

INFO20003 Database Systems

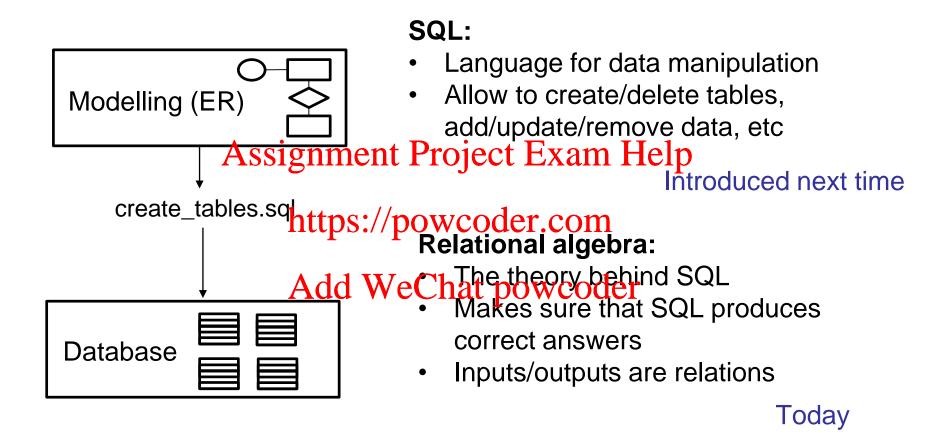
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Lecture 07 Relational Algebra



What we have done so far



How do we manipulate with this data?



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 Wellen wondere lation, but not in 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

bid	bname	Assign	ment.	Proje	ctsidx		rating	age
bia	bhaine	COIOP	(6	unois i M	22	dustin	7	45.0
101	Interlake	blue htt	ns·//r	OWCO	der c		0	
102	Interlake	red	Po.// F					55.5
			1 1 T T T T	C1 4	58	rușty	10	35.0
		green	la We	eChat	powo	coder	•	
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

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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 second of the second of
 - -Note: real systems typically 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	agent I	Project Ex	sname am Heln	rating
28	yuppy	9	35.0		yuppy	9
31	lubber	8 htt	55./3 pc	wcoder.c	du bber	8
44	guppy	5	35.0		guppy	5
58	rusty	10 Ac	ld5We	Chat power		10
S2			$\frac{1}{S}$	sname,ra	iting (S2)	

age 35.0 55.5 Removed duplicates



 $rating > 8^{(52)}$

- Selects rows that satisfy a 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?

 Example: Assignment Project Exam Help
- Example:

Find sailors who set in the sailors who set i

sid	sname	ratiAgld	WeCh	at po	W.CO	der		
28		0	35.0		<u>s1d</u>	sname	rating	age
	yuppy	9	33.0		28	yuppy	9	35.0
31	lubber	8	55.5				10	
11		_	250		58	rusty	10	35.0
44	guppy)	33.0				. ~	•
58	rusty	10	35.0			σ ratin	a>8	2)
		((())		_		raiiri	8/0	

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 Paridoes tulbosen relief is above 8

						_		
si	<u>d</u>	sname	ratings	aę	юw	coder.	com sname	rating
28	}	yuppy	9 _{Add}	35	eCh	at pow	godop y	9
3		lubber	8		5.5			10
4	+	guppy	5	35	5.0		rusty	10
5	3	rusty	10	35	5.0			

rating>8^(S2)) sname,rating (O

Relational Algebra

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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	nen ₹P	ro		
58	rusty		35.0 os://po			
S1						

		sid	sname	rating	age
		22	dustin	7	45.0
		31_	lubber	8	55.5
P	roje	es Ex	am Help	10	35.0
ן ורסי	WC	44 1	guppy	5	35.0
<i>,</i>	vv C	28	yuppy	9	35.0
Chat powcoderS1 \subset S2					

		. Add	l WeC
sid	sname	rating	age
28	yuppy	9	35.0
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 /	Assignm	เอ็กิt Pro
58	rusty	10	35.0

sid	sname	rating	age
22	dustin	7	45.0

oject Exam Holp-S2

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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



