
Spring 2019
Week 11, Lecture 22

Database Systems -

Introduction to Databases and Data Warehouses

CHAPTER 3 - Relational Database Modeling (Part 1)

MAIN TOPICS

- Review: basic concepts in relational database model
- Primary Key
- Map entity with unique attribute into relation
- Map Composite attributes (unique or not unique)
- Map Optional attribute
- Entity integrity constraint
- Foreign key
- Map relationships: 1:M, M:N, 1:1
- Example of Mapping ERD to Relational Schema
- ERD Plus tool demo



INTRODUCTION

- **Logical** database model
 - The database model that is **implementable** by a DBMS software
- **Relational** database model
 - **Logical** database model that represents a database as a **collection of related tables**
- **Relational database**
 - A database modeled using a relational database model
- **Relational schema**
 - **Visual depiction** of the relational database model
- **Most contemporary commercial** DBMS software packages
 - **Relational DBMS (RDBMS)** software packages



INTRODUCTION

- This chapter
 - Concepts of relational database modeling
 - Convert a ER diagram (conceptual database model) to a relational schema (logical database model)

INTRODUCTION

Terminology

TABLE 3.1 Synonyms Used in the Relational Database Model

Relation	=	Relational Table	=	Table
Column	=	Attribute	=	Field
Row	=	Tuple	=	Record

INTRODUCTION

- **Relational database**

- A collection of related relations
 - Each relation must have a unique name within one collection

- **Relation**

- A **table** in a relational database
- A table containing **rows and columns**
- The **main construct** in the relational database model
- **Every relation is a table, not every table is a relation**

INTRODUCTION

- **Relation** - table in a relational database
 - Conditions for a table to be a relation:
 - Must have a name for each column
 - * **Unique column name** within each table
 - **Unique row** within each table
 - **Single-valued entry**
 - * Within each row, each value in each column must be single valued
 - Must have **same (predefined) domain** for all values in **each column**
 - **Irrelevant ordering** of columns and rows

INTRODUCTION

- **Relation** - table in a relational database
 - Conditions for a table to be a relation:
 - Example: Employee information
 - * Domains of each column
 - ❖ Employee ID – 4 digits
 - ❖ Employee Name – 0 to 20 chars
 - ❖ Employee Gender – ‘M’ or ‘F’
 - ❖ Employee Phone – “xddd” //d: digit
 - ❖ Employee Bdate – date (day, month, year)



INTRODUCTION

Example of relational and non-relational tables

Relational Table (Relation)

EmpID	EmpName	EmpGender	EmpPhone	EmpBdate
0001	Joe	M	x234	1/11/1985
0002	Sue	F	x345	2/7/1983
0003	Amy	F	x456	4/4/1990
0004	Pat	F	x567	3/8/1971
0005	Mike	M	x678	5/5/1965

Not a Relational Table

EmpID	EmpInfo	EmpInfo	EmpPhone	EmpBdate
0001	Joe	M	x234	1/11/1985
0002	Sue	F	x345	2/7/1983
0001	Joe	M	x234	1/11/1985
0004	Pat	F	x567, x789	3/8/1971
0005	Mike	M	x678	a long time ago



INTRODUCTION

Different ordering of rows and columns in a relation

- But same information about Employee => same relation

A Relation

EmpID	EmpName	EmpGender	EmpPhone	EmpBdate
0001	Joe	M	x234	1/11/1985
0002	Sue	F	x345	2/7/1983
0003	Amy	F	x456	4/4/1990
0004	Pat	F	x567	3/8/1971
0005	Mike	M	x678	5/5/1965

Exact Same Relation (order of rows and columns is irrelevant)

EmpName	EmpID	EmpGender	EmpBdate	EmpPhone
Joe	0001	M	1/11/1985	x234
Amy	0003	F	4/4/1990	x456
Sue	0002	F	2/7/1983	x345
Pat	0004	F	3/8/1971	x567
Mike	0005	M	5/5/1965	x678

PRIMARY KEY

- Primary key
 - A single column (or a set of columns) that uniquely identify each row
 - Must have one primary key for each relation
 - Notation:
 - Underlined column(s)

PRIMARY KEY

Relation with the primary key underlined

EMPLOYEE

<u>EmpID</u>	EmpName	EmpGender	EmpPhone	EmpBdate
0001	Joe	M	x234	1/11/1985
0002	Sue	F	x345	2/7/1983
0003	Amy	F	x456	8/4/1990
0004	Pat	F	x567	3/8/1971
0005	Mike	M	x678	5/5/1965
0010	Mike	M	x666	8/1/1974
0007	Barbara	F	x777	4/5/1980
0011	Ivan	M	x777	3/4/1981
0009	Amy	F	x777	1/11/1985

MAPPING ER DIAGRAMS INTO RELATIONAL SCHEMAS

- Map an ER diagram into a relational schema
 - A collection of relations

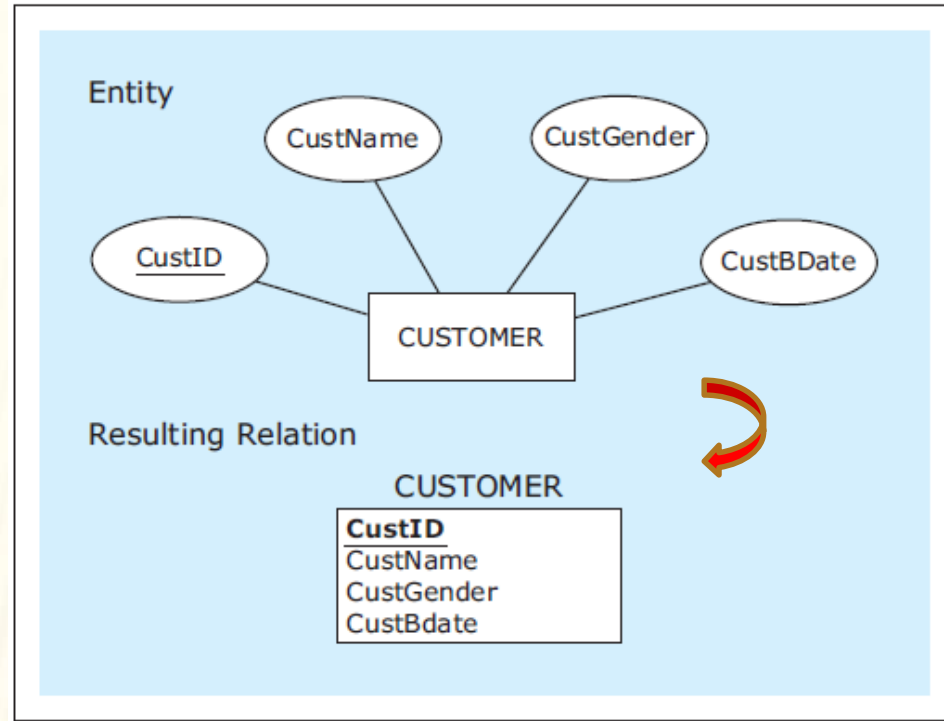
MAPPING ENTITIES

- Mapping entities into relations
 - Each **regular entity** => a **relation**
 - Each **regular attribute** of a regular entity =>
 - A **column** of the new relation
 - The **single unique attribute** in a regular entity =>
 - **Primary key** in the new relation



MAPPING ENTITIES

Entity mapped
into a relation



Sample data
records for the
mapped relation

CUSTOMER			
<u>CustID</u>	CustName	CustGender	CustBdate
1111	Tom	M	1/1/1965
2222	Jenny	F	2/2/1968
3333	Greg	M	1/2/1962
4444	Sophia	F	2/2/1983

