

Chapter 9

Advanced Query Formulation

with SQL

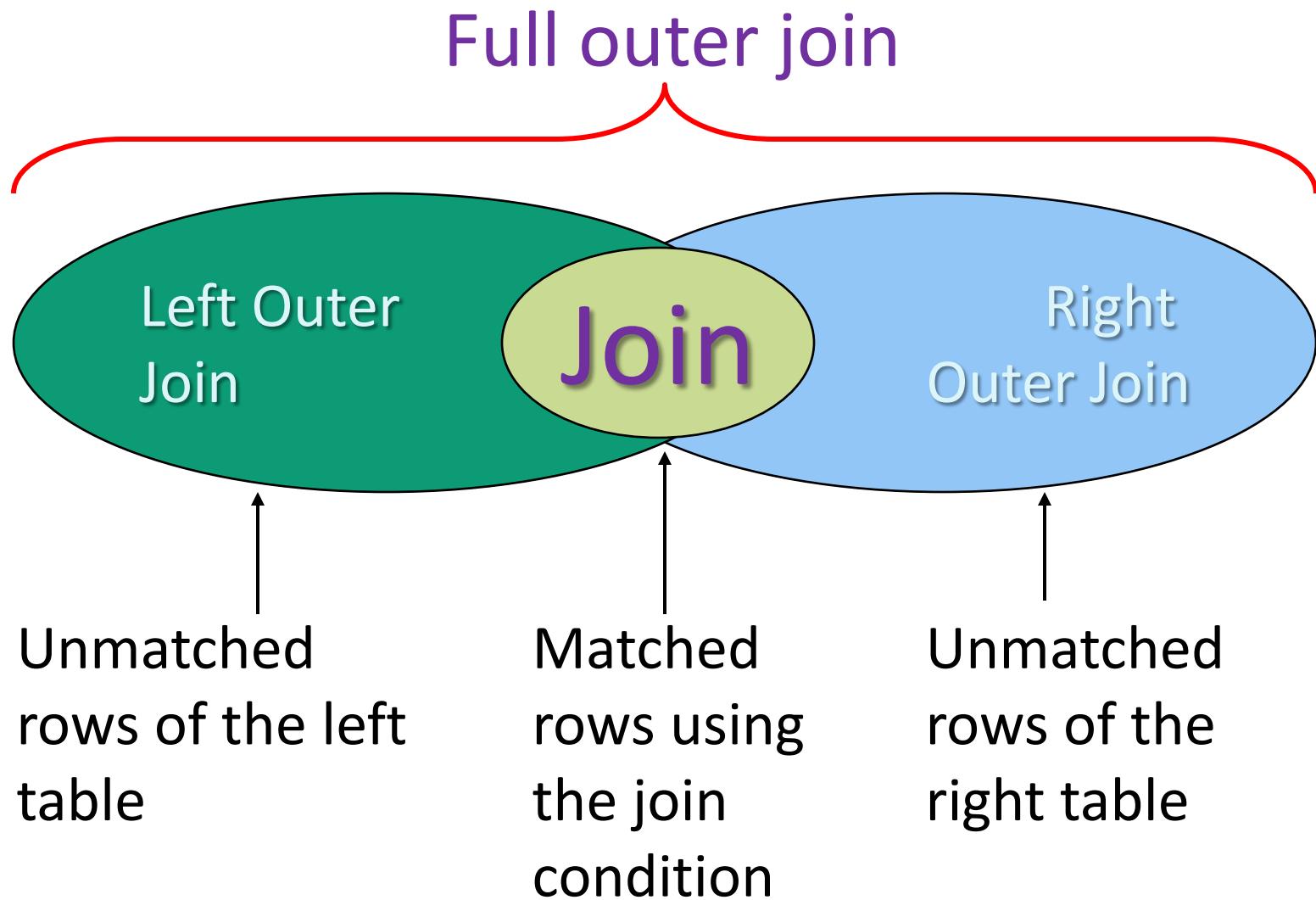
Outline

- Outer join problems
- Type I nested queries
- Type II nested queries and difference problems
- Nested queries in the FROM clause
- Division problems
- Null value effects

Outer Join Overview

- Join excludes non matching rows
- Preserving non matching rows is important in some business situations
- Outer join variations
 - ◆ Full outer join
 - ◆ One-sided outer join (left,right)

