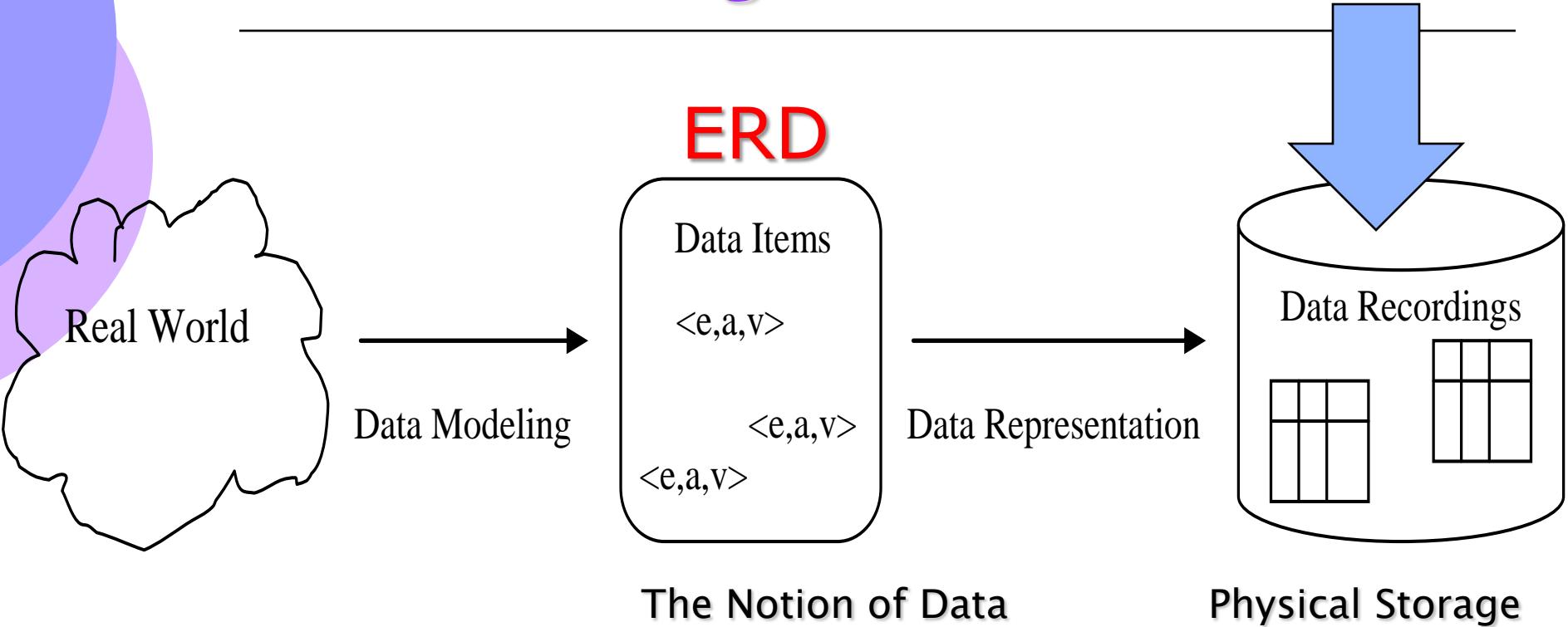


Chapter 3

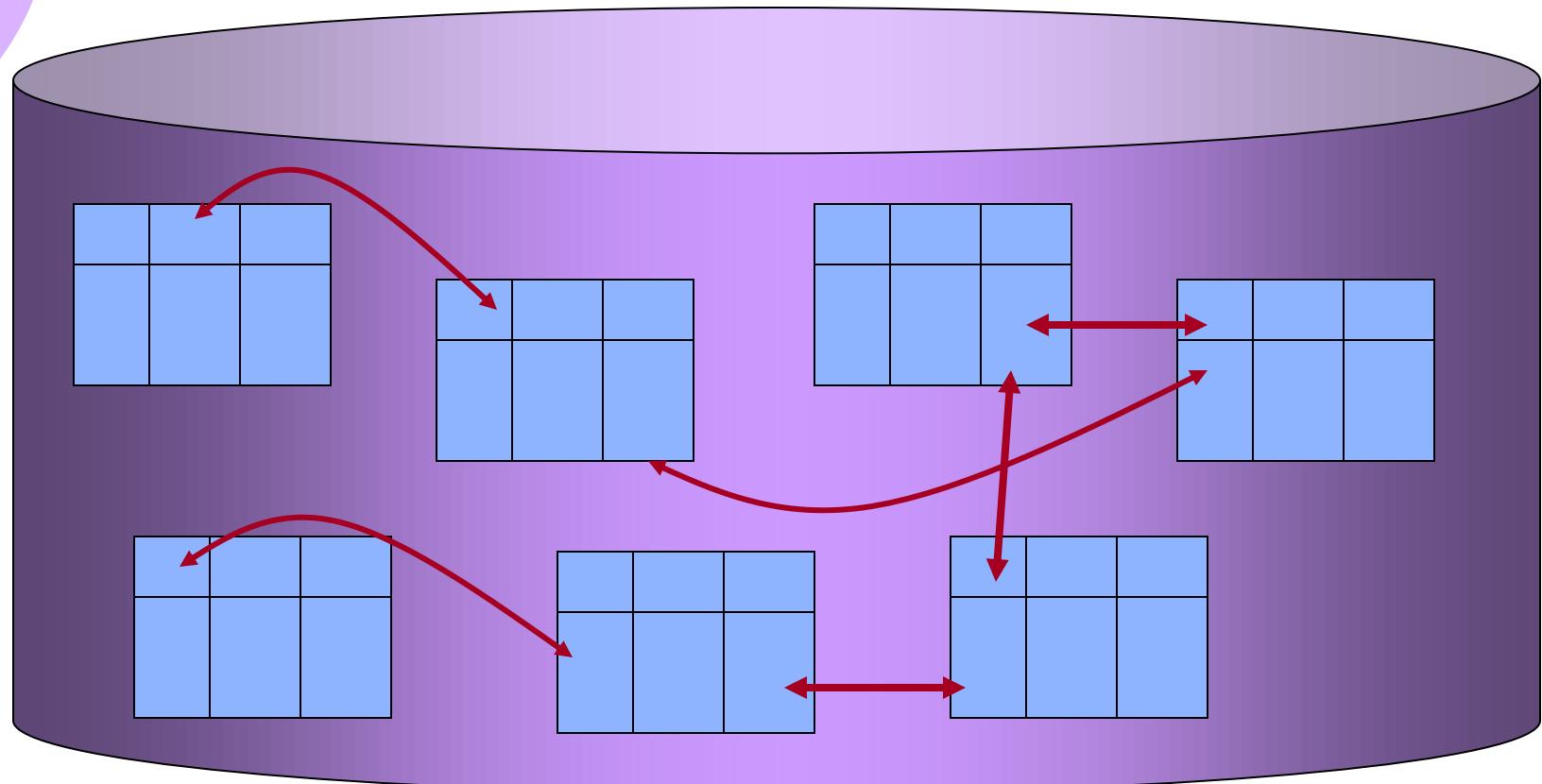
The Relational Data Model

Data Modeling



Relational Database

is a collection of tables



Tables

- Heading: table name and column names
- Body: rows, occurrences of data

Student Table

รหัส	นามสกุล	ภาควิชา	ชั้นปี	เกรดเฉลี่ย
StdSSN	StdLastName	StdMajor	StdClass	StdGPA
123-45-6789	WELLS	IS	FR	3.00
124-56-7890	NORBERT	FIN	JR	2.70
234-56-7890	KENDALL	ACCT	JR	3.50

No duplicate data

E-R Model → Relational Model

E-R Model

- Entity type
- Entity Instance
- Relationship

- Attribute
- Primary key required

Relational Model

- Table
- Row
- Entity References by using keys
- Column
- Some tables may not have a primary key**
- **Foreign key***

