
Week 9, Lecture 18

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



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

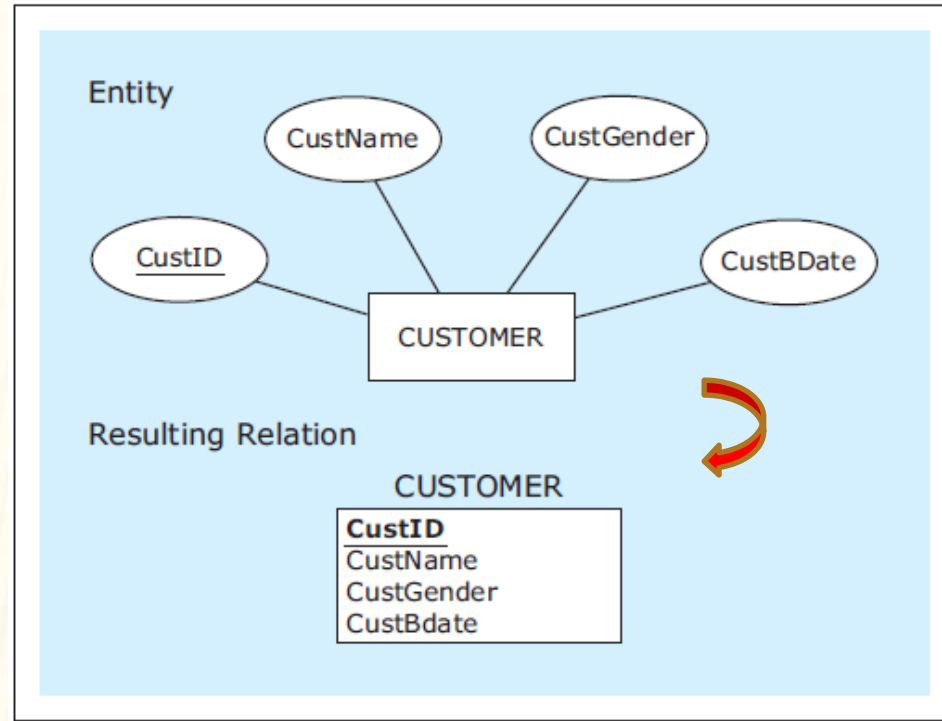
- Map an ER diagram into a relational schema
 - A collection of relations

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

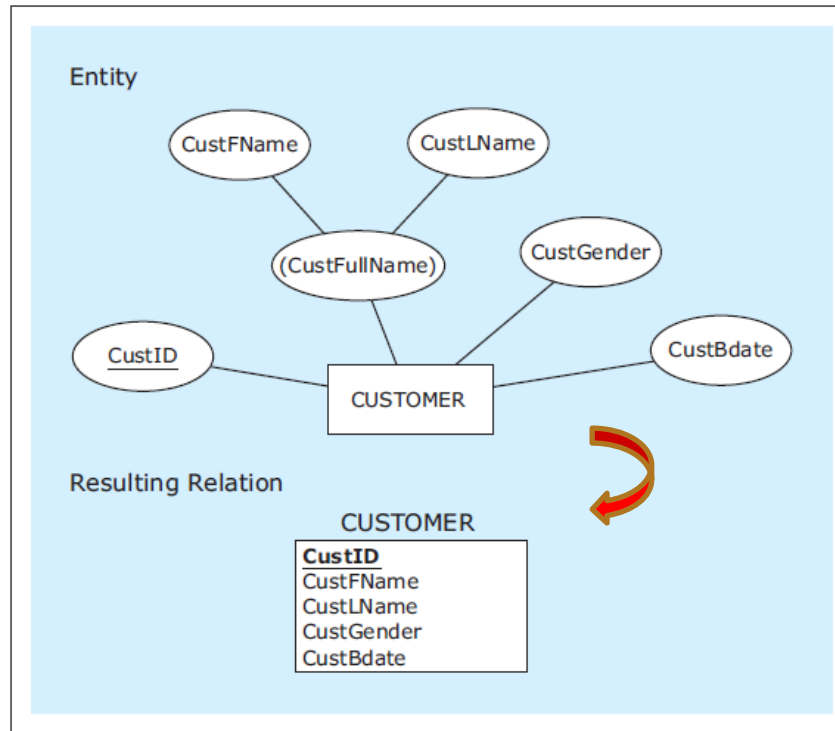
MAPPING ENTITIES WITH COMPOSITE ATTRIBUTES