Outer Join Operators



Full Outer Join Example

Faculty

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

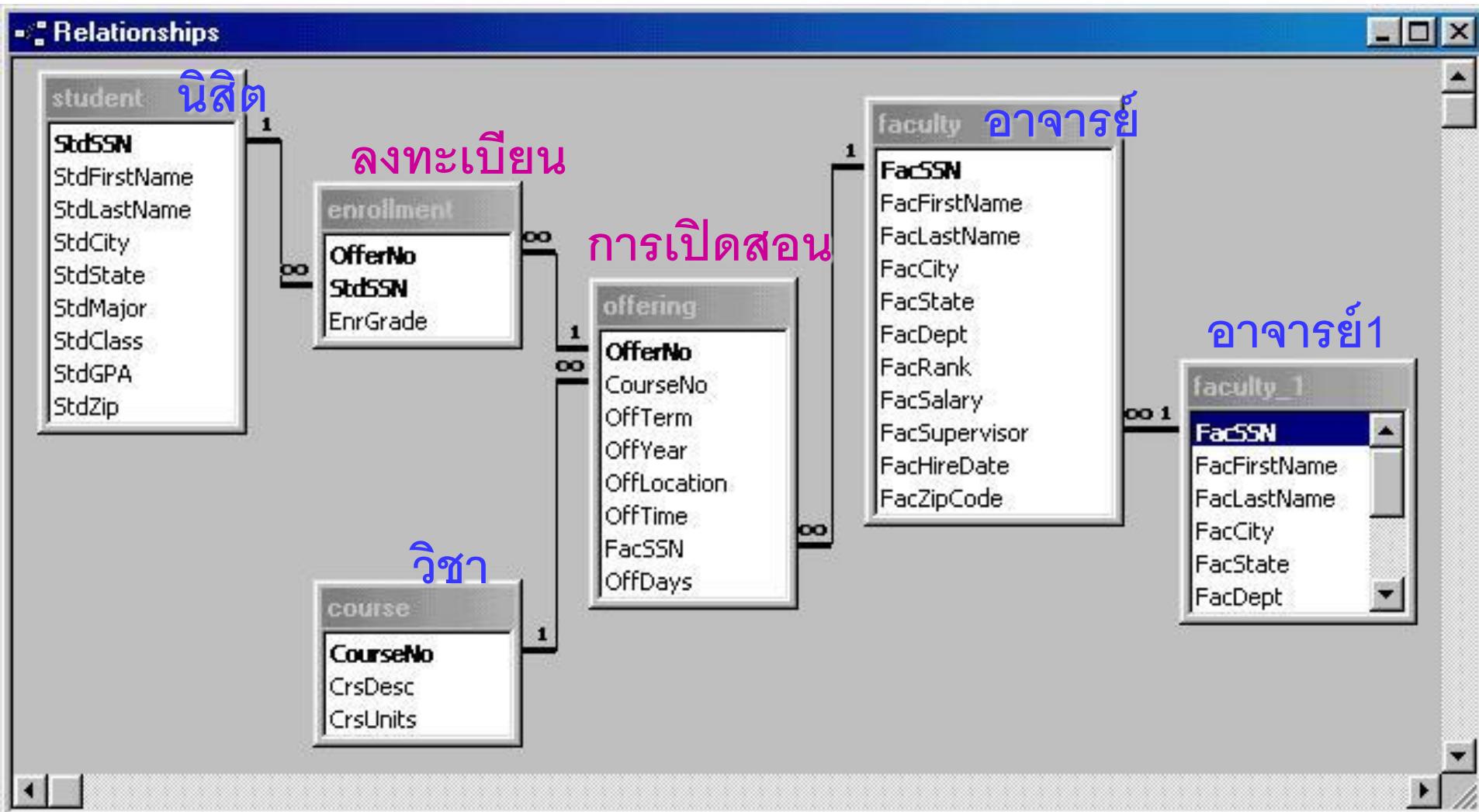
Offering

| 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 | |

UNIVERSITY DATABASE



Faculty

| FacSSN | Fac FirstName | Fac LastName | Fac HireDate | Fac Salary | Fac Supervisor | Fac Dept |
|-------------|---------------|--------------|--------------|------------|----------------|----------|
| 098-76-5432 | LEONARD | VINCE | 1995-04-10 | 35000 | 654-32-1098 | MS |
| 543-21-0987 | VICTORIA | EMMANUEL | 1996-04-15 | 120000 | | MS |
| 654-32-1098 | LEONARD | FIBON | 1994-05-01 | 70000 | 543-21-0987 | MS |
| 765-43-2109 | NICKI | MACON | 1997-04-11 | 65000 | | FIN |
| 876-54-3210 | CRISTOPHER | COLAN | 1999-03-01 | 40000 | 654-32-1098 | MS |
| 987-65-4321 | JULIA | MILLS | 2000-03-15 | 75000 | 765-43-2109 | FIN |

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Offering

| OfferNo | CourseNo | OffTerm | OffYear | OffLocation | OffTime | FacSSN | OffDays |
|---------|----------|---------|---------|-------------|----------|-------------|---------|
| 1111 | IS320 | SUMMER | 2006 | BLM302 | 10:30:00 | 098-76-5432 | MW |
| 1234 | IS320 | FALL | 2005 | BLM302 | 10:30:00 | 098-76-5432 | MW |
| 2222 | IS460 | SUMMER | 2005 | BLM412 | 13:30:00 | | TTH |
| 3333 | IS320 | SPRING | 2006 | BLM214 | 08:30:00 | 098-76-5432 | MW |
| 4321 | IS320 | FALL | 2005 | BLM214 | 15:30:00 | 098-76-5432 | TTH |
| 4444 | IS320 | WINTER | 2006 | BLM302 | 15:30:00 | 543-21-0987 | TTH |
| 5555 | FIN300 | WINTER | 2006 | BLM207 | 08:30:00 | 765-43-2109 | MW |
| 5678 | IS480 | WINTER | 2006 | BLM302 | 10:30:00 | 987-65-4321 | MW |
| 5679 | IS480 | SPRING | 2006 | BLM412 | 15:30:00 | 876-54-3210 | TTH |
| 6666 | FIN450 | WINTER | 2006 | BLM212 | 10:30:00 | 987-65-4321 | TTH |
| 7777 | FIN480 | SPRING | 2006 | BLM305 | 13:30:00 | 765-43-2109 | MW |
| 8888 | IS320 | SUMMER | 2006 | BLM405 | 13:30:00 | 654-32-1098 | MW |
| 9876 | IS460 | SPRING | 2006 | BLM307 | 13:30:00 | 654-32-1098 | TTH |