Alternative Terminology

Table-oriented	Set-oriented	Record-oriented
Table	Relation	Record-type, File
Row	Tuple	Record
Column	Attribute	Field

Primary keys

- Entity integrity

- Each table has column(s) with unique values
- Ensures entities are traceable



StdSSN	StdLastName	StdMajor	StdClass	StdGPA
123-45-6789	WELLS	IS	FR	3.00
124-56-7890	NORBERT	FIN	JR	2.70
234-56-7890	KENDALL	ACCT	JR	3.50

unique

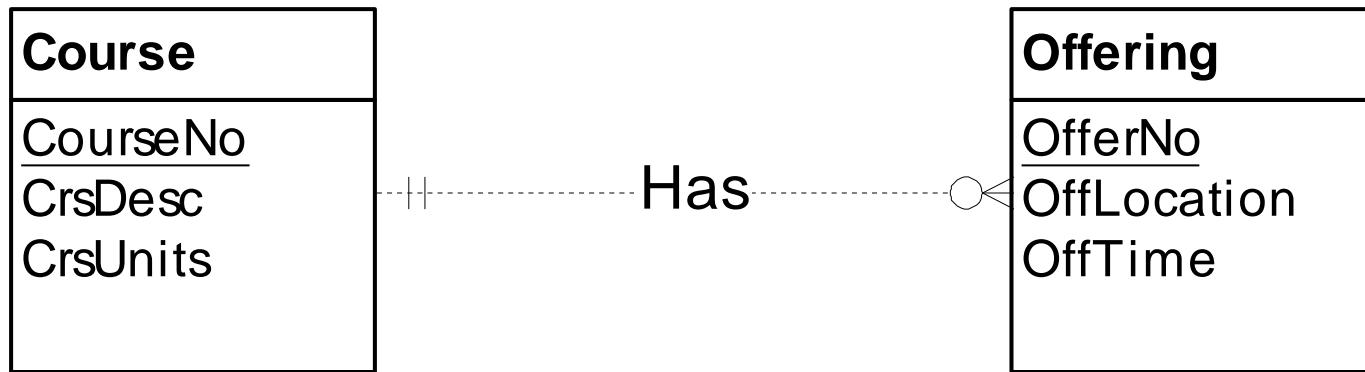
Types of Relationship

- one to one
- one to many, many to one

Do not support many to many

Relationships 1:N

Add PK of Course table in Offering table



CourseNo	CrsDesc	CrsUnits
204351	Database	3
204111	Programming	3

OfferNo	OffLocation	OffTime	CourseNo
111	CPE 203	1/2014	204351
222	CPE 204	2/2014	204351
333	CPE 204	2/2014	204111

Different OfferNo, the same CourseNo

Foreign Keys (FK)

foreign key

- Referential integrity
 - Values of FK must match values from a source table
 - Ensures valid references among tables

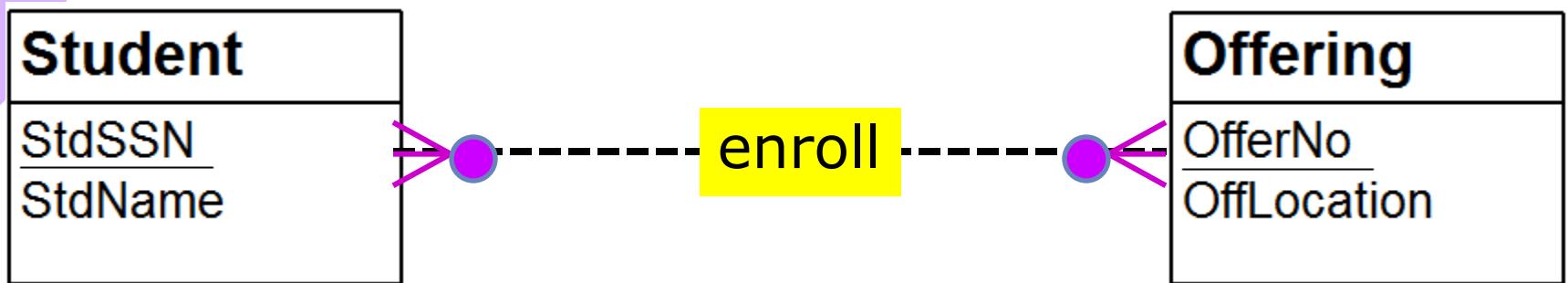
Course

CourseNo	CrsDesc	CrsUnits
204351	Database	3
204111	Programming	3

Offering

OfferNo	OffLocation	OffTime	CourseNo
111	CPE 203	1/2014	204351
222	CPE 204	2/2014	204351
333	CPE 204	2/2014	204111

