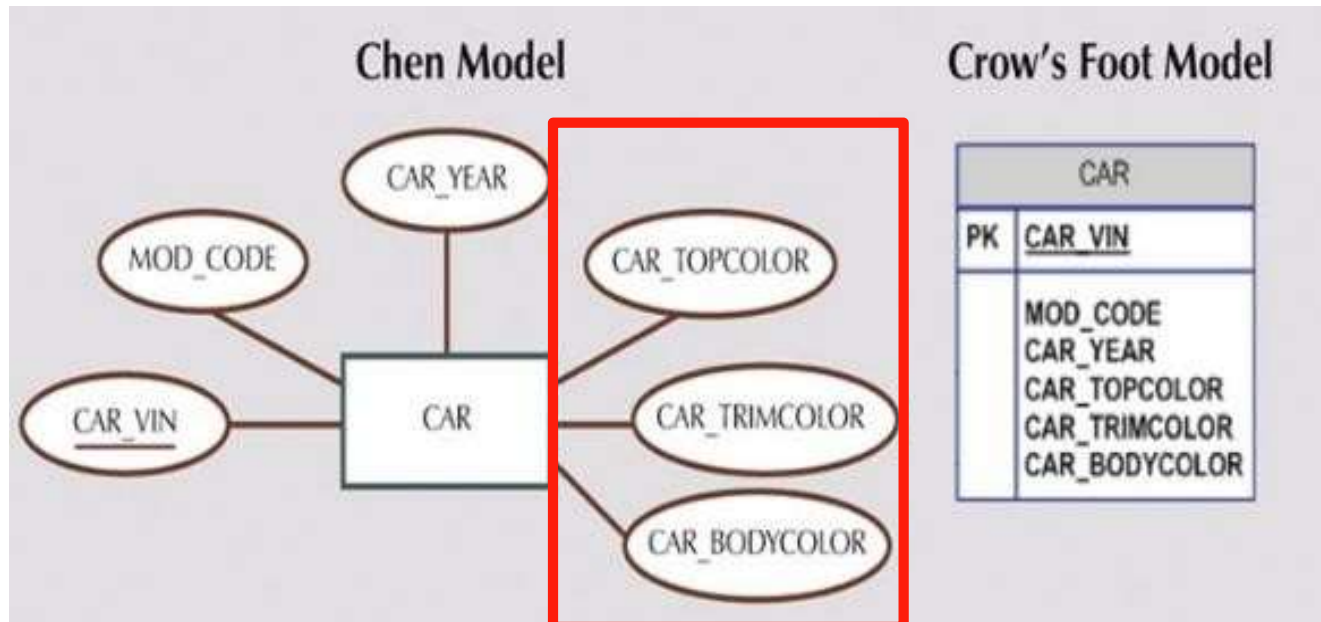
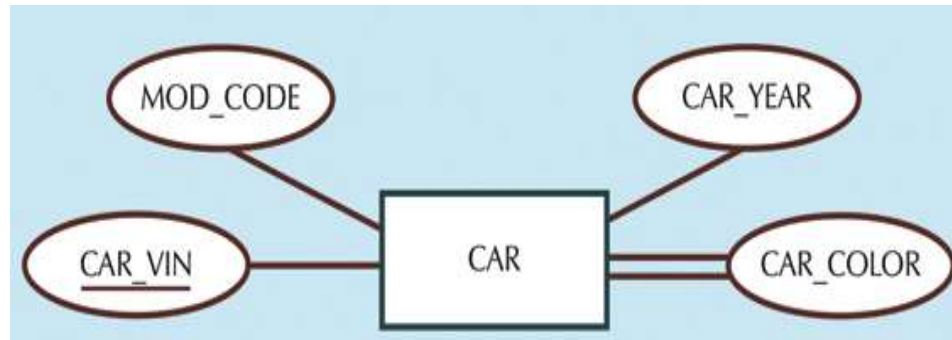
- M:N relationships and multivalued attributes should not be implemented
- Solutions for multivalued attributes:

1. *Create several new attributes for each of the original multivalued attributes' components*