LEFT JOIN and RIGHT JOIN Keywords

Example 1 (Access)

```
SELECT OfferNo, CourseNo, Offering.FacSSN,  
        FacFirstName, FacLastName  
FROM Offering LEFT JOIN Faculty  
    ON Offering.FacSSN = Faculty.FacSSN  
WHERE CourseNo LIKE 'IS*' 
```

Example 2 (Oracle)

```
SELECT OfferNo, CourseNo, Offering.FacSSN,  
        FacFirstName, FacLastName  
FROM Faculty RIGHT JOIN Offering  
    ON Offering.FacSSN = Faculty.FacSSN  
WHERE CourseNo LIKE 'IS%' 
```

Left outer join results

| Offering Table | Join Condition | Faculty Table |
|---|---|---|
| OfferNo, CourseNo, Offering.FacSSN | Offering.FacSSN = Faculty.FacSSN ? | FacSSN , FacFirstName, FacLastName |
| Show matched data | Equal | Show matched data |
| Show non matched data | Not equal | -- |

การเปิดสอน Offering

Left outer join result?

| OfferNo | CourseNo | OffTerm | OffYear | OffLocation | OffTime | FacSSN | OffDays |
|---------|----------|---------|---------|-------------|----------|-------------|---------|
| 1111 | IS320 | SUMMER | 2006 | BLM302 | 10:30:00 | | MW |
| 1234 | IS320 | FALL | 2005 | BLM302 | 10:30:00 | 098-76-5432 | MW |
| 2222 | IS460 | SUMMER | 2005 | BLM412 | 13:30:00 | | TTH |
| 3333 | IS320 | SPRING | 2006 | BLM214 | 08:30:00 | 098-76-5432 | MW |
| 4321 | IS320 | FALL | 2005 | BLM214 | 15:30:00 | 098-76-5432 | TTH |
| 4444 | IS320 | WINTER | 2006 | BLM302 | 15:30:00 | 543-21-0987 | TTH |
| 5555 | FIN300 | WINTER | 2006 | BLM207 | 08:30:00 | 765-43-2109 | MW |
| 5678 | IS480 | WINTER | 2006 | BLM302 | 10:30:00 | 987-65-4321 | MW |
| 5679 | IS480 | SPRING | 2006 | BLM412 | 15:30:00 | 876-54-3210 | TTH |
| 6666 | FIN450 | WINTER | 2006 | BLM212 | 10:30:00 | 987-65-4321 | TTH |
| 7777 | FIN480 | SPRING | 2006 | BLM305 | 13:30:00 | 765-43-2109 | MW |
| 8888 | IS320 | SUMMER | 2006 | BLM405 | 13:30:00 | 654-32-1098 | MW |
| 9876 | IS460 | SPRING | 2006 | BLM307 | 13:30:00 | 654-32-1098 | TTH |

| Faculty | FacSSN | Fac FirstName | Fac LastName | Fac HireDate | Fac Salary | Fac Supervisor | Fac Dept |
|---------|-------------|---------------|--------------|--------------|------------|----------------|----------|
| | 098-76-5432 | LEONARD | VINCE | 1995-04-10 | 35000 | 654-32-1098 | MS |
| | 543-21-0987 | VICTORIA | EMMANUEL | 1996-04-15 | 120000 | | MS |
| | 654-32-1098 | LEONARD | FIBON | 1994-05-01 | 70000 | 543-21-0987 | MS |
| | 765-43-2109 | NICKI | MACON | 1997-04-11 | 65000 | | FIN |
| | 876-54-3210 | CRISTOPHER | COLAN | 1999-03-01 | 40000 | 654-32-1098 | MS |
| | 987-65-4321 | JULIA | MILLS | 2000-03-15 | 75000 | 765-43-2109 | FIN |

Left outer join results

| OfferNo | CourseNo | FacSSN | FacFirstName | FacLastName |
|---------|----------|-------------|--------------|-------------|
| 1111 | IS320 | | | |
| 1234 | IS320 | 098-76-5432 | LEONARD | VINCE |
| 2222 | IS460 | | | |
| 3333 | IS320 | 098-76-5432 | LEONARD | VINCE |
| 4321 | IS320 | 098-76-5432 | LEONARD | VINCE |
| 4444 | IS320 | 543-21-0987 | VICTORIA | EMMANUEL |
| 5678 | IS480 | 987-65-4321 | JULIA | MILLS |
| 5679 | IS480 | 876-54-3210 | CRISTOPHER | COLAN |
| 8888 | IS320 | 654-32-1098 | LEONARD | FIBON |
| 9876 | IS460 | 654-32-1098 | LEONARD | FIBON |