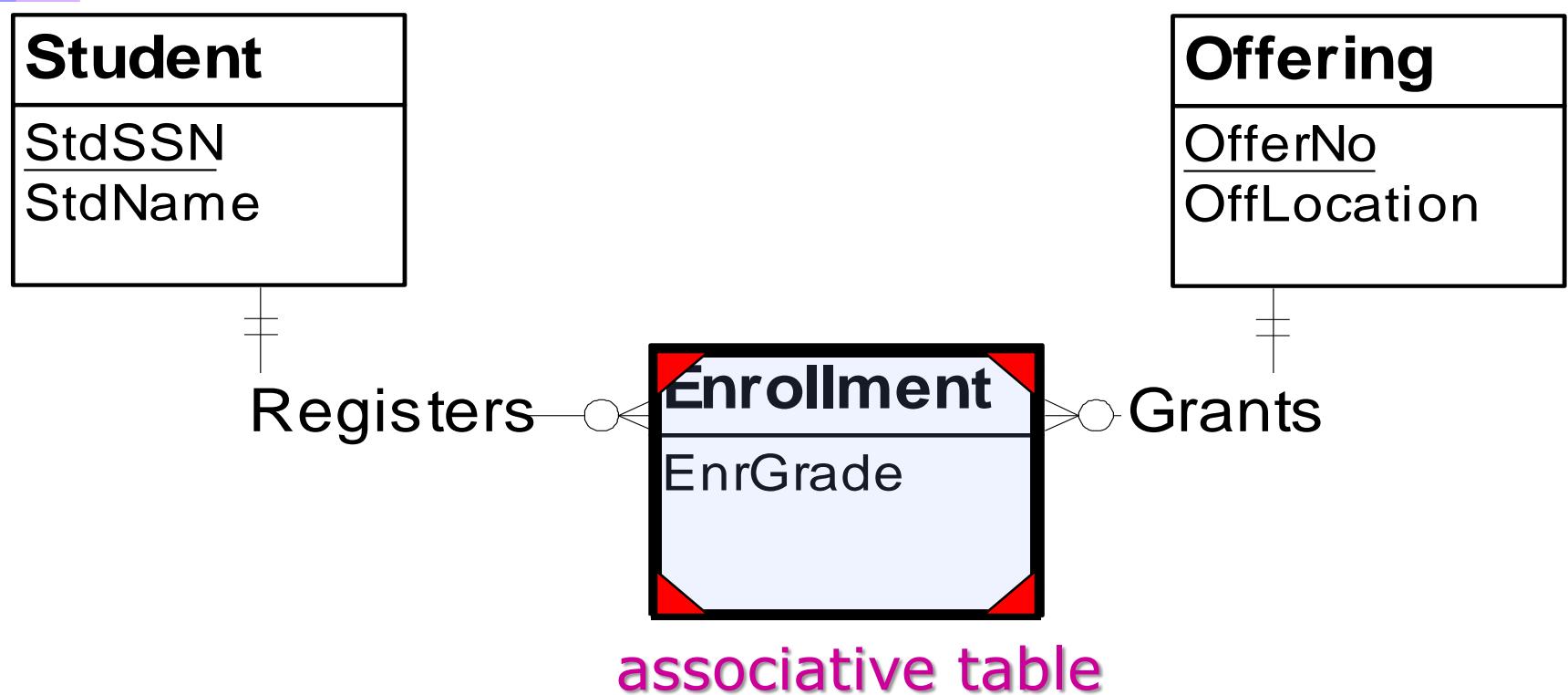
Many to Many Relationship



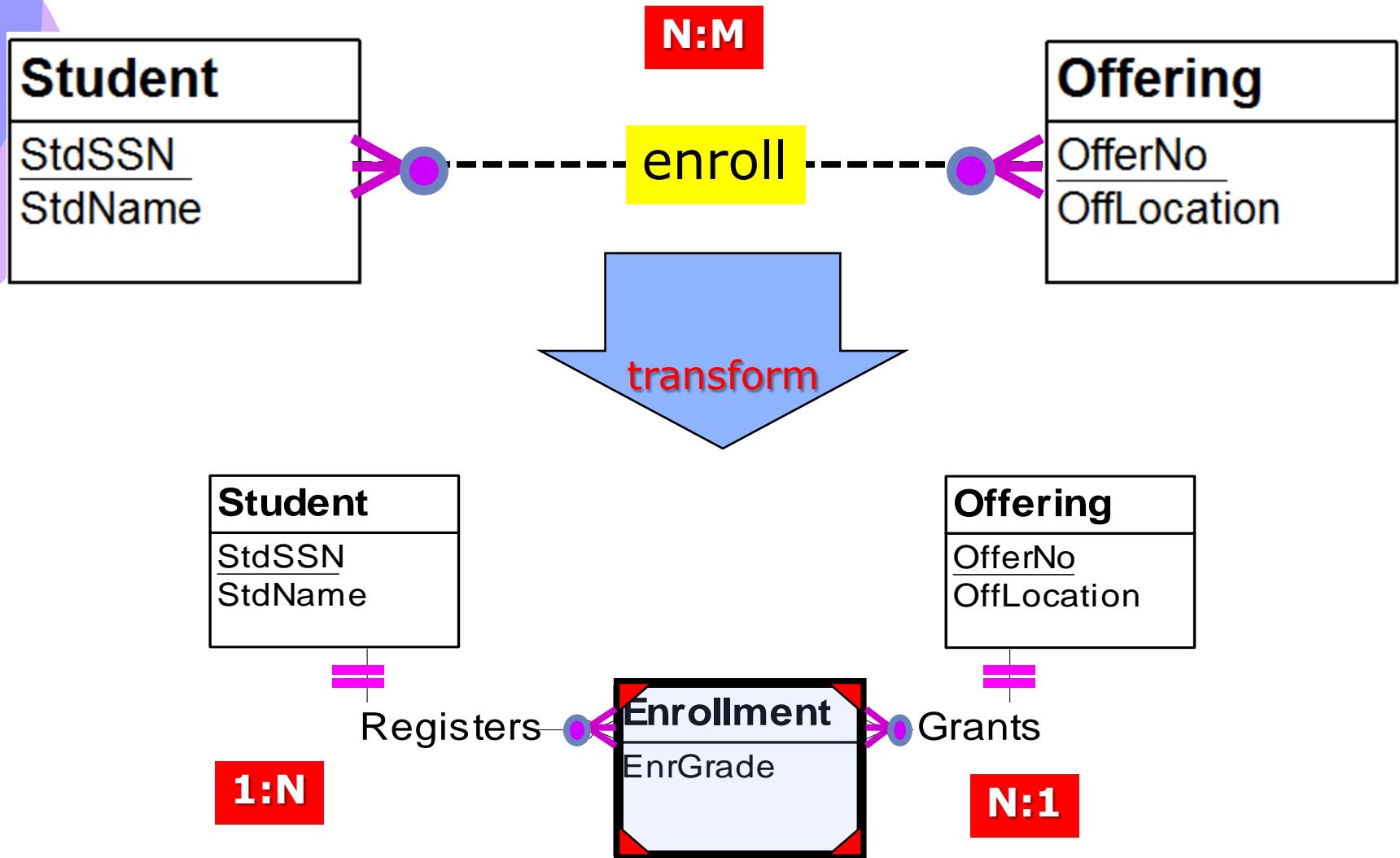
M-N Relationships

- Rows of each table are related to multiple rows of the other table
- Not directly represented in the relational model
- Use two 1-M relationships and an associative table

Relationships N:M



Many to Many Relationship



Many to Many Relationship

นักเรียน

Student

StdSSN	StdLastName
123-45-6789	WELLS
124-56-7890	KENDALL
234-56-7890	NORBERT

การเปิดสอน

Offering

OfferNo	CourseNo
1234	IS320
4321	IS320

การลงทะเบียนเรียน

Enrollment

StdSSN	OfferNo
123-45-6789	1234
234-56-7890	1234
123-45-6789	4321
124-56-7890	4321

Formal Definitions I

- **Superkey:** column(s) with unique values
- **Candidate key:** minimal superkey

BC?

A	B	C	D
1	41	500	m
1	42	600	n
2	42	600	o
3	43	750	p

AB, AC, D

Formal Definitions I

- **Primary key:** a designated candidate key; cannot contain null values
- **Foreign key:** column(s) whose values must match the values in a candidate key of another table
- **NULL value:** special value meaning value unknown or inapplicable

Formal Definitions II

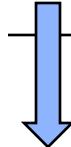
- **Entity integrity**

- No two rows with the same primary key value
- No null values in a primary key

- **Referential integrity**

- Foreign keys must match candidate key of source table
- Foreign keys in some cases can be null

Enrollment Table Example



PRIMARY KEY

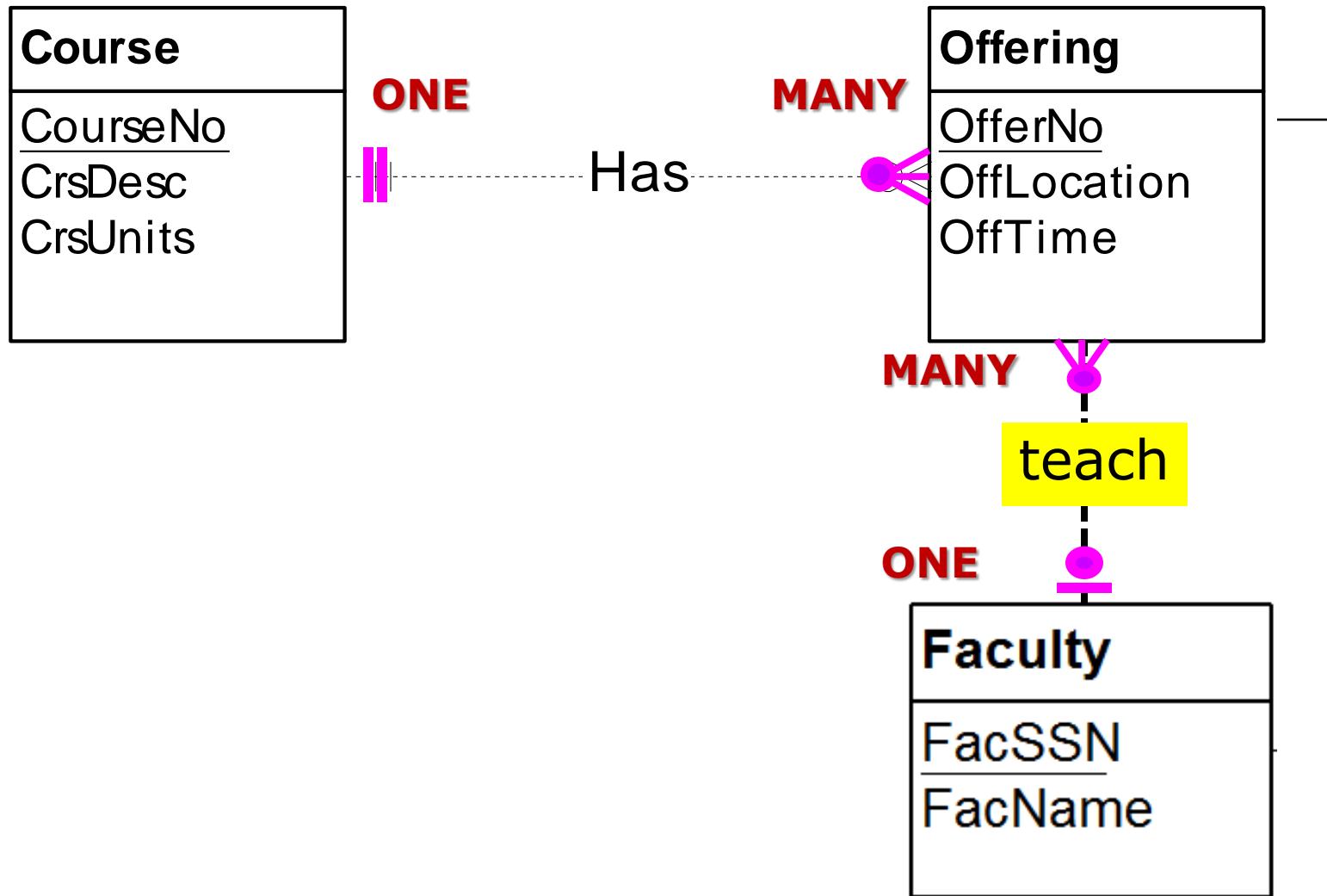
OfferNo	StdSSN	EnrGrade
<i>foreign key</i>	<i>foreign key</i>	
INTEGER	CHAR(11)	DECIMAL(3,2)