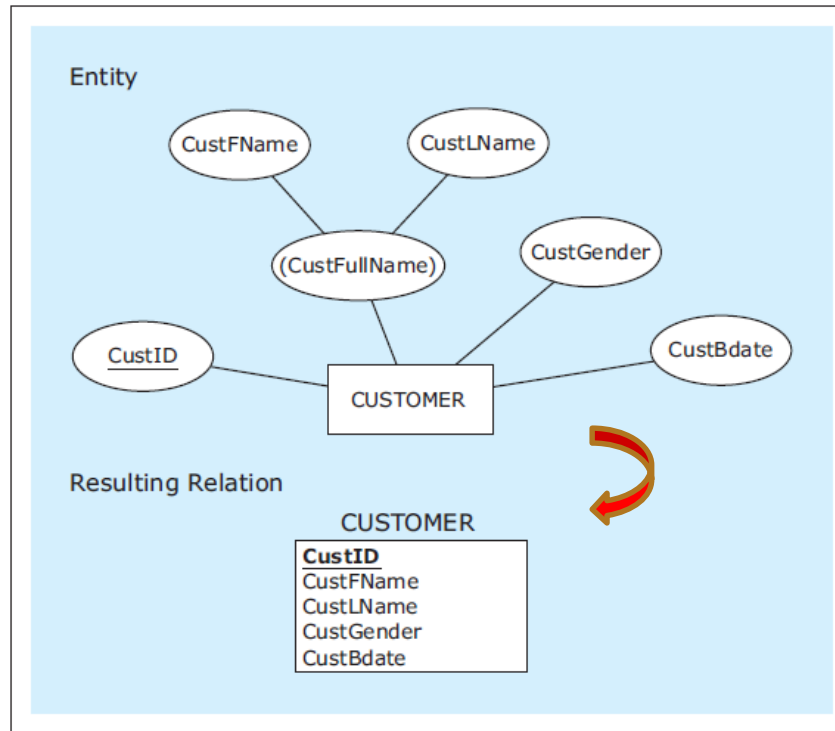
MAPPING ENTITIES WITH COMPOSITE ATTRIBUTES

- Mapping **entities with composite attributes** into relations
 - Each **component** of a composite attribute =>
 - A **column** of the new relation
 - The **composite attribute itself**
 - **Not shown** in the new relation



MAPPING ENTITIES WITH COMPOSITE ATTRIBUTES

Entity with a composite attribute mapped into a relation



Sample data records for the mapped relation

CUSTOMER				
<u>CustID</u>	CustFName	CustLName	CustGender	CustBdate
1111	Tom	Lendrum	M	1/1/1965
2222	Jenny	Jones	F	2/2/1968
3333	Greg	Newton	M	1/2/1962
4444	Sophia	Danks	F	2/2/1983



MAPPING ENTITIES **WITH COMPOSITE ATTRIBUTES**

The mapped relation as presented to a user in a **front-end application**

- **Composite attribute shown in the user interface**

CUSTOMER				
CustFullName				
<u>CustID</u>	CustFName	CustLName	CustGender	CustBdate
1111	Tom	Lendrum	M	1/1/1965
2222	Jenny	Jones	F	2/2/1968
3333	Greg	Newton	M	1/2/1962
4444	Sophia	Danks	F	2/2/1983

COMPOSITE PRIMARY KEY

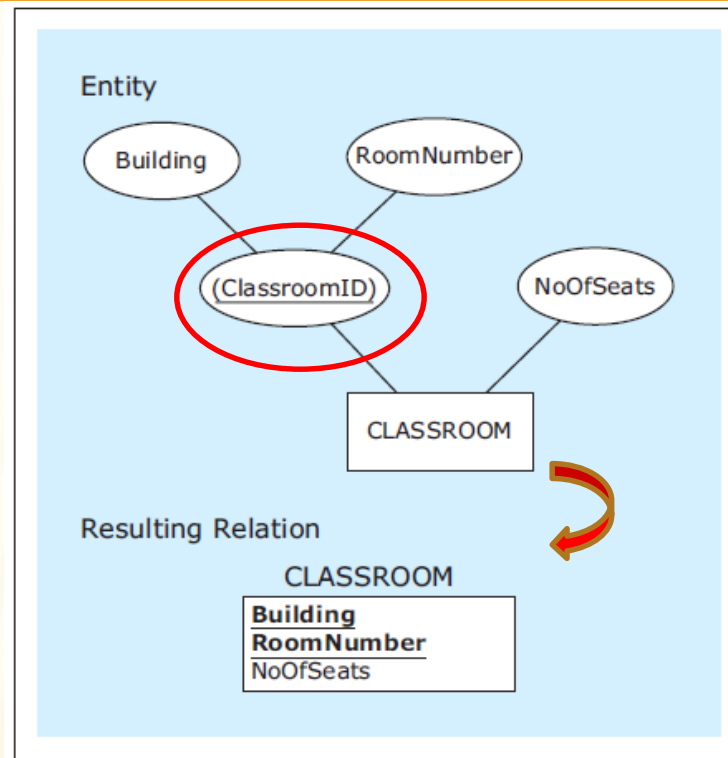
- Composite primary key
 - A primary key that is composed of multiple columns
 - All column names of a composite primary key are underlined

MAPPING ENTITIES WITH UNIQUE COMPOSITE ATTRIBUTES

- Mapping entities with **unique composite attributes** into relations
 - The **only unique composite attribute** in an entity =>
 - A **composite primary key** in the new relation

MAPPING ENTITIES WITH UNIQUE COMPOSITE ATTRIBUTES

Entity with a unique composite attribute mapped into a relation



Sample data records for the mapped relation

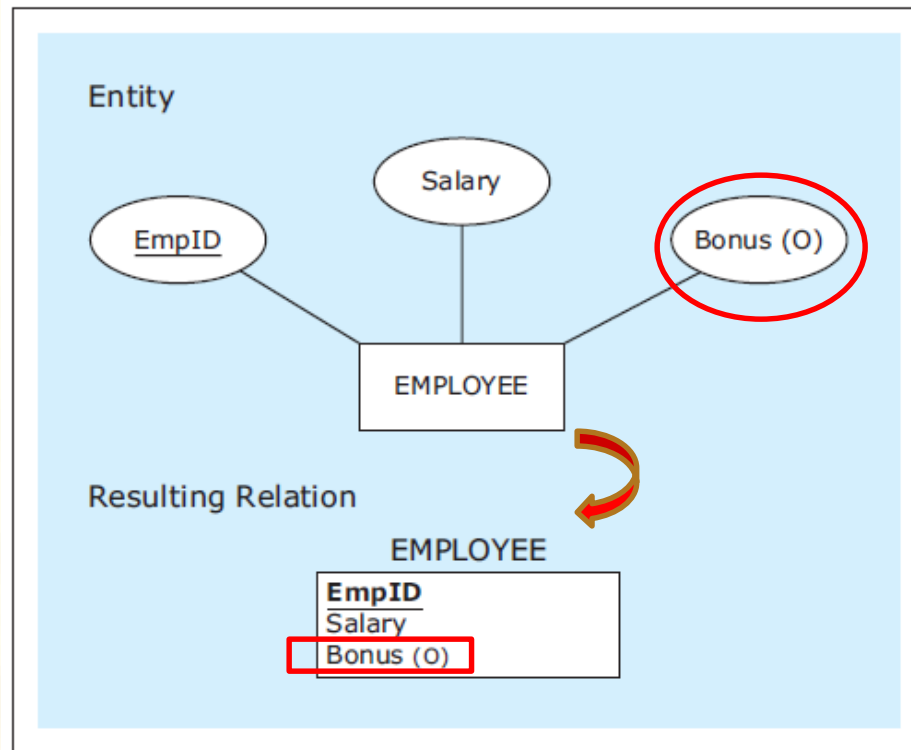
CLASSROOM		
<u>Building</u>	<u>RoomNumber</u>	NoOfSeats
Maguire	110	100
Maguire	210	50
Houser	110	50
Houser	210	50

MAPPING ENTITIES WITH OPTIONAL ATTRIBUTES

- **Mapping** entities with **optional attributes** into relations
 - Optional attribute of an entity =>
 - An **optional column** in the new relation

MAPPING ENTITIES WITH OPTIONAL ATTRIBUTES

Entity with an optional attribute mapped into a relation



Sample data records for the mapped relation

EMPLOYEE		
<u>EmpID</u>	Salary	Bonus
1234	\$75,000	
2345	\$45,000	\$10,000
3456	\$55,000	\$4,000
1324	\$70,000	

null

ENTITY INTEGRITY CONSTRAINT

- **Integrity Constraints**
 - **Rules** that make data integrate
- **Entity integrity constraint**
 - Rule: **no primary key** column can be **optional**
 - **No null (empty) values** in a **primary key column** in any relational table
 - **No null values** in a **component primary key column** if **composite** primary key
 - **Enforced** by every RBMS



ENTITY INTEGRITY CONSTRAINT

Entity integrity constraint — compliance and violation example

- Single-column primary key

EMPLOYEE		
<u>EmpID</u>	Salary	Bonus
1234	\$75,000	
2345	\$50,000	\$10,000
3456	\$55,000	\$4,000
1324	\$70,000	
VALID		

EMPLOYEE		
<u>EmpID</u>	Salary	Bonus
1234	\$75,000	
2345	\$50,000	\$10,000
	\$55,000	\$4,000
1324	\$70,000	
INVALID		

