

INFO20003 Database Systems

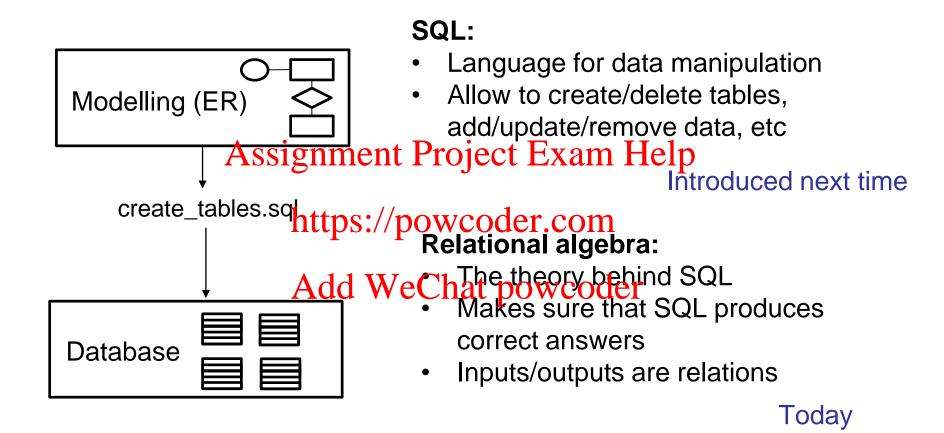
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Lecture 07 Relational Algebra



What we have done so far



How do we manipulate with relations?



Relational Algebra: 5 Basic Operations

- **1. Selection** (*): Selects a subset of *rows* from relation (horizontal filtering).
- 2. Projection (1): Retains only wanted columns from relation (vertical filter ipgo ject Exam Help
- 3. Cross-product (x): Allows us to combine two relations. https://powcoder.com
- 4. Set-difference de Notation went at la the other.
- **5.** Union (\cup) : Tuples in one relation and/or in the other.

Each operation returns a relation, operations can be composed

MELBOURNE Coverage: Relational Algebra

- Selection & Projection
- Union, Set Difference & Intersection
- Cross product & Joins Assignment Project Exam Help
- Examples

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Readings: Chapter 4, Ramakrishnan & Gehrke, Database Systems



MELBOURNE Example Instances

Reserves (R1)

sid	<u>bid</u>	day
22	101	10/10/96
58	103	11/12/96

Boats

		Aggian	ment Project	Mciav	osima i ele	rating	age
bid	bname	COLOT	ment Project	BIGY	amparel	Jacing	age
	Oname	C0101	(64)	22	dustin	7	45.0
101	Interlake	blue htt	(\$1) ps://powcod	der c	am.		
102	Interlake	l mad	ps.//powco	484.0	Hubber	8	55.5
		rea		58	rusty	10	35.0
1103	Clipper	greem c	ld WeChat	130	Tusty	10	33.0
		8-3-A(iu Wechai	powc	Jouet		
104	Marine	red			1		

Sailors 2 (S2)

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

Relational Algebra

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- Retains only attributes that are in the projection list
- Schema of result:
 - -Only the fields in the projection list, with the same names that they had in the input relation and Help
- Projection operator has to eliminate duplicates
 - -How do they and the series of the series of
 - -Note: real systems twoically don't do duplicate elimination unless the user explicitly asks for it



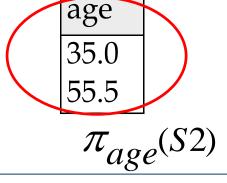
Projection Examples

- 1. Find ages of sailors :
- 2. Find names and rating of sailors:

 $\pi_{age}^{(S2)}$ $\pi_{sname,rating}^{(S2)}$

sid	sname	ratingn	nagent I	Project Ex	sname am Heln	rating
28	yuppy	9	35.0		yuppy	9
31	lubber	8 htt	55./3 pc	wcoder.c	dup ber	8
44	guppy	5	35.0		guppy	5
58	rusty	10 A c	ld5We	Chat powo	ruter	10
S2			S	sname,ra	iting (SZ)	

Removed duplicates





- Selects rows that satisfy selection condition
- Result is a relation. Schema of the result is same as that of the input relation.
- Do we need to do duplicate elimination?

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- Example:

Find sailors whose sating is above & m

sid	sname	ratiagld	WaCh	at no	WCO.	der	1	
		raumeju		at po	sid	sname	rating	age
28	yuppy	9	35.0		28		Q	35.0
31	lubber	8	55.5			yuppy	10	
44		5	25.0		58	rusty	10	35.0
	guppy	J	33.0					2)
58	rusty	10	35.0			O ratin	$\alpha > 8^{(3)}$	<i>Z)</i>
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$								
	rating	?>8	,					

Conditions are standard arithmetic expressions

Conditions are combined with AND/OR clauses

And: ∧ Assignment Project Exam Help

Or: V

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• Example: Add WeChat powcoder

Find sailors whose rating is above 8 and who are younger than 50

$$\sigma_{rating>8} \wedge age < 50$$
 (S2)