- 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

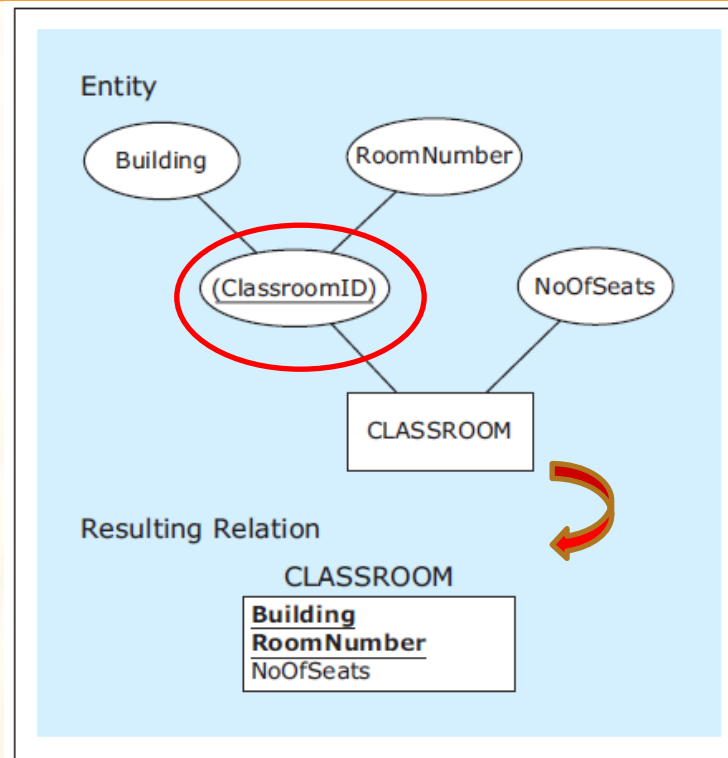
MAPPING ENTITIES WITH UNIQUE COMPOSITE ATTRIBUTES

- 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

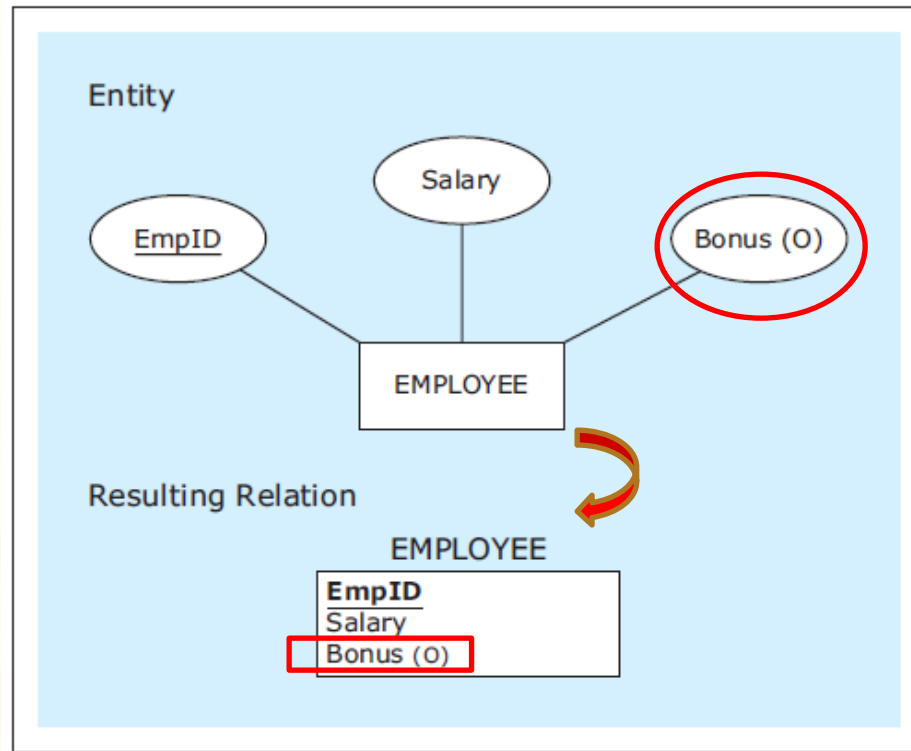
MAPPING ENTITIES WITH OPTIONAL ATTRIBUTES

- **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 integrous
- **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)

