Week 10, Week 11

Database Systems -

Introduction to Databases and Data Warehouses

CHAPTER 3 - Relational Database Modeling Part 4

MAIN TOPICS

- Relational Database Constraints
  - Implicit, User-Defined
- Map Associative Entity
- Map Ternary Relationship
- Designer-Created Primary Keys and the AutoNumber option
- Benefits of Performing Both ER and Relational Modeling
- Chapter 3 Summary
- Chapter 3 Practices

RELATIONAL DATABASE CONSTRAINTS

- **Relational database constraints**
  - Rules that a relational database has to satisfy in order to be valid
  - 2 Categories
    - **Implicit constraints**
      - The implicit relational database model rules that a relational database must satisfy in order to be valid
    - **User-defined constraints**
      - Database constraints that are added by the database designer

RELATIONAL DATABASE CONSTRAINTS

- **Implicit constraints**
  - Unique relation names in a relational schema
  - Required conditions for each relation:
    - Unique column name
    - Unique row
    - In each row, each value in each column must be **single valued**
    - **Domain constraint**
      - All values in each column must be from the same predefined domain
    - Irrelevant order of columns
    - Irrelevant order of rows

RELATIONAL DATABASE CONSTRAINTS

- Implicit constraints (cont'd)
  - Primary key constraint
    - Each relation must have a primary key (non-composite or composite)
  - Entity integrity constraint
    - No primary key column can have null values
  - Foreign key constraint
    - Foreign key column in a relation refers to primary key column in another relation (i.e referred relation)
  - Referential integrity constraint
    - The value of a foreign key in a relation must be
      - Either a matching value in the primary key column of the referred relation
      - Or null if optional

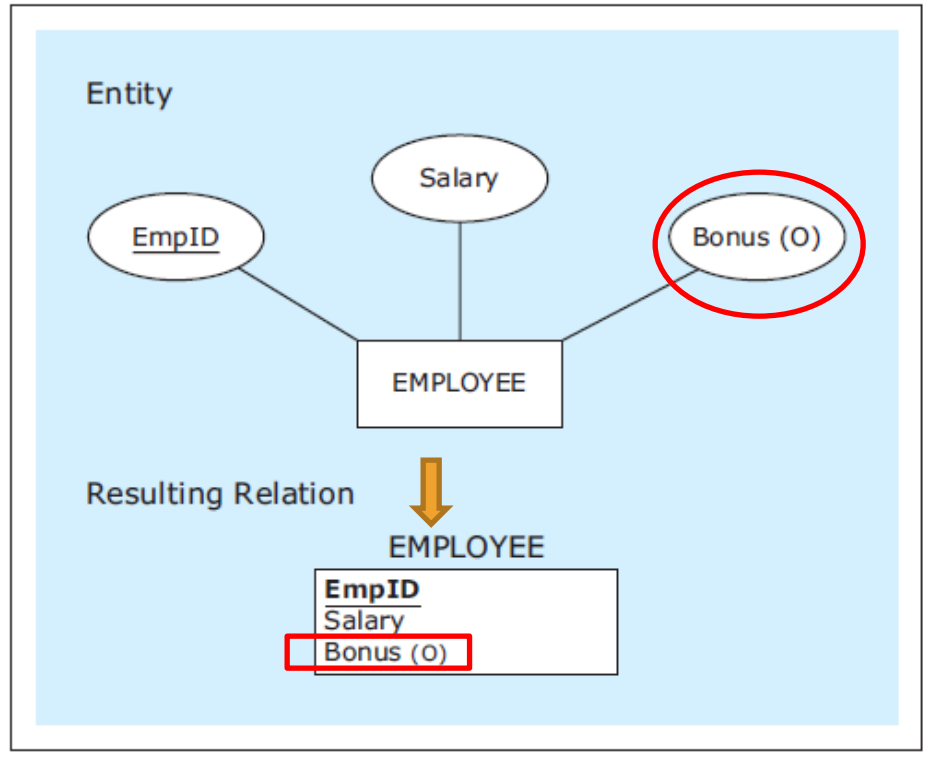
RELATIONAL DATABASE CONSTRAINTS

- User-defined constraints
  - Added by the database designers for the database being developed
  - User-defined constraints specified in ER diagram
    - Optional attribute in ER diagram
      - Figure 3.11, Figure 3.12, optional Bonus in EMPLOYEE
    - Mandatory foreign key in relational schema and mandatory participation in ER diagram
      - Figure 3.15, Figure 3.16, DeptID in EMPLOYEE relation
    - Mandatory referral of each primary key value and mandatory participation in ER diagram
      - Figure 3.15, Figure 3.16, DeptID in DEPARTMENT relation
    - Exact minimum and maximum cardinalities in ER diagram
      - Figure 3.61, Figure 3.62