Set Difference

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

sid	sname	rating	age
22	dustin	7	45.0

gnment Project Exam Help-S2

https://powcoder.com

S1

	_	Δdd	-W/A(-'h
sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

ì	at ·	nowc	oder		
		sid	U U U U	rating	age
		28	yuppy	9	35.0
		44	guppy	5	35.0

S2 - S1

Set-difference is not symmetrical

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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 which basin 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	Proje	ct Ex	am Help		
31	lubber	8	55.5		S1Cl	sname	rating	age
58	rusty					9 111 bber	8	55.5
	S1	A	dd We(Chat	58 50w	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 for 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 a heat not represent ?
 - -A: card(S1)*card(R1)



Cross Product Example

sid	sname	rating	age		sid	bid	day
22	dustin	7	45.0		22	101	10/10/96
31	lubber	8 Assignme	55.5	oio at Es	58	103	11/12/96
58	rusty	rssignme 10	35.0	oject E	xamı	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 caseAssingurenthat Perajority Experate lep

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

,							
	sid1)	snam	ndtivige	Egra t	p @20	code	p lay
	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 appoint in both relations have equal values (and we omit duplicate attributes).

- To perform a natural join a DBMS can:
 - 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

S1 Add WeChat powcoder R1

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



 $S1 \times R1 =$

	(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	hyhbert	Project.	₹ 5₽3	an H	€₽ þ	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	58 coder	103	11/12/96



(1)			
$\mathbf{S1}$	X	R 1	=



	(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	\ <u>331 e</u>	hybeat	Proiec	75.5x	a144 H	101 € ¥Ð	10/10/96
	31	lubber	8	55.5	5 8	103	11/12/96
	<u>58</u> h	t tps:// r	OMEO	leroc	om_	101	10/10/96
_	58 A		Chat	35.0 00 W 0	58 coder	103	11/12/96



(1)			
$\mathbf{S1}$	X	R 1	=

	(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	SSIE	hubbert	Projec	75.5x	a144 H	101 EVD	10/10/96
	31	lubber	8	55.5	-58	103	11/12/96
	<u>58</u> h	ttps://p	OMEO	leroc	OPA_	101	10/10/96
	58	rust y, ,	Chat	35.0	58	103	11/12/96
	<i>P</i>	Lua VV 6	Chal	powc	couer		, ,

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. $R \bowtie_{\mathcal{C}} S = \sigma_{\mathcal{C}}(R \times S)$

(sid)	sname	rating	age	(sid)	bid	day
22	dustin	giment	45.0	58 Xan	1031	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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- Examples

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Let's try it...

Boats

bid	bname	color		sid	sname	rating	age
	Interlake			22	dustin	7	45.0
102	Interlake	Red	ment Proje		dota Hol	,	
103	Clipper ¹	Green	ment Proje	SI C	Auddete:	p 8	55.5
	Marine	Red	ps://powco	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

Solution 1: $\pi_{sname}((\sigma_{bid=103} \text{Reserves}) \bowtie Sailors)$

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Solution 2:

https://powbiden.com (Reserves \bowtie Sailors))

Find the names of sailors who have reserved a blue boat

 $\pi_{sname}((\sigma_{color='blue'}Boats) \bowtie Reserves \bowtie Sailors)$

A

 $\pi_{sname}(\sigma_{color='blue'}(Boats \bowtie Reserves \bowtie Sailors))$

B Assignment Project Exam Help

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 $(\pi_{sname}Sailors) \bowtie Reserves \bowtie (\sigma_{color='blue}, Boats)$

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- $A: \pi_{sname}((\sigma_{color='blue'}Boats) \bowtie Reserves \bowtie Sailors)$
- B: $\pi_{sname}(\sigma_{color='blue'}(Boats \bowtie Reserves \bowtie Sailors))$
- C: $(\pi_{sname}Sailors) \bowtie Reserves \bowtie (\sigma_{color='blue'}Boats)$



Find all pairs sailors in the older 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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