Entity integrity constraint violation



ENTITY INTEGRITY CONSTRAINT

Entity integrity constraint — another compliance and violation example

- Composite primary key

CLASSROOM

<u>Building</u>	<u>RoomNumber</u>	NoOfSeats
Maguire	110	100
Maguire	210	50
Houser	110	50
Houser	210	50

VALID

CLASSROOM

<u>Building</u>	<u>RoomNumber</u>	NoOfSeats
Maguire	110	100
Maguire	210	50
Houser		50
Houser	210	50

INVALID

Entity integrity
constraint violation

FOREIGN KEY

- Foreign key (FK)
 - A column in a relation that refers to a primary key column in another (referred) relation
 - A mechanism used to depict relationships in the relational database model
 - Used to map ER diagram to relational schema
 - In a relational schema, draw a directed line from each foreign key to its corresponding primary key
 - Can depict all relationships (1:1, 1:M, M:N)

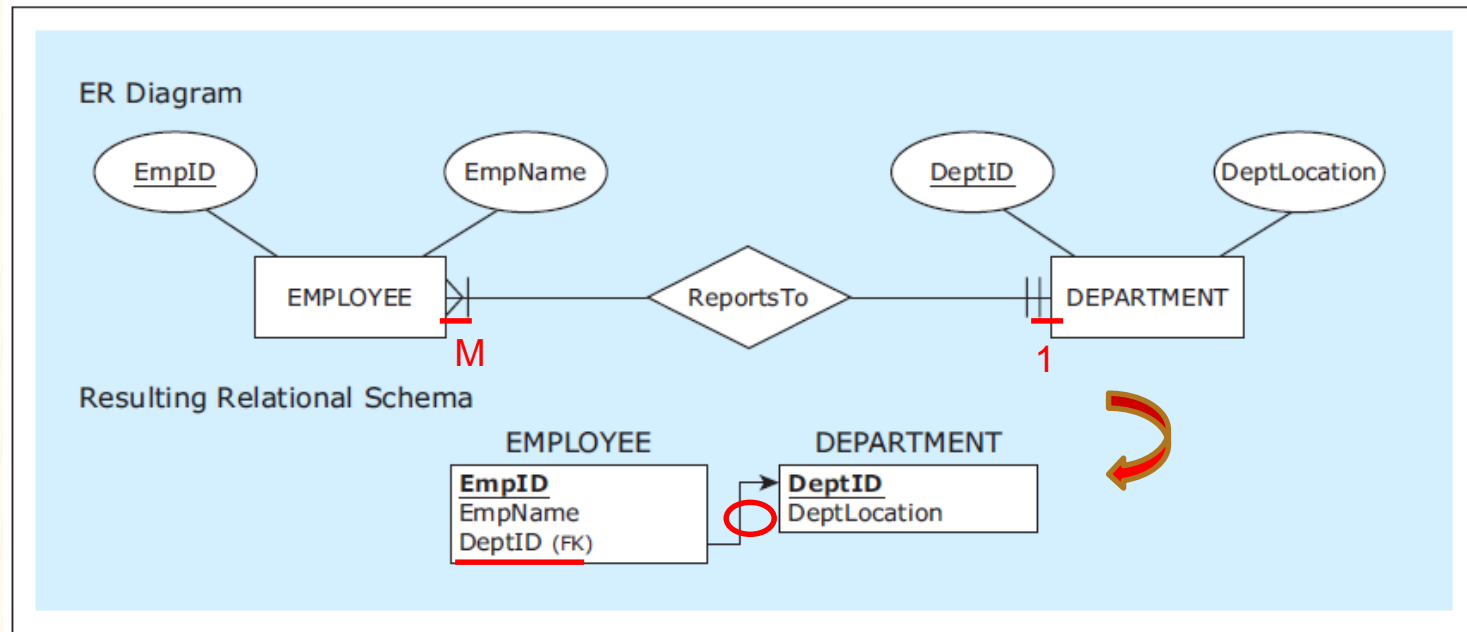
MAPPING RELATIONSHIPS

- **Mapping 1:M relationships**

- The relation mapped from the **entity on the M side** of the 1:M relationship **has a foreign key** that corresponds to the primary key of the relation mapped from the 1 side of the 1:M relationship.
 - **Add a foreign key column** in the **relation for the entity on M side**

MAPPING RELATIONSHIPS

Example -
Map 1:M
relationship



Sample data
records for the
mapped ER
diagram

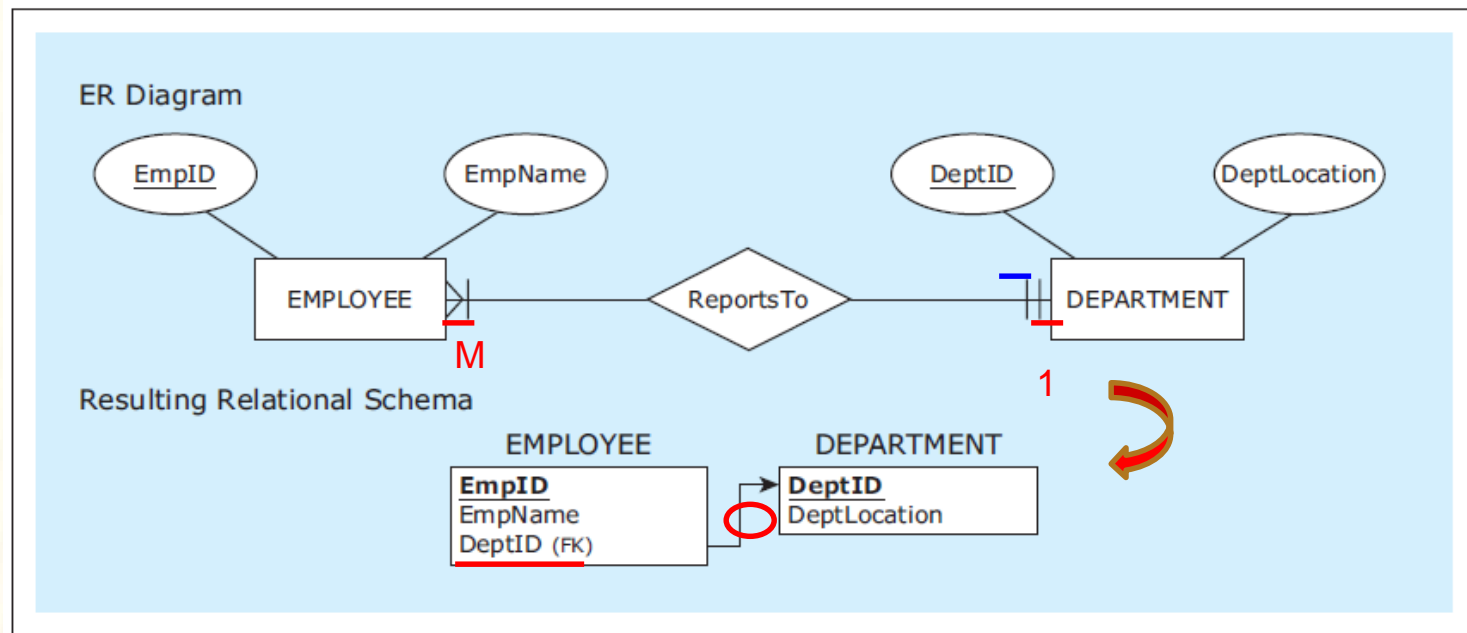
EMPLOYEE			DEPARTMENT	
<u>EmpID</u>	EmpName	DeptID	<u>DeptID</u>	DeptLocation
1234	Becky	1	1	Suite A
2345	Molly	2	2	Suite B
3456	Rob	1		
1324	Ted	2		