Student

OfferNo		
PRIMARY KEY		

Offering

StdSSN		
PRIMARY KEY		



Offering Table Example

OfferNo PRIMARY KEY	CourseNo <i>foreign key1</i>	FacSSN <i>foreign key2</i>

Course

CourseNo		
PRIMARY KEY		

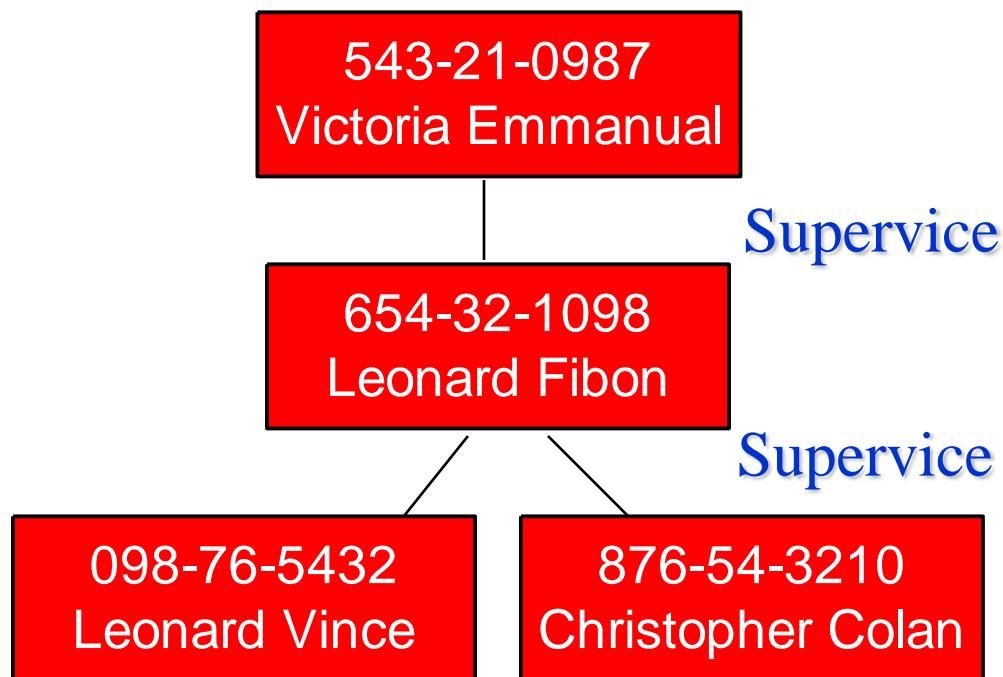
Faculty

FacSSN		
PRIMARY KEY		

Self-Referencing Relationships

- Foreign key that references the same table
- Represents relationships among members of the **same set**
- Not common but important when occurring

Hierarchical Data Display

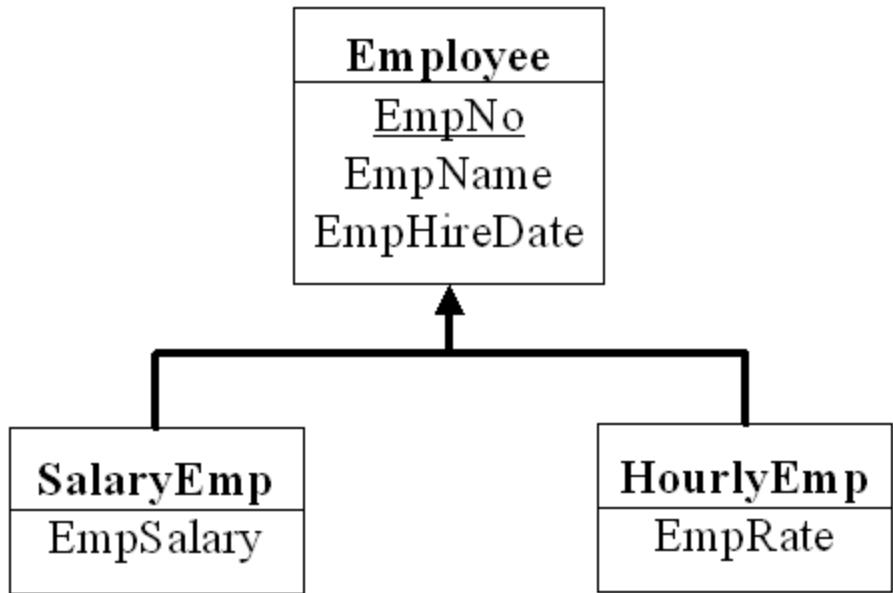


Faculty Data

FK refers to the same table

FacSSN	FacFirstName	FacLastName	FacRank	FacSalary	FacSupervisor
098-76-5432	LEONARD	VINCE	ASST	\$35,000	654-32-1098
543-21-0987	VICTORIA	EMMANUEL	PROF	\$120,000	
654-32-1098	LEONARD	FIBON	ASSC	\$70,000	543-21-0987
765-43-2109	NICKI	MACON	PROF	\$65,000	
876-54-3210	CRISTOPHER	COLAN	ASST	\$40,000	654-32-1098
987-65-4321	JULIA	MILLS	ASSC	\$75,000	765-43-2109