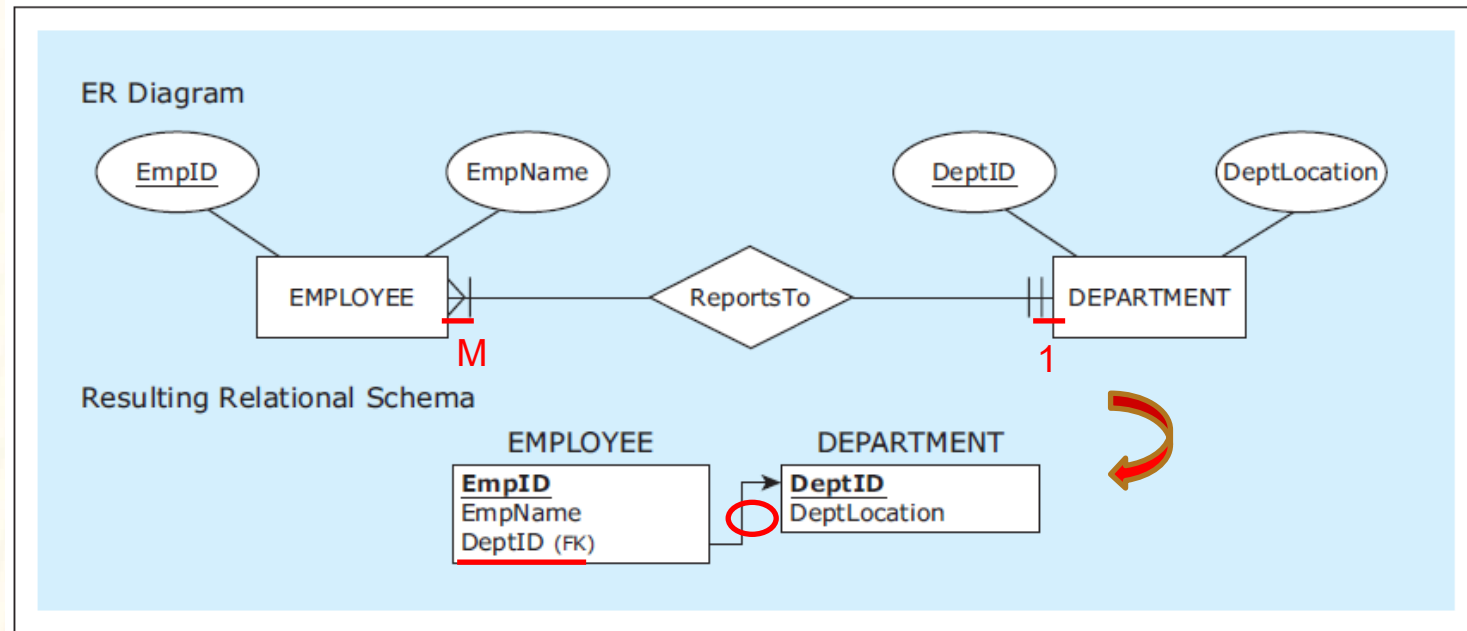
MAPPING RELATIONSHIPS

- **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

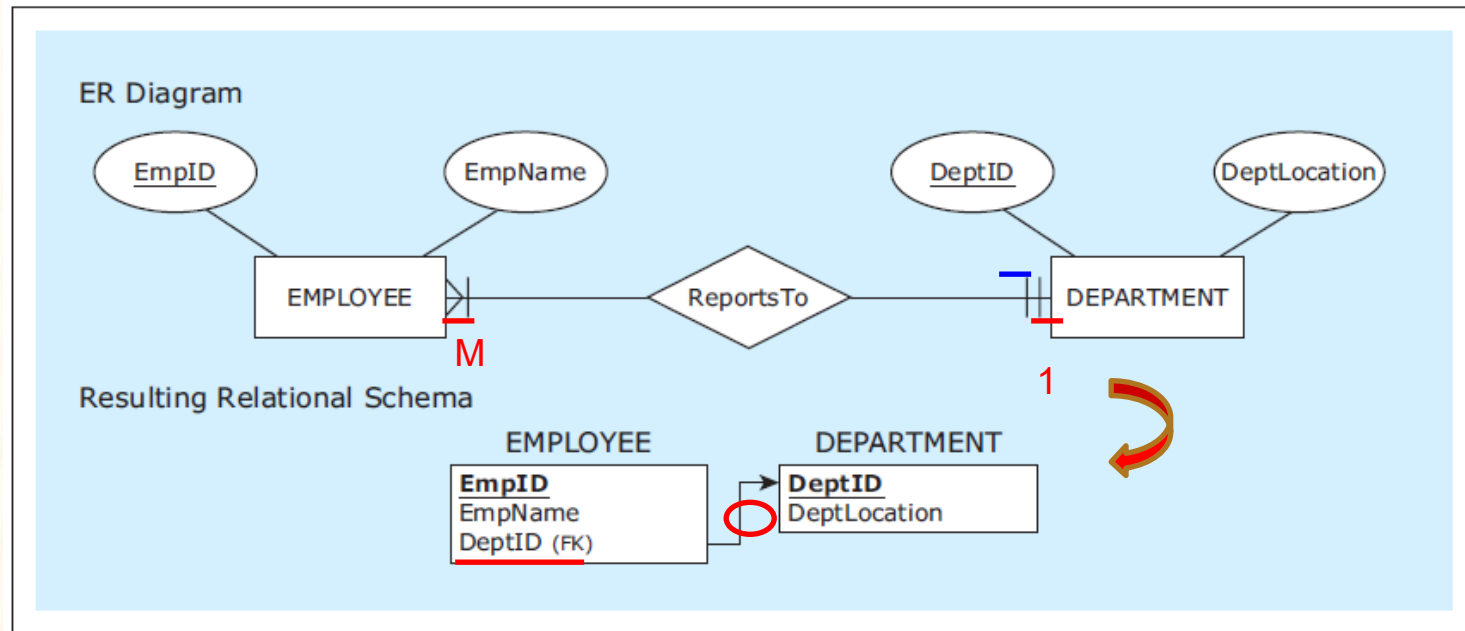
EMPLOYEE			DEPARTMENT	
<u>EmpID</u>	EmpName	DeptID	<u>DeptID</u>	DeptLocation
1234	Becky	1	1	Suite A
2345	Molly	2	2	Suite B
3456	Rob	1		
1324	Ted	2		