MAPPING RELATIONSHIPS

Example -
Map a 1:M
relationship

**Mandatory
participation on
the 1 side**

- **DeptID –
required (not
optional)
column in
EMPLOYEE**



Sample data
records for the
mapped ER
diagram

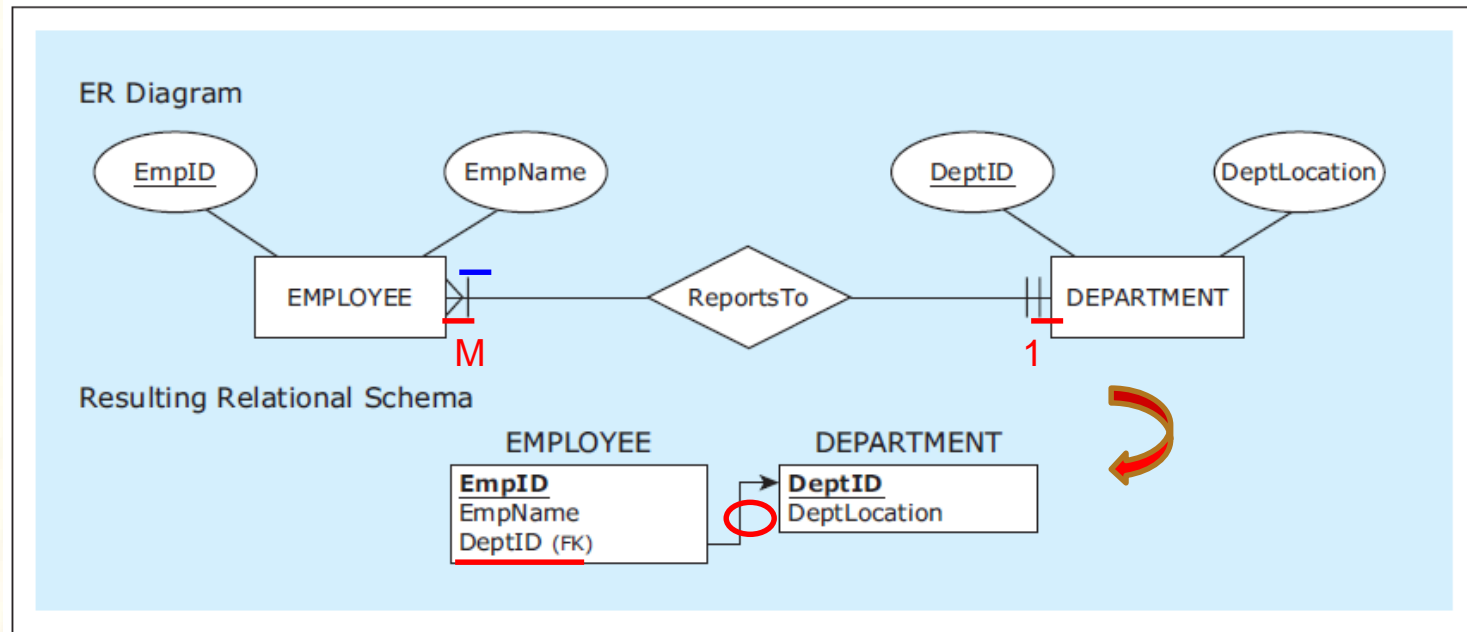
EMPLOYEE			DEPARTMENT	
<u>EmpID</u>	EmpName	DeptID	<u>DeptID</u>	DeptLocation
1234	Becky	1	1	Suite A
2345	Molly	2	2	Suite B
3456	Rob	1		
1324	Ted	2		

MAPPING RELATIONSHIPS

Example - Map
a 1:M
relationship

Mandatory
participation
on the M side

- No DeptID in
DEPARTMENT
is NOT
referred by a
DeptID in
EMPLOYEE



Sample data
records for the
mapped ER
diagram

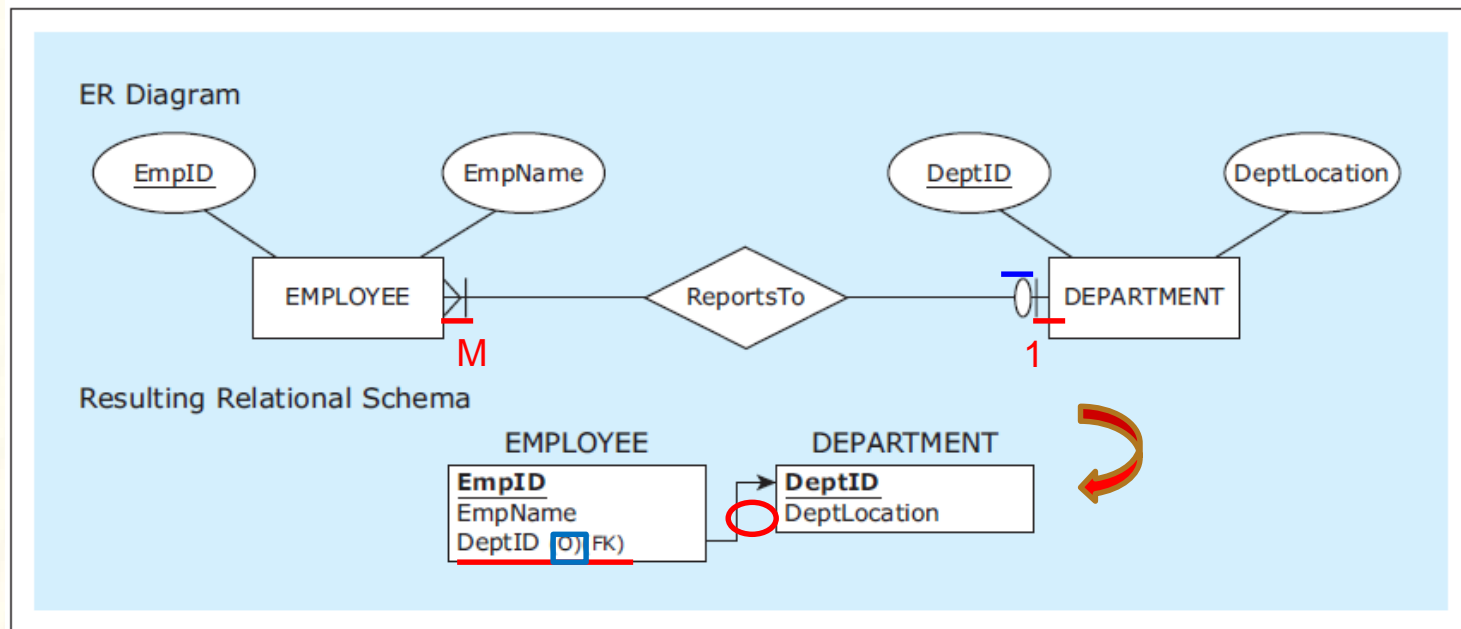
EMPLOYEE			DEPARTMENT	
<u>EmpID</u>	EmpName	DeptID	<u>DeptID</u>	DeptLocation
1234	Becky	1	1	Suite A
2345	Molly	2	2	Suite B
3456	Rob	1		
1324	Ted	2		

MAPPING RELATIONSHIPS

Example –
Map a 1:M
relationship

Optional
participation on
the 1 side

- DeptID –
optional
column in
EMPLOYEE



Sample data
records for the
mapped ER
diagram

EMPLOYEE			DEPARTMENT	
<u>EmpID</u>	EmpName	DeptID	<u>DeptID</u>	DeptLocation
1234	Becky	1	1	Suite A
2345	Molly	2	2	Suite B
3456	Rob			
1324	Ted	2		

