Database Management Systems

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Comprehensive List

 δ Duplicate elimination turns Bag into a Set

Aggregation SUM, AVG, MIN, MAX, COUNT

- γ Grouping of tuples according to their value in one or more attributes; partitioning the tuples into groups
- au Sorting Sorts given list of columns
- Extended Projection Projection includes expressions and columns that are not available in original relation
 - Outer Join Takes into account dangling tuples the tuples that do not satisfy specified condition

Duplicate Elimination

Example

F	₹	
Α	В	•
1	2	•
3	4	
1	2	
1	2	
		_

Example



Example

R			
Α	В		
1	2		
3	4		
1	2		
1	2		

SUM



Example

AVG

 $\begin{array}{c|c}
R_{AVG(A)} \\
\hline
AVG(A) \\
\hline
1.5
\end{array}$

Example

ĸ			
Α	В		
1	2		
3	4		
1	2		
_1	2		

D

MIN

 $\frac{R_{MIN(A)}}{MIN(A)}$

Example

11		
Α	В	
1	2	
3	4	
1	2	
_1	2	

R

MAX



Example

F	3	
Α	В	
1	2	
3	4	
1	2	
1	2	

COUNT



Grouping on Department attribtue

_	Department	
	EEE	
	CSE	
	EEE	
	CSE	
	 CSE	

On grouping on Department attribtue

Department	
CSE	
CSE	
CSE	
EEE	
EEE	

On grouping on Department attribtue

Department	
CSE	
CSE	
CSE	
EEE	
EEE	

- Grouping operator allows us to group a relation
- It also allows to apply aggregate operations on some attributes
- The notation is $\gamma_L(R)$
- Where L is a list of attributes each of which is either
 - ullet An attribute of R to which γ is applied known as grouping attribute
 - An aggregation operator applied to an attribtue of R
- Example: $\gamma_{\text{dept,avg(cpi)}}(R)$
- In this example, attribtue dept is the grouping attribute
- The attribute cpi is not a grouping attribute but is an attribute of *R* on which aggregate operation avg is performed

- The relation returned by the expression $\gamma_L(R)$ is constructed as follows:
- Partitions tuples of R into groups
- Each group consists of all tuples having one particular assignment of values to grouping attributes in L
- If there are no grouping attributes, entire relation is one group
- For each group produce one tuple consisting of:
 - The grouping attributes' values for that group and
 - The aggregations, over all tuples of that group, for the aggregated attributes on list L
- Example: $\gamma_{\text{dept.avg}(\text{cpi})}(R)$
- Department attribute takes several values {BT, CH, CE, CS, DD, EC, EE, MA, ME, PH}
- For each of the value, produce one tuple
- That is for BT produce one record (no constraint on which record within BT is produced)
- Apply aggregation to the specified attribute within the group
- That is within BT compute the average cpi

7 / 28

Example Relation

Student				
roll	sname	dept	срі	
22	Dustin	CSE	9.7	
29	Brutus	ECE	9.3	
31	Lubber	EEE	9.0	
32	Andy	EEE	9.2	
58	Rusty	PH	8.7	
64	Horatio	CSE	8.8	
71	Zorba	PH	9.5	
74	Horatio	CH	7.0	
85	Art	CE	10.0	
95	Bob	CE	9.9	

$\gamma_{dept,avg(cpi)}(Student)$				
roll	sname	dept	срі	
22	Dustin	CSE	9.7	
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Grouping

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8 / 28

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74	Horatio	CH	7.0
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$\gamma_{dept,.}$	$_{avg(cpi)}(Student)$
dept	avg(cpi)
CSE	9.25
ECE	9.3
EEE	9.1
PH	9.1
CH	7.0
CE	9.95

- In the projection operation L should be from list of attributes of R
- Extended projection can create new attributes from existing L
- Notation: $\pi_L(R)$

Elements of Projection

- A single attribute of R
- An expression $x \to y$ renames x to y
- An expression $E \rightarrow z$; E is an experssion involving attributes of R
- Example: $a + b \rightarrow x$; Sums attribute values a and b and rename it to x

Example Relation

	R	
Α	В	С
0	1	2
0	1	2
3	4	5

$$\pi_{A,B+C\to X}(R)$$

Α	Χ
0	3
0	3
3	9

Example Relation

R	
В	С
1	2
1	2
4	5
	1

$$\pi_{B-A\to X,C-B\to Y}(R)$$

X	Υ
1	1
1	1
1	1

Sorting Operator

Definition

Sort given attribute in ascending/descending order

Example Relation

	R	
Α	В	С
3	4	5
1	1	2
7	1	2

$\tau_A(R)$

	R	
Α	В	С
1	1	2
3	4	5
7	1	2

Outer Join

Variants

- Outer join: N
- Left outer join: $\stackrel{\circ}{\bowtie}_{L}$
- Right outer join:

Outer join

Definition: In addition to the Natural join, add any dangling tuples from R or S.