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Full Outer Join Example I

Example 3 (SQL:2003 and Oracle 9i/10g)

```
SELECT FacSSN, FacFirstName, FacLastName,  
       FacSalary, StdSSN, StdFirstName,  
       StdLastName, StdGPA  
FROM Faculty FULL JOIN Student  
ON Student.StdSSN = Faculty.FacSSN
```

MS Access does not support FULL JOIN

Full outer join

| Faculty Table | Join Condition | Student Table |
|--|-------------------|--|
| FacSSN , FacFirstName, FacLastName, FacSalary | FacSSN = StdSSN ? | StdSSN, StdFirstName, StdLastName, StdGPA |
| Show matched data | Equal | Show matched data |
| Show non matched data | Not equal | -- |
| -- | Not equal | Show non matched data |

Full outer join results

| FacSSN | FacFirstName | FacLastName | FacSalary | StdSSN | StdFirstName | StdLastName | StdGPA |
|-------------|--------------|-------------|-----------|-------------|--------------|-------------|--------|
| | | | | 123-45-6789 | HOMER | WELLS | 3 |
| | | | | 124-56-7890 | BOB | NORBERT | 2.7 |
| | | | | 234-56-7890 | CANDY | KENDALL | 3.5 |
| | | | | 345-67-8901 | WALLY | KENDALL | 2.8 |
| | | | | 456-78-9012 | JOE | ESTRADA | 3.2 |
| | | | | 567-89-0123 | MARIAH | DODGE | 3.6 |
| | | | | 678-90-1234 | TESS | DODGE | 3.3 |
| | | | | 789-01-2345 | ROBERTO | MORALES | 2.5 |
| | | | | 890-12-3456 | LUKE | BRAZZI | 2.2 |
| | | | | 901-23-4567 | WILLIAM | PILGRIM | 3.8 |
| 098-76-5432 | LEONARD | VINCE | 35000 | | | | |
| 543-21-0987 | VICTORIA | EMMANUEL | 120000 | | | | |
| 654-32-1098 | LEONARD | FIBON | 70000 | | | | |
| 765-43-2109 | NICKI | MACON | 65000 | | | | |
| 876-54-3210 | CRISTOPHER | COLAN | 40000 | 876-54-3210 | CRISTOPHER | COLAN | 4 |
| 987-65-4321 | JULIA | MILLS | 75000 | | | | |

?

Full Outer Join Example II

Example 4 (Access)

```
SELECT FacSSN, FacFirstName, FacLastName,  
      FacSalary, StdSSN, StdFirstName,  
      StdLastName, StdGPA  
FROM Faculty RIGHT JOIN Student  
      ON Student.StdSSN = Faculty.FacSSN  
UNION
```

```
SELECT FacSSN, FacFirstName, FacLastName,  
      FacSalary, StdSSN, StdFirstName,  
      StdLastName, StdGPA  
FROM Faculty LEFT JOIN Student  
      ON Student.StdSSN = Faculty.FacSSN
```

Full outer join II

| Faculty Table | Join Condition | Student Table |
|--|--|---|
| FacSSN , FacFirstName, FacLastName, FacSalary | FacSSN = StdSSN ? UNION | StdSSN, StdFirstName, StdLastName, StdGPA |
| Show matched data | Equal (left&Right join) | Show matched data |
| Show non- matched data | Left join | -- |
| -- | Right join | Show non- matched data |

Mixing Inner and Outer Joins I

Example 5 (Access)

SELECT OfferNo, Offering.CourseNo, OffTerm,
CrsDesc, Faculty.FacSSN, Faculty.FacLastName

FROM (**Faculty RIGHT JOIN Offering**
ON Offering.FacSSN = Faculty.FacSSN)

INNER JOIN Course

ON Course.CourseNo = Offering.CourseNo

WHERE Course.CourseNo LIKE 'IS*' 

2 steps

1. รายวิชาที่เปิดพร้อม"ชื่ออาจารย์ผู้สอน(ละได)"

2. รายวิชาที่เปิดพร้อมชื่ออาจารย์ผู้สอน และ "รายละเอียดวิชา(ดองมี)"

Type I Nested Queries

- Query inside a query
- Use in WHERE and HAVING conditions
- Similar to a nested procedure
- Executes one time
- No reference to outer query
- Also known as non-correlated or independent nested query

Type I Nested Query Examples I

Example 6 (Access): List finance faculty who teach IS courses.

```
SELECT FacSSN, FacLastName, FacDept  
FROM Faculty  
WHERE FacDept = 'FIN' AND FacSSN IN
```

```
( SELECT FacSSN FROM Offering  
WHERE CourseNo LIKE 'IS*' )
```



Nested query executes one time

Type I Nested Query Examples I



Example 6 (Access): List finance faculty who teach IS courses.

```
SELECT FacSSN, FacLastName, FacDept  
FROM Faculty  
WHERE FacDept = 'FIN' AND
```

FacSSN **IN**

```
( SELECT FacSSN FROM Offering  
WHERE Course_N LIKE 'IS*'  )
```