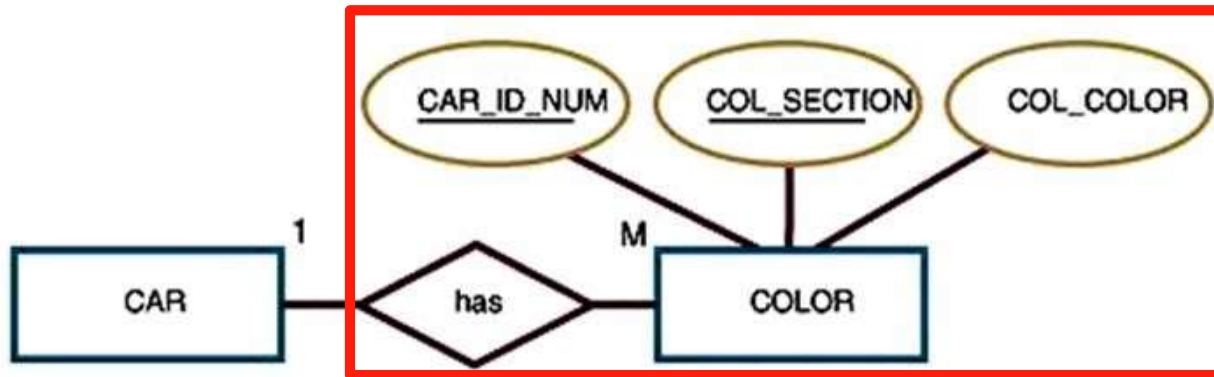
or

2. *Create new entity composed of original multivalued attributes' components*

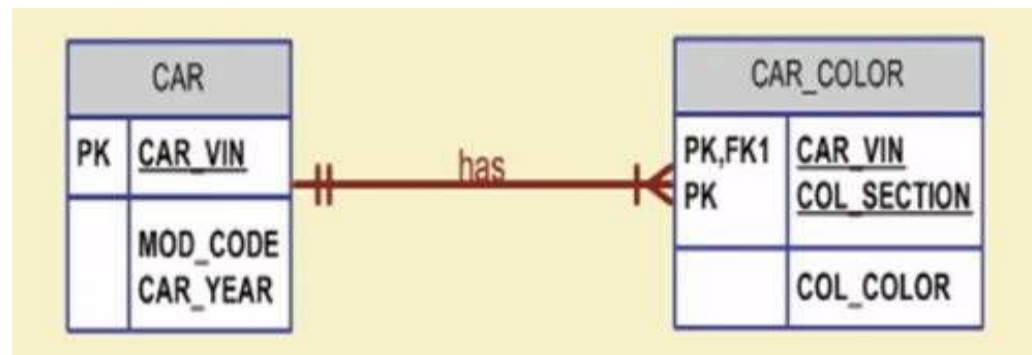
Splitting Multivalued Attribute into New Attributes



Creating New Entity from a Multivalued Attribute

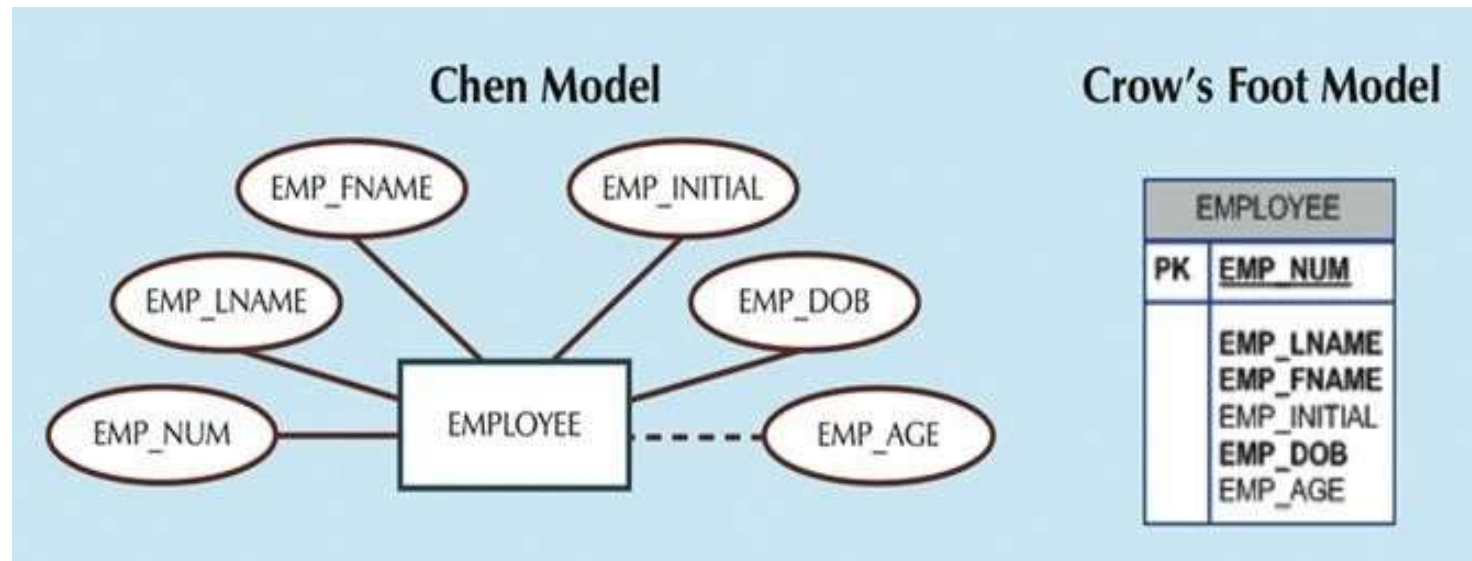


SECTION	COLOR
Top	White
Body	Blue
Trim	Green
Interior	Blue



Derived Attribute

- **Derived attribute:** value may be calculated from other attributes (e.g., age)
 - Need not be physically stored within database



Derived Attribute

	Stored	Not Stored
Advantage	<ul style="list-style-type: none">- Saves CPU processing cycles- Saves data access time- Data value is readily available	<ul style="list-style-type: none">- Saves storage space- Computation always gives current value
Disadvantage	<ul style="list-style-type: none">- Requires constant maintenance to ensure derived value is current	<ul style="list-style-type: none">- Adds coding complexity to queries