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

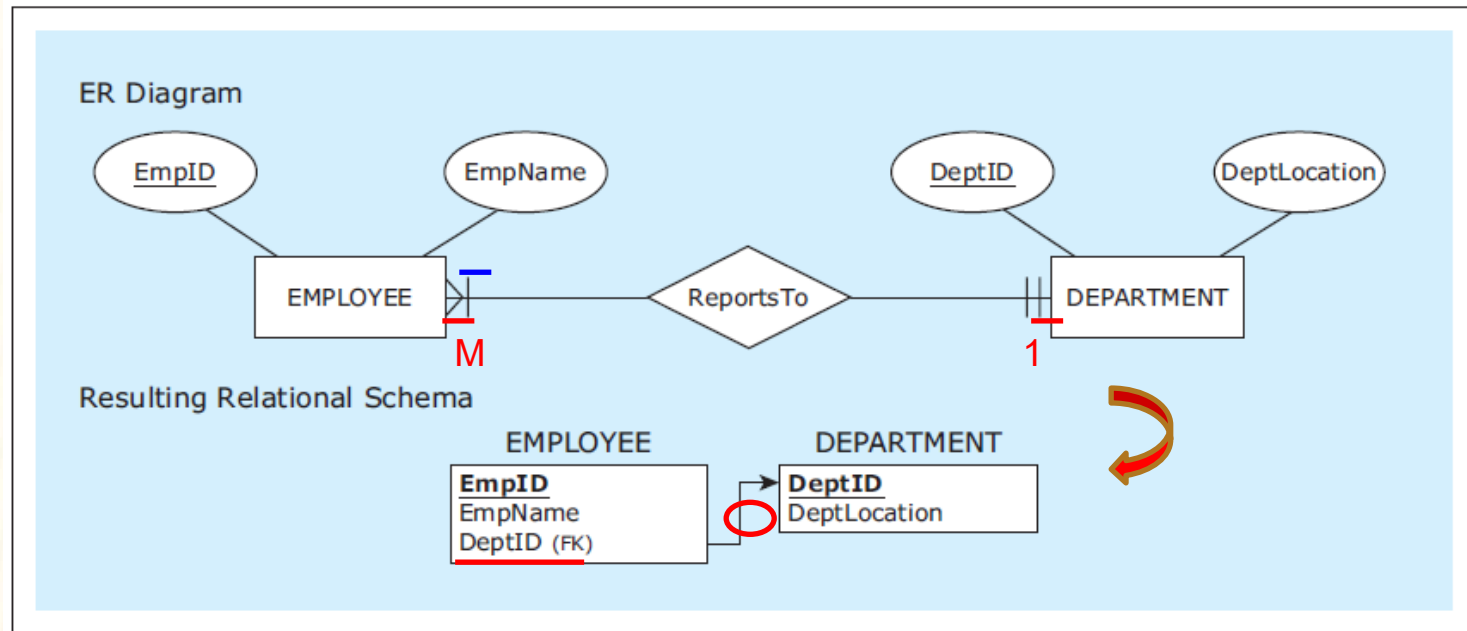
EMPLOYEE			DEPARTMENT	
<u>EmpID</u>	EmpName	DeptID	<u>DeptID</u>	DeptLocation
1234	Becky	1	1	Suite A
2345	Molly	2	2	Suite B
3456	Rob	1		
1324	Ted	2		

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

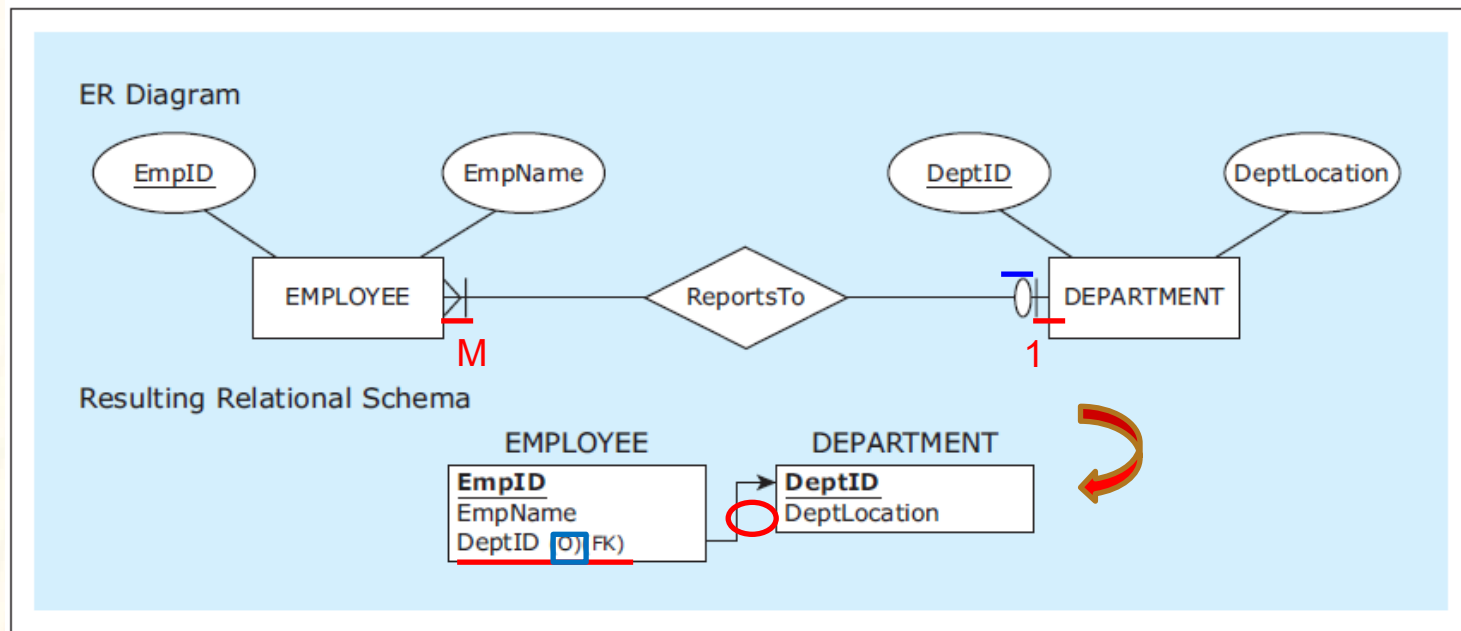
EMPLOYEE			DEPARTMENT	
<u>EmpID</u>	EmpName	DeptID	<u>DeptID</u>	DeptLocation
1234	Becky	1	1	Suite A
2345	Molly	2	2	Suite B
3456	Rob	1		
1324	Ted	2		