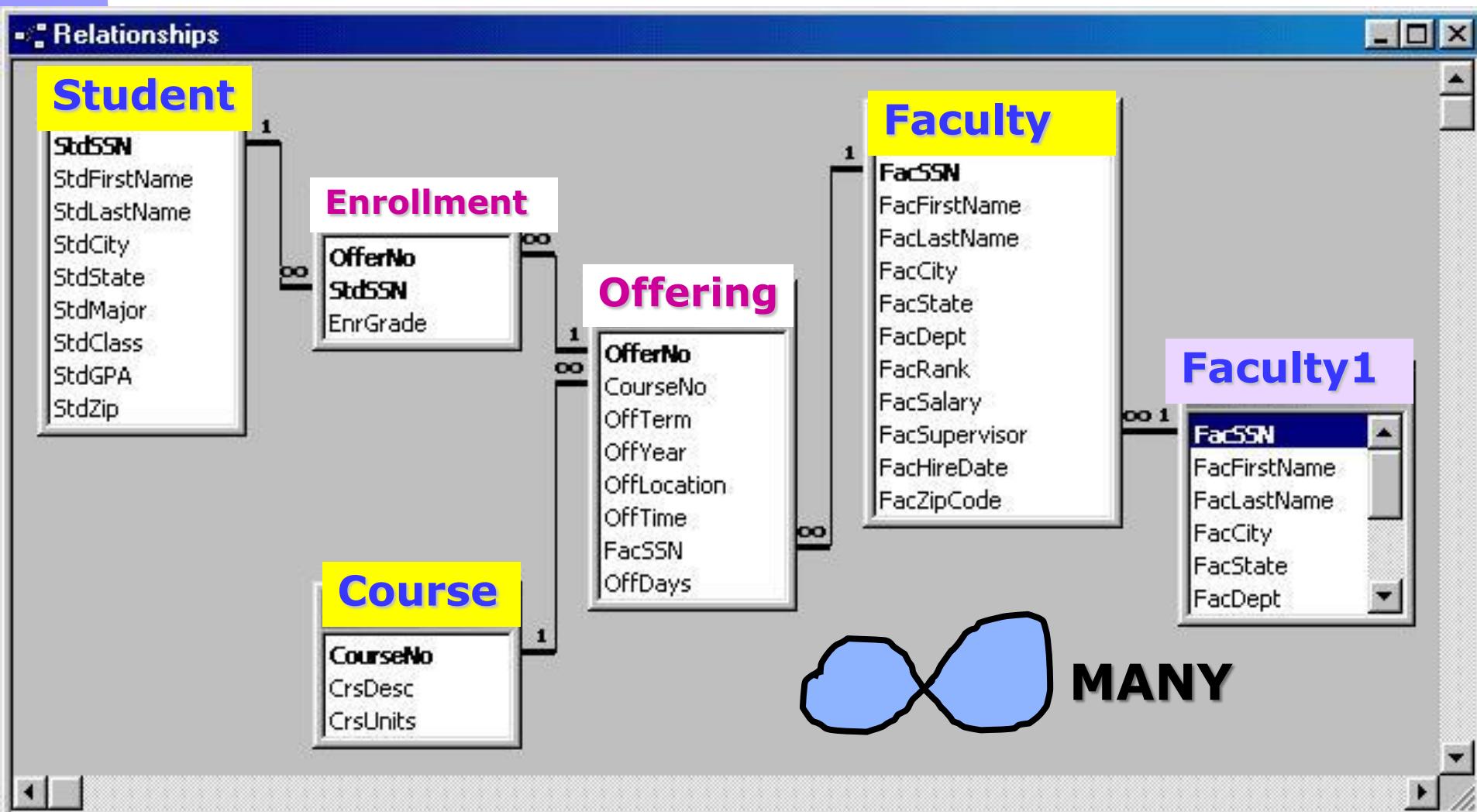
Generalization Hierarchy Example



CASCADE DELETE for Foreign Keys

Table	Attribute	PK	FK
Employee	EmpNo, EmpName, EmpHireDate	Emp No	-
SalaryEmp	EmpNo, EmpSalary	Emp No	Emp No
Hourly Emp	EmpNo, EmpRate	Emp No	Emp No

Relationship Window with 1-M Relationships



Referenced Rows

- Referenced row
 - **Foreign keys** reference rows in the associated *primary key table*
 - Enrollment rows refer to Student and Offering
- **Actions** on referenced rows
 - Delete a referenced row
 - Change the primary key of a referenced row
 - **Referential integrity** should not be violated

Offering Table

2. What will happen with OfferNo 1?

PRIMARY KEY

OfferNo	CourseNo	FacSSN
1	204351	

1. If 204351 is deleted

Course

**PRIMARY
KEY**

CourseNo	CourseName	CourseUnit
204351	Database Systems	3

Possible Actions on referenced rows

- **Restrict:** do not permit action on the referenced row Ex. Course
- **Cascade:** perform action on related rows e.g., deletion or Ex. Offering
 - **Nullify:** set foreign key of related row to NULL
 - only valid if foreign keys accept null values
 - **Default:** set foreign keys to a default value

Data Retrieval

Relational Database

Relational Algebra Overview

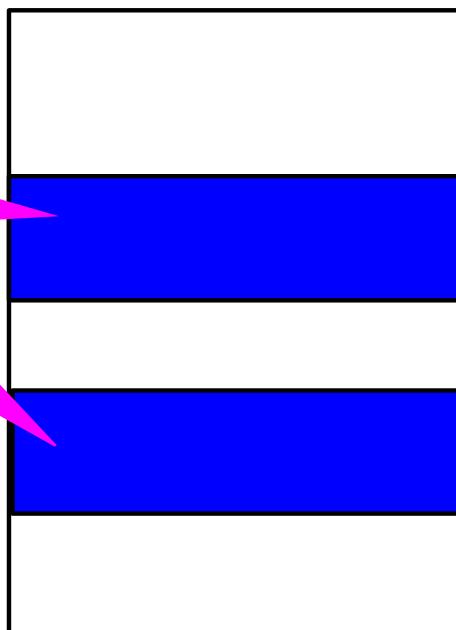
- Table operators
- Transform one or two tables into a new table
- Understand operators in isolation
 - Input, calculation, output
- Classification
 - Table specific operators
 - Traditional set operators (\cup , \cap , $-$)
 - Advanced operators