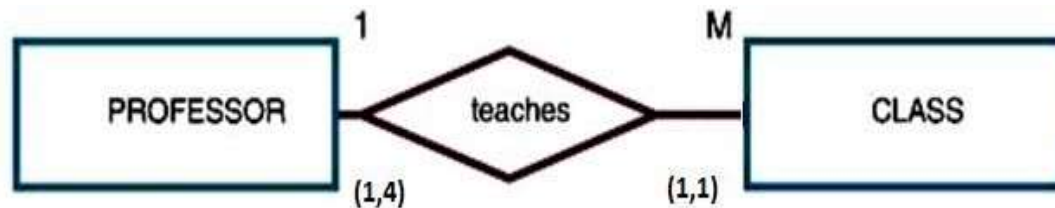
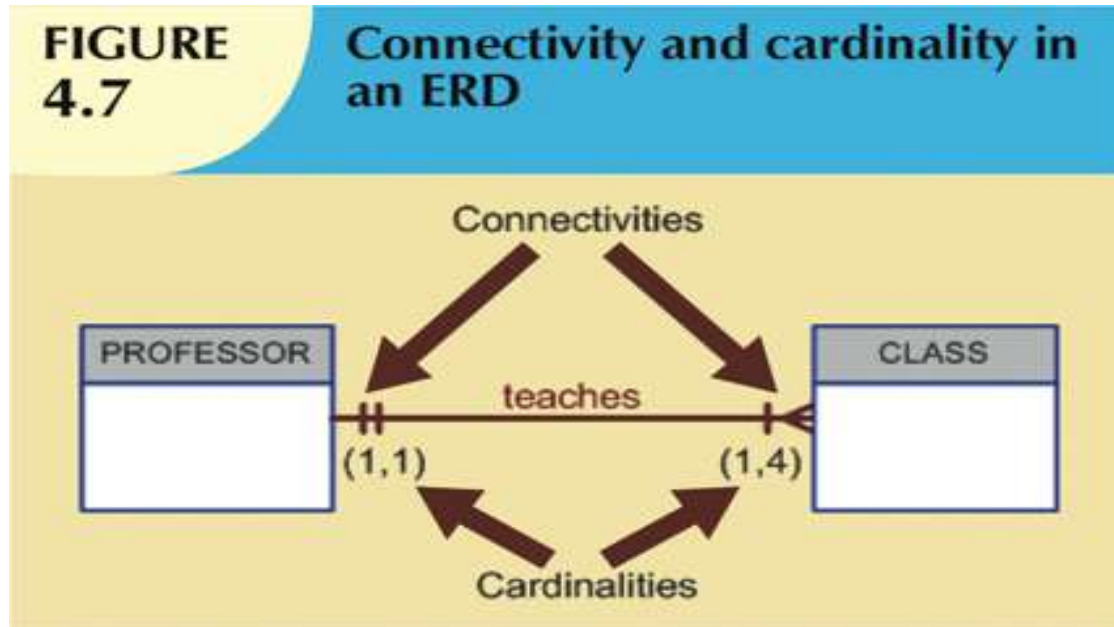
Relationships

- Association between entities
- Participants are entities that participate in a relationship
- Relationships between entities always operate in both directions
 - Relationship classification is difficult to establish if only one side of the relationship is known
- Relationship can be classified as **1:M**, **1:1** or **M:N**

Connectivity and Cardinality

- **Connectivity**
 - Describes the relationship classification
- **Cardinality**
 - Expresses minimum and maximum number of entity occurrences associated with one occurrence of related entity

Samples of ERD with Connectivity and Cardinality



Relationship Strength

- **Weak (non-identifying) relationships**
 - Exists if PK of related entity does not contain PK component of parent entity
 - In Crow's foot notation, a weak relationship is represented by a **dashed line** between entities

FIGURE 4.8

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

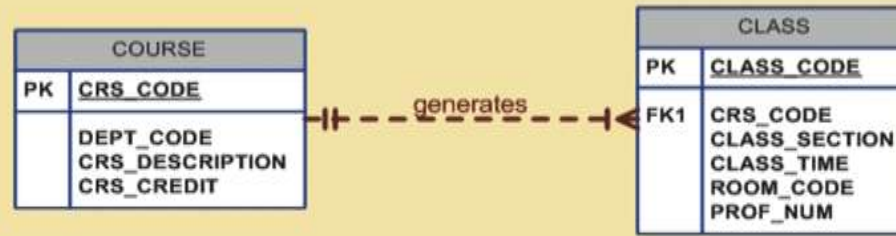


Table name: COURSE

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

Database name: Ch04_TinyCollege

Table name: CLASS

CLASS_CODE	CRS_CODE	CLASS_SECTION	CLASS_TIME	ROOM_CODE	PROF_NUM
10012	ACCT-211	1	M/W/F 8:00-8:50 a.m.	BUS311	105
10013	ACCT-211	2	M/W/F 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	M/W/F 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	M/W/F 9:00-9:50 a.m.	KLR209	228
10018	CIS-220	2	M/W/F 9:00-9:50 a.m.	KLR211	114
10019	CIS-220	3	M/W/F 10:00-10:50 a.m.	KLR209	228
10020	CIS-420	1	TTh 6:00-8:40 p.m.	KLR209	162
10021	QM-261	1	M/W/F 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	M/W/F 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

- CRS_CODE is only a FK in the CLASS entity
- CLASS PK did not inherit PK from COURSE entity

Relationship Strength

- **Strong (identifying) relationships**
 - Exists when PK of related entity contains PK component of parent entity
 - In Crow's foot notation, a strong relationship is represented by a ***solid line*** between entities