Dangling tuples: The tuples that did not meet the Natural join criteria

Outer Join

Outer join - Example



$U\stackrel{\circ}{\bowtie} V$					
Α	В	С	D		
1	2	3	10		
1	2	3	11		
4	5	6	Τ		
7	8	9	Τ		
\perp	6	7	12		

Left/Right Outer Join

Left/Right Outer Join - Example



	U	∘ ⋈ V L	
Α	В	C	D
1	2	3	10
1	2	3	11
4	5	6	Τ
7	8	9	\perp

Left/Right Outer Join

Left/Right Outer Join - Example



$U \overset{\circ}{\bowtie} V$					
Α	В	С	D		
1	2	3	10		
1	2	3	11		
	6	7	12		

Definition

• Useful for expressing certain kinds of queries

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- Useful for expressing certain kinds of queries
- Example: Find the names of sailors who have reserved all boats
- Let A and B be two relation instances
- A has exactly two attributes x, y
- B has exactly one attribute y
- $A/B = \{x | \forall y \in B, \exists (x,y) \in A\}$ For every value of $y \in B$ there exists $(x, y) \in A$

Alternate Definition

$$A/B = \pi_{\mathsf{x}}(A) - \pi_{\mathsf{x}}(\pi_{\mathsf{x}}(A) \times B - A)$$

Explanation

• Compute all x values in A that are not disqualified

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- Compute all x values in A that are not disqualified
- Disqualification: By attaching y value from B to $x \in A$ such that $(x,y) \notin A$
- Step 1: attaching y value from B to $x \in A$: $\pi_x(A) \times B$

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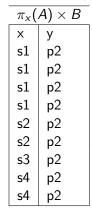
Explanation

- Compute all x values in A that are not disqualified
- Disqualification: By attaching y value from B to $x \in A$ such that $(x,y) \notin A$
- Step 1: attaching y value from B to $x \in A$: $\pi_x(A) \times B$
- Step 2: check the pair (x, y) is not in A

$$(\pi_{\times}(A)\times B)-A$$

А		
у		
p1		
p2		
р3		
p4		
p1		
p2		
p2		
p2		
p4		

• Step 1: attaching y value from B to every $x \in A$: $\pi_x(A) \times B$



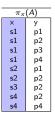
Α		
Х	У	
s1	p1	
s1	p2	
s1	р3	
s1	p4	
s2	p1	
s2	p2	
s3	p2	
s4	p2	
s4	p4	
s3 s4	p2 p2	

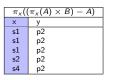


• Step 2: check the pair (x, y) is not in A $(\pi_X(A) \times B) - A$

$\pi_{\times}(\lambda)$	4) × B		P	4
×	у		×	у
s1	p2		s1	р1
s1	p2		s1	p2
s1	p2		s1	p2 p3
s1	p2	_	s1	p4
s2	p2		s2	p1
s2	p2		s2	p2
s3	p2		s3	p2
s4	p2		s4	p2 p2 p2 p4
s4	p2		s4	p4

(π_x)	$(A) \times B) - A$
×	у
s1	p2
s1	p2 p2
s1	p2
s2	p2
c4	n2

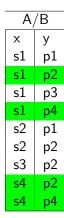




$\pi_X A - \pi_X (\pi_X(A) \times B - A)$
у
s1
s2
s3
s4

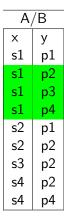
Α		
х	у	
s1	p1	
s1	p2	
s1	р3	
s1	p4	
s2	p1	
s2	p2	
s3	p2	
s4	p2	
s4	p4	

$$A/B =$$



Α		
Х	у	
s1	p1	
s1	p2	
s1	р3	
s1	p4	
s2	p1	
s2	p2	
s3	p2	
s4	p2	
s4	p4	

$$A/B =$$



Relational Algebra as a Constraint Language

Constraints on Relations

- Two ways of expressing constraints using relational algebra
- If R is an expression of relational algebra then $R = \Phi$. That is there are no tuples in the result of R
- If R and S are expressions of relational algebra then $R \subseteq S$ is a constraint
- States Every tuple in the result of R must also be a tuple in the result of S
- $R \subseteq S$ could just as well have been written as $R S = \Phi$