1. Subset Operators

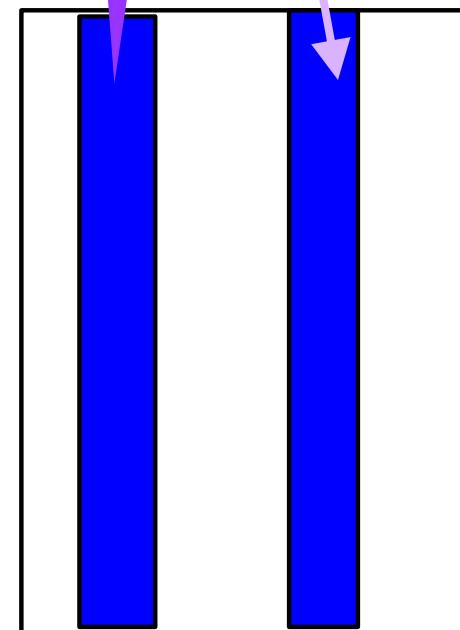
Select
columns

Restrict

Select
rows



Project

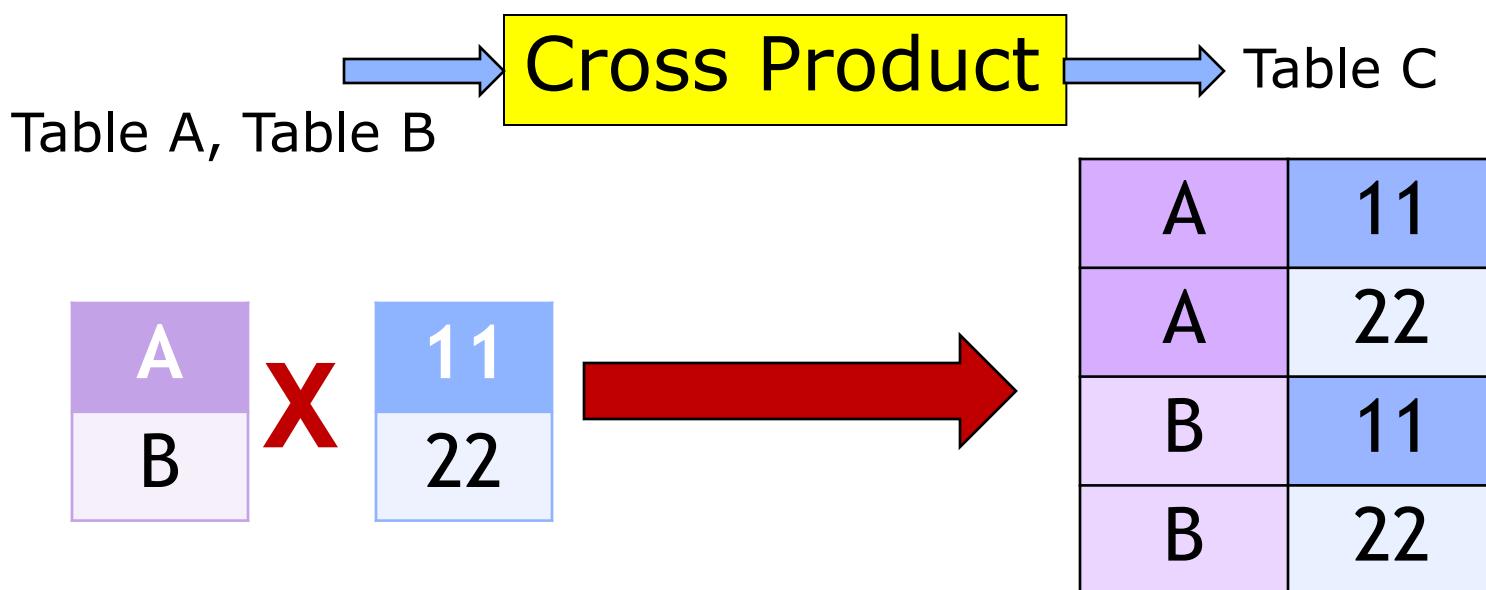


Subset Operator Notes

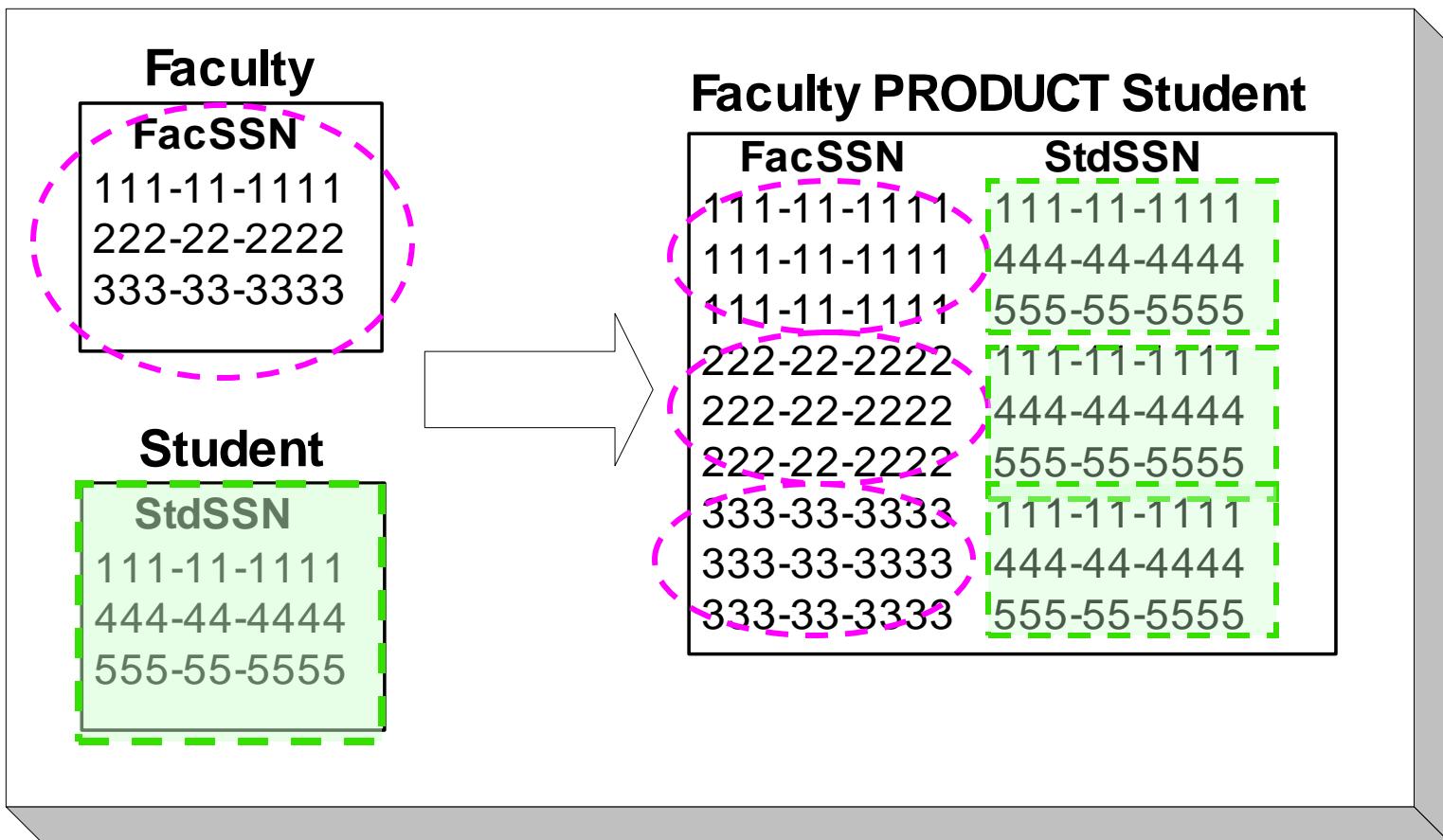
- **Restrict (Select Data)**
 - Logical expression as input
 - Example: OffDays = 'MW' AND OffTerm = 'SPRING' AND OffYear = 2003
- **Project**
 - List of **columns** is input
 - Duplicate rows eliminated if present
- Often used together

2. Extended Cross Product

- Builds a table consisting of all combinations of rows from each of the two input tables



