Join Operations

Inner, Outer and other types of Join

Relational Algebra operations

Selection	σ
Projection	π
Cartesian Product	×
Union	∪
Set Difference	-
Join	⋈
Intersection	∩
Division	÷

Relational Algebra operations

Selection	σ	
Projection	π	
Cartesian Product	×	
Union	∪	
Set Difference	-	
Join	⋈	We have seen Inner Join performed using CP and selection
Intersection	∩	
Division	÷	

Inner join

$$R \underset{f}{\bowtie} S$$

The resulting relation contains tuples that satisfy the predicate f from the cartesian product of relation R and relation S

$R \underset{f}{\bowtie} S$ is the same as $\sigma_f(R \times S)$

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Emp / Dept example

$$emp \underset{emp.deptno=dept.deptno}{\bowtie} dept \qquad \sigma_{emp.deptno=dept.deptno} (\ emp \times dept\ )$$

EMPNO	ENAME	JOB	MGR	HIREDATE	SAL	COMM	emp.DEPTNO	dept.DEPTNO	DNAME	LOC
405	MARCH	ADMIN	938	13/06/1997	18000		2	2	RESEARCH	YORK
535	BYRNE	SALES	734	15/08/1997	26000	300	3	3	SALES	BIRMINGHAM
557	BELL	SALES	734	26/03/2000	22500	500	3	3	SALES	BIRMINGHAM
602	BIRD	MANAGER	875	31/10/1997	39750		2	2	RESEARCH	YORK
690	AHMAD	SALES	734	05/12/1997	22500	1400	3	3	SALES	BIRMINGHAM
734	COX	MANAGER	875	11/06/2002	38500		3	3	SALES	BIRMINGHAM
818	POLLARD	MANAGER	875	14/05/2000	34500		1	1	ACCOUNTING	LONDON
824	REES	ANALYST	602	05/03/2000	40000		2	2	RESEARCH	YORK
875	PARKER	PRESIDENT		09/07/2002	60000		1	1	ACCOUNTING	LONDON
880	TURNER	SALES	734	04/06/2001	25000	0	3	3	SALES	BIRMINGHAM
912	HAYES	ADMIN	824	04/06/2001	21000		2	2	RESEARCH	YORK
936	CASSY	ADMIN	734	23/07/2002	19500		3	3	SALES	BIRMINGHAM
938	GIBSON	ANALYST	602	05/12/1997	40000		2	2	RESEARCH	YORK
970	BLACK	ADMIN	818	21/11/1997	23000		1	1	ACCOUNTING	LONDON

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In SQL: Implicit Inner Join syntax

Can construct an inner join using CP and a predicate

select * or expression
from relations ← table names go here
where expression ← the predicate goes here

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In SQL: Implicit Inner Join syntax

Can construct an inner join using CP and a predicate

select *
from emp, dept
where emp.deptno=dept.deptno

EMPNO	ENAME	JOB	MGR	HIREDATE	SAL	COMM	emp.DEPTNO	dept.DEPTNO	DNAME	LOC
405	MARCH	ADMIN	938	13/06/1997	18000		2	2	RESEARCH	YORK
535	BYRNE	SALES	734	15/08/1997	26000	300	3	3	SALES	BIRMINGHAM
557	BELL	SALES	734	26/03/2000	22500	500	3	3	SALES	BIRMINGHAM
602	BIRD	MANAGER	875	31/10/1997	39750		2	2	RESEARCH	YORK
690	AHMAD	SALES	734	05/12/1997	22500	1400	3	3	SALES	BIRMINGHAM
734	COX	MANAGER	875	11/06/2002	38500		3	3	SALES	BIRMINGHAM
818	POLLARD	MANAGER	875	14/05/2000	34500		1	1	ACCOUNTING	LONDON
824	REES	ANALYST	602	05/03/2000	40000		2	2	RESEARCH	YORK
875	PARKER	PRESIDENT		09/07/2002	60000		1	1	ACCOUNTING	LONDON
880	TURNER	SALES	734	04/06/2001	25000	0	3	3	SALES	BIRMINGHAM
912	HAYES	ADMIN	824	04/06/2001	21000		2	2	RESEARCH	YORK
936	CASSY	ADMIN	734	23/07/2002	19500		3	3	SALES	BIRMINGHAM
938	GIBSON	ANALYST	602	05/12/1997	40000		2	2	RESEARCH	YORK
970	BLACK	ADMIN	818	21/11/1997	23000		1	1	ACCOUNTING	LONDON

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SQL 92: Explicit Inner Join syntax

