Database Systems -

Introduction to Databases and Data Warehouses

CHAPTER 3 - Relational Database Modeling

INTRODUCTION

- **Relational database model** - logical database model that represents a database as a collection of related tables
- **Relational schema** - visual depiction of the relational database model
- Most contemporary commercial DBMS software packages, are **relational DBMS (RDBMS)** software packages

INTRODUCTION

Terminology

TABLE 3.1 Synonyms Used in the Relational Database Model

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

INTRODUCTION

- **Relation** - 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
  - In order for a table to be a relation the following conditions must hold:
    - *Each column must have a name (within one table, each column name must be unique)*
    - *Within one table, each row must be unique*
    - *Within each row, each value in each column must be single valued (multiple values of the content represented by the column are not allowed in any rows of the table)*
    - *All values in each column must be from the same (predefined) domain*
    - *Order of columns is irrelevant*
    - *Order of rows is irrelevant*

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

Example of a relation with rows and columns appearing in a different order

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

INTRODUCTION

- **Relational database** - collection of related relations within which each relation has a unique name

PRIMARY KEY

- **Primary key** - column (or a set of columns) whose value is unique for each row
  - Each relation must have a primary key
  - The name of the primary key column is underlined in order to distinguish it from the other columns in the relation

PRIMARY KEY

Relation with the primary key underlined

EMPLOYEE

EmpID	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

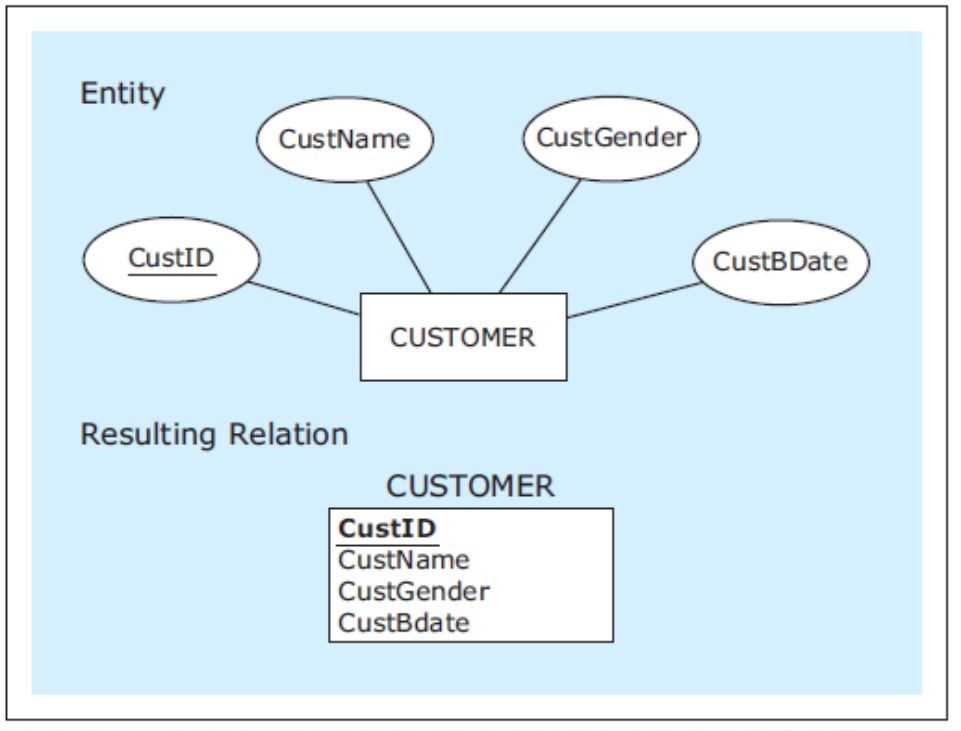
- Once an ER diagram is constructed, it is subsequently mapped into a relational schema (collection of relations)

MAPPING ENTITIES

- **Mapping entities into relations**
  - Each regular entity becomes a relation
  - Each regular attribute of a regular entity becomes a column of the newly created relation
  - If an entity has a single unique attribute, then that attribute becomes the primary key in the resulting mapped relation

MAPPING ENTITIES

Entity mapped into a relation



Sample data records for the mapped relation

CUSTOMER

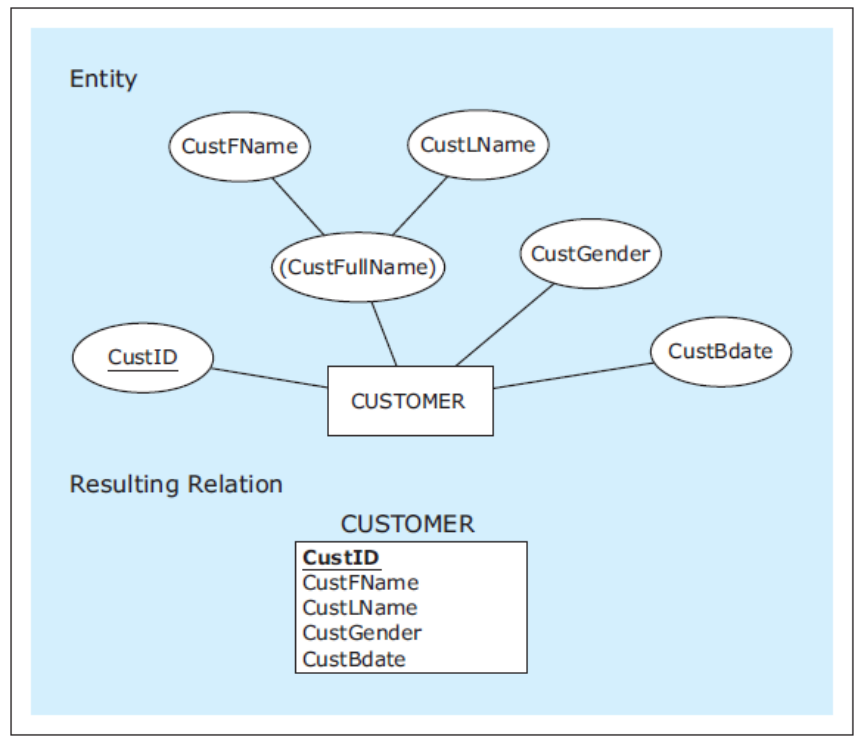
CustID	CustName	CustGender	CustBdate
1111	Tom	M	1/1/1965
2222	Jenny	F	2/2/1968
3333	Greg	M	1/2/1962
4444	Sophia	F	2/2/1983

MAPPING ENTITIES WITH COMPOSITE ATTRIBUTES

- **Mapping entities with composite attributes into relations**
  - Each component of a composite attribute is mapped as a column of a relation
  - The composite attribute itself does not appear in the mapped relation