RELATIONAL DATABASE CONSTRAINTS

Figure3.11

Entity with an optional attribute mapped into a relation



Optional attribute constraint

Figure3.12

Sample data records for the mapped relation

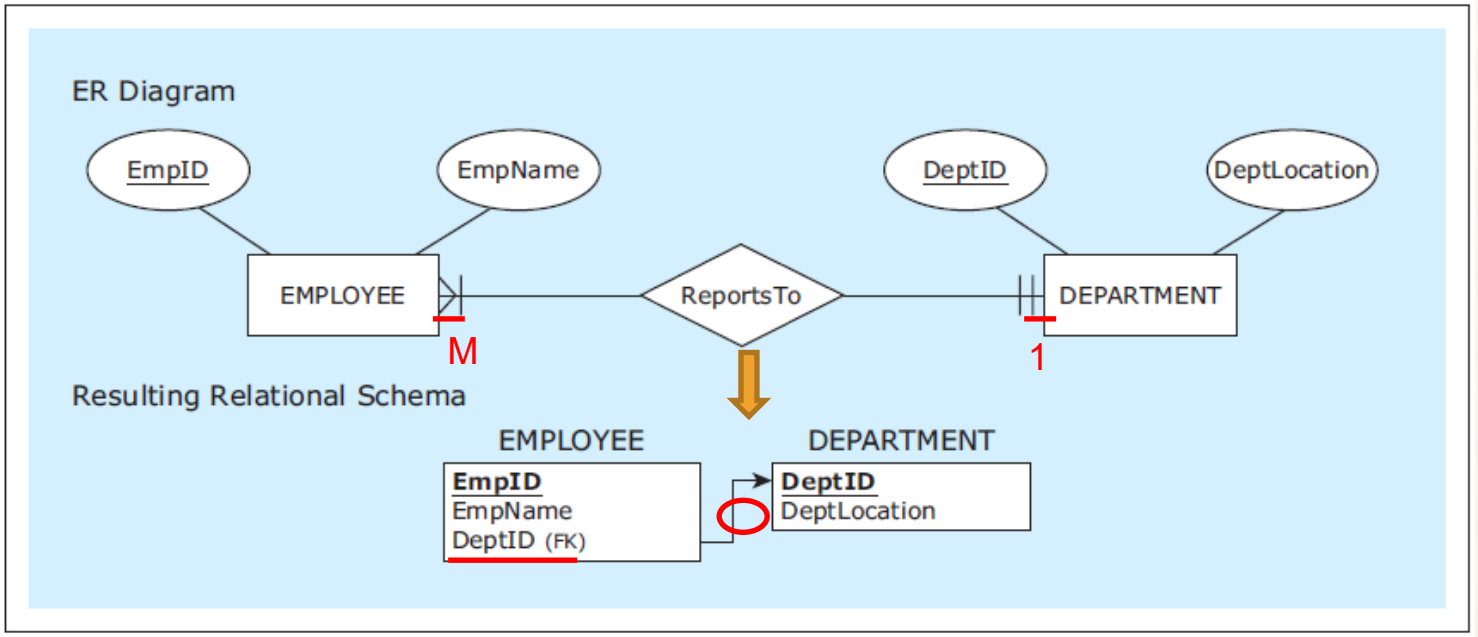
EMPLOYEE

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

RELATIONAL DATABASE CONSTRAINTS

Figure3.15

Example - Map 1:M relationship



Mandatory foreign key constraint

Figure3.16

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

And Mandatory referral of each primary key value

RELATIONAL DATABASE CONSTRAINTS

Figure3.19

Example - Map a 1:M relationship

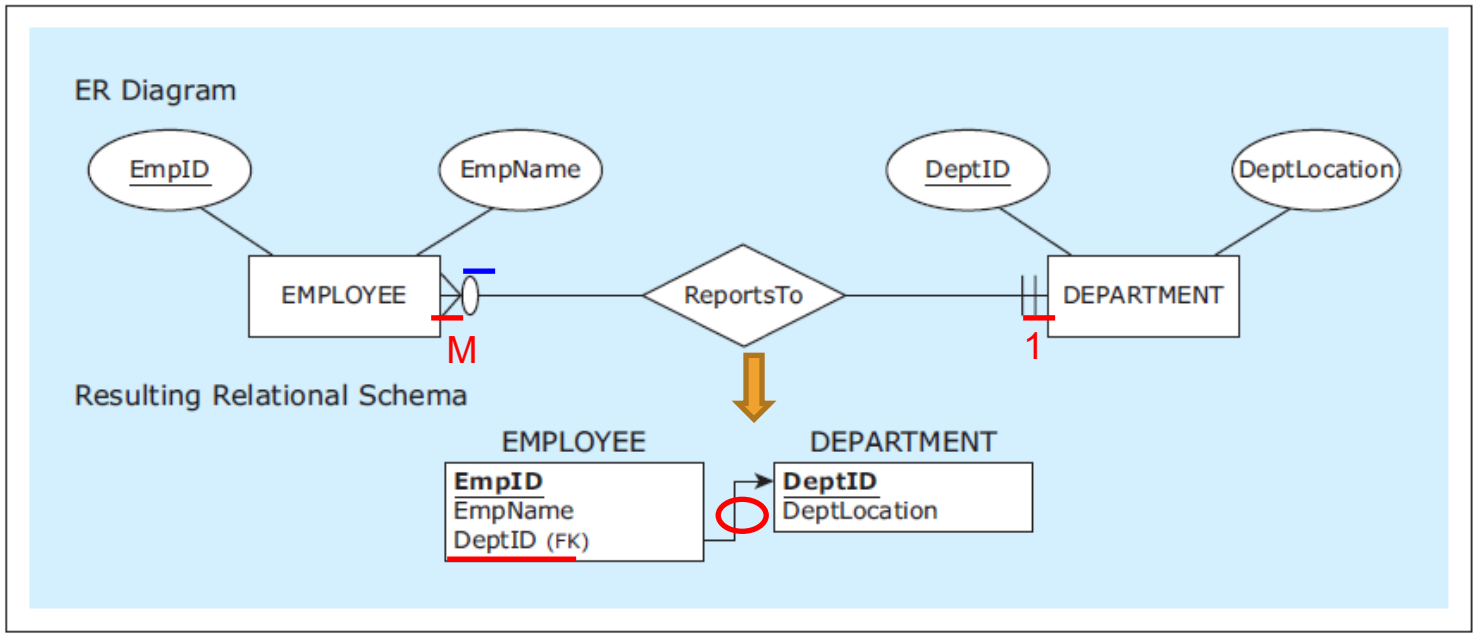


Figure3.20

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

NO mandatory referral of each primary key value

RELATIONAL DATABASE CONSTRAINTS

Figure3.61

Specific minimum and maximum cardinalities

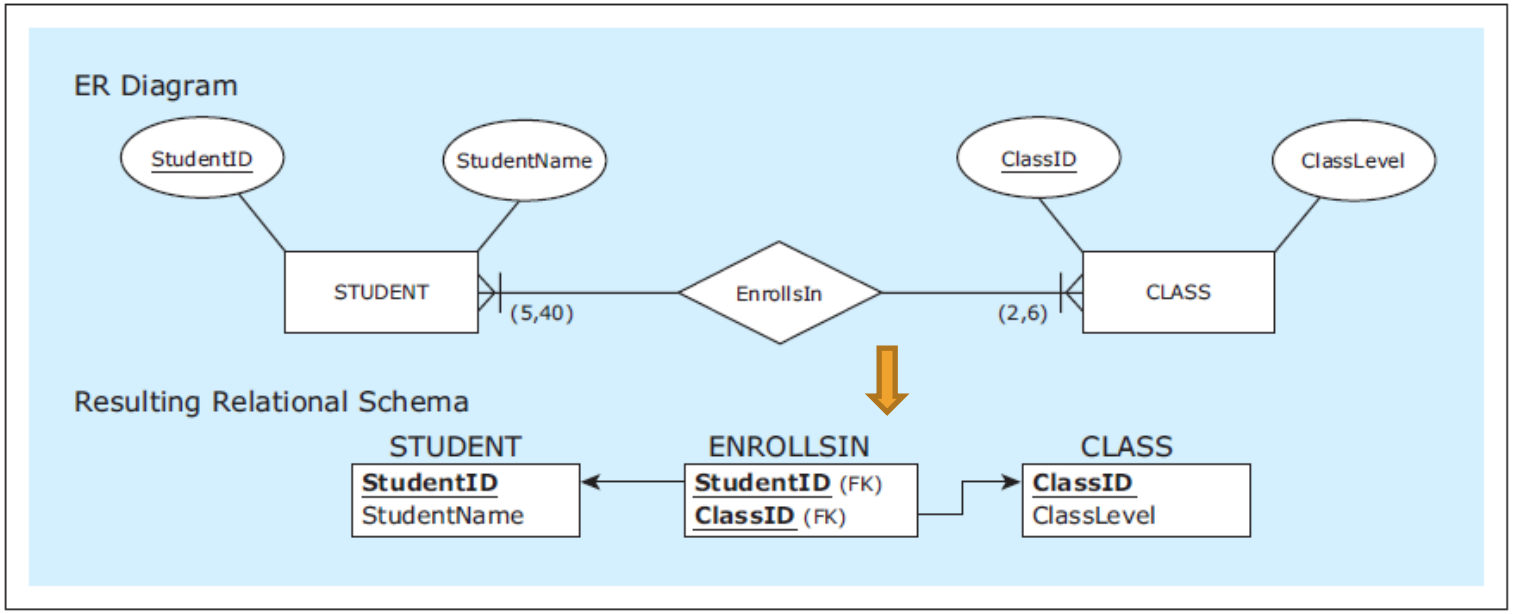


Figure3.62

Sample data records for the mapped relations

STUDENT

StudentID	SName
1111	Robin
2222	Pat
3333	Jami
4444	Zach
5555	Louie

CLASS

ClassID	ClassLevel
IS346	Junior
IS401	Senior

ENROLLSIN

StudentID	ClassID
1111	IS346
2222	IS346
3333	IS346
4444	IS346
5555	IS346
1111	IS401
2222	IS401
3333	IS401
4444	IS401
5555	IS401