Faculty

| | FacSSN | Fac FirstName | Fac LastName | Fac HireDate | Fac Salary | Fac Supervisor | Fac Dept |
|----|-------------|---------------|--------------|--------------|------------|----------------|----------|
| | 098-76-5432 | LEONARD | VINCE | 1995-04-10 | 35000 | 654-32-1098 | MS |
| | 543-21-0987 | VICTORIA | EMMANUEL | 1996-04-15 | 120000 | | MS |
| | 654-32-1098 | LEONARD | FIBON | 1994-05-01 | 70000 | 543-21-0987 | MS |
| Q1 | 765-43-2109 | NICKI | MACON | 1997-04-11 | 65000 | FIN | ✓ |
| | 876-54-3210 | CRISTOPHER | COLAN | 1999-03-01 | 40000 | 654-32-1098 | MS |
| Q1 | 987-65-4321 | JULIA | MILLS | 2000-03-15 | 75000 | 765-43-2109 | FIN |

การเปิดสอน Offering

IN

| | OfferNo | CourseNo | OffTerm | OffYear | OffLocation | OffTime | FacSSN | OffDays |
|----|---------|----------|---------|---------|-------------|----------|-------------|---------|
| Q2 | 1111 | IS320 | SUMMER | 2006 | BLM302 | 10:30:00 | 098-76-5432 | MW |
| | 1234 | IS320 | FALL | 2005 | BLM302 | 10:30:00 | | MW |
| | 2222 | IS460 | SUMMER | 2005 | BLM412 | 13:30:00 | | TTH |
| | 3333 | IS320 | SPRING | 2006 | BLM214 | 08:30:00 | | MW |
| | 4321 | IS320 | FALL | 2005 | BLM214 | 15:30:00 | | TTH |
| | 4444 | IS320 | WINTER | 2006 | BLM302 | 15:30:00 | | TTH |
| Q2 | 5555 | FIN300 | WINTER | 2006 | BLM207 | 08:30:00 | 765-43-2109 | MW |
| | 5678 | IS480 | WINTER | 2006 | BLM302 | 10:30:00 | 987-65-4321 | MW |
| | 5679 | IS480 | SPRING | 2006 | BLM412 | 15:30:00 | 876-54-3210 | TTH |
| | 6666 | FIN450 | WINTER | 2006 | BLM212 | 10:30:00 | 987-65-4321 | TTH |
| Q2 | 7777 | FIN480 | SPRING | 2006 | BLM305 | 13:30:00 | 765-43-2109 | MW |
| | 8888 | IS320 | SUMMER | 2006 | BLM405 | 13:30:00 | 654-32-1098 | MW |
| | 9876 | IS460 | SPRING | 2006 | BLM307 | 13:30:00 | 654-32-1098 | TTH |

Type I Nested Query Examples II

Example 7 (Oracle): List finance faculty who teach 4 unit IS courses.

```
SELECT FacSSN, FacLastName, FacDept  
FROM Faculty
```

```
WHERE FacDept = 'FIN' AND FacSSN IN
```

```
( SELECT FacSSN FROM Offering
```

```
    WHERE CourseNo LIKE 'IS%' AND CourseNo IN
```

```
( SELECT CourseNo FROM Course  
    WHERE CrsUnits = 4 )
```

```
)
```

```
SELECT CourseNo FROM Course  
WHERE CrsUnits = 4 )
```

| Course | | |
|---------------|---|----------|
| CourseNo | crsDesc | CrsUnits |
| <i>FIN300</i> | <i>FUNDAMENTALS OF FINANCE</i> | 4 |
| FIN450 | PRINCIPLES OF INVESTMENTS | 3 |
| <i>FIN480</i> | <i>CORPORATE FINANCE</i> | 4 |
| <i>IS320</i> | <i>FUNDAMENTALS OF BUSINESS PROGRAMMING</i> | 4 |
| IS460 | SYSTEMS ANALYSIS | 3 |
| IS470 | BUSINESS DATA COMMUNICATIONS | 3 |
| IS480 | FUNDAMENTALS OF DATABASE MANAGEMENT | 3 |

Type I Nested Query Examples II (Cont.)

Example 7 (Oracle): List finance faculty who teach 4 unit IS courses.

```
SELECT FacSSN, FacLastName, FacDept  
FROM Faculty  
WHERE FacDept = 'FIN' AND FacSSN IN  
  
( SELECT FacSSN FROM Offering  
    WHERE CourseNo LIKE 'IS%' AND CourseNo IN  
        [FIN300, FIN480,IS320]  
)
```

SELECT FacSSN FROM Offering

WHERE CourseNo LIKE 'IS%' AND CourseNo IN

[FIN300, FIN480, IS320]

| OfferNo | CourseNo | OffTerm | OffYear | OffLocation | OffTime | FacSSN | OffDays |
|---------|----------|---------|---------|-------------|----------|-------------|---------|
| 1111 | IS320✓ | SUMMER | 2006 | BLM302 | 10:30:00 | | MW |
| 1234 | IS320✓ | FALL | 2005 | BLM302 | 10:30:00 | 098-76-5432 | MW |
| 2222 | IS460 | SUMMER | 2005 | BLM412 | 13:30:00 | | TTH |
| 3333 | IS320✓ | SPRING | 2006 | BLM214 | 08:30:00 | 098-76-5432 | MW |
| 4321 | IS320✓ | FALL | 2005 | BLM214 | 15:30:00 | 098-76-5432 | TTH |
| 4444 | IS320✓ | WINTER | 2006 | BLM302 | 15:30:00 | 543-21-0987 | TTH |
| 5555 | FIN300 | WINTER | 2006 | BLM207 | 08:30:00 | 765-43-2109 | MW |
| 5678 | IS480 | WINTER | 2006 | BLM302 | 10:30:00 | 987-65-4321 | MW |
| 5679 | IS480 | SPRING | 2006 | BLM412 | 15:30:00 | 876-54-3210 | TTH |
| 6666 | FIN450 | WINTER | 2006 | BLM212 | 10:30:00 | 987-65-4321 | TTH |
| 7777 | FIN480 | SPRING | 2006 | BLM305 | 13:30:00 | 765-43-2109 | MW |
| 8888 | IS320✓ | SUMMER | 2006 | BLM405 | 13:30:00 | 654-32-1098 | MW |
| 9876 | IS460 | SPRING | 2006 | BLM307 | 13:30:00 | 654-32-1098 | TTH |