MAPPING ENTITIES WITH COMPOSITE ATTRIBUTES

Entity with a composite attribute mapped into a relation



Sample data records for the mapped relation

CUSTOMER

CustID	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

CUSTOMER

	CustFullName			
CustID	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

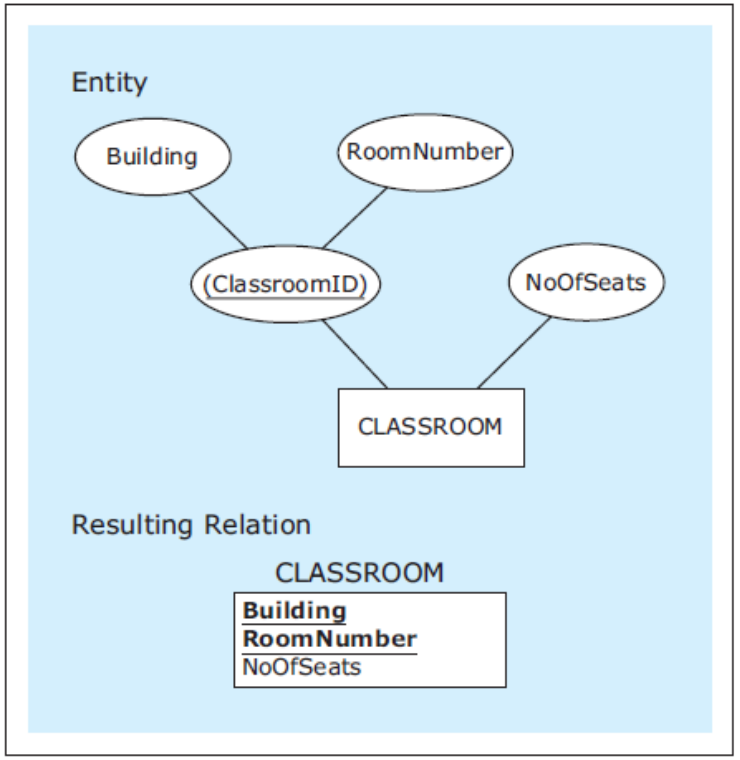
- **Composite primary key** - a primary key that is composed of multiple columns
  - Column names of a composite primary key are underlined, because combined together they form the primary key

MAPPING ENTITIES WITH UNIQUE COMPOSITE ATTRIBUTES

- **Mapping entities with unique composite attributes into relations**
  - An entity whose only unique attribute is a composite attribute is mapped as a relation with a composite primary key

MAPPING ENTITIES WITH UNIQUE COMPOSITE ATTRIBUTES

Entity with a unique composite attribute mapped into a relation



Sample data records for the mapped relation

CLASSROOM

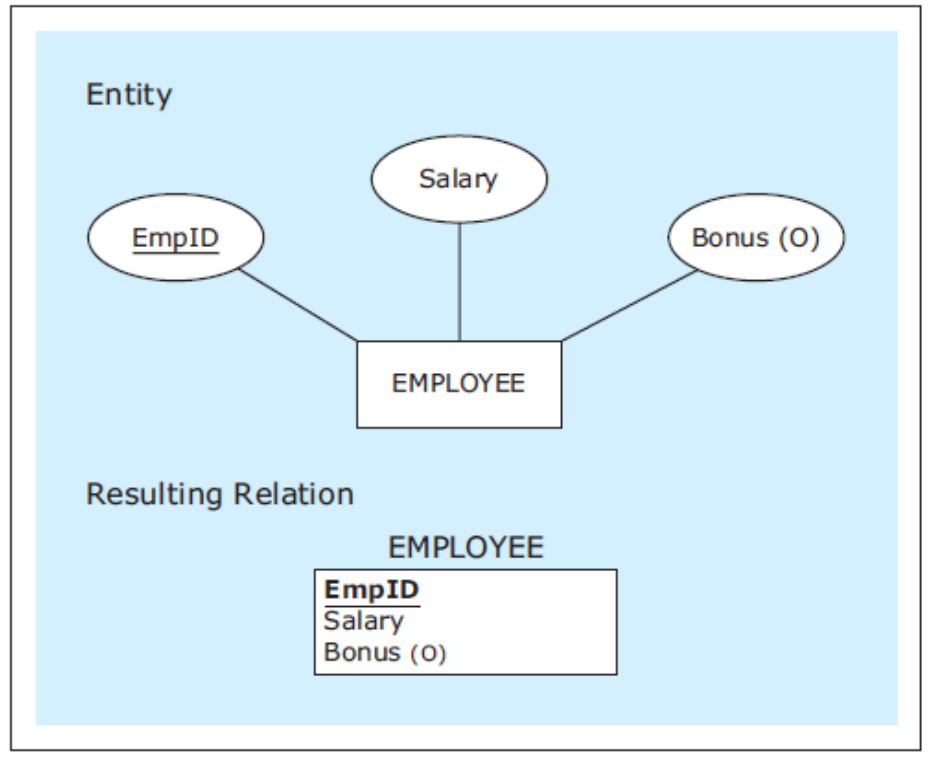
Building	RoomNumber	NoOfSeats
Maguire	110	100
Maguire	210	50
Houser	110	50
Houser	210	50

MAPPING ENTITIES WITH OPTIONAL ATTRIBUTES

- **Mapping entities with optional attributes into relations**
  - Optional attribute of an entity is mapped as an optional column

MAPPING ENTITIES WITH OPTIONAL ATTRIBUTES

Entity with an optional attribute mapped into a relation



Sample data records for the mapped relation

EMPLOYEE

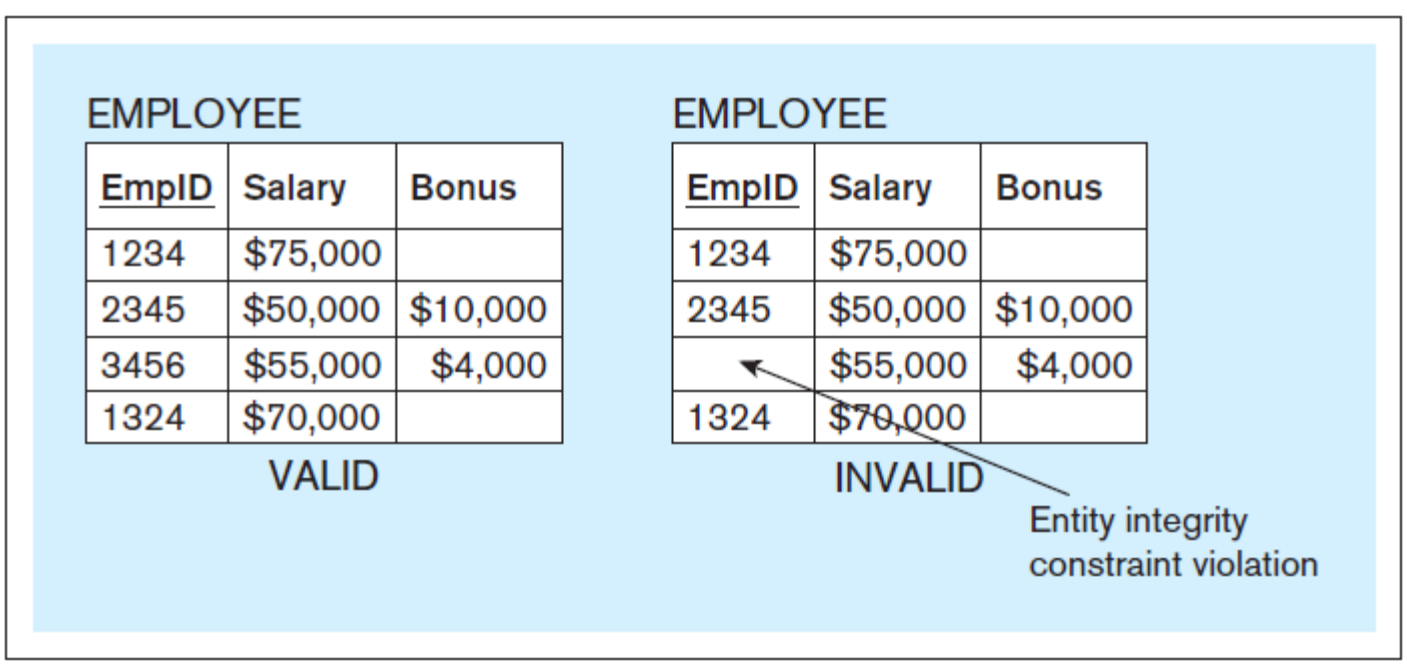
EmpID	Salary	Bonus
1234	$75,000	
2345	$45,000	$10,000
3456	$55,000	$4,000
1324	$70,000	

ENTITY INTEGRITY CONSTRAINT

- **Entity integrity constraint** - *in a relational table, no primary key column can have null (empty) values*
  - A rule stating that no primary key column can be optional
  - Every RBMS enforces this rule