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		

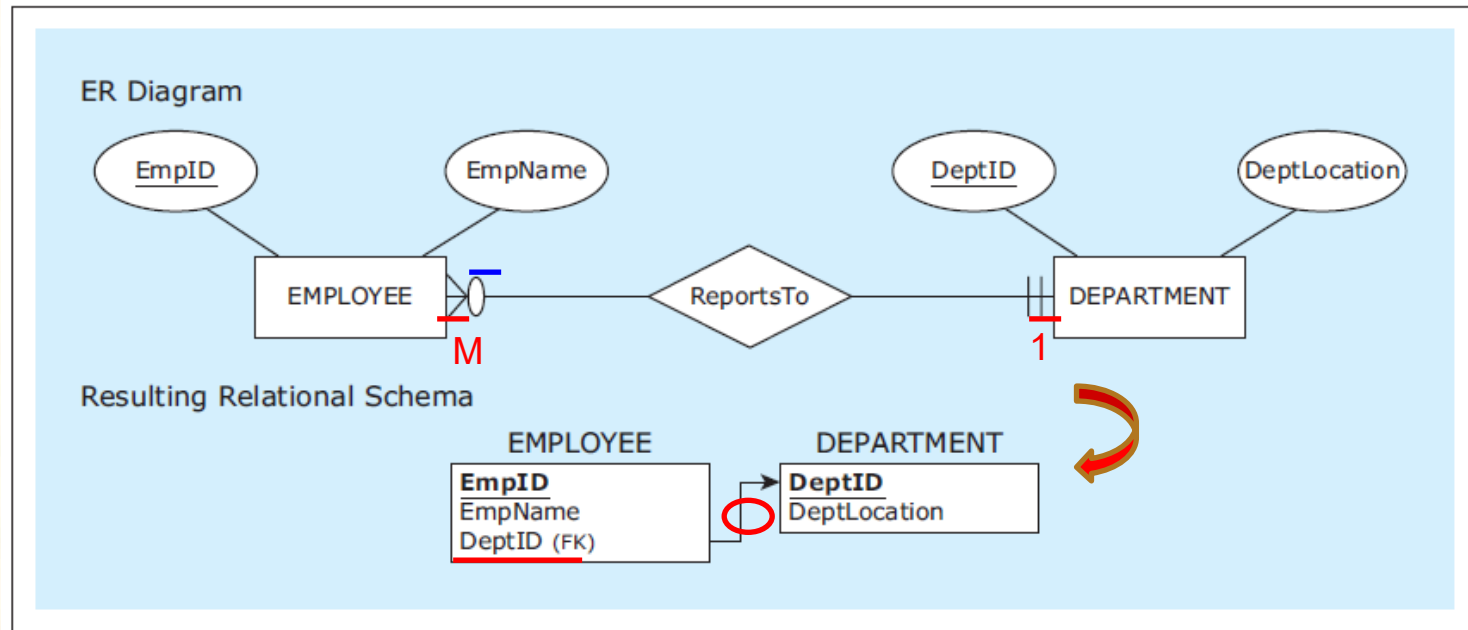
MAPPING RELATIONSHIPS

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



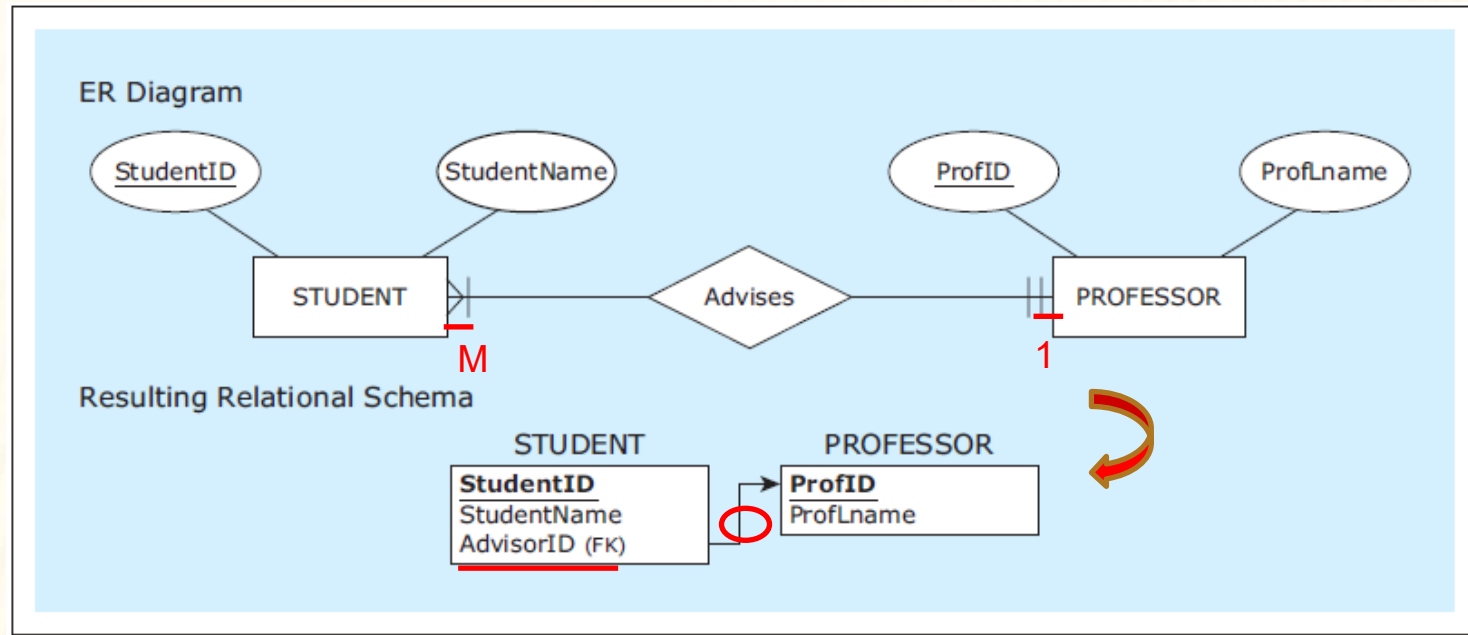
EMPLOYEE			DEPARTMENT	
<u>EmpID</u>	EmpName	DeptID	<u>DeptID</u>	DeptLocation
1234	Becky	1	1	Suite A
2345	Molly	2	2	Suite B
3456	Rob	1	3	Suite C
1324	Ted	2		