FIGURE 4.9

A strong (identifying) relationship between COURSE and CLASS



Table name: COURSE

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

Database name: Ch04_TinyCollege_Alt

Table name: CLASS

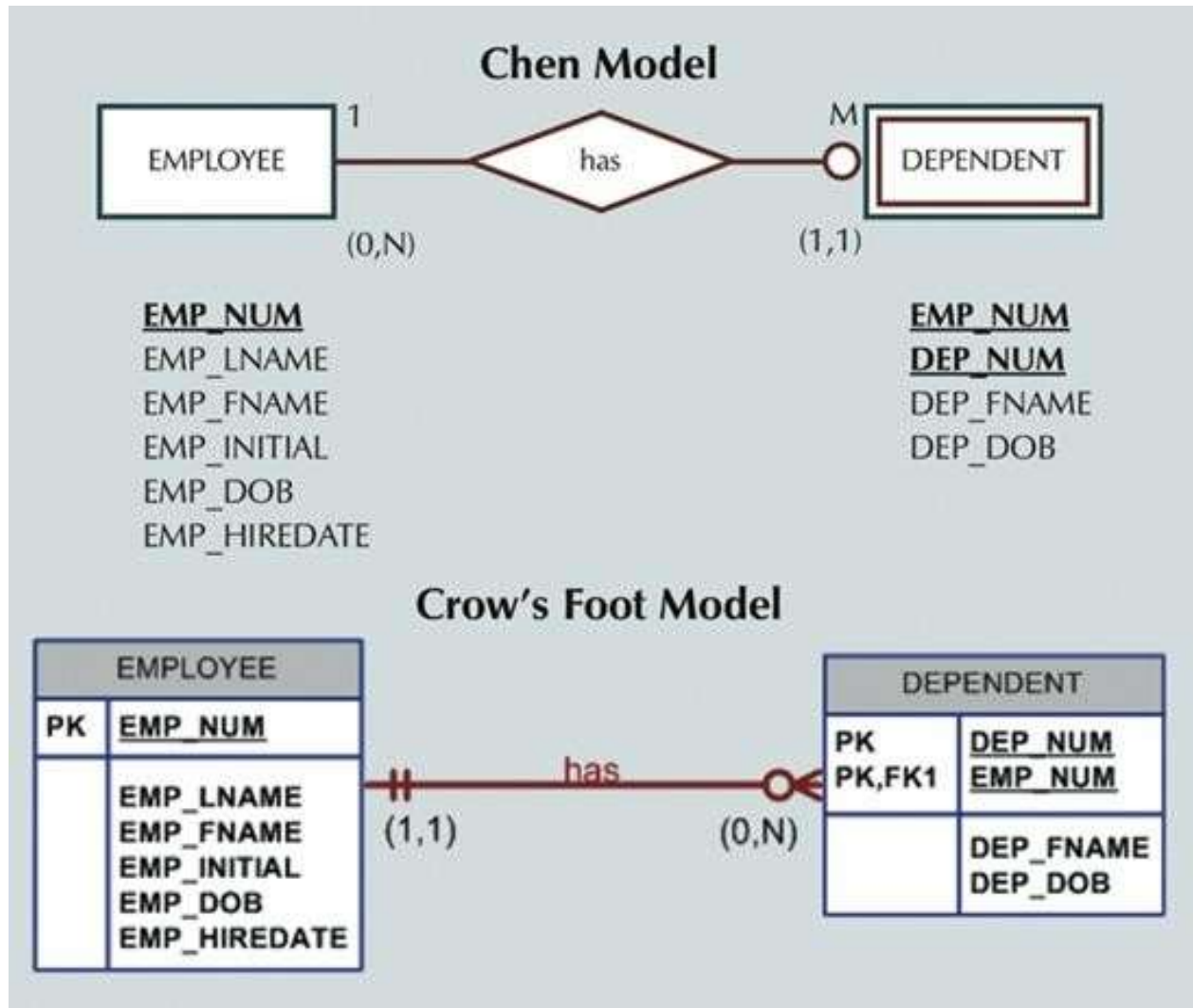
CRS_CODE	CLASS_SECTION	CLASS_TIME	ROOM_CODE	PROF_NUM
ACCT-211	1	M/W/F 8:00-8:50 a.m.	BUS311	105
ACCT-211	2	M/W/F 9:00-9:50 a.m.	BUS200	105
ACCT-211	3	TTh 2:30-3:45 p.m.	BUS252	342
ACCT-212	1	M/W/F 10:00-10:50 a.m.	BUS311	301
ACCT-212	2	Th 6:00-8:40 p.m.	BUS252	301
CIS-220	1	M/W/F 9:00-9:50 a.m.	KLR209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

- CLASS entity is composed of CRS_CODE and CLASS_SECTION
 - CLASS PK did inherit PK from COURSE entity

Weak Entities

- Weak entity meets two conditions
 - *Existence-dependent (an entity cannot exist without the entity with which it has a relationship)*
 - *Primary key partially or totally derived from parent entity in relationship*
- In Chen's notation: represented by a double-walled rectangle
- In Crow's foot notation: represented by PK/FK designation