ENTITY INTEGRITY CONSTRAINT

Entity integrity constraint — compliance and violation example



ENTITY INTEGRITY CONSTRAINT

Entity integrity constraint — another compliance and violation example

CLASSROOM

Building	RoomNumber	NoOfSeats
Maguire	110	100
Maguire	210	50
Houser	110	50
Houser	210	50

VALID

CLASSROOM

Building	RoomNumber	NoOfSeats
Maguire	110	100
Maguire	210	50
Houser		50
Houser	210	50

INVALID

Entity integrity constraint violation

FOREIGN KEY

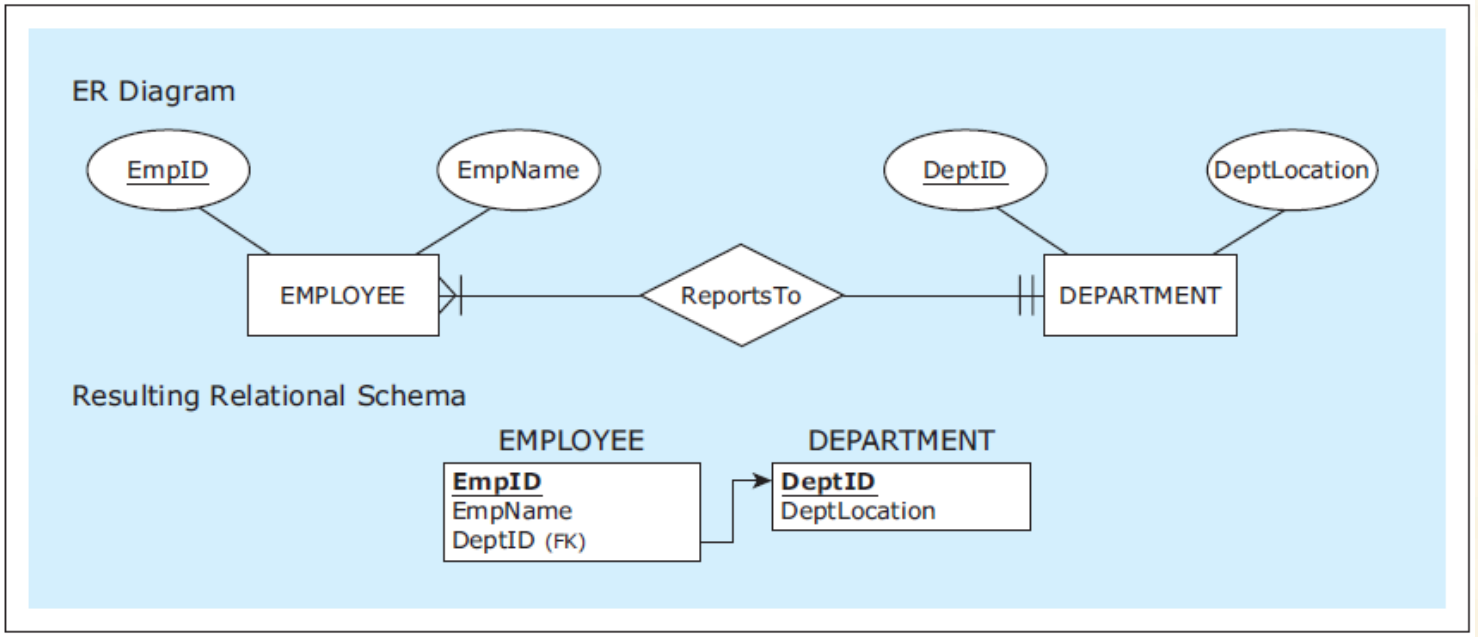
- **Foreign key** - *column in a relation that refers to a primary key column in another (referred) relation*
  - A mechanism that is used to depict relationships in the relational database model
  - For every occurrence of a foreign key, the relational schema contains a line pointing *from* the *foreign key* to the *corresponding primary key*