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

<u>StudentID</u>	StudentName	AdvisorID
1111	Robin	P11
2222	Pat	P22
3333	Jami	P11

PROFESSOR

<u>ProfID</u>	ProfLName
P11	Zydiak
P22	Lash

MAPPING RELATIONSHIPS

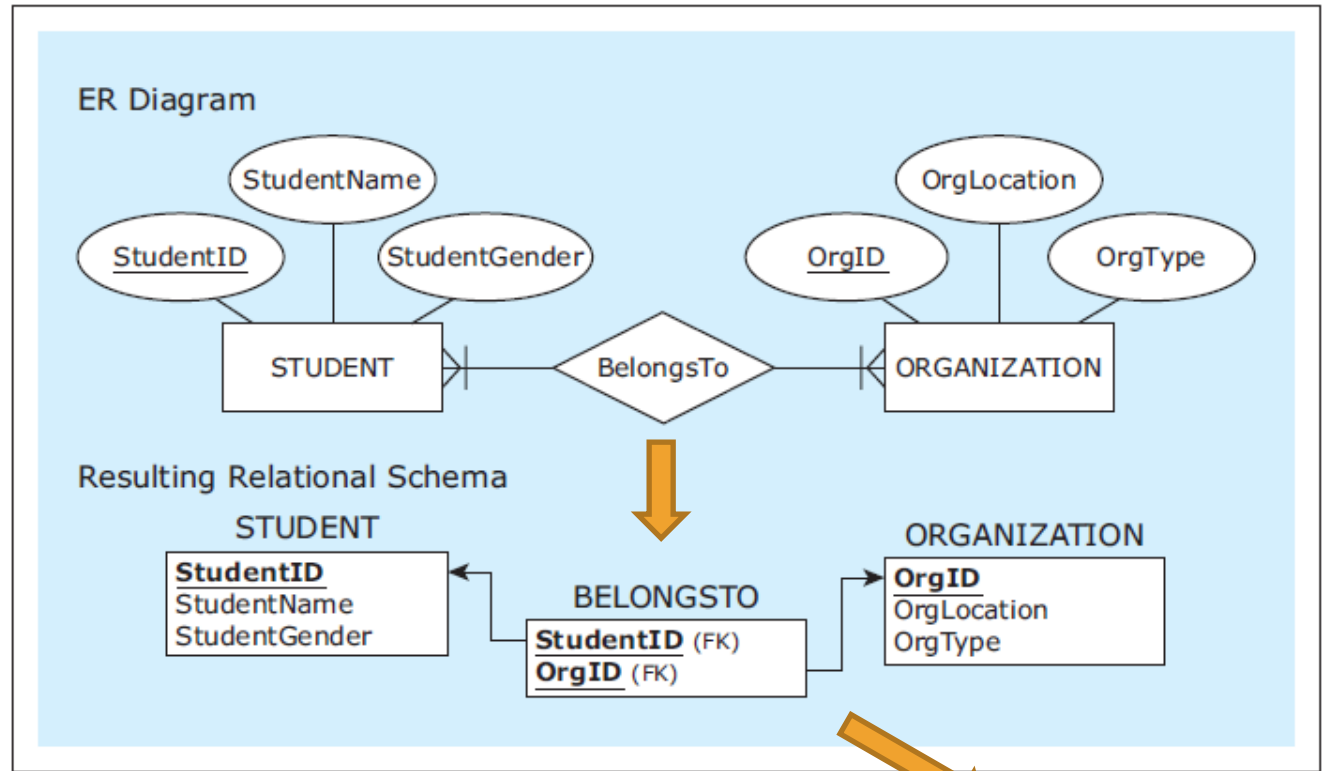