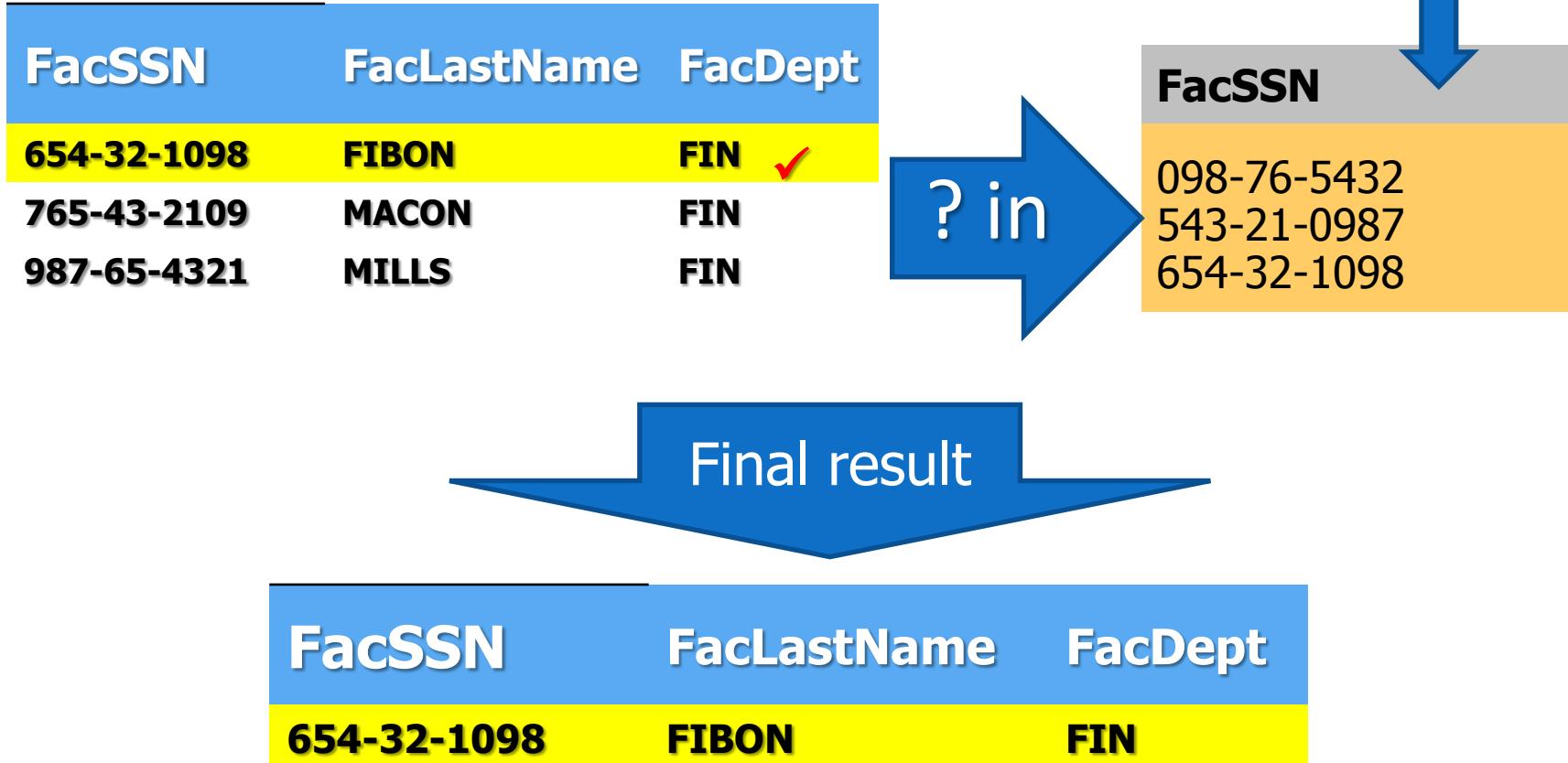
Type I Nested Query Examples II (Cont.)

```
SELECT FacSSN, FacLastName, FacDept  
FROM Faculty
```

```
WHERE FacDept = 'FIN' AND FacSSN IN
```

| OfferNo | CourseNo | OffTerm | OffYear | OffLocation | OffTime | FacSSN | OffDays |
|---------|----------|---------|---------|-------------|----------|-------------|---------|
| 1111 | IS320 | SUMMER | 2006 | BLM302 | 10:30:00 | 098-76-5432 | MW |
| 1234 | IS320 | FALL | 2005 | BLM302 | 10:30:00 | 098-76-5432 | MW |
| 3333 | IS320 | SPRING | 2006 | BLM214 | 08:30:00 | 098-76-5432 | MW |
| 4321 | IS320 | FALL | 2005 | BLM214 | 15:30:00 | 098-76-5432 | TTH |
| 4444 | IS320 | WINTER | 2006 | BLM302 | 15:30:00 | 543-21-0987 | TTH |
| 8888 | IS320 | SUMMER | 2006 | BLM405 | 13:30:00 | 654-32-1098 | MW |