Can construct an inner join using specific inner join syntax

select * or expression
from relation inner join relation ← table names go here
on field operator field ← the predicate goes here

The on clause must be included

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SQL 92: Explicit Inner Join syntax

Can construct an inner join using specific inner join syntax

    select *
    from emp inner join dept
    on emp.deptno=dept.deptno

EMPNO	ENAME	JOB	MGR	HIREDATE	SAL	COMM	emp.DEPTNO	dept.DEPTNO	DNAME	LOC
405	MARCH	ADMIN	938	13/06/1997	18000		2	2	RESEARCH	YORK
535	BYRNE	SALES	734	15/08/1997	26000	300	3	3	SALES	BIRMINGHAM
557	BELL	SALES	734	26/03/2000	22500	500	3	3	SALES	BIRMINGHAM
602	BIRD	MANAGER	875	31/10/1997	39750		2	2	RESEARCH	YORK
690	AHMAD	SALES	734	05/12/1997	22500	1400	3	3	SALES	BIRMINGHAM
734	COX	MANAGER	875	11/06/2002	38500		3	3	SALES	BIRMINGHAM
818	POLLARD	MANAGER	875	14/05/2000	34500		1	1	ACCOUNTING	LONDON
824	REES	ANALYST	602	05/03/2000	40000		2	2	RESEARCH	YORK
875	PARKER	PRESIDENT		09/07/2002	60000		1	1	ACCOUNTING	LONDON
880	TURNER	SALES	734	04/06/2001	25000	0	3	3	SALES	BIRMINGHAM
912	HAYES	ADMIN	824	04/06/2001	21000		2	2	RESEARCH	YORK
936	CASSY	ADMIN	734	23/07/2002	19500		3	3	SALES	BIRMINGHAM
938	GIBSON	ANALYST	602	05/12/1997	40000		2	2	RESEARCH	YORK
970	BLACK	ADMIN	818	21/11/1997	23000		1	1	ACCOUNTING	LONDON

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Join using something other than =

$$R \bowtie_f S$$

The predicate f may use any of the comparison operators =, <, >, <=. >=, ≠

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Example: join with >= and <=

Many organisations use a grade for jobs with an associated salary range

See the emp, grade tables for an example of this

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grade table

GRADE	LOSAL	HISAL
1	17000	21999
2	22000	23999
3	24000	29999
4	30000	49999
5	50000	99999

Consider: What grade is March ?

emp table

EMPNO	ENAME	JOB	MGR	HIREDATE	SAL	COMM	DEPTNO
405	MARCH	ADMIN	938	13/06/1997	18000		2
535	BYRNE	SALES	734	15/08/1997	26000	300	3
557	BELL	SALES	734	26/03/2000	22500	500	3
602	BIRD	MANAGER	875	31/10/1997	39750		2
690	AHMAD	SALES	734	05/12/1997	22500	1400	3
734	COX	MANAGER	875	11/06/2002	38500		3
818	POLLARD	MANAGER	875	14/05/2000	34500		1
824	REES	ANALYST	602	05/03/2000	40000		2
875	PARKER	PRESIDENT		09/07/2002	60000		1
880	TURNER	SALES	734	04/06/2001	25000	0	3
912	HAYES	ADMIN	824	04/06/2001	21000		2
936	CASSY	ADMIN	734	23/07/2002	19500		3
938	GIBSON	ANALYST	602	05/12/1997	40000		2
970	BLACK	ADMIN	818	21/11/1997	23000		1

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grade table

GRADE	LOSAL	HISAL
1	17000	21999
2	22000	23999
3	24000	29999
4	30000	49999
5	50000	99999

Consider: What grade is March ?

Sal is 18000, which indicates Grade 1

emp table

EMPNO	ENAME	JOB	MGR	HIREDATE	SAL	COMM	DEPTNO
405	MARCH	ADMIN	938	13/06/1997	18000		2
535	BYRNE	SALES	734	15/08/1997	26000	300	3
557	BELL	SALES	734	26/03/2000	22500	500	3
602	BIRD	MANAGER	875	31/10/1997	39750		2
690	AHMAD	SALES	734	05/12/1997	22500	1400	3
734	COX	MANAGER	875	11/06/2002	38500		3
818	POLLARD	MANAGER	875	14/05/2000	34500		1
824	REES	ANALYST	602	05/03/2000	40000		2
875	PARKER	PRESIDENT		09/07/2002	60000		1
880	TURNER	SALES	734	04/06/2001	25000	0	3
912	HAYES	ADMIN	824	04/06/2001	21000		2
936	CASSY	ADMIN	734	23/07/2002	19500		3
938	GIBSON	ANALYST	602	05/12/1997	40000		2
970	BLACK	ADMIN	818	21/11/1997	23000		1