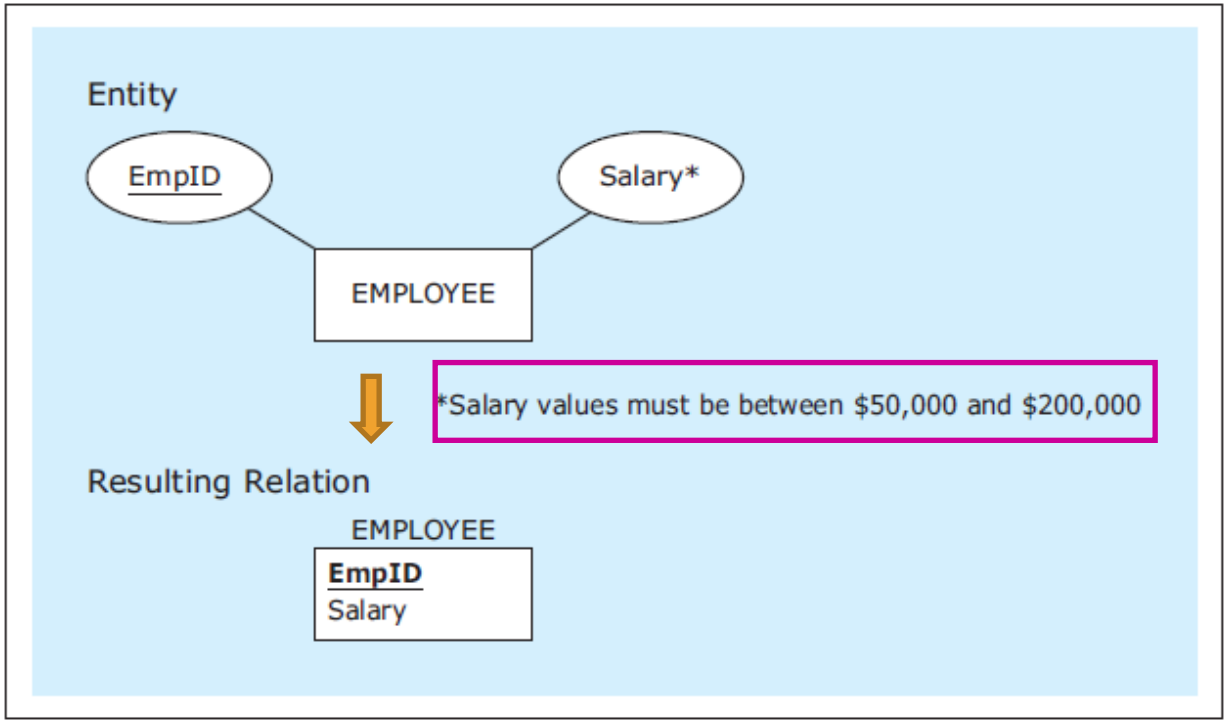
Exact minimum and maximum cardinalities

RELATIONAL DATABASE CONSTRAINTS

- User-defined constraints (cont'd)
  - Business rules
    - User defined constraints that specify restrictions on databases
    - Not part of standard notation for creating ER diagrams
      - Listed as **notes** in the diagrams or in separate documentation
        - Footnotes, comments, special symbols, etc

RELATIONAL DATABASE CONSTRAINTS

Business rule for salary amounts



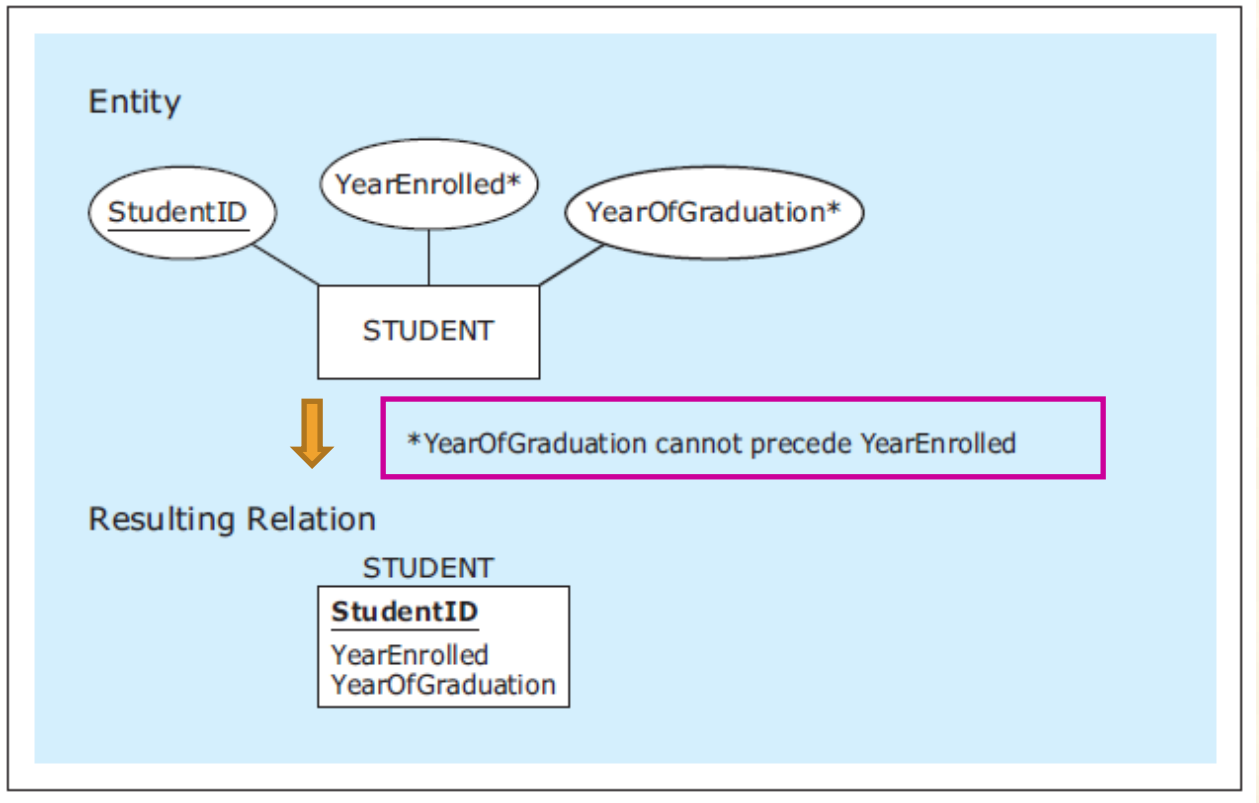
Sample data records for the mapped relation