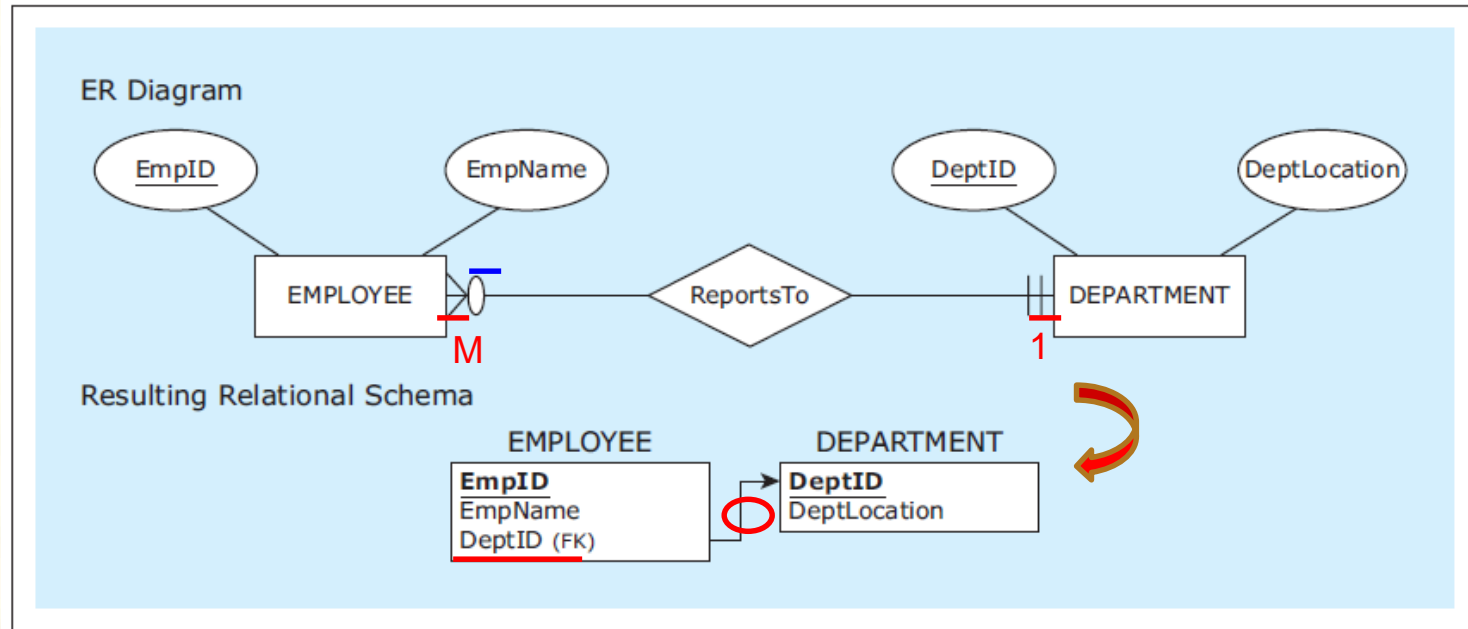
MAPPING RELATIONSHIPS

Example -
Map a 1:M
relationship

Optional
participation on
the M side

- Some
DeptIDs in
DEPARTMENT
are not
referred by
any DeptID in
EMPLOYEE

Sample data
records for the
mapped ER
diagram



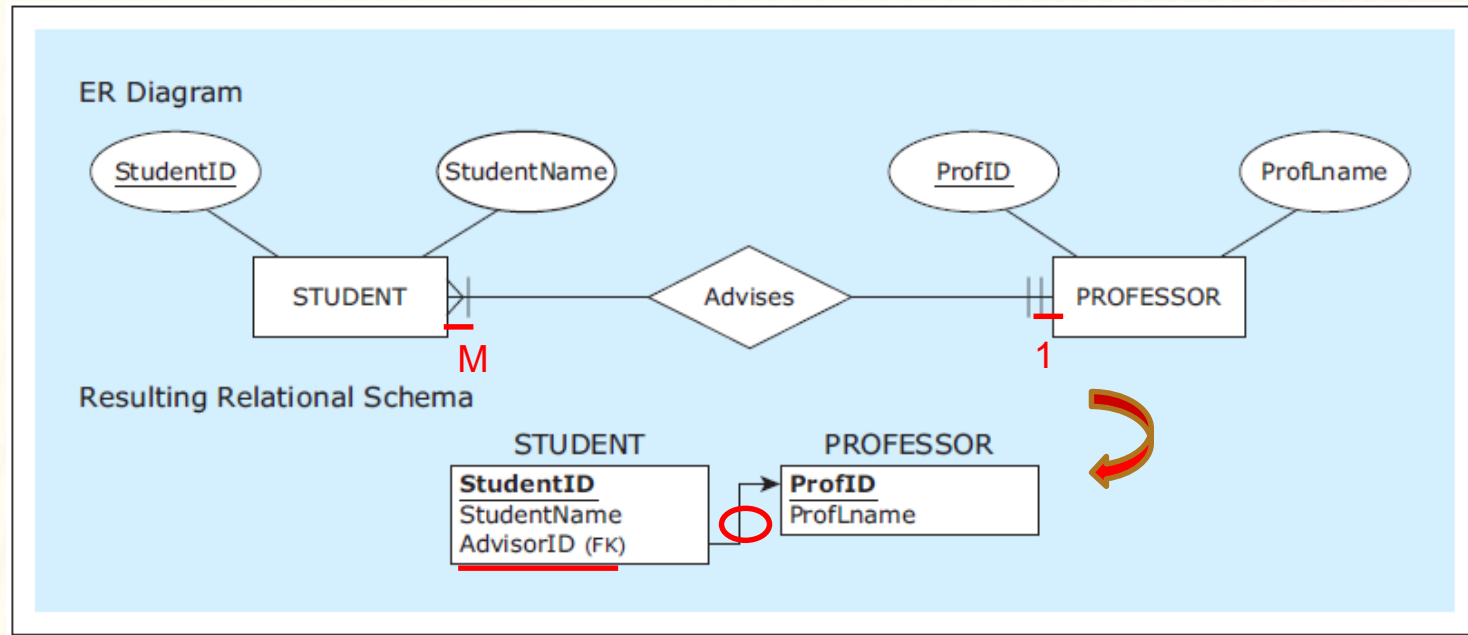
EMPLOYEE			DEPARTMENT	
<u>EmpID</u>	EmpName	DeptID	<u>DeptID</u>	DeptLocation
1234	Becky	1	1	Suite A
2345	Molly	2	2	Suite B
3456	Rob	1	3	Suite C
1324	Ted	2		

MAPPING RELATIONSHIPS

Example -
Map a 1:M
relationship

Rename a
foreign key

- better in
some cases
- Data shows
FK rule



Sample data
records for the
mapped ER
diagram

STUDENT			PROFESSOR	
<u>StudentID</u>	StudentName	<u>AdvisorID</u>	<u>ProfID</u>	ProfLname
1111	Robin	P11	P11	Zydiak
2222	Pat	P22	P22	Lash
3333	Jami	P11		

MAPPING RELATIONSHIPS

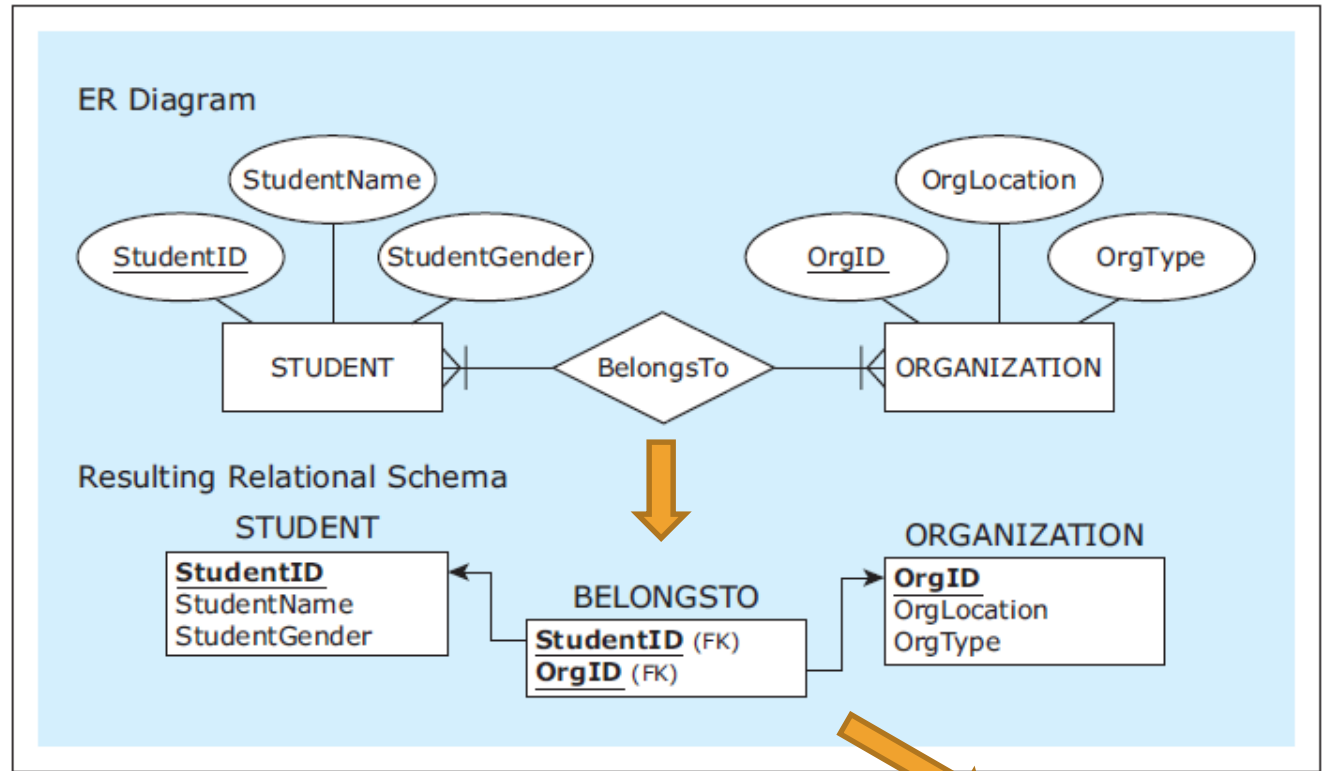
■ Mapping M:N relationships

- In addition to the two relations representing the two entities involved in the M:N relationship, **another relation** is created to **represent the M:N relationship** itself
 - Add a new relation for the M:N relationship
 - **Bridge relation** whose name may or may not = M:N relationship
- This **new relation has two foreign keys**, corresponding to the primary keys of the two relations representing the two entities involved in the M:N relationship
 - Add **two foreign key columns** to the new relation
 - **Point to primary keys of two relations involved**
- The **two foreign keys form the composite primary key** of the new relation
 - **Two foreign keys = primary key of new relation**