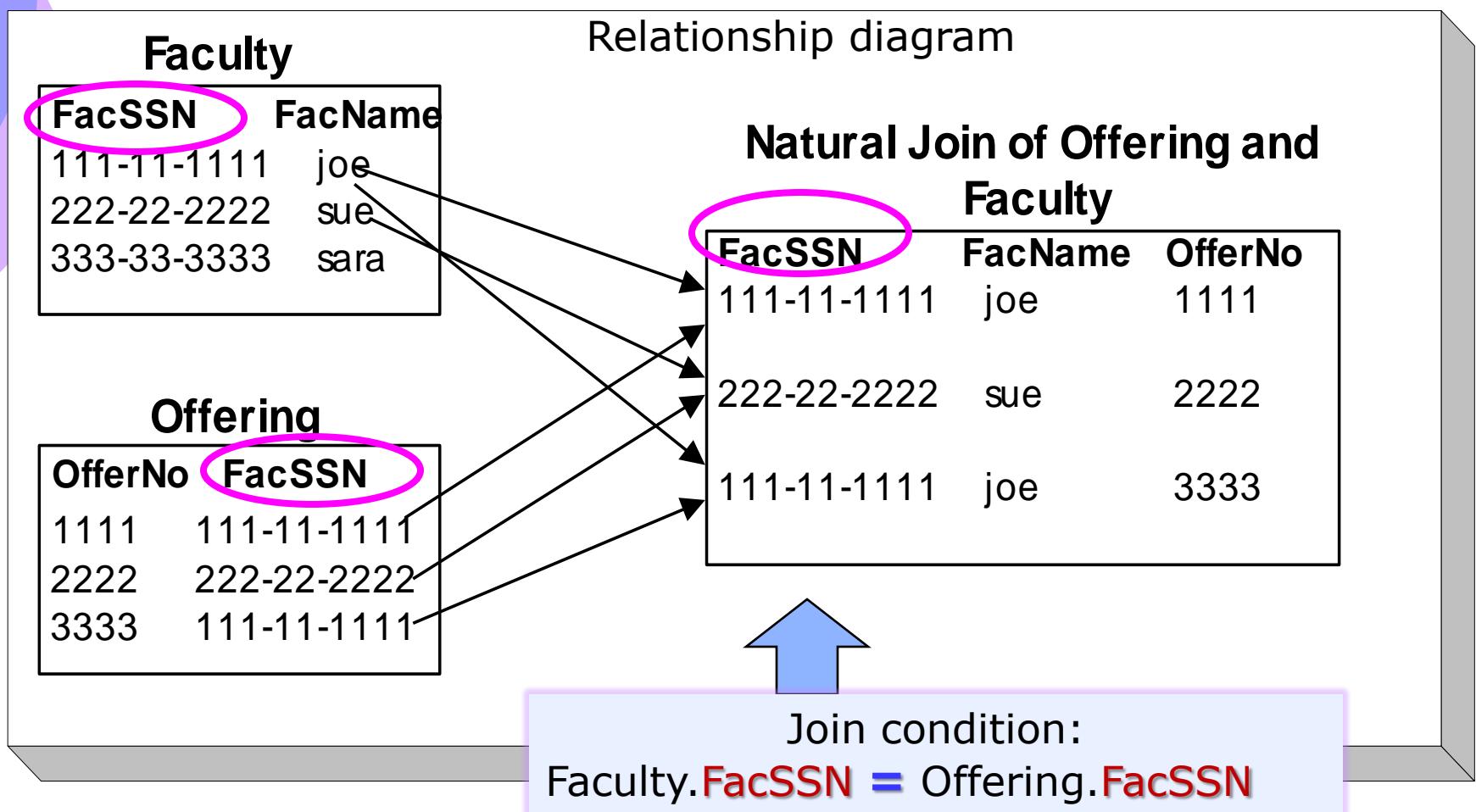
Extended Cross Product Example



3. Join Operator

- Most databases have many tables
- Combine tables using the join operator
- Specify matching condition
 - Can be any comparison but **usually =**
 - **PK = FK** most common join condition

Natural Join Example

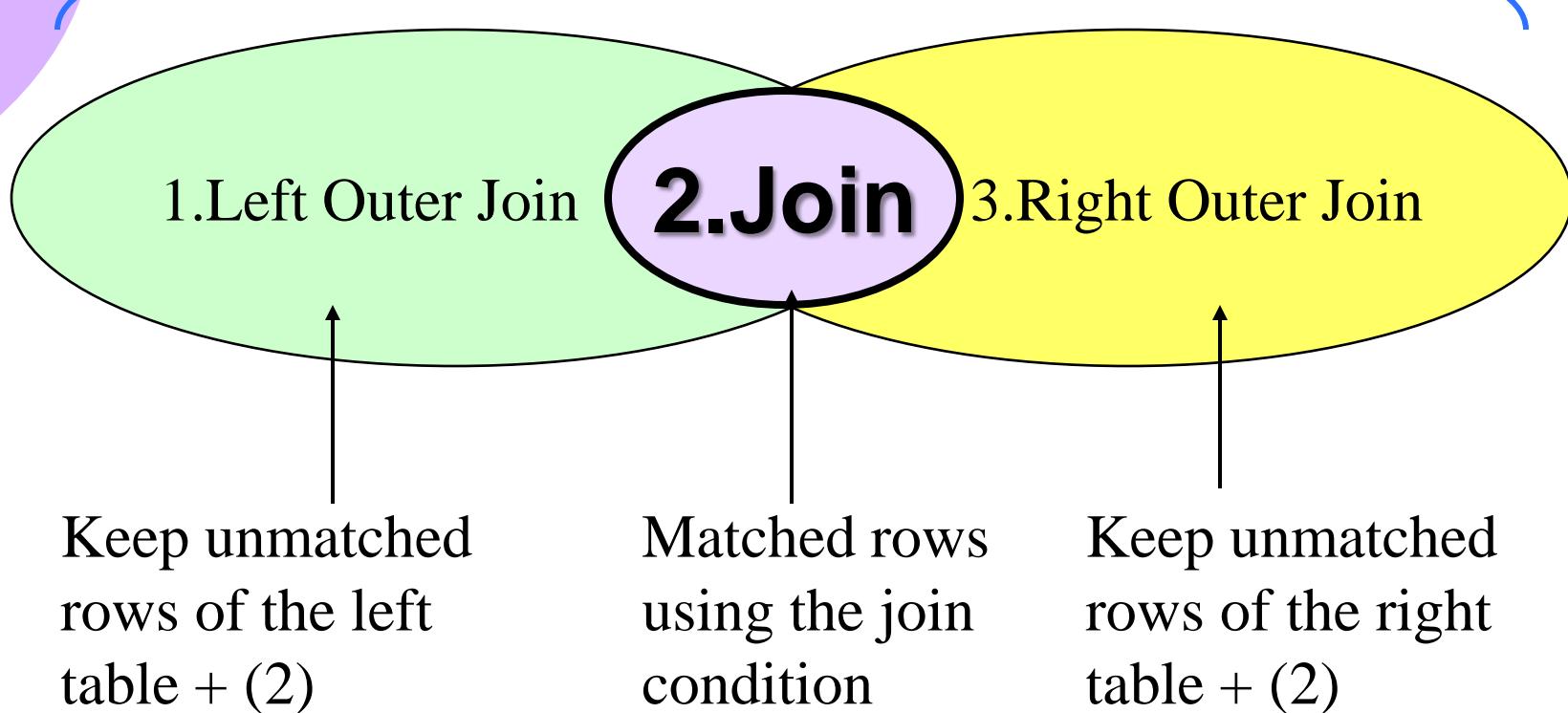


4. Outer Join Overview

- Join excludes non matching rows
- Preserving non matching rows is important in some problems
- Outer join variations
 - Full outer join
 - One-sided outer join
 - Left
 - right