EMPLOYEE

EmpID	Salary
1234	$75,000
2345	$50,000
3456	$55,000
1324	$70,000

RELATIONAL DATABASE CONSTRAINTS

Business rule for the dates of enrollment and graduation



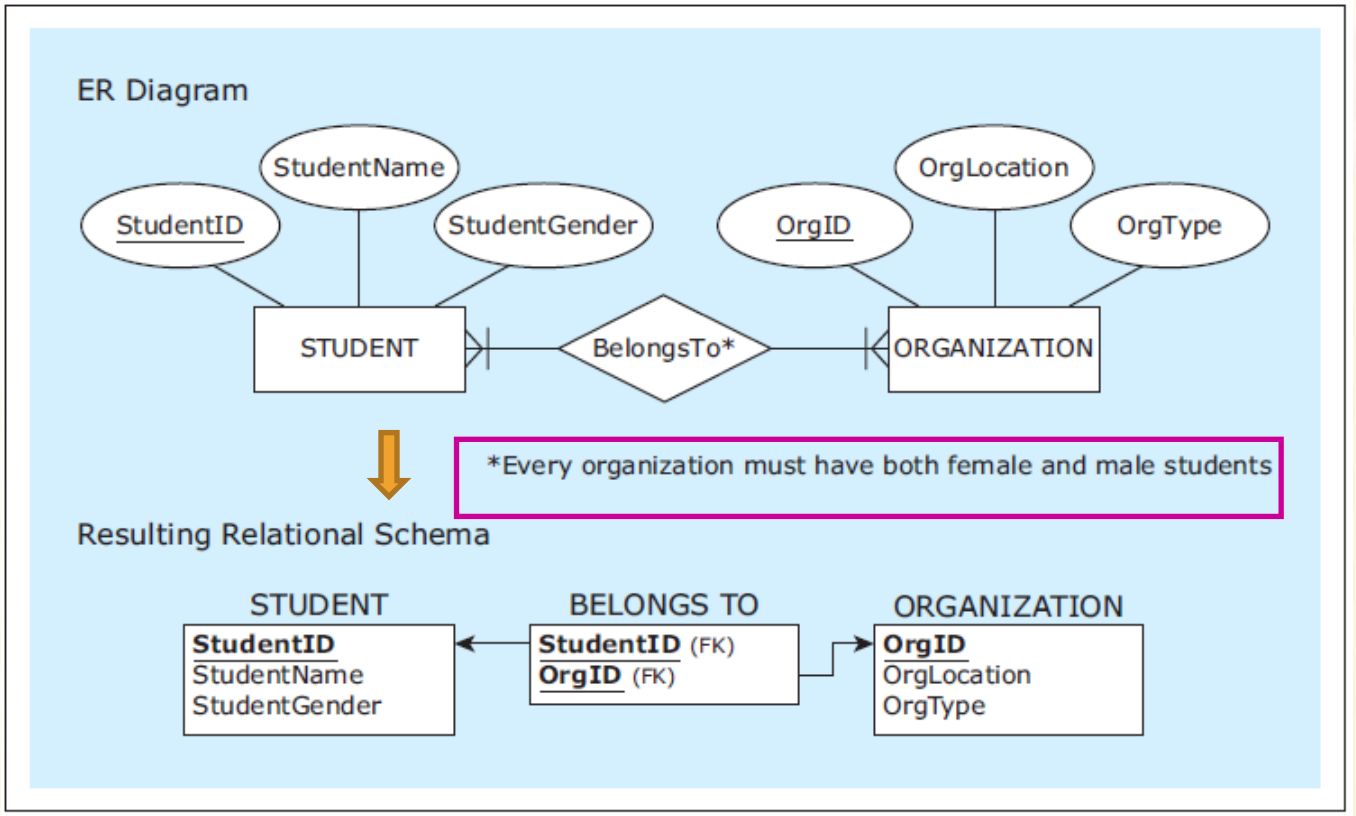
Sample data records for the mapped relation

STUDENT

StudentID	YearEnrolled	YearOfGraduation
1111	2012	2016
2222	2013	2017
3333	2013	2017

RELATIONAL DATABASE CONSTRAINTS

Business rule for gender of students in an organization



Sample data records for the mapped relation

STUDENT

StudentID	StudentName	StudentGender
1111	Robin	M
2222	Pat	M
3333	Jami	F

ORGANIZATION

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

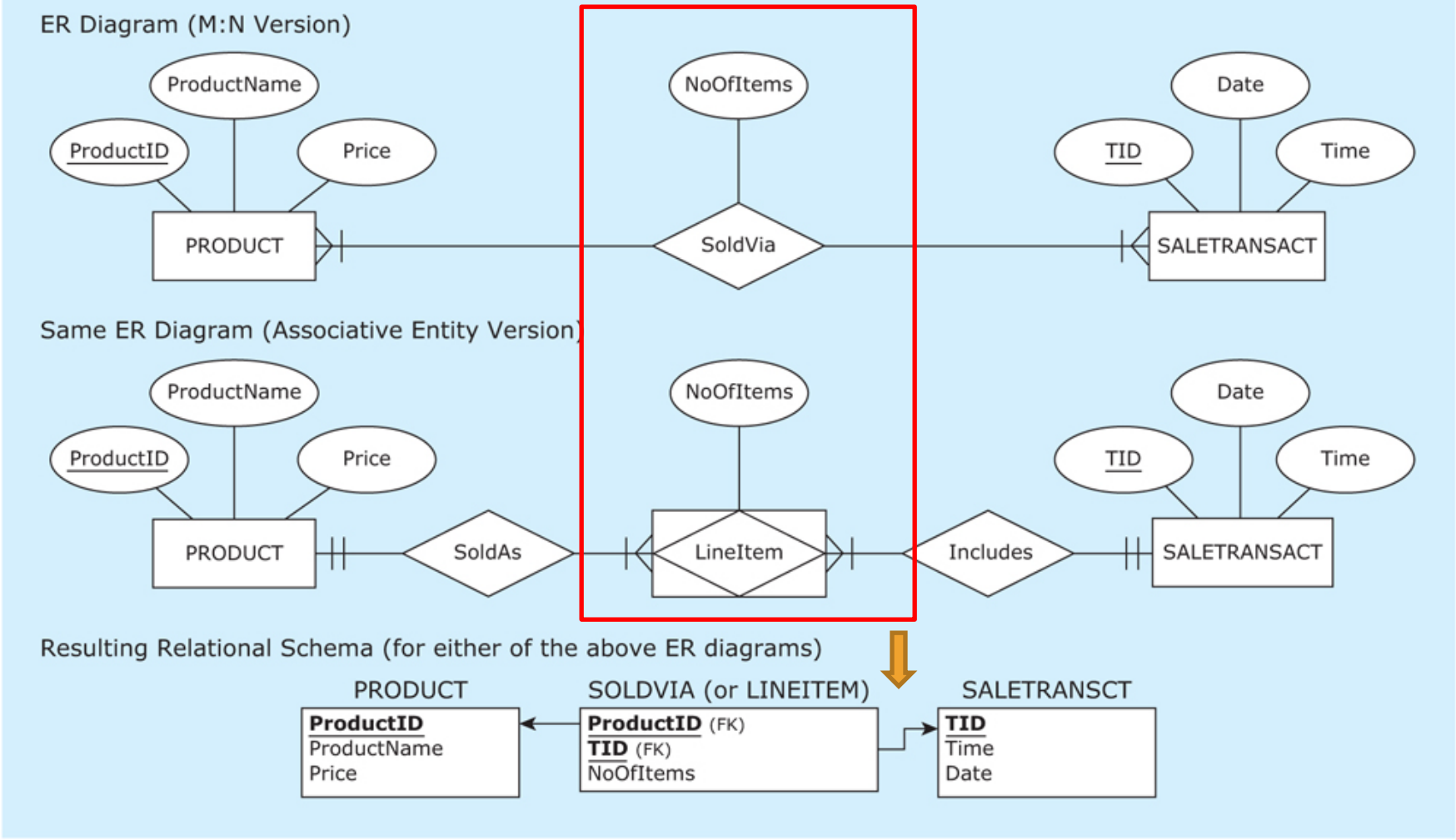
BELONGSTO

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

Mapping Associative Entities

- Associative entities
  - Alternative method to depict M:N relationships
    - Particularly used to depict ternary relationships
- Mapping associative entities
  - Same as mapping M:N relationships
    - Add a new relation with
      - Two foreign keys
        - Point to the primary keys of relations from two entities involved
      - One composite primary key
        - Two foreign keys combined