FacDept = 'FIN' AND FacSSN **IN**



DELETE Example

- Use Type I nested queries to test conditions on other tables
- Use for **UPDATE** statements also

Example 8: Delete offerings taught by Leonard Vince.

```
DELETE FROM Offering  
WHERE Offering.FacSSN IN  
  (SELECT FacSSN FROM Faculty  
   WHERE FacFirstName = 'Leonard'  
   AND FacLastName = 'Vince' )
```

Type II Nested Queries

- Similar to nested loops
- *Executes one time for each row of outer query*
- Reference to outer query
- Also known as correlated or variably nested query
- Use for difference problems not joins

Type II Nested Query

Example for a Difference Problem

Example 9: Retrieve MS faculty who are **not** teaching in winter 2006.

```
SELECT FacSSN, FacLastName, FacDept  
FROM Faculty  
WHERE FacDept = 'MS' AND NOT EXISTS  
( SELECT * FROM Offering  
    WHERE OffTerm = 'WINTER'  
    AND OffYear = 2006  
    AND Faculty.FacSSN = Offering.FacSSN )
```

corelated



ทุกรายการ faculty ที่ Dept='MS' ตรวจสอบ sub-query is NULL

| FacSSN | FacFirstName | FacLastName | FacDept |
|--------|--------------|-------------|---------|
|--------|--------------|-------------|---------|

| | | | |
|-------------|------------|----------|-----|
| 098-76-5432 | LEONARD | VINCE | MS |
| 543-21-0987 | VICTORIA | EMMANUEL | MS |
| 654-32-1098 | LEONARD | FIBON | MS |
| 765-43-2109 | NICKI | MACON | FIN |
| 876-54-3210 | CRISTOPHER | COLAN | MS |
| 987-65-4321 | JULIA | MILES | FIN |

Sub-query

Sub-query

```
SELECT * FROM Offering  
WHERE OffTerm = 'WINTER'  
AND OffYear = 2006  
AND '098765432' = Offering.FacSSN
```

```
SELECT * FROM Offering  
WHERE OffTerm = 'WINTER'  
AND OffYear = 2006  
AND '543210987' = Offering.FacSSN
```

Limited Formulations for Difference Problems

- Type I nested query with NOT IN condition
- One-sided outer join with IS NULL condition
- Difference operation using MINUS (EXCEPT) operator

Type I Difference Formulation

Example 10: Retrieve MS faculty who are not teaching in winter 2006.

```
SELECT FacSSN, FacLastName, FacDept  
FROM Faculty  
WHERE FacDept = 'MS' AND FacSSN NOT IN  
( SELECT FacSSN FROM Offering  
  WHERE OffTerm = 'WINTER'  
    AND OffYear = 2006 )
```



Faculty

| FacSSN | Fac FirstName | Fac LastName | Fac HireDate | Fac Salary | Fac Supervisor | Fac Dept |
|-------------|------------------|-----------------|-----------------|---------------|-------------------|-------------|
| 098-76-5432 | LEONARD | VINCE | 1995-04-10 | 35000 | 654-32-1098 | MS |
| 543-21-0987 | VICTORIA | EMMANUEL | 1996-04-15 | 120000 | | MS |
| 654-32-1098 | LEONARD | FIBON | 1994-05-01 | 70000 | 543-21-0987 | MS |
| 765-43-2109 | NICKI | MACON | 1997-04-11 | 65000 | | FIN |
| 876-54-3210 | CRISTOPHER | COLAN | 1999-03-01 | 40000 | 654-32-1098 | MS |
| 987-65-4321 | JULIA | MILLS | 2000-03-15 | 75000 | 765-43-2109 | FIN |

Offering อาจารย์ที่เปิดสอน in Winter 2006

Check if in

| OfferNo | CourseNo | OffTerm | OffYear | OffLocation | OffTime | FacSSN | OffDays |
|---------|----------|---------|---------|-------------|----------|-------------|---------|
| 4444 | IS320 | WINTER | 2006 | BLM302 | 15:30:00 | 543-21-0987 | TTH |
| 5555 | FIN300 | WINTER | 2006 | BLM207 | 08:30:00 | 765-43-2109 | MW |
| 5678 | IS480 | WINTER | 2006 | BLM302 | 10:30:00 | 987-65-4321 | MW |
| 6666 | FIN450 | WINTER | 2006 | BLM212 | 10:30:00 | 987-65-4321 | TTH |

One-Sided Outer Join Difference Formulation

Example 11: Retrieve MS faculty who have never taught a course (research faculty).

```
SELECT FacSSN, FacLastName, FacDept  
FROM Faculty LEFT JOIN Offering  
ON Faculty.FacSSN = Offering.FacSSN  
WHERE FacDept = 'MS'  
AND Offering.FacSSN IS NULL
```