MAPPING RELATIONSHIPS

Example -
Map an M:N
relationship

- Bridge
relation
BELONGSTO



Sample data
records for the
mapped ER
diagram

STUDENT

<u>StudentID</u>	StudentName	StudentGender
1111	Robin	Male
2222	Pat	Male
3333	Jami	Female

ORGANIZATION

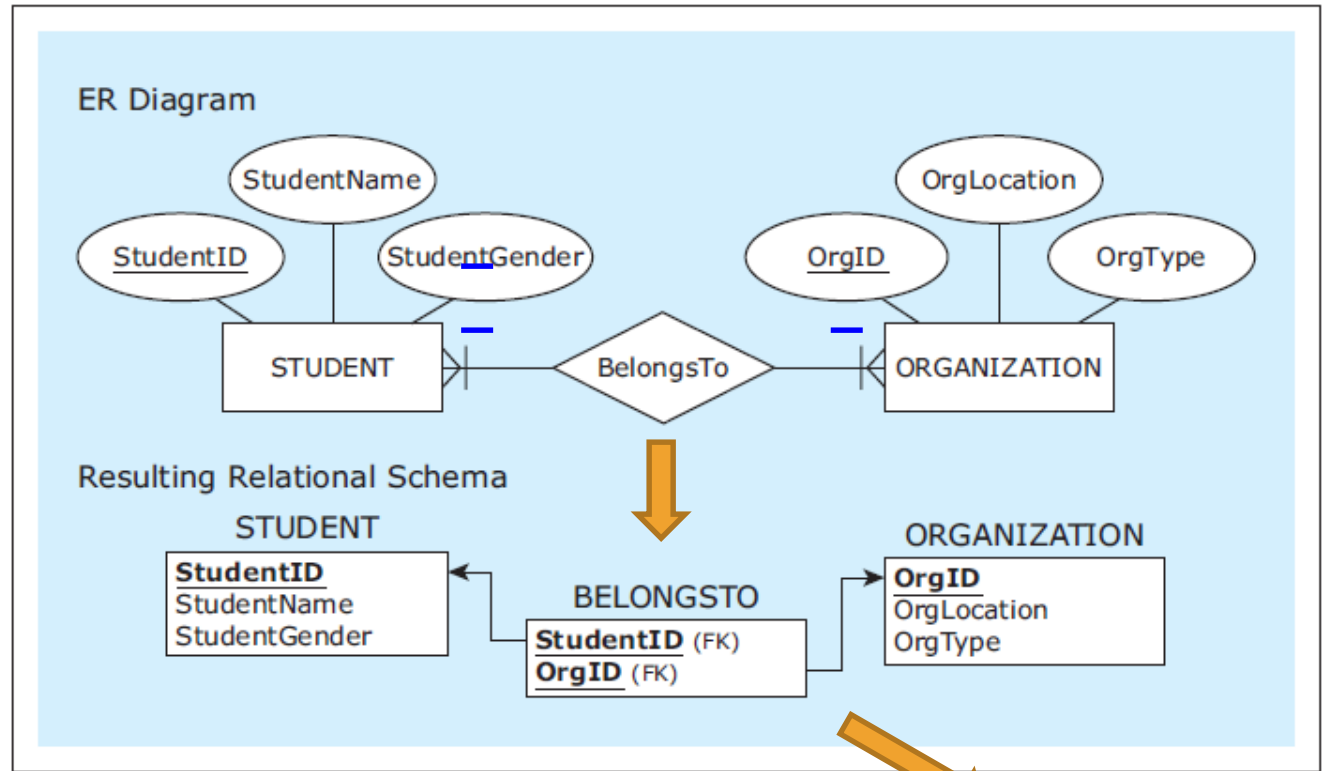
<u>OrgID</u>	OrgLocation	OrgType
O11	Student Hall	Charity
O41	Damen Hall	Sport
O47	Student Hall	Charity

BELONGSTO

<u>StudentID</u>	<u>OrgID</u>
1111	O11
1111	O41
2222	O11
2222	O41
2222	O47
3333	O11

MAPPING RELATIONSHIPS

Example -
Map an M:N
relationship
Mandatory
participation
on both sides



Sample data
records for the
mapped ER
diagram

STUDENT

<u>StudentID</u>	StudentName	StudentGender
1111	Robin	Male
2222	Pat	Male
3333	Jami	Female

ORGANIZATION

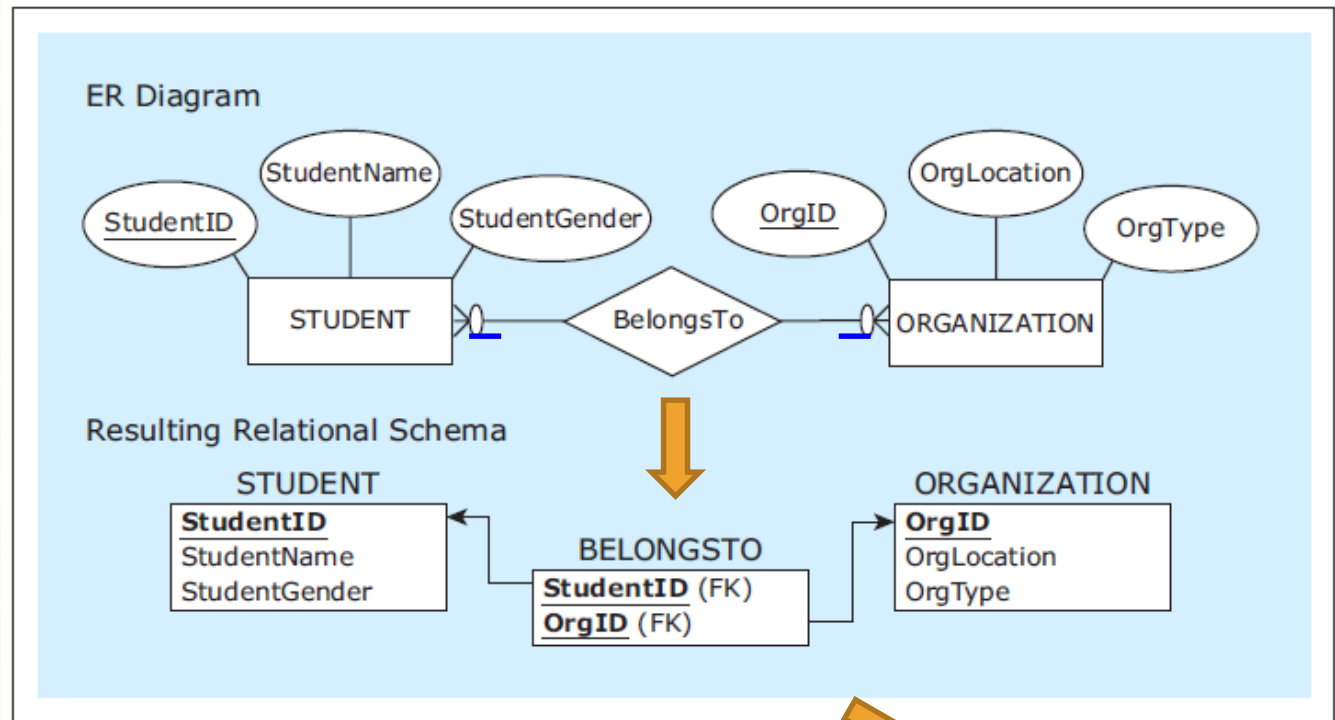
<u>OrgID</u>	OrgLocation	OrgType
O11	Student Hall	Charity
O41	Damen Hall	Sport
O47	Student Hall	Charity

BELONGSTO

<u>StudentID</u>	<u>OrgID</u>
1111	O11
1111	O41
2222	O11
2222	O41
2222	O47
3333	O11