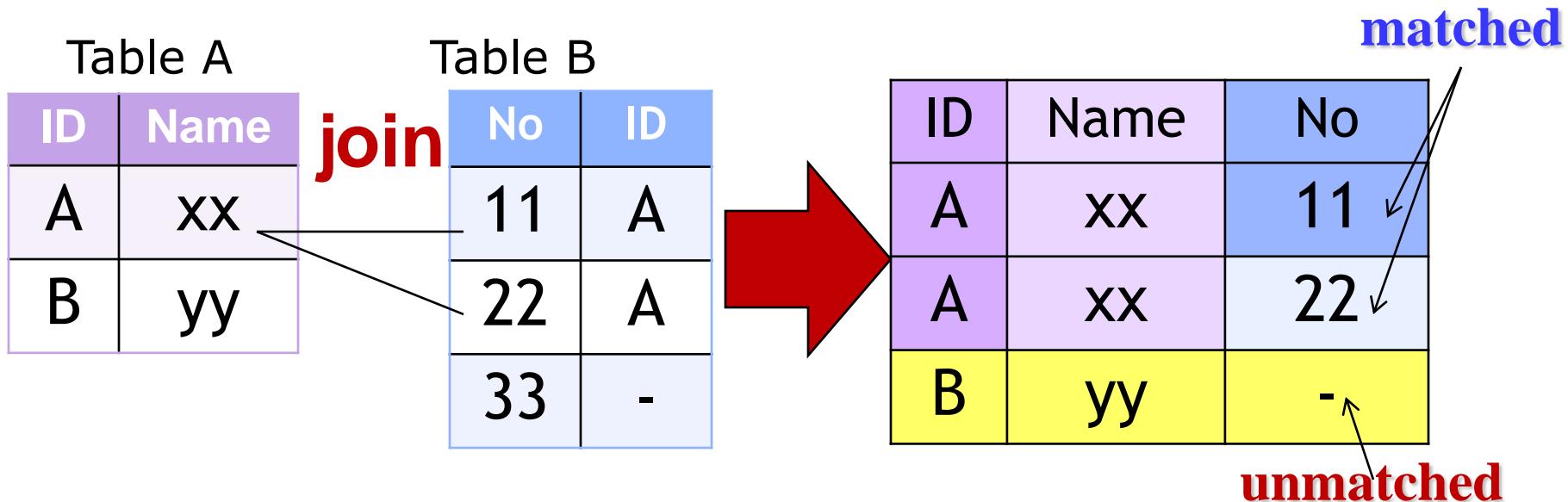
4 of Outer Join Operators

4. Full outer join

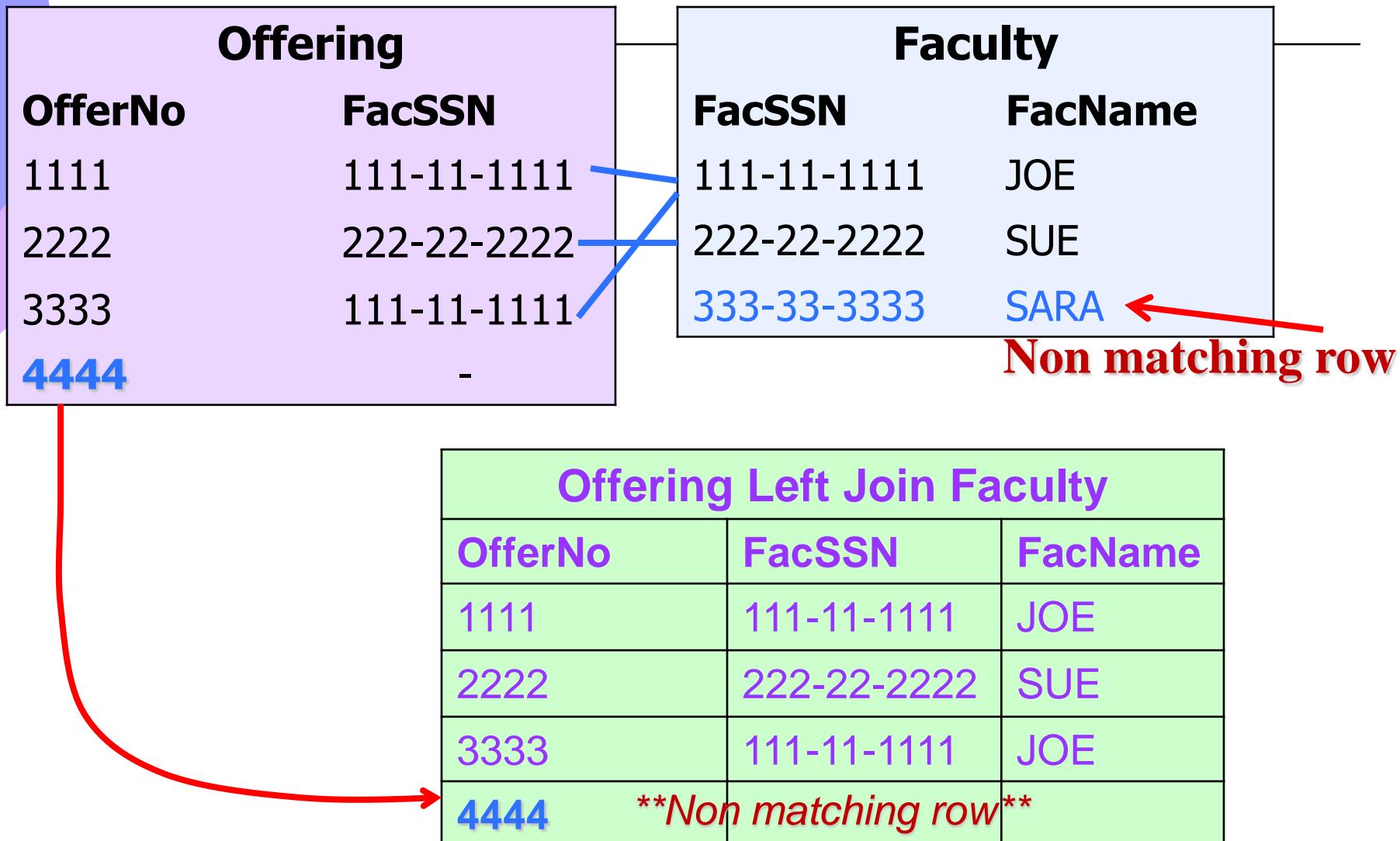


Left outer join

- Builds a table consisting of all matched rows of the two input tables
- Keep unmatched rows of the left table too



Left Outer Join



Full Outer Join Example

Faculty

FacSSN	FacName
111-11-1111	joe
222-22-2222	sue
333-33-3333	sara

Offering

OfferNo	FacSSN
1111	111-11-1111
2222	222-22-2222
3333	111-11-1111
4444	

Outer Join of Offering and Faculty

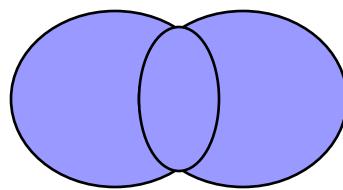
FacSSN	FacName	OfferNo
111-11-1111	joe	1111
222-22-2222	sue	2222
111-11-1111	joe	3333
333-33-3333	sara	

matched

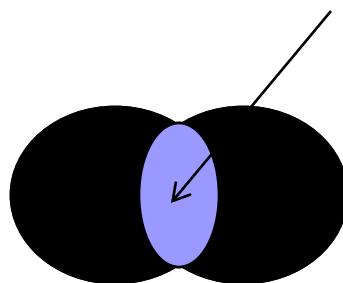
Unmatched L

Unmatched R

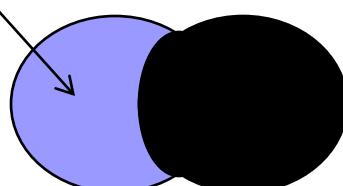
Traditional Set Operators



A **UNION** B



A **INTERSECT** B



A **MINUS** B

A B

Union Compatibility

- Requirement for the traditional set operators
- **Strong requirement**
 - Same number of columns
 - Each corresponding column is compatible
 - Positional correspondence
- Apply to similar tables by removing columns first

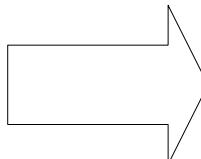
Summarize Operator

- Decision-making operator
- Compress groups of rows into calculated values
- Simple statistical (aggregate) functions
- Not part of original relational algebra

Summarize Example

Enrollment

StdSSN	OfferNo	EnrGrade
111-11-1111	1111	3.8
111-11-1111	2222	3.0
111-11-1111	3333	3.4
222-22-2222	1111	3.5
222-22-2222	3333	3.1
333-33-3333	1111	3.0



**SUMMARIZE Enrollment
ADD AVG(EnrGrade)
GROUP BY StdSSN**

StdSSN	AVG(EnrGrade)
111-11-1111	3.4
222-22-2222	3.3
333-33-3333	3.0

Divide Operator

- Match on a subset of values
 - Suppliers who supply all parts
 - Faculty who teach every IS course
- Specialized operator
- Typically applied to associative tables representing M-N relationships

Division Example

SuppPart	
SuppNo	PartNo
s3	p1
s3	p2
s3	p3
s0	p1
s1	p2

Part	
PartNo	
p1	
p2	

SuppPart DIVIDEBY Part

SuppNo
s3

s3 {p1, p2, p3}
contains {p1, p2}

ตัวอย่างเช่น ลูกค้าคนใดซื้อ nm และขนมปังด้วยในใบเสร็จเดียวกัน

Relational Algebra Summary

Operator	Meaning
Restrict (Select)	Extracts rows that satisfy a specified condition
Project	Extracts specified columns.
Product	Builds a table from two tables consisting of all possible combinations of rows, one from each of the two tables.
Union	Builds a table consisting of all rows appearing in either of two tables
Intersect	Builds a table consisting of all rows appearing in both of two specified tables
Difference	Builds a table consisting of all rows appearing in the first table but not in the second table
Join	Extracts rows from a product of two tables such that two input rows contributing to any output row satisfy some specified condition.
Outer Join	Extracts the matching rows (the join part) of two tables and the “unmatched” rows from both tables.
Divide	Builds a table consisting of all values of one column of a binary (2 column) table that match (in the other column) all values in a unary (1 column) table.
Summarize	Organizes a table on specified grouping columns. Specified aggregate computations are made on each value of the grouping columns.

Summary

- Relational model is commercially dominant
- Learn relations, primary keys and foreign keys,
- Learn to represent data relationships
- Understand concept of data operations