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.*

MAPPING RELATIONSHIPS

Example - Mapping a 1:M relationship



Sample data records for the mapped ER diagram

EMPLOYEE

EmpID	EmpName	DeptID
1234	Becky	1
2345	Molly	2
3456	Rob	1
1324	Ted	2

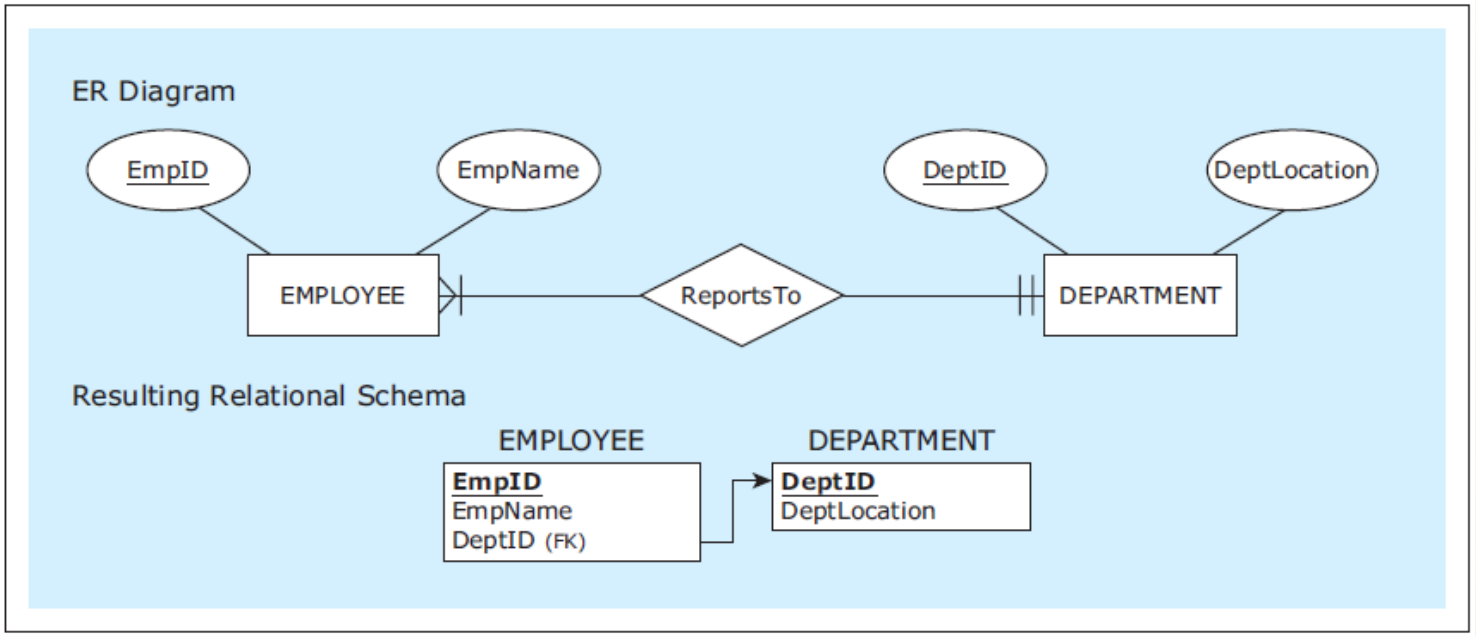
DEPARTMENT

DeptID	DeptLocation
1	Suite A
2	Suite B

MAPPING RELATIONSHIPS

Example - Mapping a 1:M relationship

Mandatory participation on both sides



Sample data records for the mapped ER diagram

EMPLOYEE

EmpID	EmpName	DeptID
1234	Becky	1
2345	Molly	2
3456	Rob	1
1324	Ted	2

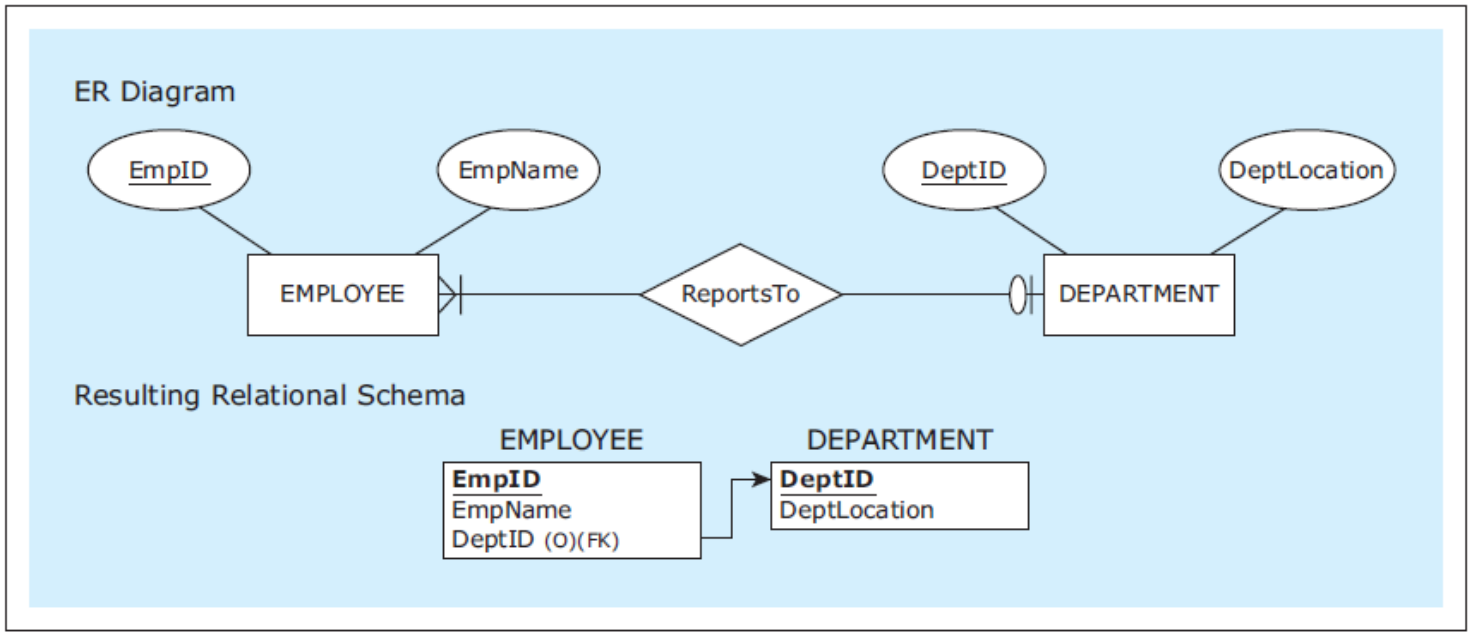
DEPARTMENT

DeptID	DeptLocation
1	Suite A
2	Suite B

MAPPING RELATIONSHIPS

Example - Mapping a 1:M relationship

Optional participation on the 1 side



Sample data records for the mapped ER diagram

EMPLOYEE

EmpID	EmpName	DeptID
1234	Becky	1
2345	Molly	2
3456	Rob	
1324	Ted	2

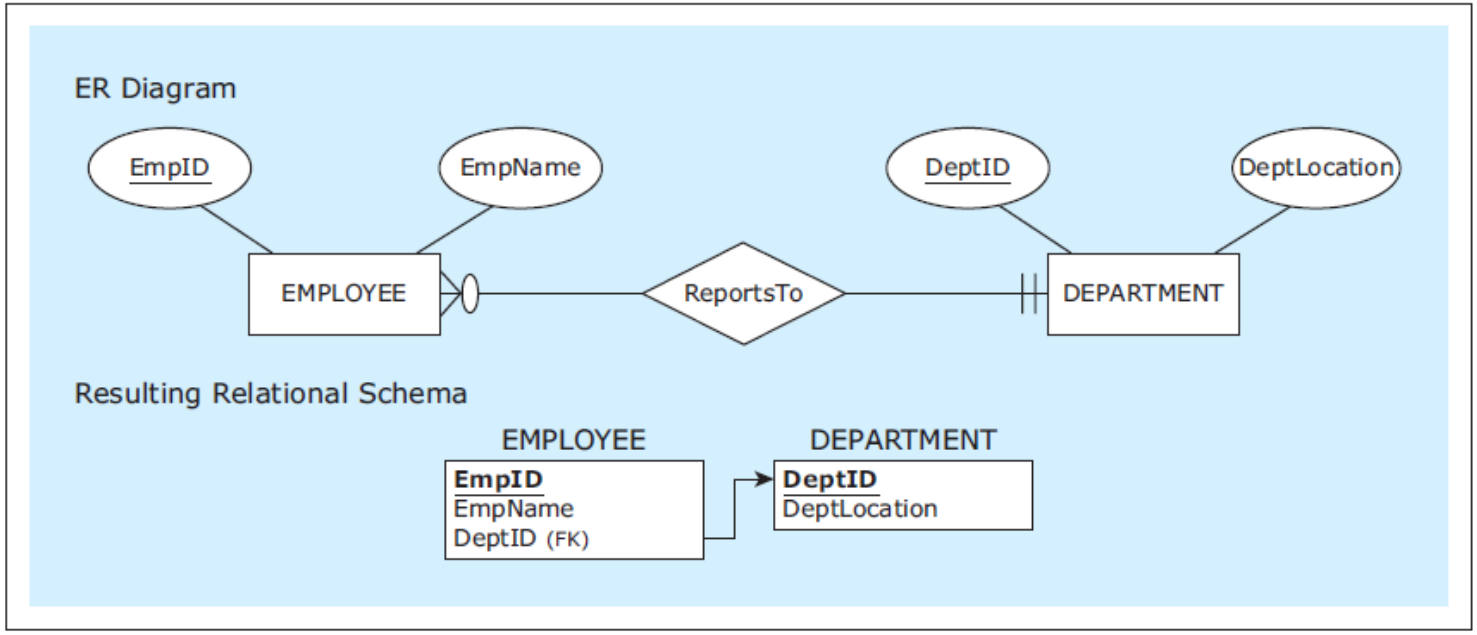
DEPARTMENT

DeptID	DeptLocation
1	Suite A
2	Suite B

MAPPING RELATIONSHIPS

Example - Mapping a 1:M relationship

Optional participation on the M side