■ Mapping M:N relationships

- 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

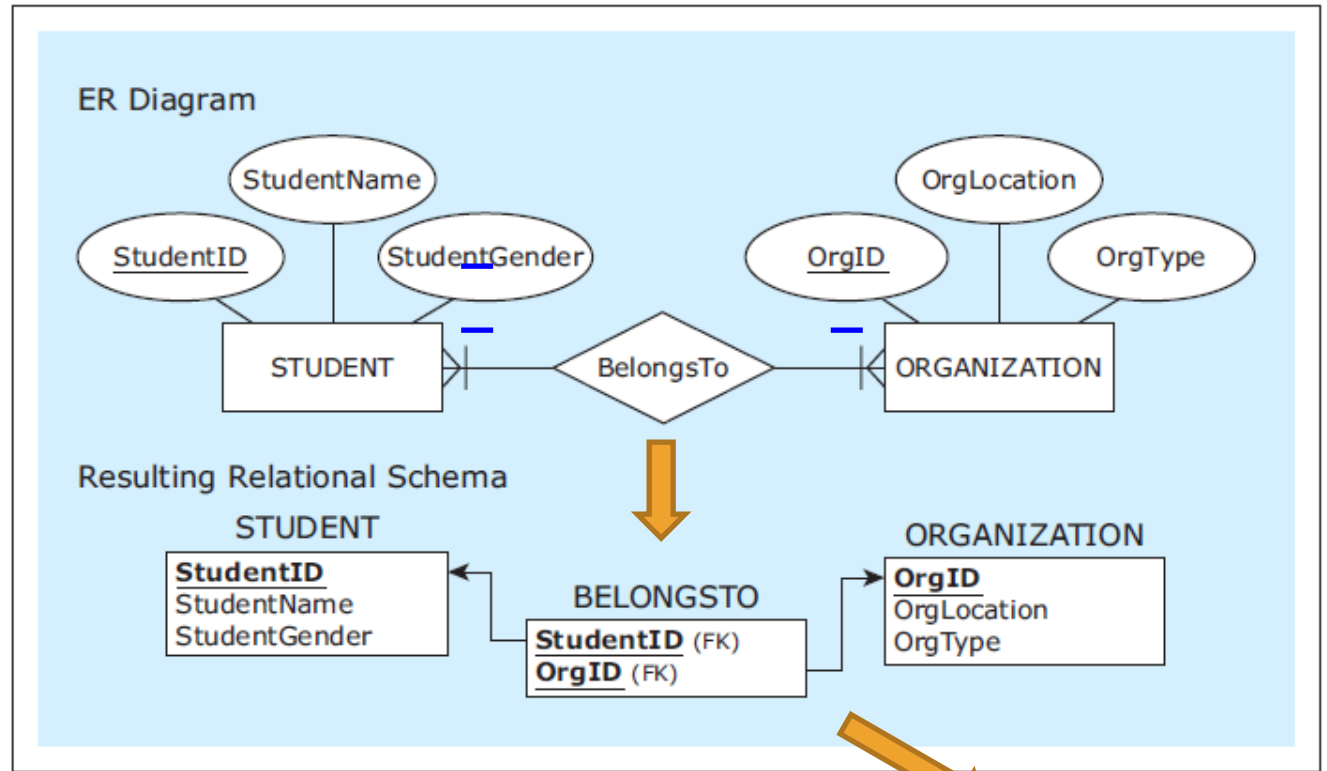
<u>OrgID</u>	OrgLocation	OrgType
O11	Student Hall	Charity
O41	Damen Hall	Sport
O47	Student Hall	Charity