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EMPNO	ENAME	JOB	MGR	HIREDATE	SAL	COMM	DEPTNO
405	MARCH	ADMIN	938	13/06/1997	18000		2
535	BYRNE	SALES	734	15/08/1997	26000	300	3
557	BELL	SALES	734	26/03/2000	22500	500	3
602	BIRD	MANAGER	875	31/1			
690	AHMAD	SALES	734	05/			
734	COX	MANAGER	875	11/0			
818	POLLARD	MANAGER	875	14/0			
824	REES	ANALYST	602	05/0			
875	PARKER	PRESIDENT		09/0			
880	TURNER	SALES	734	04/0			
912	HAYES	ADMIN	824	04/06/2001	21000		
936	CASSY	ADMIN	734	23/07/2002	19500		3
938	GIBSON	ANALYST	602	05/12/1997	40000		2
970	BLACK	ADMIN	818	21/11/1997	23000		1

GRADE	LOSAL	HISAL
1	17000	21999
2	22000	23999
3	24000	29999
4	30000	49999
5	50000	99999

Our match condition is

losal<=sal and sal<=hisal

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Example: join with >= and <=

So to combine emp and grade

CP and selection notation

$\sigma_{\text{losal<= sal and sal <= hisal}} (\text{emp} \times \text{grade})$

Join notation

$\text{emp} \bowtie \text{grade}$
losal<= sal and sal <= hisal

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SQL

With implicit join syntax

select ename, grade, sal, hisal
from emp, grade
where losal<= sal and sal <= hisal

ename	grade	sal	hisal
BELL	2	22500	23999
AHMAD	2	22500	23999
HAYES	1	21000	21999
BLACK	2	23000	23999

Outer join

Often when joining relations there are no matching values in the join columns. The condition used will exclude these values. To include values that don't match, use an Outer Join

$$R \bowtie_f S \qquad\qquad R \bowtie_f S$$

Right Outer Join　　　　　Left Outer Join

Best explained by example

Show a list of all departments and the employees who work in them

First attempt using implicit join syntax

select dept.deptno, dname, loc, ename
from emp, dept
where emp.deptno=dept.deptno

Best explained by example

Show a list of all departments and the employees who work in them

deptno	dname	loc	ename
1	ACCOUNTING	LONDON	BLACK
1	ACCOUNTING	LONDON	PARKER
1	ACCOUNTING	LONDON	POLLARD
2	RESEARCH	YORK	GIBSON
2	RESEARCH	YORK	HAYES
2	RESEARCH	YORK	REES
2	RESEARCH	YORK	BIRD
2	RESEARCH	YORK	MARCH
3	SALES	BIRMINGHAM	CASSY
3	SALES	BIRMINGHAM	TURNER
3	SALES	BIRMINGH	
3	SALES	BIRMINGH	
3	SALES	BIRMINGH	

Fails to show deptno 4

DEPTNO	DNAME	LOC
1	ACCOUNTING	LONDON
2	RESEARCH	YORK
3	SALES	BIRMINGHAM
4	OPERATIONS	LEEDS

Best explained by example

Show a list of all departments and the employees who work in them

select dept.deptno, dname, loc, ename
from emp, dept
where emp.deptno=dept.deptno

We need to include unmatched rows from the dept relation

A Right Outer Join

Right Outer join

Show a list of all departments and the employees who work in them

$$Emp \bowtie Dept$$

emp.deptno=dept.deptno

Includes unmatched tuples from the right

Explicit Outer Join syntax

Can construct an Outer join using explicit right or left join syntax

select * or expression
from relation left join relation
on field operator field

$$R \bowtie_{f} S$$

select * or expression
from relation right join relation
on field operator field

$$R \bowtie_{f} S$$

SQL

With explicit right outer join syntax

select dept.deptno, dname, loc, ename
from emp right join dept
on emp.deptno = dept.deptno

deptno	dname	loc	ename
1	ACCOUNTING	LONDON	POLLARD
1	ACCOUNTING	LONDON	PARKER
1	ACCOUNTING	LONDON	BLACK
2	RESEARCH	YORK	MARCH
2	RESEARCH	YORK	BIRD
2	RESEARCH	YORK	REES
2	RESEARCH	YORK	HAYES
2	RESEARCH	YORK	GIBSON
3	SALES	BIRMINGHAM	BYRNE
3	SALES	BIRMINGHAM	BELL
3	SALES	BIRMINGHAM	AHMAD
3	SALES	BIRMINGHAM	COX
3	SALES	BIRMINGHAM	TURNER
3	SALES	BIRMINGHAM	CASSY
4	OPERATIONS	LEEDS	