Selection & Projection

- Operations can be combined
- Select rows that satisfy *selection condition* & retain only certain attributes (columns)
- **Example:**

Find names and retirent Partices to Prosentation is above 8

si	<u>d</u>	sname	rating	ag	юw	coder.	com sname	rating
28	3	yuppy	9Add	W	eCh	at pow	yodop y	9
3		lubber	8	5.			rusty	10
4	+	guppy	5	3.	0.0		Tusty	10
5	3	rusty	10	35	5.0			

 $rating > 8^{(S2)}$ sname,rating (O

Relational Algebra

- Selection & Projection
- Union, Set Difference & Intersection
- Cross production Project Exam Help
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- Union: Combines both relations together
- **Set-difference:** Retains rows of one relation that do not appear in the other relation
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 These operations take two input relations, which must be union-compatiblettps://powcoder.com
 - -Same number of fields
 - -Corresponding fields have the same type

sid	sname	rating	age		
22	dustin	7	45.0		
31	lubber	As <mark>§</mark> ignı	nent P	roj	
58	rusty		35.0 os://po		
S1					

	sid	sname	rating	age
	22	dustin	7	45.0
	31	lubber	8	55.5
(es Ex	am Help	10	35.0
	44 r	guppy	5	35.0
	28	yuppy	9	35.0

		Add	l WeC l	nat powcoderS1 US2
sid	sname	rating	age	
28	yuppy	9	35.0	Duplicates are rem
31	lubber	8	55.5	
44	guppy	5	35.0	
58	rusty	10	35.0	

Duplicates are removed



sid	sname	rating	age
22	dustin	7	45.0
31	lubber A	Assignm	เอ็กิ _t Pr
58	rustv	10	35.0

sid	sname	rating	age
22	dustin	7	45.0

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S1

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sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

S2



sid	sname	rating	age
22	dustin	7	45.0
31	lubber /	Assegnn	เอ็กิ _t Pr
58	rusty	10	35.0

sid	sname	rating	age
22	dustin	7	45.0

oject Exam HSlp-S2

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S1

		Λ dd	M/Δ 'b
sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

nat	powe	ender		
	sid		rating	age
	28	yuppy	9	35.0
	44	guppy	5	35.0

S2 - S1

Set-difference is not symmetrical



Compound Operator: Intersection

- In addition to the 5 basic operators, there are several additional "Compound Operators"
 - -These add no computational power to the language, but are useful shorthands
 - -Can be expressed solely with the basic operations

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- Intersection retains rows that appear in both relations
- Intersection takes two Mput helations, which must be union-compatible
- Q: How to express it using basic operators?

$$R \cap S = R - (R - S)$$



Intersection

Example:

Find sailors who appear in both relations S1 and S2

sid	sname	rating	age					
22	dustin	7 Assign	45.0 ment F	Proie	ct Ex	<mark>am Help</mark> sname		
31	lubber	8	55.5		sid	sname	rating	age
58	rusty	10 ^{ht} 1	BS:/opc)WCC	ger.c	9 111 bber	8	55.5
	S1	A	dd We(Chat	58w	rusty	10	35.0

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

 $S1 \cap S2$

S2

Relational Algebra

- Selection & Projection
- Union, Set Difference & Intersection
- Cross products and Project Exam Help
- Examples https://powcoder.com

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Cross Product

- Cross product combines two relations:
 - -Each row of one input is merged with each row from another input
 - -Output is a new relation with all attributes of both inputs
 - -X is used to density Project Exam Help
- Example: S1 x R1_{https://powcoder.com}
 - -Each row of S1 paired with each row of R1
- Question: How many dows Ghet not receive ?
 - -A: card(S1)*card(R1)



Cross Product Example

sid	sname	rating	age		sid	<u>bid</u>	day
22	dustin	7	45.0		22	101	10/10/96
31	lubber	8 Assignme	55.5	oio of E	58	103	11/12/96
58	rusty	issignme 10	35.0	bject E	xam	R1	

S1 https://powcoder.com

S1 X R1 =

Aidd	Weelh	aatipev	væd	(sid)	bid	day
22	dustin	7	45.0	22	101	10/10/96
22	dustin	7	45.0	58	103	11/12/96
31	lubber	8	55.5	22	101	10/10/96
31	lubber	8	55.5	58	103	11/12/96
58	rusty	10	35.0	22	101	10/10/96
58	rusty	10	35.0	58	103	11/12/96



Cross Product: Conflicting names

- Result schema has one field per field of S1 and R1, with field names "inherited" if possible.
 - -May have a naming conflict, i.e. both S1 and R1 have a field with the same name (e.g. sid).
 - -In this case Assingurenthat Penajoring Experate lep

$$\rho (C1 \xrightarrow{sid1.5} sid2), S1 \times R1)$$
Result relation name

(sid1)	snam A (lid time	agra (pid2v)	dødle	rlay
	22	dustin	7	45.0	22	101	10/10/96
	22	dustin	7	45.0	58	103	11/12/96
С	31	lubber	8	55.5	22	101	10/10/96
	31	lubber	8	55.5	58	103	11/12/96
	58	rusty	10	35.0	22	101	10/10/96
	58	rusty	10	35.0	58	103	11/12/96

MELBOURNE Compound Operator: Join

- Joins are compound operators involving cross product, selection, and (sometimes) projection.
- Most common type of join is a **natural join** (often just called **join**). R Sconceptually is a cross product that matches rows where attributes that appearing both relations have equal values (and we omit duplicate attributes).