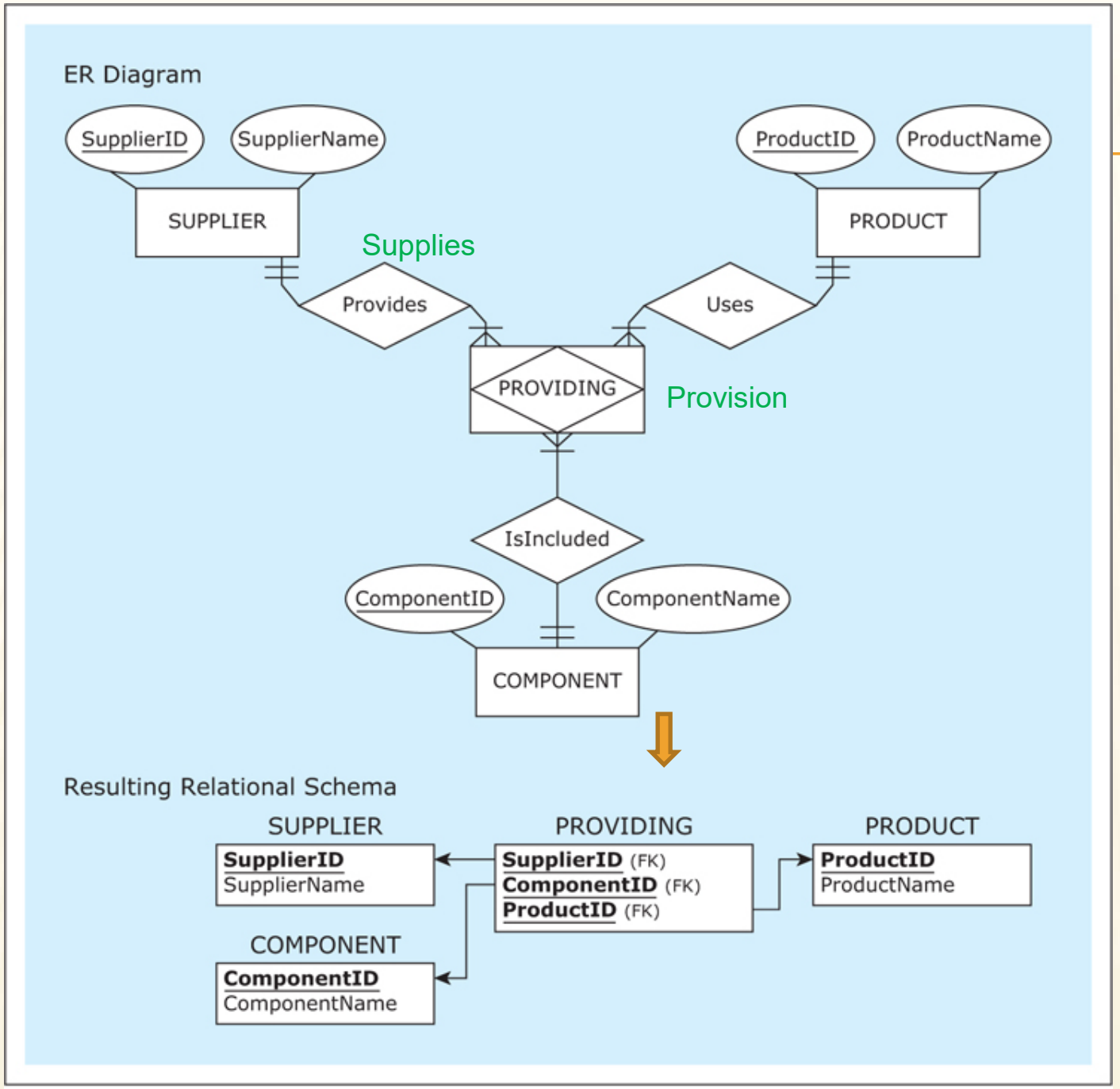
Mapping Associative Entities



M:N relationship and associative entity mapped into a relation in the same way

Mapping Ternary Relationships

- Ternary relationship
  - Relationship that involves three entities
  - Many-to-many-to-many relationship (most common)
- Mapping ternary relationships
  - Same as mapping M:N relationships
    - Add a new relation with
      - Three foreign keys
        - Point to primary keys of relations from entities involved
      - One composite primary key
        - Three foreign keys combined



Map a ternary relationship

SUPPLIER

SupplierID	SupplierName
S1	Acme
S2	Xparts
S3	Compy

PRODUCT

ProductID	ProductName
P1	Bicycle
P2	Tricycle
P3	Scooter

COMPONENT

ComponentID	ComponentName
C1	Wheel
C2	Handle
C3	Seat

PROVIDING

SupplierID	ProductID	ComponentID
S1	P1	C1
S2	P1	C1
S3	P1	C1
S1	P1	C2
S2	P1	C2
S3	P1	C2
S1	P1	C3
S2	P1	C3
S3	P1	C3
S1	P2	C1
S1	P2	C2
S1	P2	C3
S1	P3	C1
S1	P3	C2

Sample data records for the relational database in previous slide

Designer-Created Primary Keys and Autonumber Option

- Designer-created primary key
  - Column added by database designers to serve as primary key
- Autonumber data type option
  - Used by designers to create designer-created primary key column
  - Available in most modern database design and DBMS tools
- Example
  - Requirements:
    - *The hospital database will keep track of patients.*
    - *For each patient, the hospital will keep track of his or her unique SSN as well as birthdate and name.*
  - Resulting ER diagram
    - Figure 3.72 next slide