MAPPING RELATIONSHIPS

Example -
Mapping an
M:N
relationship
Optional
participation on
both sides



Sample data
records for the
mapped ER
diagram

STUDENT

<u>StudentID</u>	StudentName	StudentGender
1111	Robin	Male
2222	Pat	Male
3333	Jami	Female
4444	Abby	Female

ORGANIZATION

<u>OrgID</u>	OrgLocation	OrgType
O11	Student Hall	Charity
O41	Damen Hall	Sport
O47	Student Hall	Charity
O50	Damen Hall	Politics

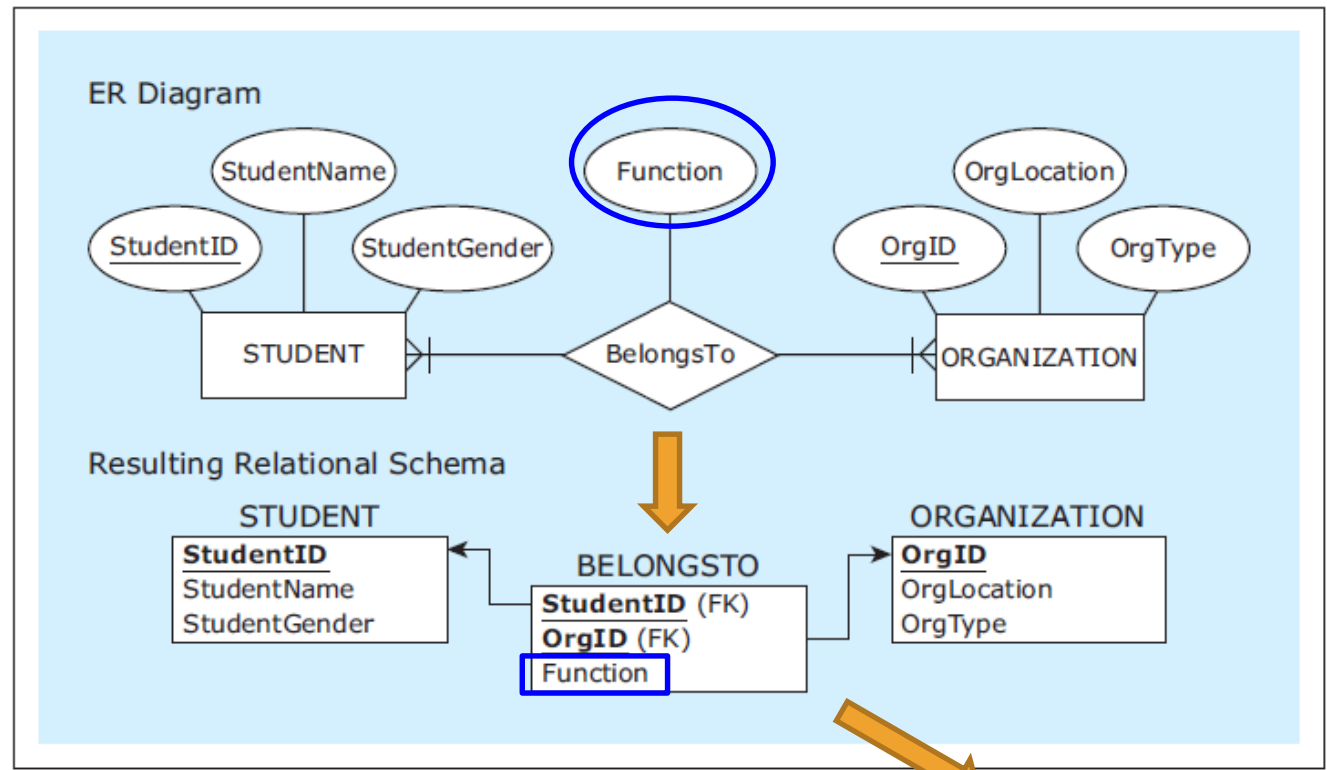
BELONGSTO

<u>StudentID</u>	<u>OrgID</u>
1111	O11
1111	O41
2222	O11
2222	O41
2222	O47
3333	O11

MAPPING RELATIONSHIPS

Example - Map
a M:N
relationship
with an
attribute

- Add a column for each attribute to the new relation for M:N relationship



Sample data
records for the
mapped ER
diagram

STUDENT

<u>StudentID</u>	StudentName	StudentGender
1111	Robin	Male
2222	Pat	Male
3333	Jami	Female

ORGANIZATION

<u>OrgID</u>	OrgLocation	OrgType
O11	Student Hall	Charity
O41	Damen Hall	Sport
O47	Student Hall	Charity

BELONGSTO

<u>StudentID</u>	<u>OrgID</u>	Function
1111	O11	President
1111	O41	Member
2222	O11	V.P.
2222	O41	Member
2222	O47	Treasurer
3333	O11	Member



MAPPING RELATIONSHIPS

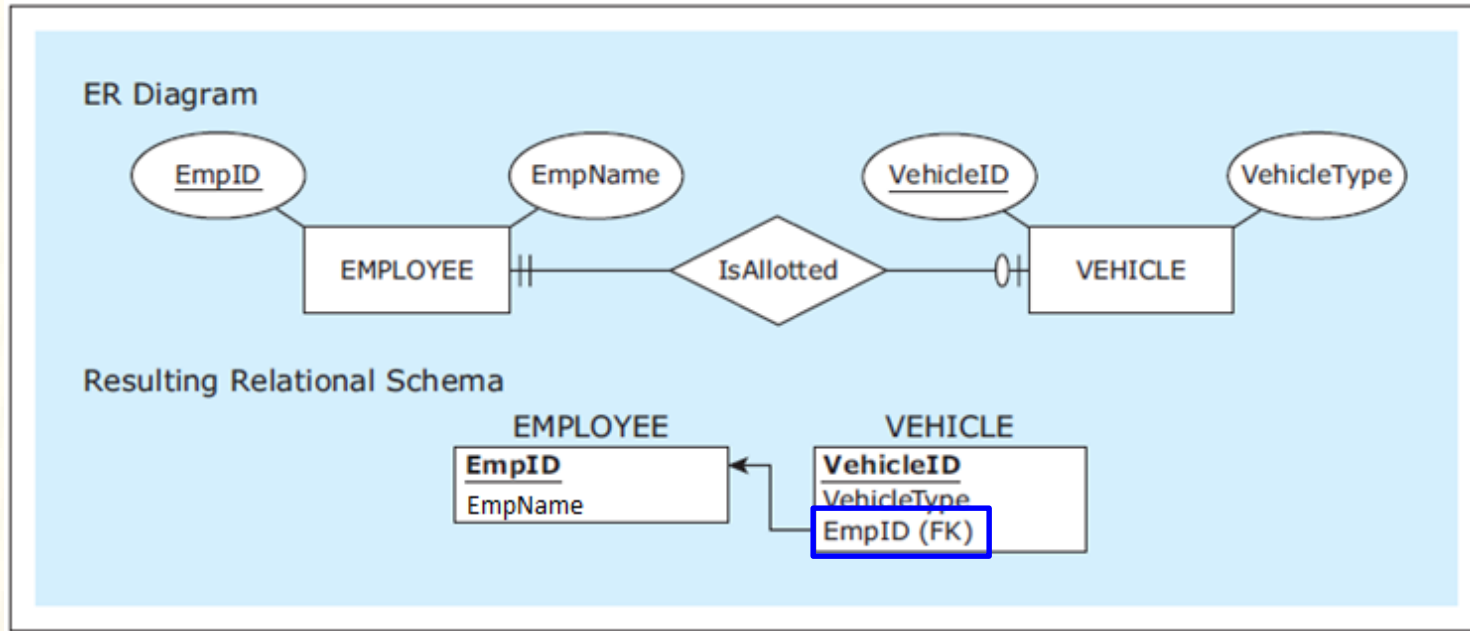
■ Mapping 1:1 relationships

- In the same way as mapping 1:M relationships
- Add a foreign key column to either of the two resulting relations
 - The foreign key points to the primary key of the other resulting relation
- Recommendation for choosing the resulting relation to add a FK column
 - Choose the one that has an advantage if possible
 - * Choose mandatory foreign key over optional foreign key
 - ❖ The case of mandatory—1 : optional—1 relationship
 - ❖ Example in next slide
 - ❖ Advantage: not have to manage null values
 - Otherwise, choose either relation
 - * The case of mandatory—1 : mandatory—1 or
 - * The case of optional—1 : optional—1