Sample data records for the mapped ER diagram

EMPLOYEE

EmpID	EmpName	DeptID
1234	Becky	1
2345	Molly	2
3456	Rob	1
1324	Ted	2

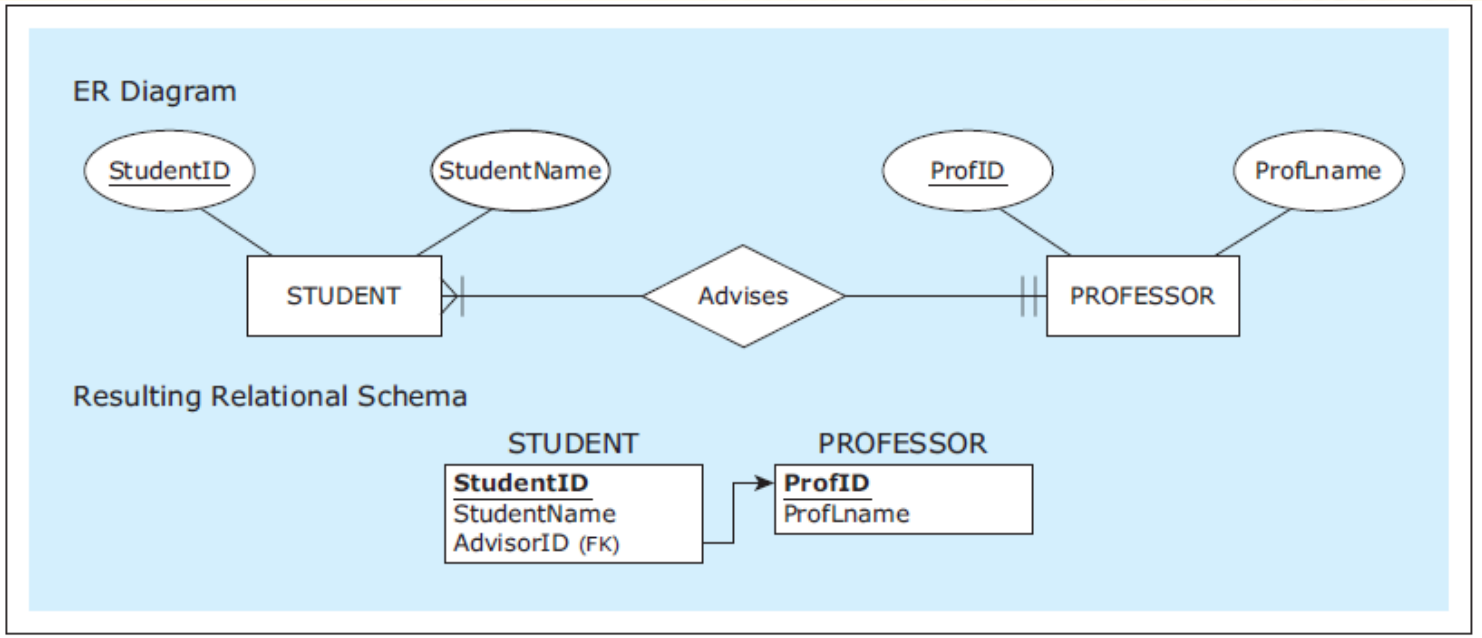
DEPARTMENT

DeptID	DeptLocation
1	Suite A
2	Suite B
3	Suite C

MAPPING RELATIONSHIPS

Example - Mapping a 1:M relationship

Renaming a foreign key



Sample data records for the mapped ER diagram

STUDENT

StudentID	StudentName	AdvisorID
1111	Robin	P11
2222	Pat	P22
3333	Jami	P11

PROFESSOR

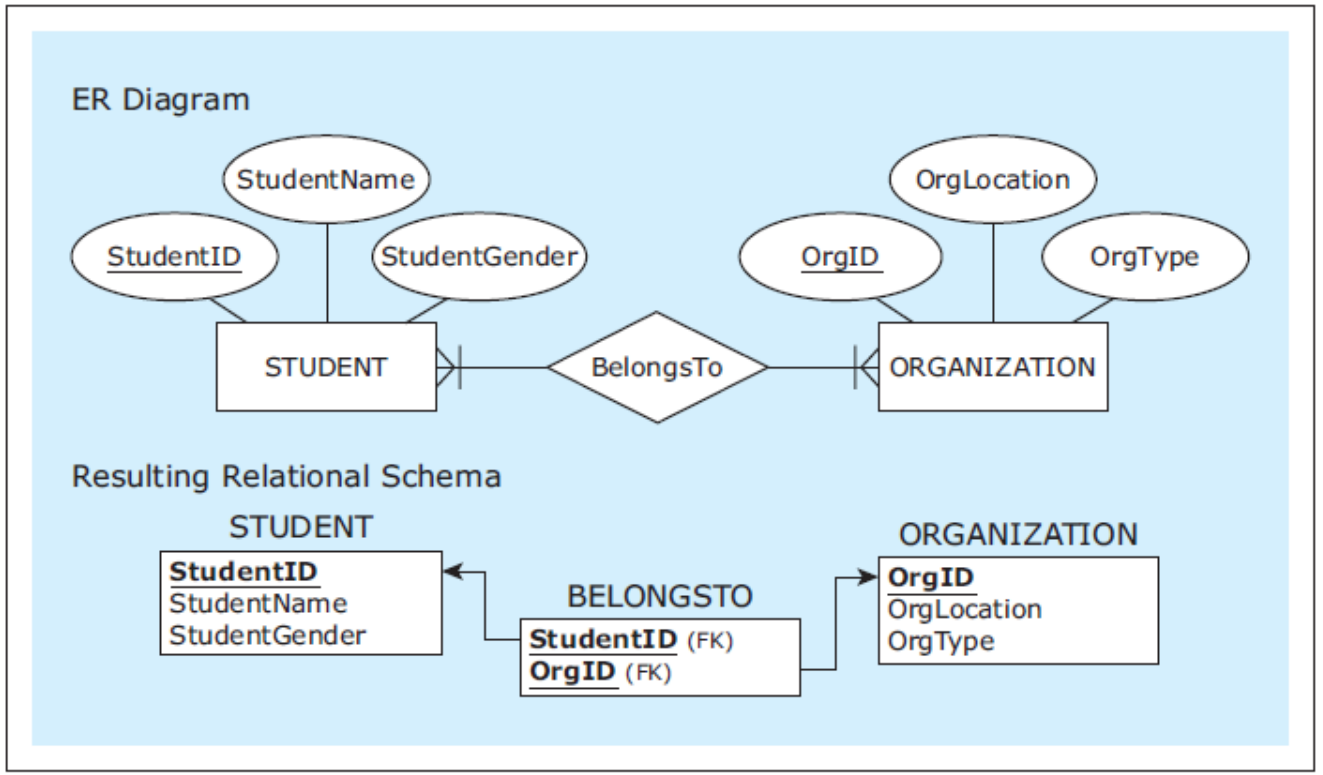
ProfID	ProfLname
P11	Zydiak
P22	Lash

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*
  - *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*
  - *The **two foreign keys form the composite primary key** of the new relation*

MAPPING RELATIONSHIPS

Example - Mapping an M:N relationship



Sample data records for the mapped ER diagram

STUDENT

StudentID	StudentName	StudentGender
1111	Robin	Male
2222	Pat	Male
3333	Jami	Female

ORGANIZATION

OrgID	OrgLocation	OrgType
O11	Student Hall	Charity
O41	Damen Hall	Sport
O47	Student Hall	Charity