Weak Entity in ERD



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

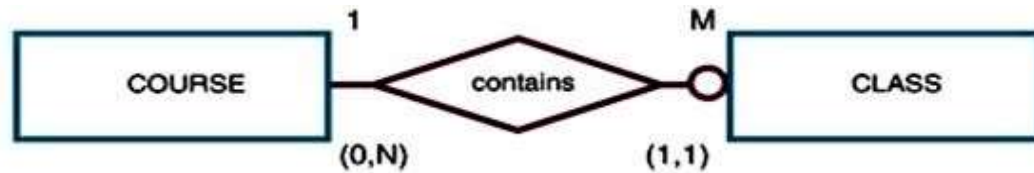
EMP_NUM	DEP_NUM	DEP_FNAME	DEP_DOB
1001	1	Annelise	05-Dec-97
1001	2	Jorge	30-Sep-02
1003	1	Suzanne	25-Jan-04
1006	1	Carlos	25-May-01
1008	1	Michael	19-Feb-95
1008	2	George	27-Jun-98
1008	3	Katherine	18-Aug-03

Relationship Participation

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

Optional Participation

- Chen Model

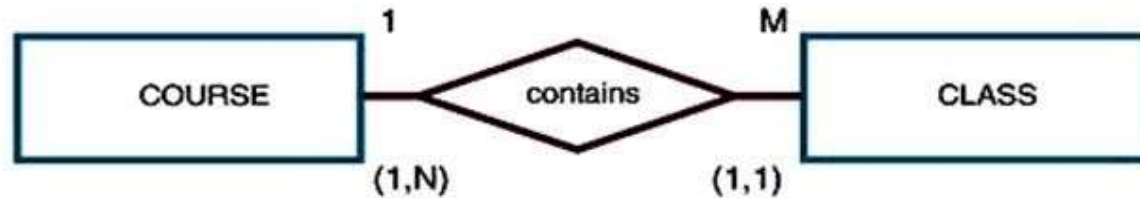


- Crow's Foot Model



Mandatory Participation

- Chen Model



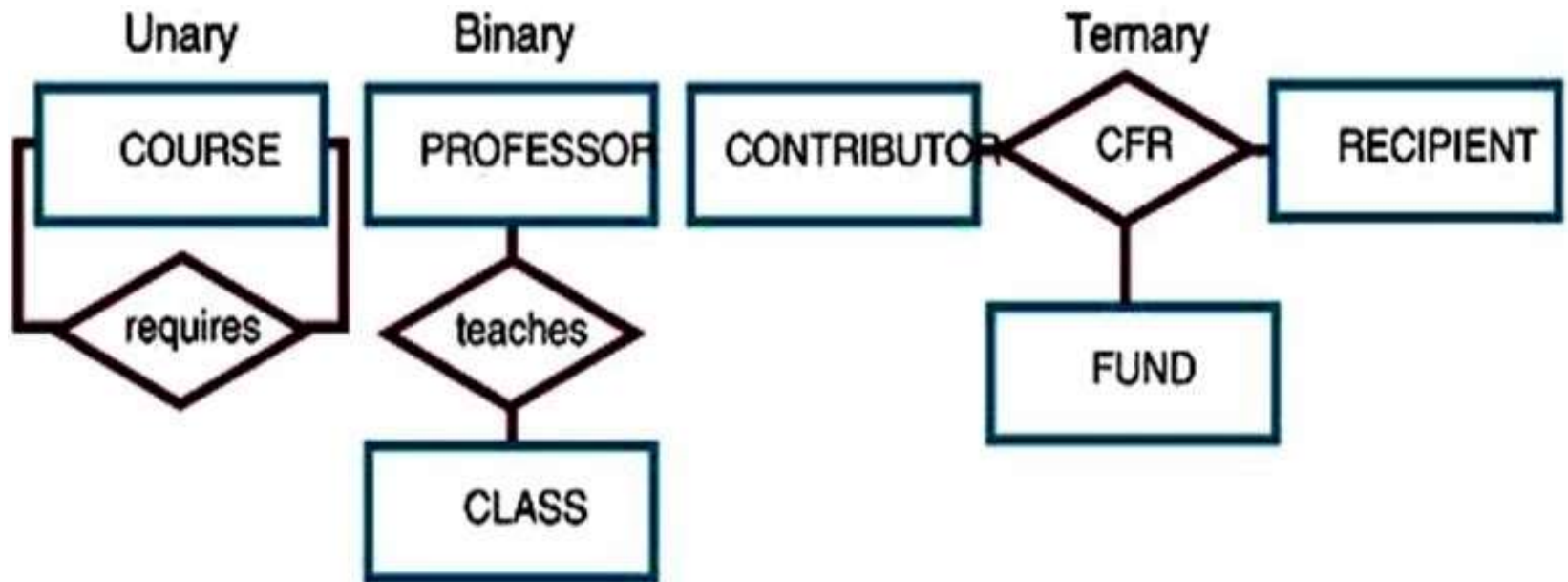
- Crow's Foot Model



Relationship Degree

- Indicates number of entities or participants associated with a relationship
- **Unary relationship**
 - Association is maintained within single entity
- **Binary relationship**
 - Two entities are associated
- **Ternary relationship**
 - Three (or more) entities are associated