MAPPING RELATIONSHIPS INTO RELATIONAL DATABASE CONSTRUCTS

Example -
Map a 1:1
relationship

mandatory-1:
optional-1



Sample data
records for the
mapped ER
diagram

EMPLOYEE	
EmpID	EmpName
1234	Becky
2345	Molly
3456	Rob
1324	Ted

VEHICLE		
VehicleID	VehicleType	EmpID
111	Sedan	1234
222	Van	2345
333	Van	3456

REFERENTIAL INTEGRITY CONSTRAINT

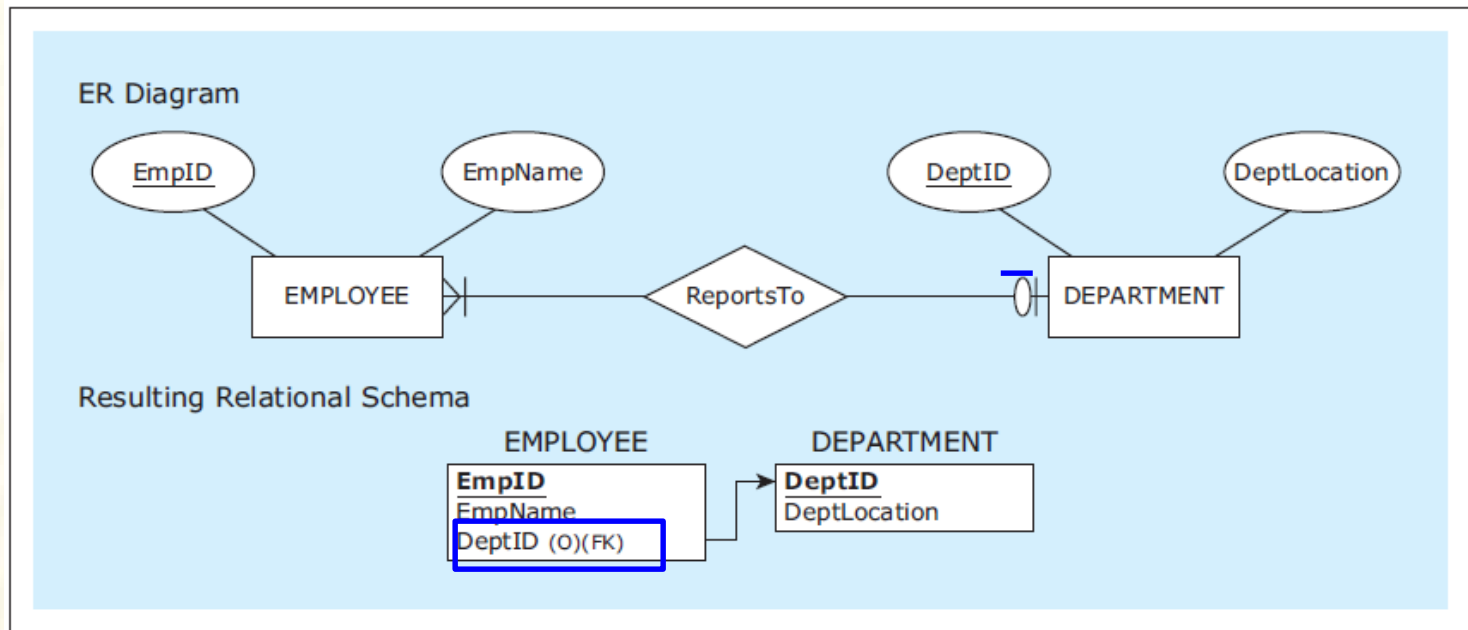
▪ Referential integrity constraint

- A rule defining **valid values of foreign keys**
- In each row of a relation containing a foreign key, the value of the **foreign key EITHER matches** one of the values in the **primary key** column of the referred relation **OR** the value of **the foreign key is null** (empty).
 - Valid foreign key value: either of
 - * **Matching primary key value of the referred relation**
 - ❖ Existing primary key value in the referred relation
 - * **Null**
 - ❖ In the case of optional participation
- **Referential integrity constraint lines**
 - Lines **pointing from the foreign key to the corresponding primary key** in a relational schema



REFERENTIAL INTEGRITY CONSTRAINT

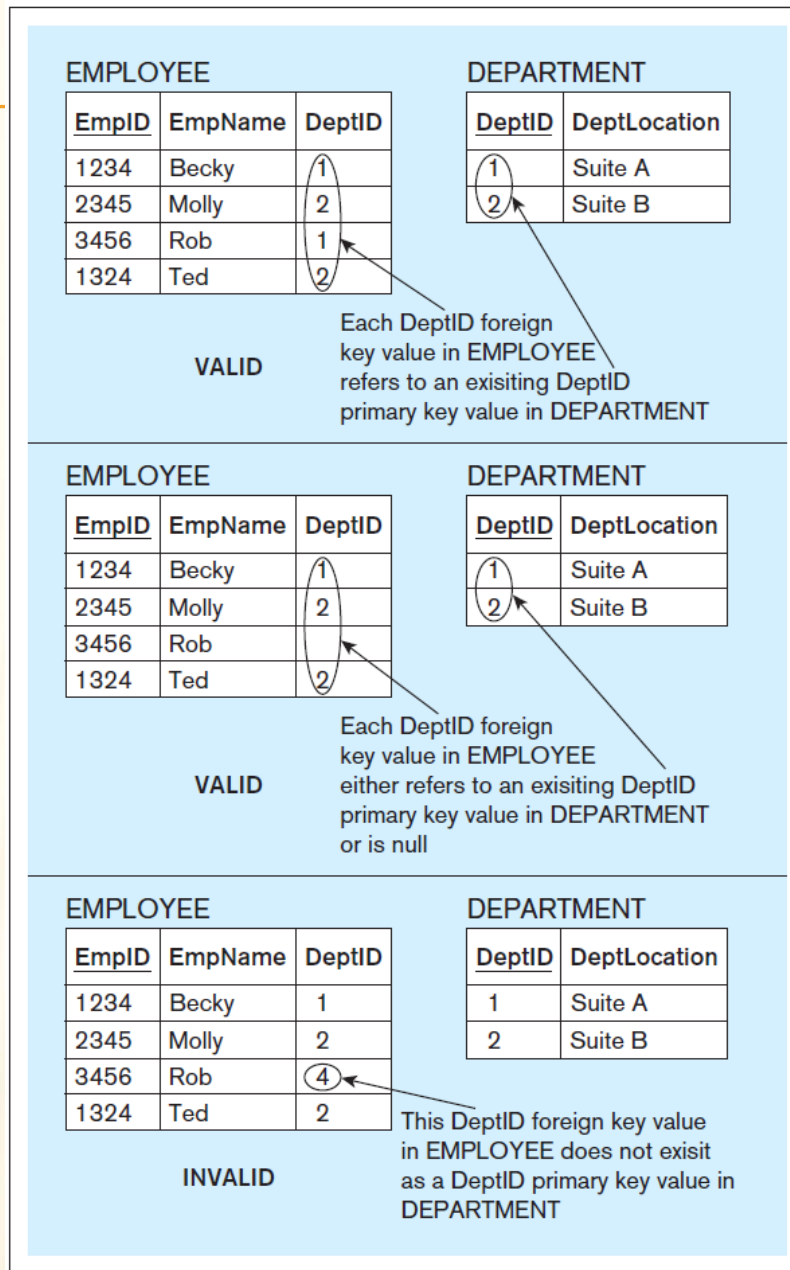
Example of Foreign Key column with optional participation



Optional Foreign Key column DeptID in EMPLOYEE

REFERENTIAL INTEGRITY CONSTRAINT

Referential integrity
constraint —
compliance and violation
examples



Matching PK

Matching PK
or null

Not
matching
PK

MAPPING ER DIAGRAM INTO RELATIONAL SCHEMA

- Mapping an ER diagram into a relational schema
 1. Map all entities and their attributes
 - From left to right and from top to bottom
 2. Map all relationships
 - From left to right and from top to bottom
 - Steps to map each relationship
 - 1) Identify the type: 1:1, 1:M, or M:N
 - 2) Map the relationship according to its type
 - ❖ M:N, add a new relation with composite PK
 - ❖ 1:M, add a FK to relation for entity on M side
 - ❖ 1:1, decide which relation to add a FK, then add FK
 3. Verify the resulting relational schema
 - Compare the relational schema to the ER diagram



Map Example ER diagram : ZAGI Retail Company Sales Department Database

Try to use ERD PLUS tool to map this ERD before next lecture.