MINUS Operator Difference Formulation

Example 12 (Oracle): Retrieve faculty who are not students

```
SELECT FacSSN AS SSN, FacFirstName AS FirstName,  
      FacLastName AS LastName, FacCity AS City,  
      FacState AS State
```

```
FROM Faculty  
      MINUS
```

```
SELECT StdSSN AS SSN, StdFirstName AS FirstName,  
      StdLastName AS LastName, StdCity AS City,  
      StdState AS State  
FROM Student
```

Nested Queries in the FROM Clause

- More recent introduction than nested queries in the WHERE and HAVING clauses
- Consistency in language design
- *Wherever table appears, table expression can appear*
- Specialized uses
 - ◆ Nested aggregates
 - ◆ Multiple independent aggregate calculations

Nested FROM Query Example

Example 13: Retrieve the course number, course description, the number of offerings, and the average enrollment across offering.

```
SELECT T.CourseNo, T.CrsDesc,  
       COUNT(*) AS NumOfferings,  
       Avg(T.EnrollCount) AS AvgEnroll  
FROM  
  (SELECT Course.CourseNo, CrsDesc,  
         Offering.OfferNo,  
         COUNT(*) AS EnrollCount  
    FROM Offering, Enrollment, Course  
   WHERE Offering.OfferNo = Enrollment.OfferNo  
     AND Course.CourseNo = Offering.CourseNo  
   GROUP BY Course.CourseNo, CrsDesc,  
           Offering.OfferNo) T  
GROUP BY T.CourseNo, T.CrsDesc
```

table expression

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 |
| p3 |

SuppPart DIVIDEBY Part

| SuppNo |
|--------|
| s3 |

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

COUNT Method for Division Problems

- Compare the number of rows associated with a group to the total number in the subset of interest
- Type I nested query in the HAVING clause

Example 14: List the students who belong to all clubs.

```
SELECT StdNo  
      FROM StdClub  
      GROUP BY StdNo  
      HAVING COUNT(*) =  
            ( SELECT COUNT(*) FROM Club )
```

Typical Division Problems

- Compare to an interesting subset rather than entire table
- Use similar conditions in outer and nested query

Example 15: List the students who belong to all social clubs.

```
SELECT Student1.StdNo, SName  
      FROM StdClub, Club, Student1  
     WHERE StdClub.ClubNo = Club.ClubNo  
       AND Student1.StdNo = StdClub.StdNo  
       AND CPurpose = 'SOCIAL'  
GROUP BY Student1.StdNo, SName  
HAVING COUNT(*) =  
      ( SELECT COUNT(*) FROM Club  
        WHERE CPurpose = 'SOCIAL'  )
```

Advanced Division Problems

- Count distinct values rather than rows
 - ◆ Faculty who teach at least one section of selected course offerings
 - ◆ Offering table has duplicate CourseNo values
- Use COUNT(DISTINCT column)
- Use stored query or nested FROM query in Access

Advanced Division Problem Example

Example 16: List the SSN and the name of faculty who teach at least one section of all of the fall 2005, IS courses.

```
SELECT Faculty.FacSSN, FacFirstName,  
       FacLastName  
FROM Faculty, Offering  
WHERE Faculty.FacSSN = Offering.FacSSN  
      AND OffTerm = 'FALL'  
      AND CourseNo LIKE 'IS%'  
      AND OffYear = 2005  
GROUP BY Faculty.FacSSN, FacFirstName,  
         FacLastName  
HAVING COUNT(DISTINCT CourseNo) = → No of courses taught  
( SELECT COUNT(DISTINCT CourseNo)  
    FROM Offering  
    WHERE OffTerm = 'FALL' AND  
        OffYear = 2005 AND  
        CourseNo LIKE 'IS%' )→ No of all of  
the fall 2005, IS courses
```

Null Value Effects

- Simple conditions
- Compound conditions
- Grouping and aggregate functions
- SQL:2003 standard but implementation may vary

Simple Conditions

- Simple condition *is null if* either left-hand or right-hand side is null.
- *Discard rows* evaluating to false or null
- Retain rows evaluating to true
- Rows evaluating to null will *not appear* in the result of the simple condition or its negation

Aggregate Functions

- Null values ignored
- Effects can be subtle
 - ◆ $COUNT(*)$ may differ from $Count(Column)$
 - $COUNT(column)$ returns the number of non-null values in the column
 - ◆ $SUM(Column1) + SUM(Column2)$ may differ from $SUM(Column1 + Column2)$
 - Since $1+NULL = Null$

| A | B |
|-----------------------|-----------|
| 10 | 10 |
| Null | 20 |
| 30 | 30 |
| Sum(A)=40 | Sum(B)=60 |
| $SUM(A)+SUM(B) = 100$ | |
| $SUM(A+B) =$ | |
| $20+Null+60=80$ | |

Grouping Effects

- Rows with null values are grouped together
- Grouping column contains null values
- Null group can be placed at beginning or end of the non-null groups

Summary

- Advanced matching problems not common but important when necessary
- Understand outer join, difference, and division operators
- Nested queries important for advanced matching problems
- Lots of practice to master query formulation and SQL