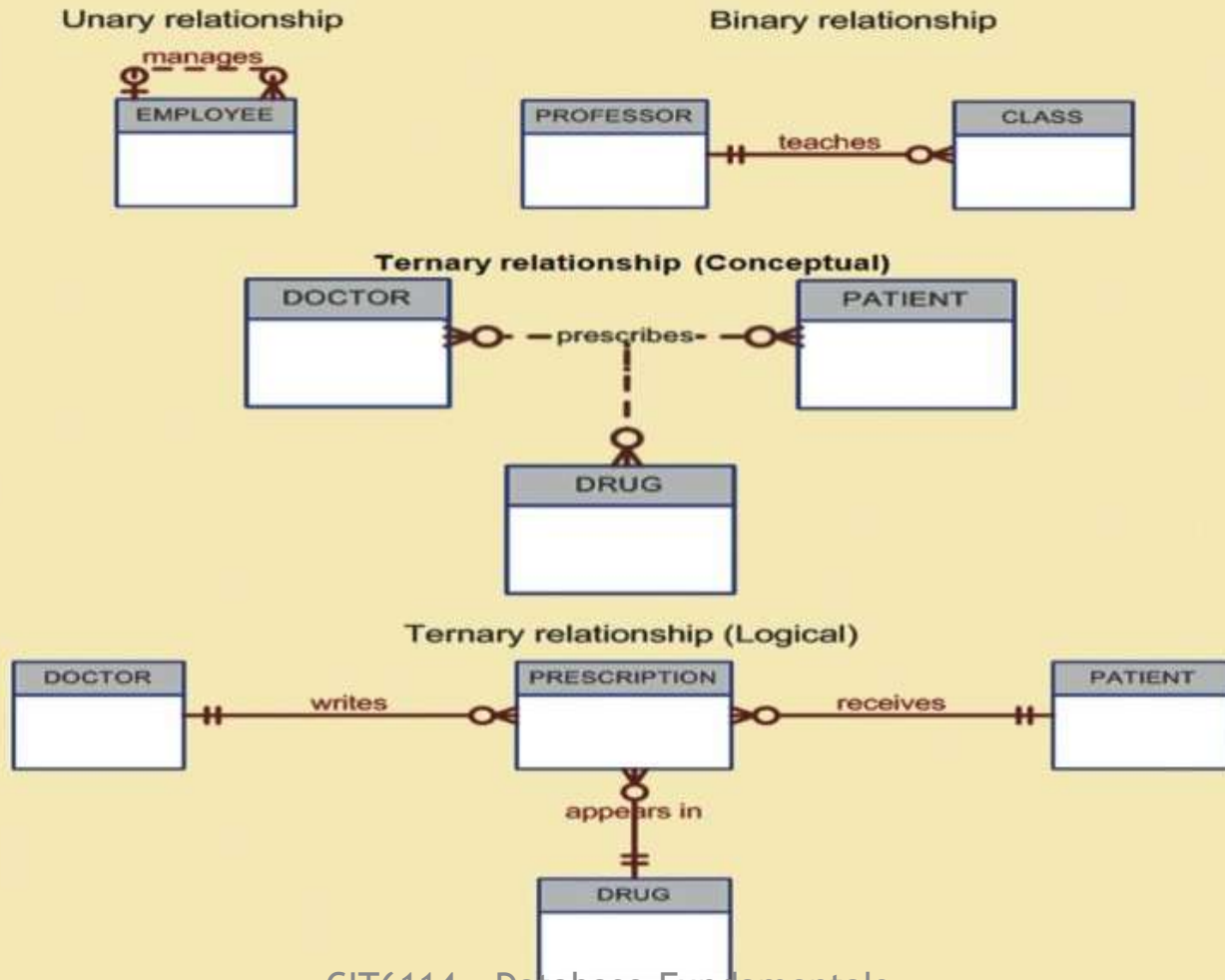
Three Types of Relationship Degree in Chen Model



Three Types of Relationship Degree in Crow's Foot Model

FIGURE 4.15

Three types of relationship degree



Ternary Relationship in Relational Model

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.	vWilliams	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.	vWesenbach	Paul	R	14-Feb-1966	615	897-4358
109	Mr.	Smith	George	K	18-Jun-1961	901	504-3339
110	Mrs.	Genkazi	Leighia	vV	19-May-1970	901	569-0093
111	Mr.	vWashington	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

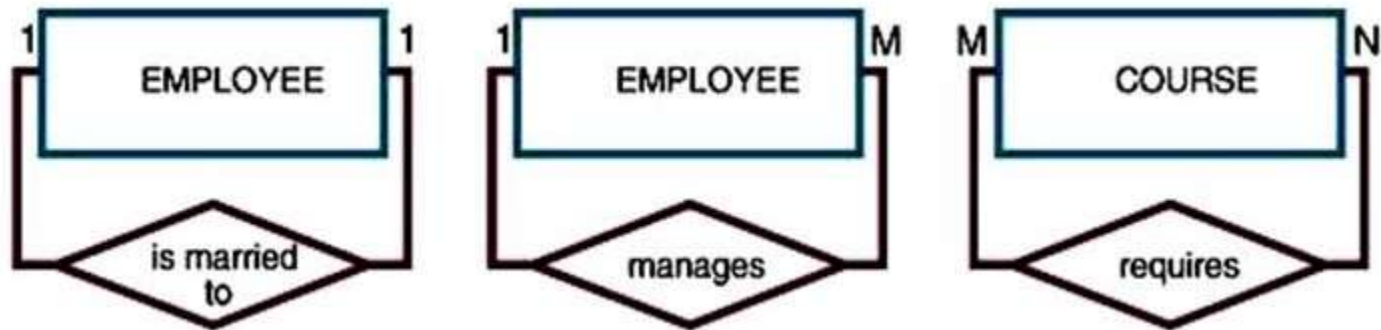
DOC_ID	DOC_LNAME	DOC_FNAME	DOC_INITIAL	DOC_SPECIALTY
29827	Sanchez	Julio	J	Dermatology
32445	Jorgensen	Annelise	G	Neurology
33456	Korenski	Anatoly	A	Urology
33989	LeGrande	George		Pediatrics
34409	vWashington	Dennis	F	Orthopaedics
36221	McPherson	Katye	H	Dermatology
36712	Dreifag	Herman	G	Psychiatry
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-09
32445	113	OLE	1 teaspoon with each meal -- 250 ml total	14-Nov-09
34409	101	KO15	1 tablet every six hours -- 30 tablets total	14-Nov-09
36221	109	DRO	2 tablets with every meal -- 60 tablets total	14-Nov-09
38995	107	KO15	1 tablet every six hours -- 30 tablets total	14-Nov-09