Designer-Created Primary Keys and Autonumber Option

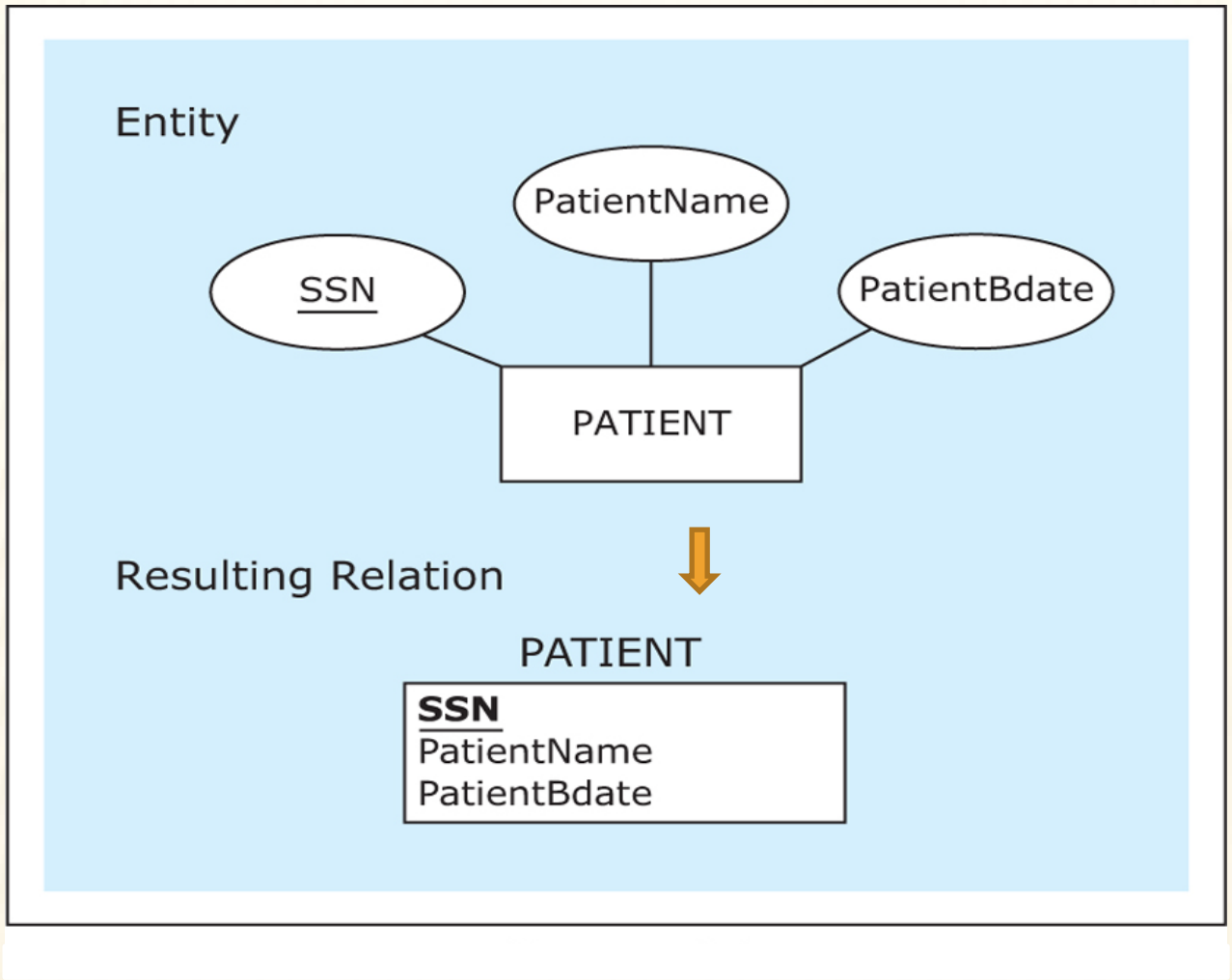


Figure 3.72
Entity and the resulting relation PATIENT

- NO designer-created primary key

Designer-Created Primary Keys and Autonumber Option

- Example - add a designer-created primary key PatientID
  - Change Requirements:
    - *The hospital database will keep track of patients.*
    - *For each patient, the hospital will keep track of his or her unique SSN, **unique PatientID (which will be a simple integer, where each new patient is assigned the next available consecutive integer)**, as well as birthdate and name.*
  - Resulting **new** ER diagram
    - Figure 3.73 next slide
  - Resulting data
    - Figure 3.74 slide 24

Designer-Created Primary Keys and Autonumber Option

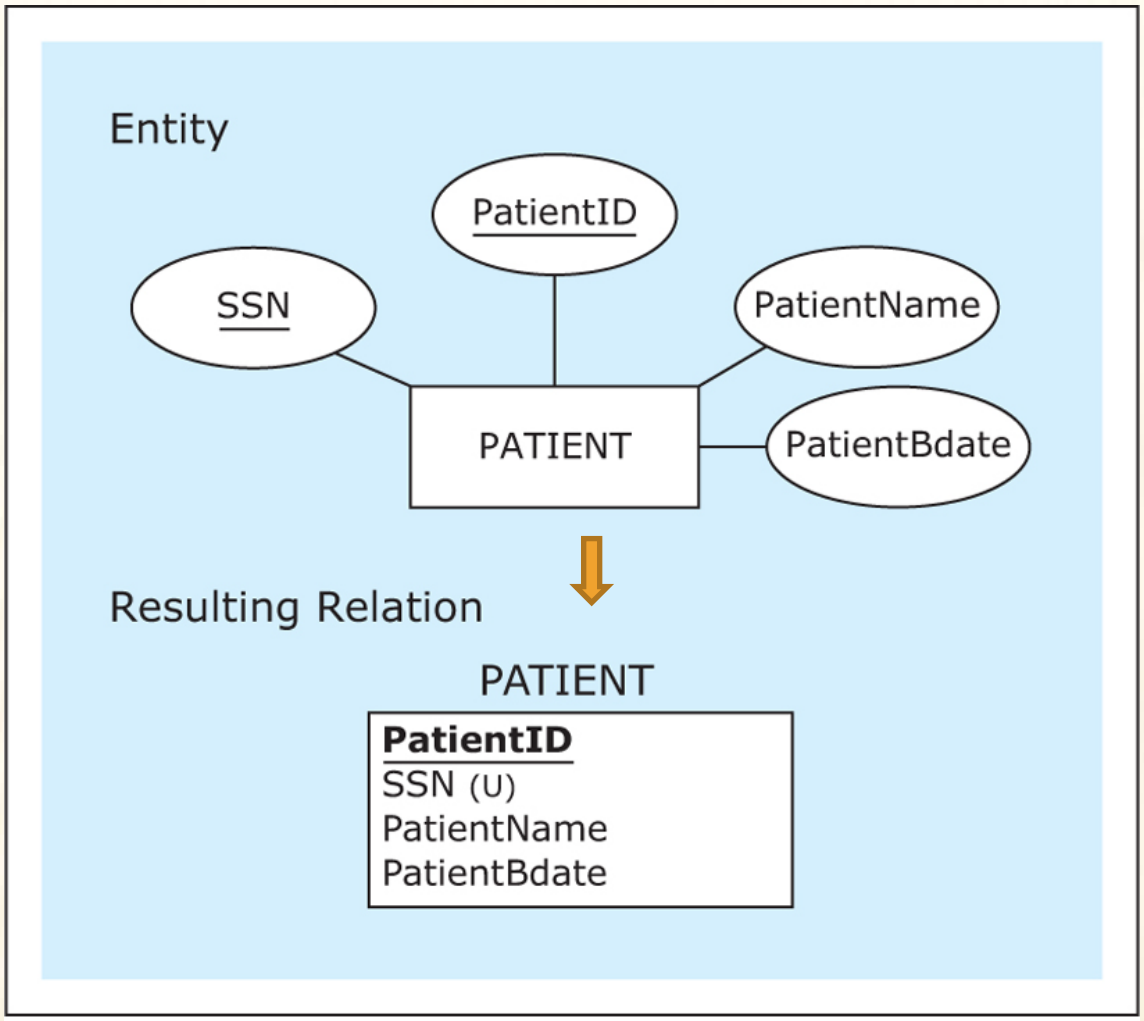
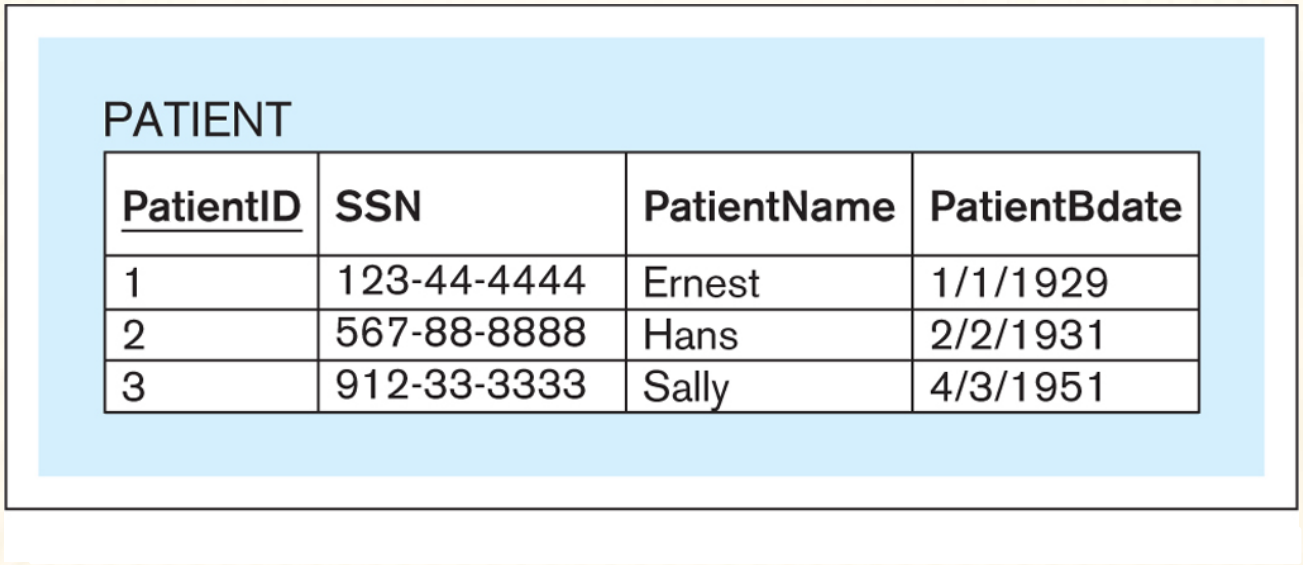