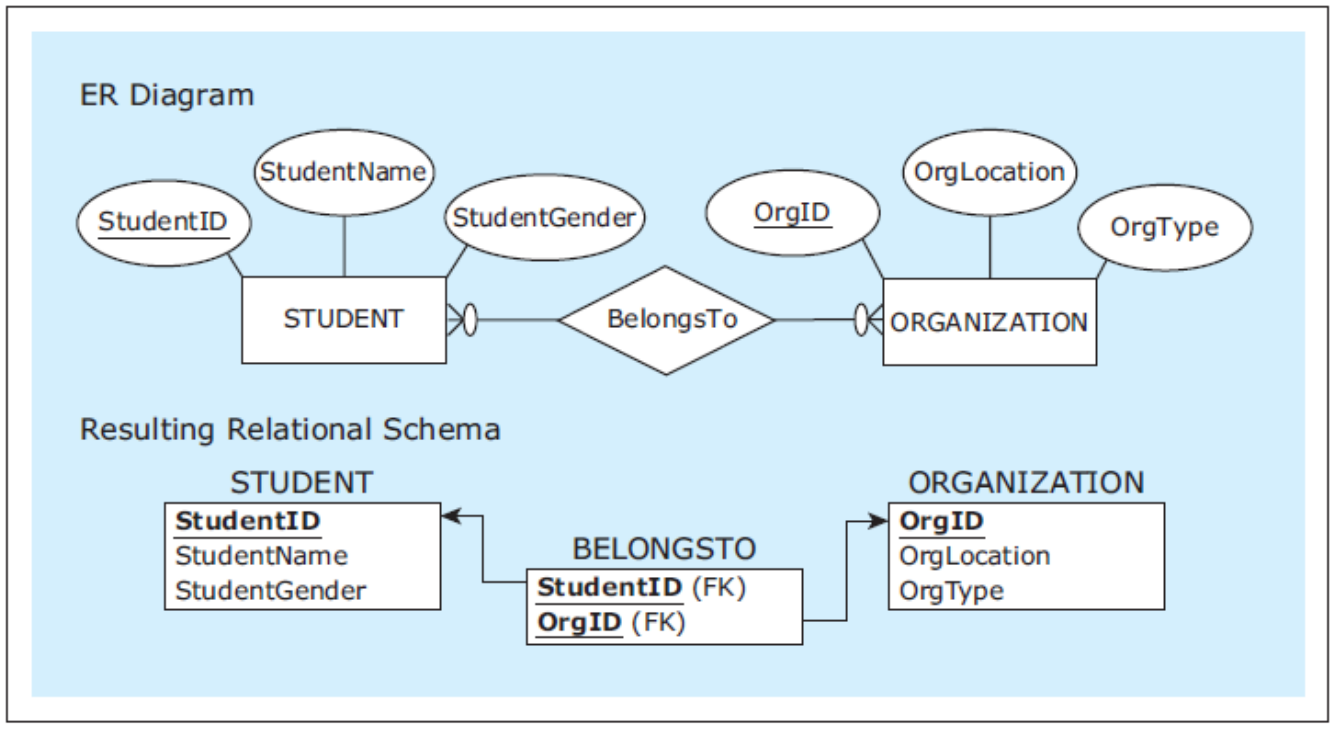
BELONGSTO

StudentID	OrgID
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

StudentID	StudentName	StudentGender
1111	Robin	Male
2222	Pat	Male
3333	Jami	Female
4444	Abby	Female

ORGANIZATION

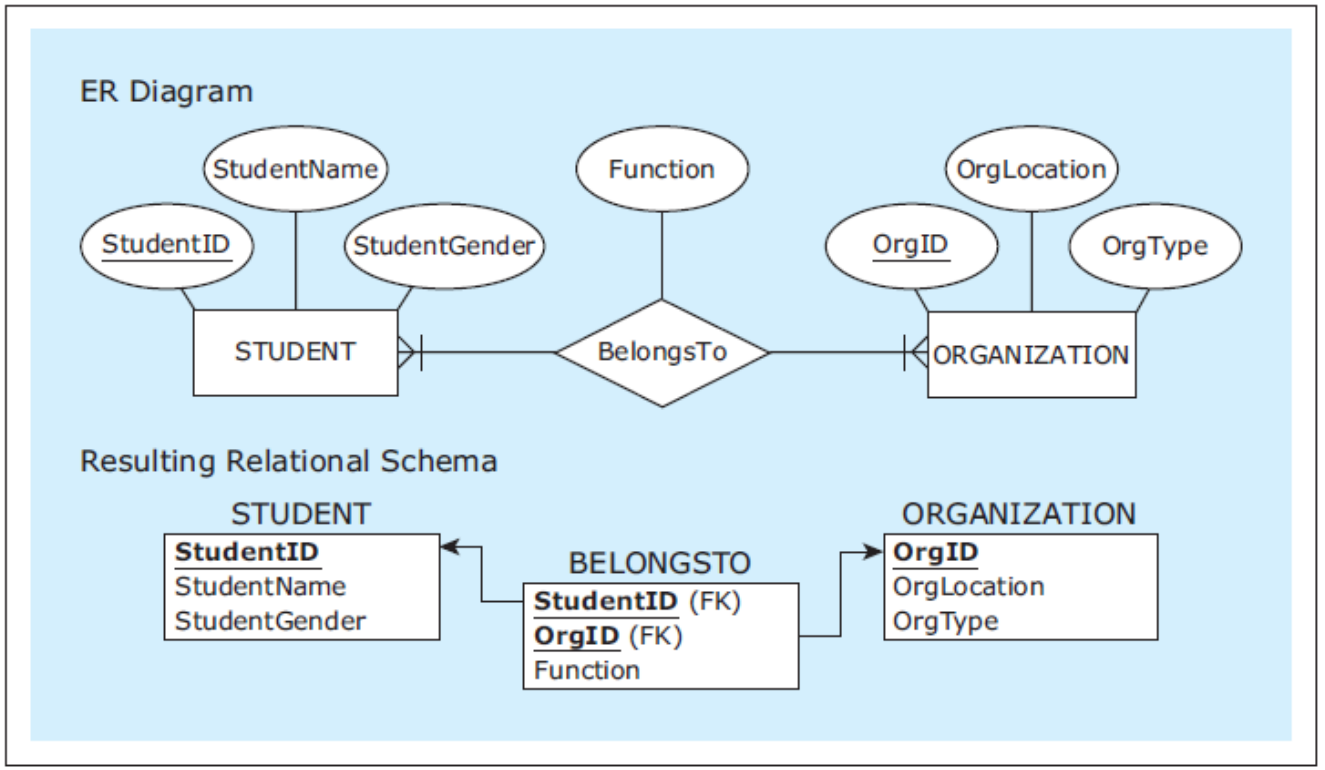
OrgID	OrgLocation	OrgType
O11	Student Hall	Charity
O41	Damen Hall	Sport
O47	Student Hall	Charity
O50	Damen Hall	Politics

BELONGSTO

StudentID	OrgID
1111	O11
1111	O41
2222	O11
2222	O41
2222	O47
3333	O11

MAPPING RELATIONSHIPS

Example - Mapping a M:N relationship with an attribute



Sample data records for the mapped ER diagram

STUDENT

StudentID	StudentName	StudentGender
1111	Robin	Male
2222	Pat	Male
3333	Jami	Female

ORGANIZATION

OrgID	OrgLocation	OrgType
O11	Student Hall	Charity
O41	Damen Hall	Sport
O47	Student Hall	Charity

BELONGSTO

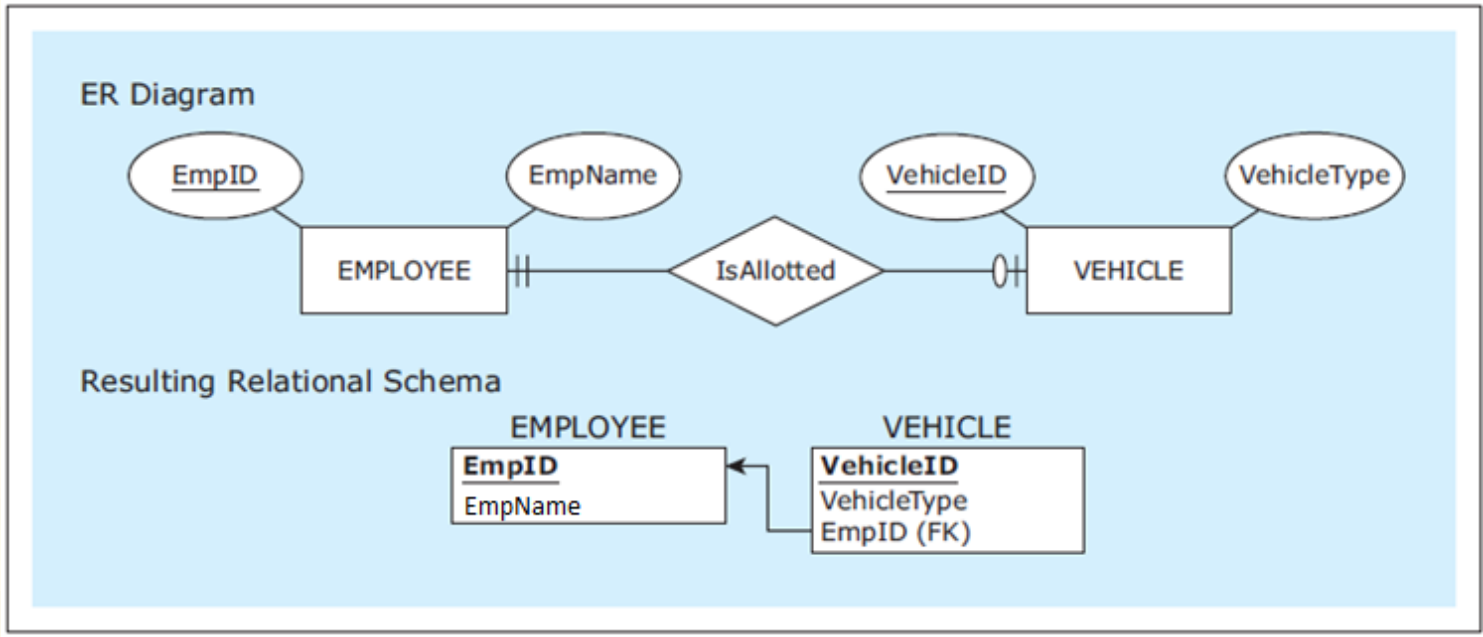
StudentID	OrgID	Function
1111	O11	President
1111	O41	Member
2222	O11	V.P.
2222	O41	Member
2222	O47	Treasurer
3333	O11	Member