Recursive Relationships

- Relationship can exist between occurrences of the same entity set
 - Naturally found within unary relationship



1:1 Recursive Relationship

Employee is married to Employee

Emp_Num	EmpName	Emp_Spouse
345	James Ramirez	347
346	Anne Jones	349
347	Louise John	345
348	Robert Delaney	
349	Anton Robert	346



1:M Recursive Relationship

**FIGURE
4.22**

Implementation of the 1:M recursive relationship “EMPLOYEE manages EMPLOYEE”

Database name: Ch04_PartCo
Table name: EMPLOYEE_V2

EMP_CODE	EMP_LNAME	EMP_MANAGER
101	Waddell	102
102	Orincona	
103	Jones	102
104	Reballoh	102
105	Robertson	102
106	Deltona	102

M:N Recursive Relationship

- A subject may have many other subjects as prerequisites and is itself may be a prerequisite to many other subjects

SubjectPrerequisite	SubjectCode
TCP1101	TSE1201
TCP1101	TCP1201
TXX1234	TCP1201
TCP1201	TGD2151
TCP1201	TCP2101

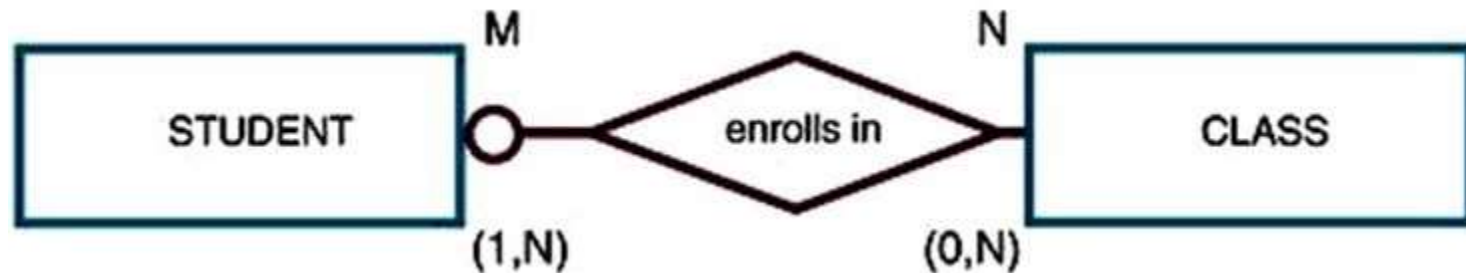
SubjectCode	SubjectName
TCP1101	Programming Fundamentals
TCP1201	OOP and Data Structures
TSE2101	Software Engineering Fundamentals
TCP2101	Algorithm Design & Analysis
TGD2151	Computer Graphics Fundamentals
TXX1234	O O Fundamentals

Associative (Composite) Entities

- Also known as **bridge** entities
- Used to implement M:N relationships
- Composed of primary keys of each of the entities to be connected