Figure 3.73

Entity and the resulting relation PATIENT

- WITH a designer-created primary key

Designer-Created Primary Keys and Autonumber Option



PATIENT

PatientID	SSN	PatientName	PatientBdate
1	123-44-4444	Ernest	1/1/1929
2	567-88-8888	Hans	2/2/1931
3	912-33-3333	Sally	4/3/1951

Figure 3.74 Sample data for the relation in Figure 3.73

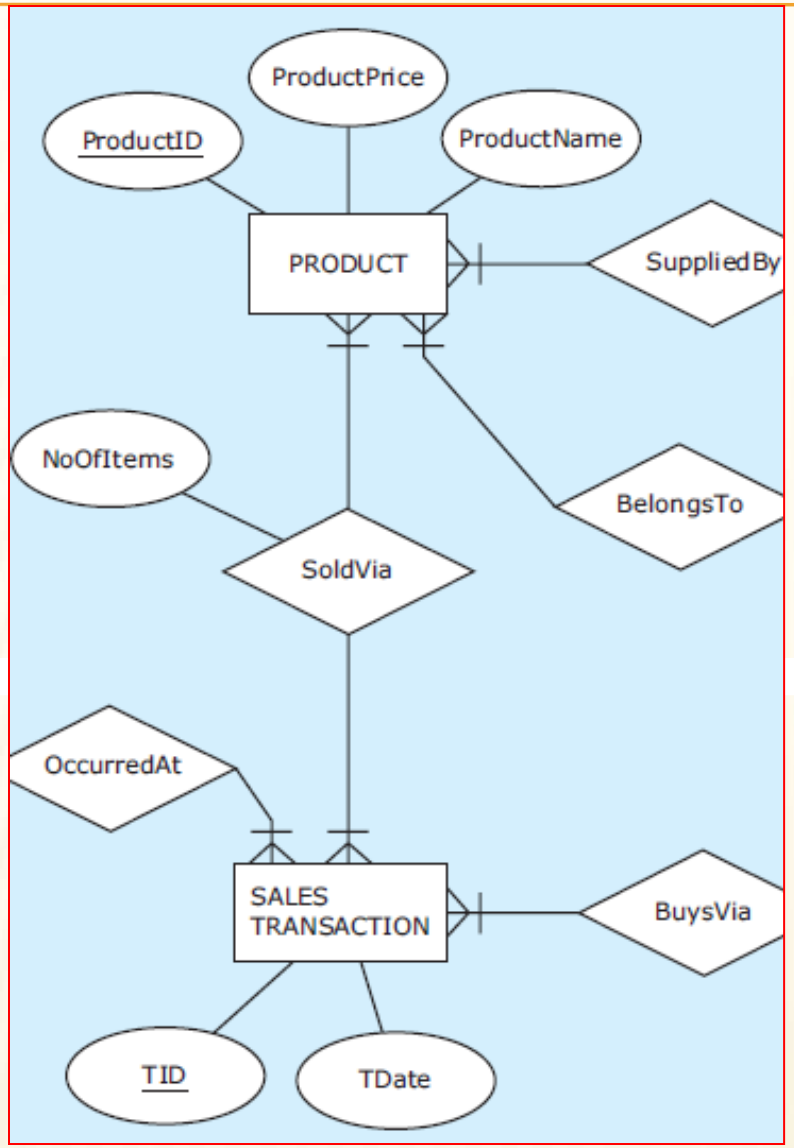
Performing Both ER and Relational Modeling

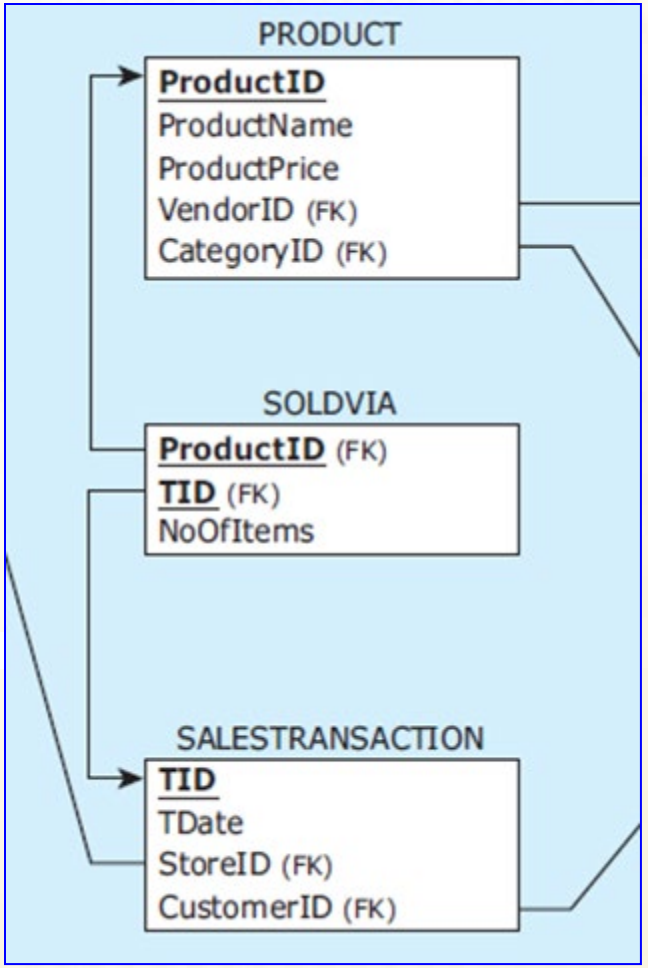
- Benefits for not skipping ER modeling
  - ER modeling is **more suited for visualization** of requirements
    - Figure 3.32, relationship SOLDVIA between PRODUCT and SALES TRANSACTION for requirement:
      - *Each product is sold via one or more sales transactions and each sales transaction includes one or more products.*
  - Certain concepts can be **visualized graphically only** in ER diagrams
    - Figure 3.15, ER diagram for requirement:
      - *Each department must have at least one employee reporting to it.*
  - Every **attribute** is **mentioned only once** in ER diagrams
    - Figure 3.59, attribute BuildingID of entity BUILDING
      - 4 occurrences in resulting relational schema
  - An ER model is a **better communication and documentation** device
    - For all: database designers, business constituents, regular business users
    - For database development and database-in-use