- To obtain cross product a DBMS must:
 - 1. Compute R X S
 - 2. Select rows where attributes that appear in both relations have equal values
 - 3. Project all unique attributes and one copy of each of the common ones.



MELBOURNE Natural Join Example

Example:

Find all sailors (from relation S1) who have reserved a boat

sid	sname	rating	age				
22	dustin _{As}	signmer	4 5 10j	ect Ex	aid H	biol	<u>day</u>
31	lubber	8 https://	55.5	oder c	22	101	10/10/96
58	rusty	10	35.0	rouci.c	58	103	11/12/96

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S1 ⋈R1 =

sid	sname	rating	age	bid	day
22	dustin	7	45.0	101	10/10/96
58	rusty	10	35.0	103	11/12/96

R1



S1 X R1 =

	(sid)	sname	rating	age	(sid)	bid	day
•	22	dustin	7	45.0	22	101	10/10/96
	22	dustin	7	45.0	58	103	11/12/96
A	Assig	hyhent	Projec	5.5 3	an H	ep b	10/10/96
		lubber	8	55.5	58	103	11/12/96
	58 h	ttps://p	OWCO	deroc	OM	101	10/10/96
	58 A	rusty dd We	Chat	35.0 00W (58 coder	103	11/12/96



(1)	
\sim S1 X	R1 =



	(sid)	sname	rating	age	(sid)	bid	day
	22	dustin	7	45.0	22	101	10/10/96
	22	dustin	7	45.0	58	103	11/12/96
Å	SS12	hybeat	Proiec	\$5.5x	a144 H	101 € ΨĐ	10/10/96
	31	lubber	8	55.5	58	103	11/12/96
	<u>58</u> h	ttps://r	OMEO	leroc	om_	101	10/10/96
	58 A		Chat	35.0 00W (58 coder	103	11/12/96



(1)			
S1	X	R1	=

(sid)	sname	rating	age	(sid)	bid	day
22	dustin	7	45.0	22	101	10/10/96
-22	dustin	7	45.0	58	103	11/12/96
A 331 2	dyheart	Présied	55.5x	a 22 H	1.01 €Ψ Β	10/10/96
31	lubber	8	55.5	-5 8	103	11/12/96
58h	ttps://r	OWEO	leroc	opp_	101	10/10/96
58		Chat	35.0	58	103	11/12/96
	laa We	Chat	DÓWC	coder		

sid	sname	rating	age	bid	day
22	dustin	7	45.0	101	10/10/96
58	rusty	10	35.0	103	11/12/96



Other Types of Joins

 Condition Join (or theta-join) is a cross product with a condition. $R \bowtie_{C} S = \sigma_{C}(R \times S)$

(sid)	sname	rating	age	(sid)	bid	day
22	dustin	giment	45.0°C	58 Xan	103	11/12/96
31	lubber	https://r	55.500	ter.con	103	11/12/96
S1 R1 Add Weshat Bowiebder						

- -Result schema is the same as that of cross-product
- Equi-Join is a special case of condition join, where condition c contains only equalities (e.g. S1.sid = R1.sid)
 - —Is this then a natural join? What is different?

Relational Algebra

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Let's try it...

Boats

bid	bname	color		sid	sname	rating	age
101	Interlake	Blue		22	dustin	7	45.0
102	Interlake	Red	ment Proje	22 24 E	daba Ual	, D 0	
103	Clipper ⁴	Green	ment Froje	TOULL.	Mander	p 8	55.5
104	Marine	Red	ps://powco	58 58	rusty	10	35.0

Sailors

Reserves

sid	<u>bid</u>	<u>day</u>
22	101	10/10/96
58	103	11/12/96

Find names of sailors who have reserved boat #103

Boats

bid	bname	color
101	Interlake	Blucks
102	Interlake	Red
103	Clipper	Green
104	Marine	Red

Sailors

	<u>sid</u>	sname	rating	age	
g		dustin	ject i	45.01	
h	31 tips 58	lubber <mark>://pow rusty</mark>	code	55.5 1. CO 1 35.0	r

Reserves

	T	<u>bid</u>	day
J	<u> 2811</u>	101	10/10/96
	58	103	11/12/96

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Solution 1:

$$\pi_{sname}((\sigma_{bid=103} \text{Reserves}) \bowtie Sailors)$$

Solution 2:

$$\pi_{sname}(\sigma_{bid=103}(Reserves \bowtie Sailors))$$



Find all pairs and sailor has a lower rating der.com

- Relational Algebra Operations: Selection, Projection, Union, Set, Difference, Intersection, JOINS...
- Draw different queries with Relational Algebra operations

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Introducing SQL

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