MAPPING RELATIONSHIPS

- **Mapping 1:1 relationships**
  - 1:1 relationships are mapped in the same way as 1:M relationships
  - One of the resulting relations will have a foreign key pointing to the primary key of another resulting relation
  - One of the mapped relations is chosen to have a foreign key referring to the primary key of the other mapped relation
    - In cases when there is no particular advantage in choosing which resulting relation will include a foreign key, the choice can be arbitrary
    - In other cases one choice can be more efficient than the other

MAPPING RELATIONSHIPS INTO RELATIONAL DATABASE CONSTRUCTS

Example - Mapping a 1:1 relationship



Sample data records for the mapped ER diagram

EMPLOYEE

EmpID	EmpName
1234	Becky
2345	Molly
3456	Rob
1324	Ted

VEHICLE

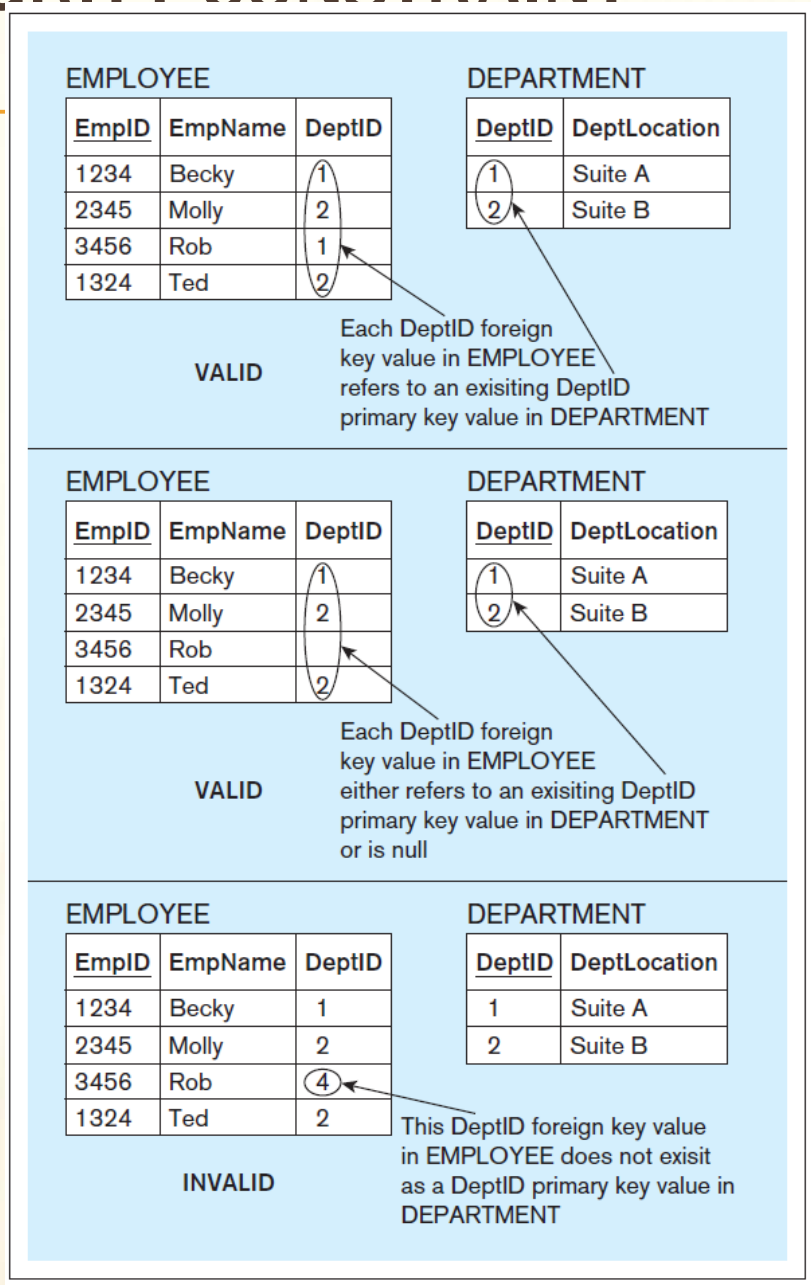
VehicleID	Vehicletype	EmpID
111	Sedan	1234
222	Van	2345
333	Van	3456

REFERENTIAL INTEGRITY CONSTRAINT

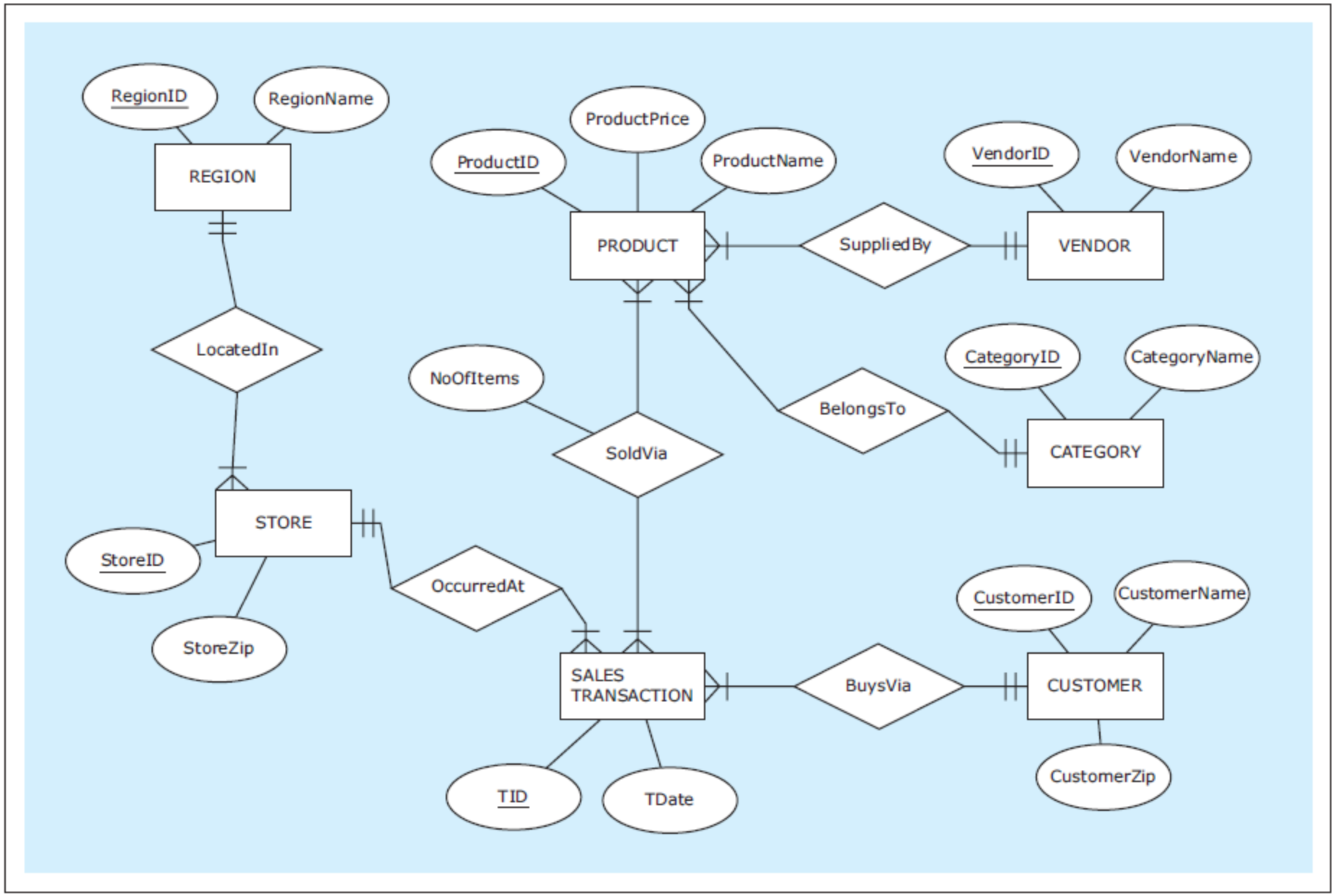
- **Referential integrity constraint** - *In each row of a relation containing a foreign key, the value of the **foreign key EITHER matches** one of the values in the **primary key** column of the referred relation **OR** the value of **the foreign key is null** (empty).*
  - A rule that defines values that are valid for use in foreign keys
  - In a relational schema lines pointing from the foreign key to the corresponding primary key are referred to as **referential integrity constraint lines**