Referential Integrity

Using Relational Algebra

- Student(roll_number, name, email, phone)
- Course(cid, cname, credits)
- Registers(roll_number, cid, semester, year)
- $\pi_{roll_number}(Registers) \subseteq \pi_{roll_number}(Student)$
- $\pi_{roll_number}(Registers) \pi_{roll_number}(Student) = \Phi$

Example Database

Sailors				
sid	sname	rating	age	
22	Dustin	7	45.0	
29	Brutus	1	33.0	
31	Lubber	8	55.5	
32	Andy	8	25.5	
58	Rusty	10	35.0	
64	Horatio	7	35.0	
71	Zorba	10	16.0	
74	Horatio	9	35.0	
85	Art	3	25.5	
95	Bob	3	63.5	

	Reserves			
sid	bid	day		
22	101	10-Oct-2019		
22	102	10-Oct-2019		
22	103	08-Oct-2019		
22	104	07-Oct-2019		
31	102	10-Nov-2019		
31	103	06-Nov-2019		
31	104	12-Nov-2019		
64	101	05-Sep-2019		
64	102	08-Sep-2019		
74	103	08-Sep-2019		

Boats	
bname	color
Interlake	blue
Interlanke	red
Clipper	gree
Marine	red
	bname Interlake Interlanke Clipper

Queries

Q1 Find the names of the Sailors who have reserved Boat 103

- Q1 Find the names of the Sailors who have reserved Boat 103
- Q2 Find the names of the Sailors who reserved a red boat

- Q1 Find the names of the Sailors who have reserved Boat 103
- Q2 Find the names of the Sailors who reserved a red boat
- Q3 Find the colors of boats reserved by Lubber

- Q1 Find the names of the Sailors who have reserved Boat 103
- Q2 Find the names of the Sailors who reserved a red boat
- Q3 Find the colors of boats reserved by Lubber
- Q4 Find the names of Sailors who have reserved at least one boat

- Q1 Find the names of the Sailors who have reserved Boat 103
- Q2 Find the names of the Sailors who reserved a red boat
- Q3 Find the colors of boats reserved by Lubber
- Q4 Find the names of Sailors who have reserved at least one boat
- Q5 Find the names of Sailors who have reserved a red or a green Boat

- Q1 Find the names of the Sailors who have reserved Boat 103
- Q2 Find the names of the Sailors who reserved a red boat
- Q3 Find the colors of boats reserved by Lubber
- Q4 Find the names of Sailors who have reserved at least one boat
- Q5 Find the names of Sailors who have reserved a red or a green Boat
- Q6 Find the names of Sailors who have reserved a red AND a green Boat

- Q1 Find the names of the Sailors who have reserved Boat 103
- Q2 Find the names of the Sailors who reserved a red boat
- Q3 Find the colors of boats reserved by Lubber
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- Q7 Find the names of Sailors who have reserved at least two boats

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- Q7 Find the names of Sailors who have reserved at least two boats
- Q8 Find the sids of Sailors with age over 20 who have not reserved a red

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- Q8 Find the sids of Sailors with age over 20 who have not reserved a red boat
- Q9 Find the names of sailors who have reserved all boats

```
Q2: Find the names of the Sailors who reserved a red boat
\rho(Temp1, \sigma_{color='red'}(Boats))
Schema for Temp1: Temp1(bid, bname, color)
\rho(Temp2, Temp1 \bowtie Reserves \bowtie Sailors)
Schema for Temp2: Temp2(bid, bname, color, sid, day, sname,
rating, age)
\pi_{sname}(Temp2)
Schema for \pi_{sname}(\text{Temp2}): Temp2(sname)
```

Q2: Find the names of the Sailors who reserved a red boat

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

Q3: Find the colors of boats reserved by Lubber

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