Full Outer join

Includes tuples from both sides where there are null values

$$R \bowtie_{f} S$$

Full Outer Join

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Full Outer join

Change to emp table to demonstrate this - the president doesn't have a department

EMPNO	ENAME	JOB	MGR	HIREDATE	SAL	COMM	DEPTNO
405	MARCH	ADMIN	938	13/06/1997	18000		2
535	BYRNE	SALES	734	15/08/1997	26000	300	3
557	BELL	SALES	734	26/03/2000	22500	500	3
602	BIRD	MANAGER	875	31/10/1997	39750		2
690	AHMAD	SALES	734	05/12/1997	22500	1400	3
734	COX	MANAGER	875	11/06/2002	38500		3
818	POLLARD	MANAGER	875	14/05/2000	34500		1
824	REES	ANALYST	602	05/03/2000	40000		2
875	PARKER	PRESIDENT		09/07/2002	60000		
880	TURNER	SALES	734	04/06/2001	25000	0	3
912	HAYES	ADMIN	824	04/06/2001	21000		2
936	CASSY	ADMIN	734	23/07/2002	19500		3
938	GIBSON	ANALYST	602	05/12/1997	40000		2
970	BLACK	ADMIN	818	21/11/1997	23000		1

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Full Outer join

Show a list of all departments and all the employees

select dept.deptno, dname, loc, ename
from emp, dept
where emp.deptno=dept.deptno

We lose both department 4 and the President

deptno	dname	loc	ename
1	ACCOUNTING	LONDON	BLACK
1	ACCOUNTING	LONDON	PARKER
1	ACCOUNTING	LONDON	POLLARD
2	RESEARCH	YORK	GIBSON
2	RESEARCH	YORK	HAYES
2	RESEARCH	YORK	REES
2	RESEARCH	YORK	BIRD
2	RESEARCH	YORK	MARCH
3	SALES	BIRMINGHAM	CASSY
3	SALES	BIRMINGHAM	TURNER
3	SALES	BIRMINGHAM	COX
3	SALES	BIRMINGHAM	AHMAD
3	SALES	BIRMINGHAM	BELL
3	SALES	BIRMINGHAM	BYRNE

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Show a list of all departments and all the employees

select dept.deptno, dname, loc, ename
from emp full outer join dept
on emp.deptno = dept.deptno

$emp \bowtie dept$
emp.deptno=dept.deptno

deptno	dname	loc	ename
			PARKER
1	ACCOUNTING	LONDON	BLACK
1	ACCOUNTING	LONDON	POLLARD
2	RESEARCH	YORK	BIRD
2	RESEARCH	YORK	GIBSON
2	RESEARCH	YORK	HAYES
2	RESEARCH	YORK	MARCH
2	RESEARCH	YORK	REES
3	SALES	BIRMINGHAM	AHMAD
3	SALES	BIRMINGHAM	BELL
3	SALES	BIRMINGHAM	BYRNE
3	SALES	BIRMINGHAM	CASSY
3	SALES	BIRMINGHAM	COX
3	SALES	BIRMINGHAM	TURNER
4	OPERATIONS	LEEDS	

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Full Outer join

However - not many databases support the full outer join syntax

Emulate it with a Union

$$R \underset{f}{\rtimes} S \cup R \underset{f}{\ltimes} S$$

Show a list of all departments and all the employees

```sql
select dept.deptno, dname, loc, ename
from emp left join dept
on emp.deptno = dept.deptno
UNION
select dept.deptno, dname, loc, ename
from emp right join dept
on emp.deptno = dept.deptno
```

deptno	dname	loc	ename
			PARKER
1	ACCOUNTING	LONDON	BLACK
1	ACCOUNTING	LONDON	POLLARD
2	RESEARCH	YORK	BIRD
2	RESEARCH	YORK	GIBSON
2	RESEARCH	YORK	HAYES
2	RESEARCH	YORK	MARCH
2	RESEARCH	YORK	REES
3	SALES	BIRMINGHAM	AHMAD
3	SALES	BIRMINGHAM	BELL
3	SALES	BIRMINGHAM	BYRNE
3	SALES	BIRMINGHAM	CASSY
3	SALES	BIRMINGHAM	COX
3	SALES	BIRMINGHAM	TURNER
4	OPERATIONS	LEEDS	