REFERENTIAL INTEGRITY CONSTRAINT

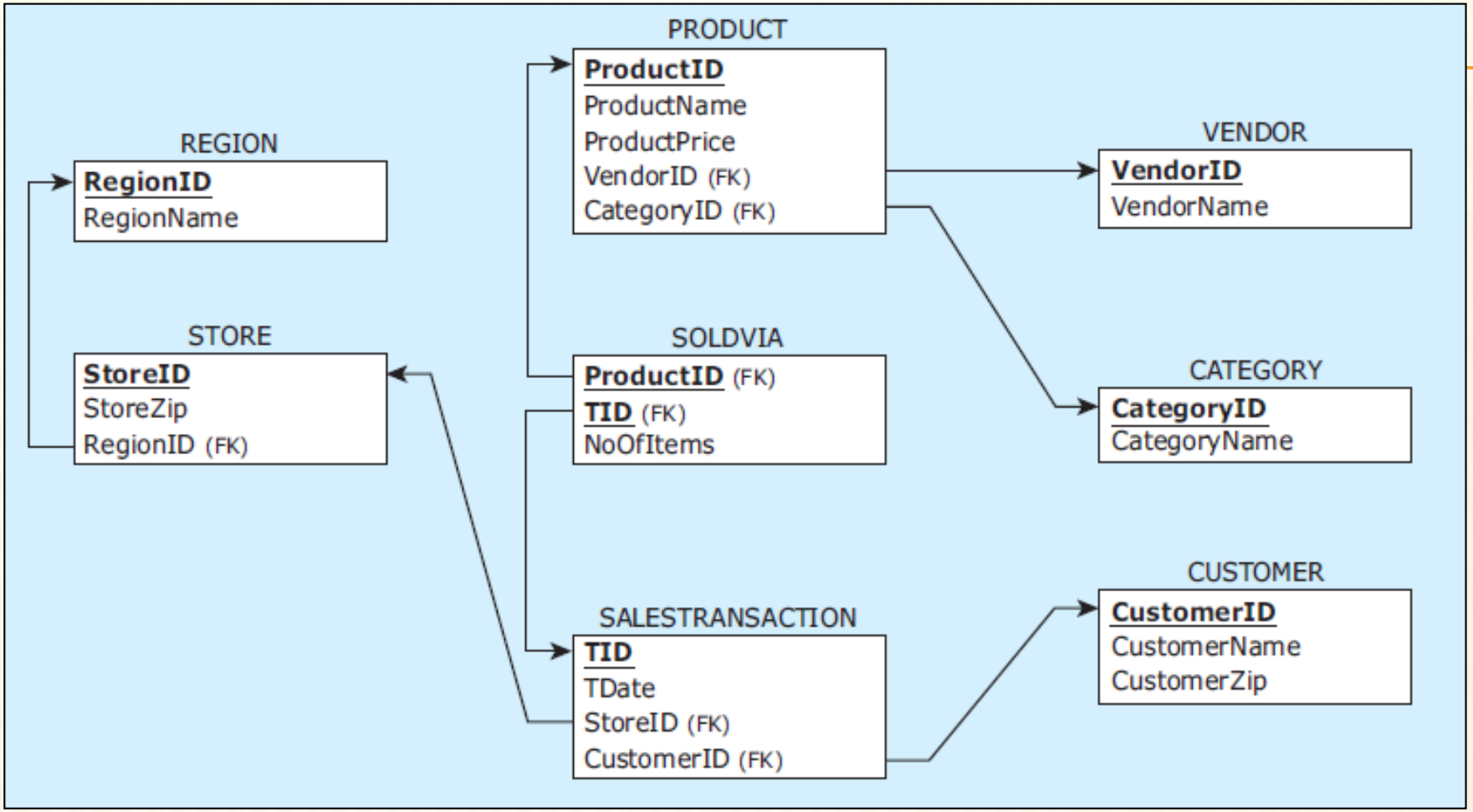
Referential integrity constraint — compliance and violation examples



Example ER diagram : ZAGI Retail Company Sales Department Database



Example mapped relational schema: ZAGI Retail Company Sales Department Database



Example: Sample data records for the ZAGI Retail Company Sales Department Database

REGION

RegionID	RegionName
C	Chicagoland
T	Tristate

PRODUCT

ProductID	ProductName	ProductPrice	VendorID	CategoryID
1X1	Zzz Bag	$100	PG	CP
2X2	Easy Boot	$70	MK	FW
3X3	Cosy Sock	$15	MK	FW
4X4	Dura Boot	$90	PG	FW
5X5	Tiny Tent	$150	MK	CP
6X6	Biggy Tent	$250	MK	CP

VENDOR

VendorID	VendorName
PG	Pacifica Gear
MK	Mountain King

STORE

StoreID	StoreZip	RegionID
S1	60600	C
S2	60605	C
S3	35400	T

CATEGORY

CategoryID	CategoryName
CP	Camping
FW	Footwear

SALES TRANSACTION

TID	CustomerID	StoreID	TDate
T111	1-2-333	S1	1-Jan-2013
T222	2-3-444	S2	1-Jan-2013
T333	1-2-333	S3	2-Jan-2013
T444	3-4-555	S3	2-Jan-2013
T555	2-3-444	S3	2-Jan-2013

SOLDVIA

ProductID	TID	NoOfItems
1X1	T111	1
2X2	T222	1
3X3	T333	5
1X1	T333	1
4X4	T444	1
2X2	T444	2
4X4	T555	4
5X5	T555	2
6X6	T555	1

CUSTOMER

CustomerID	CustomerName	CustomerZip
1-2-333	Tina	60137
2-3-444	Tony	60611
3-4-555	Pam	35401

Example : Entity with various types of attributes mapped into a relation