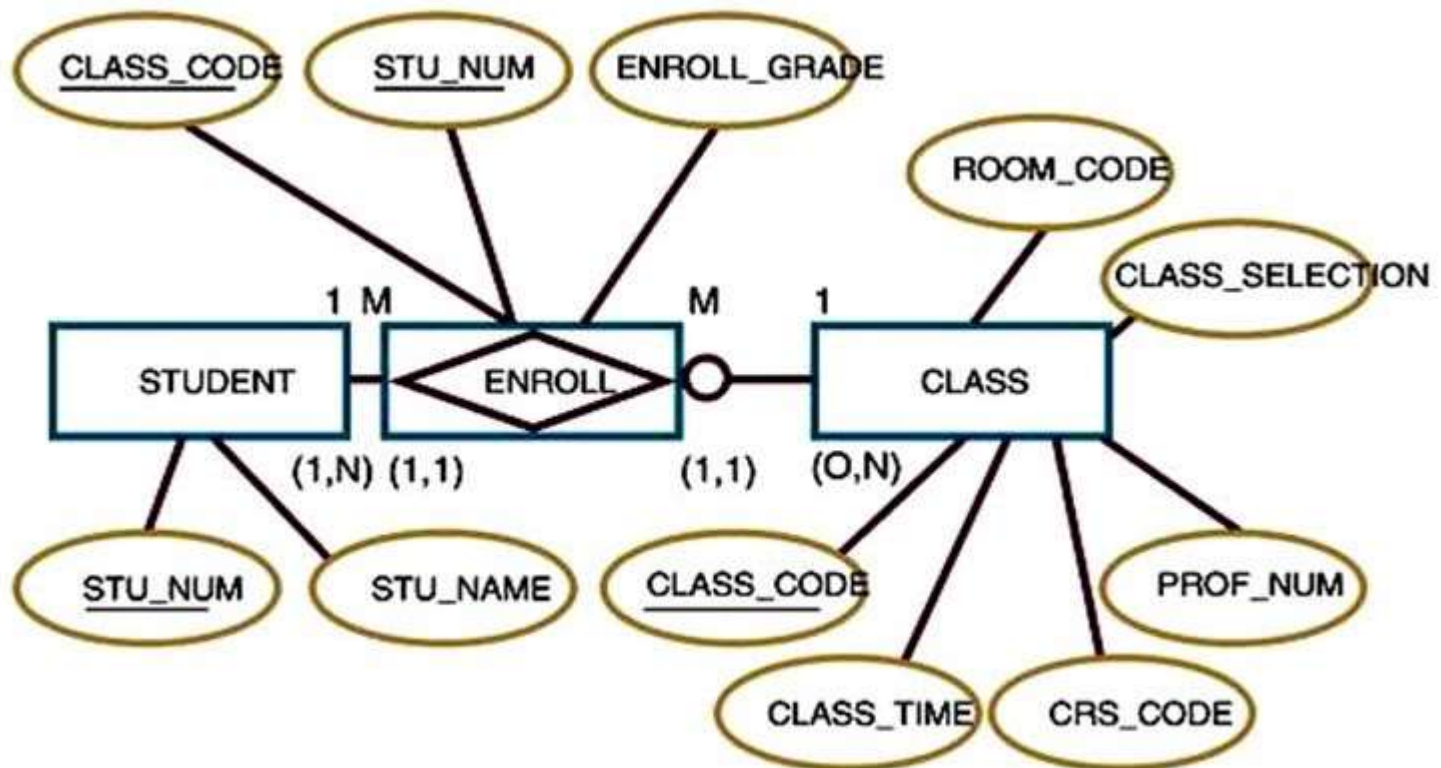
M:N Relationship in ERD (Conceptual model)

- One student enrolls in many classes
- One class may be enrolled by many students



Composite Entity in ERD (Logical model)

- The relationship is converted into a composite entity.



M:N Relationship in Crow's Foot Model

FIGURE 4.24

The M:N relationship between STUDENT and CLASS

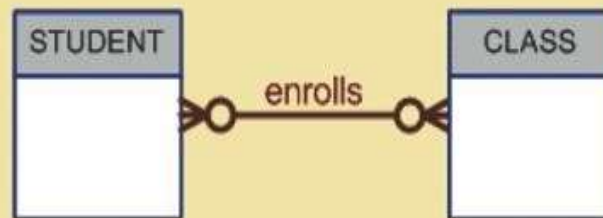
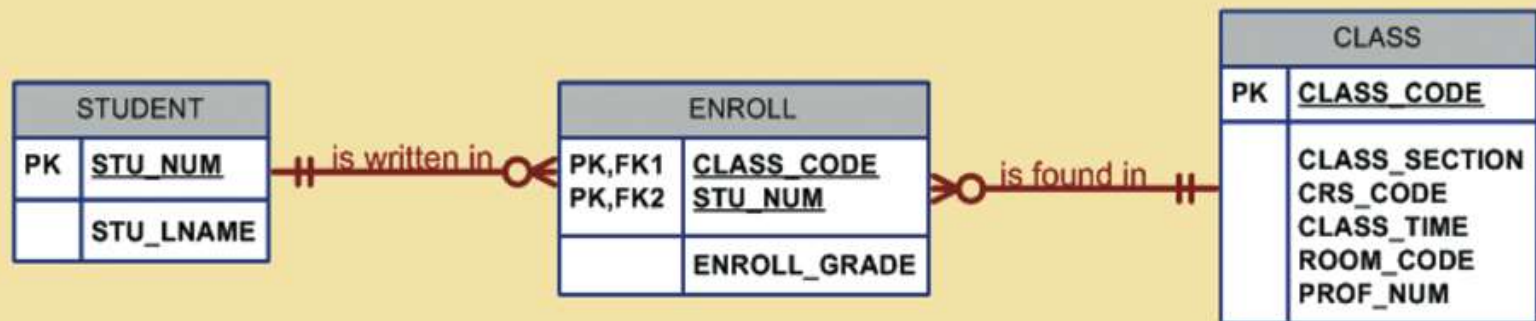


FIGURE 4.25

A composite entity in an ERD



Implementing M:N Relationship in Relational Model

FIGURE 4.23

Converting the M:N relationship into two 1:M relationships

Table name: STUDENT

STU_NUM	STU_LNAME
321452	Bowser
324257	Smithson

Database name: Ch04_CollegeTry

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	CLASS_ROOM	PROF_NUM
10014	ACCT-211	3	TTh 2:30-3:45 p.m.	BUS252	342
10018	CIS-220	2	MWTF 9:00-9:50 a.m.	KLR211	114
10021	QM-261	1	MWTF 8:00-8:50 a.m.	KLR200	114