ER modeling is more suited for visualization of requirements

Figure 3.32

ER diagram

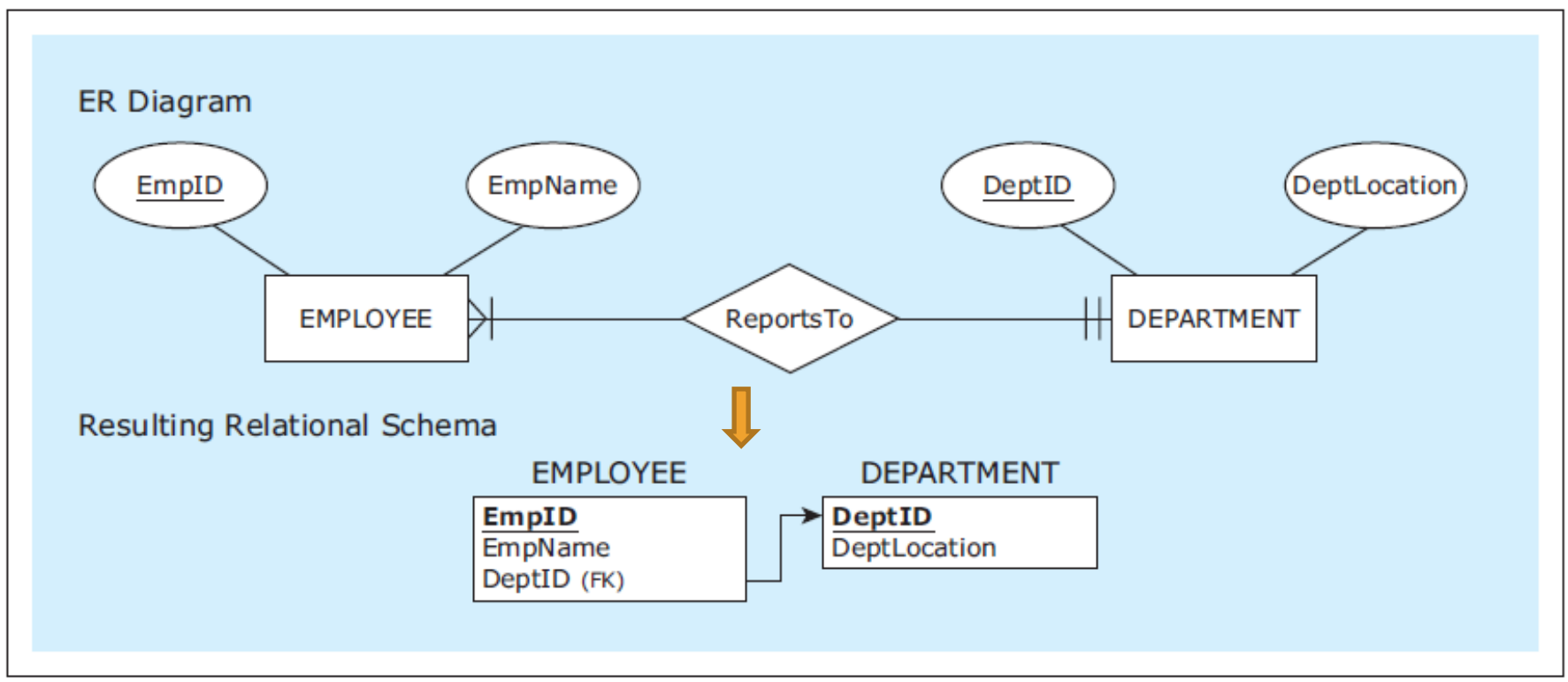




Relational Schema

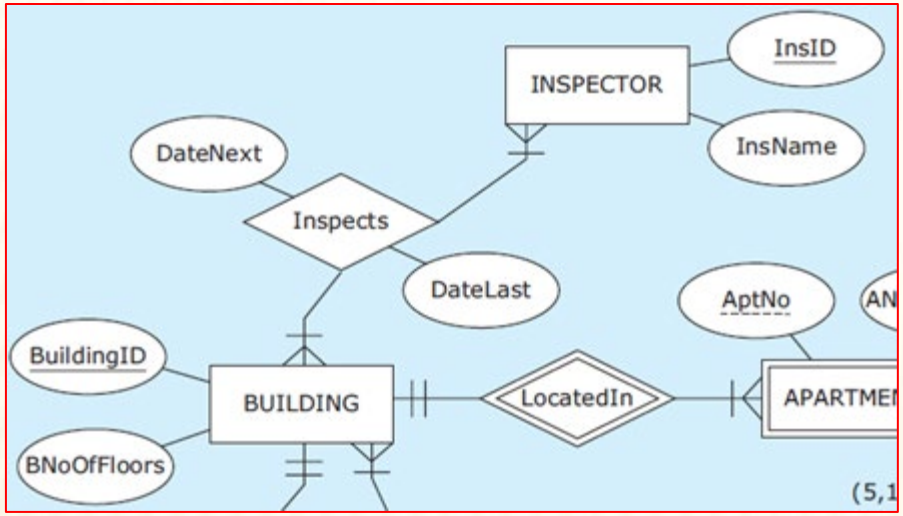
Certain concepts can be visualized graphically only in ER diagram

Figure 3.15

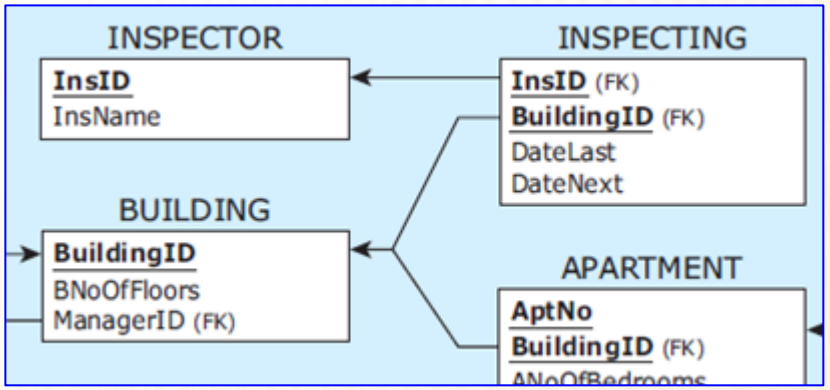


Every attribute is mentioned only once in ER diagrams

Figure 3.59



ER diagram



Relational Schema

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    - For all: database designers, business constituents, regular business users
    - For database development and database-in-use

Chapter 3 Summary

File Jukic-Ch3-RDBModeling-Summary-4Print.pdf includes:

- Table 3.2
  - Summary of Basic Relational Database Constraints
- Table 3.3
  - Summary of Basic ER to Relational Schema Mapping Rules

Chapter 3 Practice

Mapping the ER Diagram to its Relational Schema

- MC1 Investco Scout
  - MC1-Question-ERD.png
- ERD Example 2
  - ERD-Model Example-Diagram-Lec19.png

MAPPING ER DIAGRAM INTO RELATIONAL SCHEMA

- **Mapping an ER diagram into a relational schema (more)**
  1. Map all entities and their attributes
     - From left to right & from top to down (**can map weak entities last if desired**)
     - **Special-Mapping of multivalued attributes and weak entities**
  2. Map all relationships
     - From left to right & from top to down
     - Steps to map each relationship
       1) Identify the type: 1:1, 1:M, or M:N; unary or binary
       2) Map the relationship according to its type
          - M:N, add a new relation with composite PK
          - 1:M, add a FK to relation from entity on M side
          - 1:1, decide which relation to add FK, then add FK
          - **May need to rename FK columns in unary relationships**
     - **No additional mapping of identifying relationships**
       - **Already done during mapping weak entities**
  3. Verify the resulting relational schema
     - Compare the relational schema to the ER diagram