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

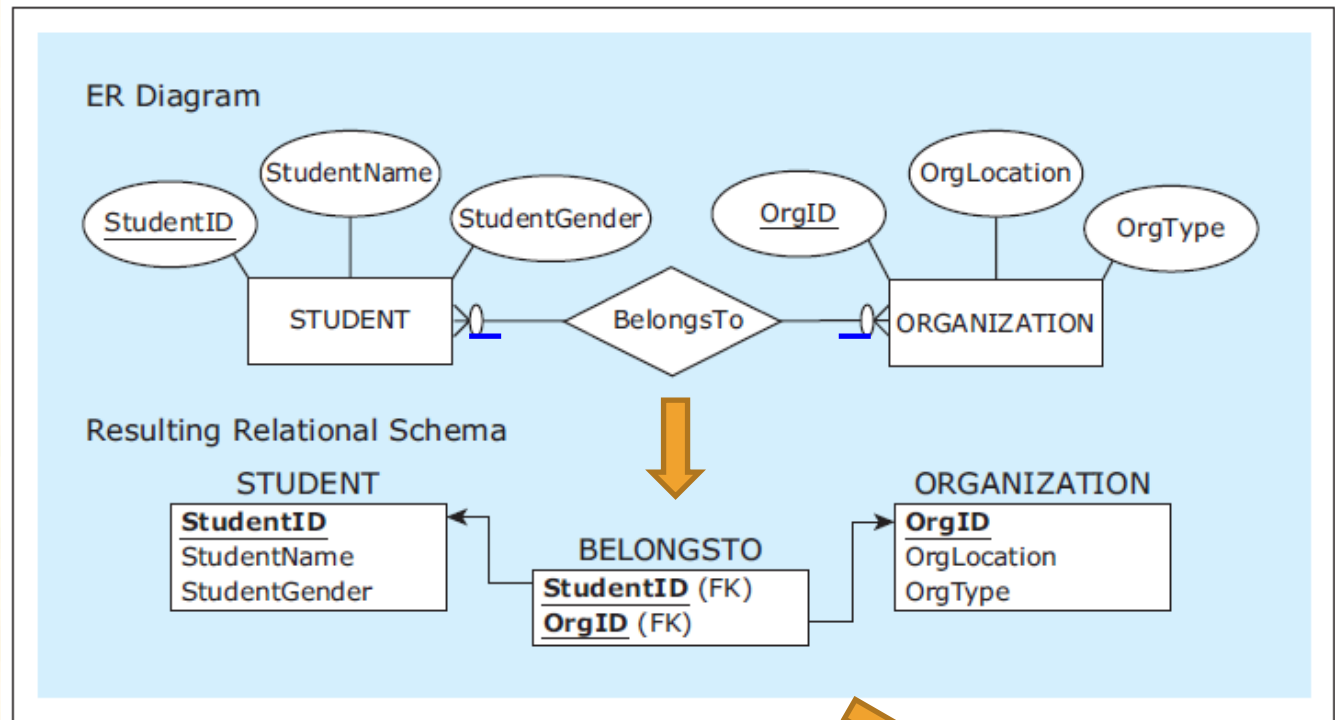
<u>OrgID</u>	OrgLocation	OrgType
O11	Student Hall	Charity
O41	Damen Hall	Sport
O47	Student Hall	Charity

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

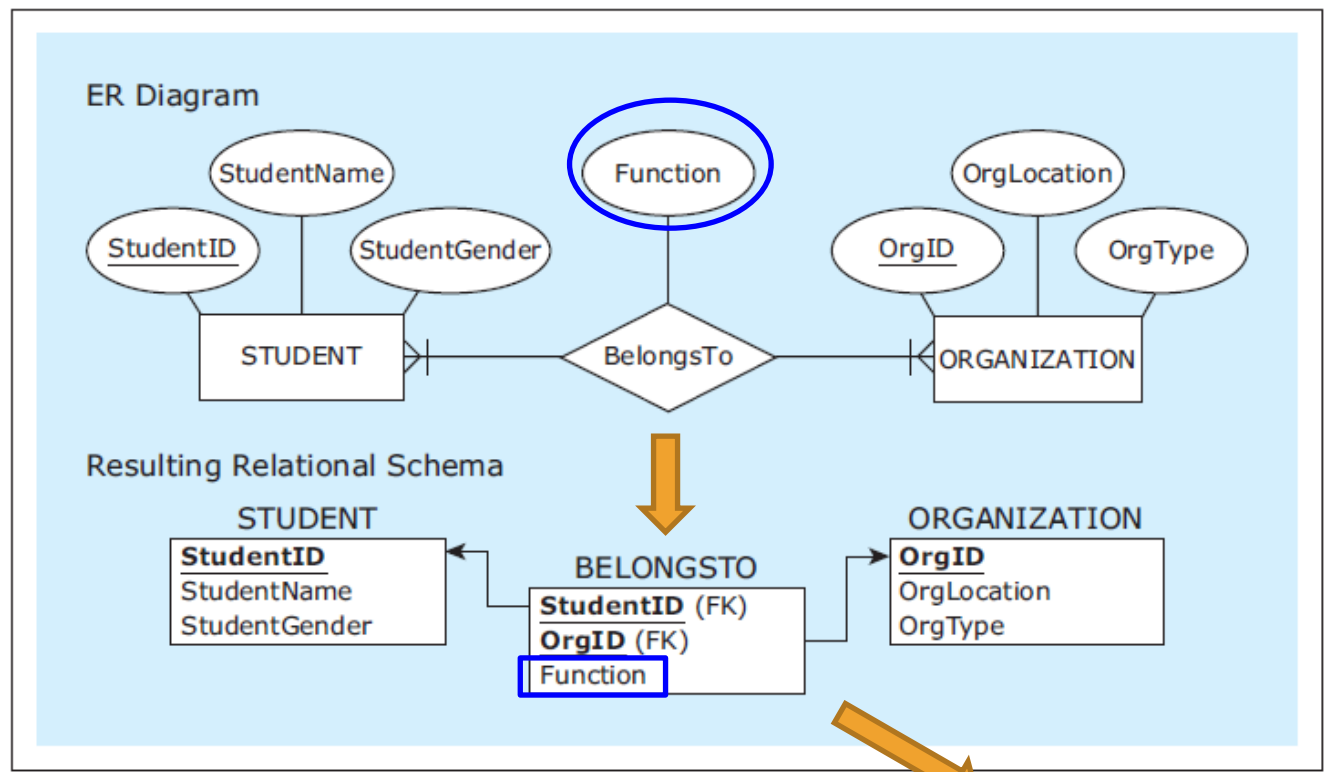
BELONGSTO

<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