

Partha Pratim Das

Week Recar

Objectives & Outline

D. J. C. . . .

Algebra

Select

Project

Union

Difference

Intersection

Cartesian Produ

Divisio

Module Summary

### Database Management Systems

Module 16: Formal Relational Query Languages/1

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#### Week Recap

Objectives Outline

Relationa Algebra Select Project

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- SQL Examples have been practiced for basic query structures
- Nested Subquery in SQL
- Data Modification
- SQL expressions for Join and Views
- Transactions
- Integrity Constraints
- More data types in SQL
- Authorization in SQL
- Functions and Procedures in SQL
- Triggers

# Module Objectives

#### Module 16

Objectives & Outline

• To understand formal query language through relational algebra

### Module Outline

#### Module 16

#### Objectives & Outline

• Relational Algebra



## Formal Relational Query Language

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- Relational Algebra
  - o Procedural and Algebra based
- Tuple Relational Calculus
  - o Non-Procedural and Predicate Calculus based
- Domain Relational Calculus
  - o Non-Procedural and Predicate Calculus based



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Module Summar

# **Relational Algebra**

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- Created by Edgar F Codd at IBM in 1970
- Procedural language
- Six basic operators
  - $\circ$  select:  $\sigma$
  - o project: Π
  - $\circ$  union:  $\cup$
  - o set difference: -
  - Cartesian product: x
  - $\circ$  rename: ho
- The operators take one or two relations as inputs and produce a new relation as a result

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- Notation:  $\sigma_p(r)$
- p is called the selection predicate
- Defined as:

$$\sigma_p(\mathbf{r}) = \{t | t \in r \text{ and } p(t)\}$$

where p is a formula in propositional calculus consisting of terms connected by :  $\land$  (and),  $\lor$  (or),  $\neg$  (not) Each terms is one of:

$$<$$
 attribute  $>$  op  $<$  attribute  $>$  or  $<$  constant  $>$ 

where op is one of:  $=, \neq, >, \geq$  . < .  $\leq$ 

• Example of selection:

$$\sigma_{dept\_name = 'Physics'}(instructor)$$

4	В	C	D
χ	α	1	7
χ	β	5	7
3	β	12	3
3	β	23	10

$$\sigma_{A=B^{\wedge}D>5}(r)$$

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Relation: Algebra Select Project

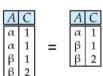
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- Notation:  $\Pi_{A_1,A_2,...A_k}$  (r) where  $A_1$ ,  $A_2$  are attribute names and r is a relation
- The result is defined as the relation of *k* columns obtained by erasing the columns that are not listed
- Duplicate rows removed from result, since relations are sets
- Example: To eliminate the dept\_name attribute of instructor

$$\Pi_{ID,name,salary}(instructor)$$





- Notation:  $r \cup s$
- Defined as:  $r \cup s = \{t | t \in r \text{ or } t \in s\}$
- For  $r \cup s$  to be valid.
  - a) r, s must have the same arity (same number of attributes)
  - b) The attribute domains must be compatible (example: 2nd column of r deals with the same type of values as does the 2nd column of s)
  - c) Example: to find all courses taught in the Fall 2009 semester, or in the Spring 2010 semester, or in both

$\boldsymbol{A}$	В			A	В
α	1	1	Γ	α	2
α α β	2		L	β	3
β	1			- 1	S
1	1	-			
		A	В		
		α	1		
		$\alpha$	2		
		β	1		
		β	3		
		ru	s	•	

 $\Pi_{course\_id}(\sigma_{semester="Fall" \land vear=2009}(section)) \cup \Pi_{course\_id}(\sigma_{semester="Spring" \land vear=2010}(section))$ 

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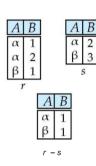
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- Notation r-s
- Defined as:  $r s = \{t | t \in r \text{ and } t \notin s\}$
- Set differences must be taken between compatible relations
  - o r and s must have the same arity
  - o attribute domains of r and s must be compatible
- Example: to find all courses taught in the Fall 2009 semester, but not in the Spring 2010 semester

$$\Pi_{course\_id}(\sigma_{semester="Fall" \land year=2009}(section)) - \Pi_{course\_id}(\sigma_{semester="Spring" \land year=2010}(section))$$





## Intersection Operation

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• Notation:  $r \cap s$ 

• Defined as:

$$r \cap s = \{t | t \in r \text{ and } t \in s\}$$

- Assume:
  - o r, s have the same arity
  - $\circ$  attributes of r and s are compatible
- Note:  $r \cap s = r (r s)$

4	В	]	A
χ	1	]	α
χ	2		β
3	1		
1			



$$r \cap s$$

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- Notation  $r \times s$
- Defined as:

$$r \times s = \{t \ q | t \in r \text{ and } q \in s\}$$

- Assume that attributes of r(R) and s(S) are disjoint. (That is,  $R \cap S = \phi$ )
- If attributes of r(R) and s(S) are not disjoint, then renaming must be used







 $r \times s$ 



### Rename Operation

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• Allows us to name, and therefore to refer to, the results of relational-algebra expressions.

- Allows us to refer to a relation by more than one name.
- Example:

$$\rho_x(E)$$

returns the expression E under the name X

• If a relational-algebra expression E has arity n, then

$$\rho_{\times(A_1,A_2,\cdots,A_n)}(E)$$

returns the result of expression E under the name X, and with the attributes renamed to

$$A_1, A_2, \ldots, A_n$$

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Cartesian Product Rename Division

- The division operation is applied to two relations
- $R(Z) \div S(X)$ , where X subset Z. Let Y = Z X (and hence  $Z = X \cup Y$ ); that is, let Y be the set of attributes of R that are not attributes of S
- The result of DIVISION is a relation T(Y) that includes a tuple t if tuples  $t_R$  appear in R with  $t_R$  [Y] = t, and with
  - o  $t_R[X] = t_s$  for every tuple  $t_s$  in S.
- For a tuple t to appear in the result T of the DIVISION, the values in t must appear in R in combination with every tuple in S
- Division is a derived operation and can be expressed in terms of other operations
- $r \div s \equiv \Pi_{R-S}(r) \Pi_{R-S}((\Pi_{R-S}(r) \times s) \Pi_{R-S,S}(r))$



Division

R

Module Lecturer Brown Compilers Brown Databases Prolog Green Databases Green Lewis Prolog Smith Databases

S

Subject Prolog

RIS

Lecturer Green Lewis

# Division Examples (2)

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Module Summary

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Lecturer	Module	
Brown	Compilers	
Brown	Databases	
Green	Prolog	
Green	Databases	
Lewis	Prolog	
Smith	Databases	

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Subject

Databases

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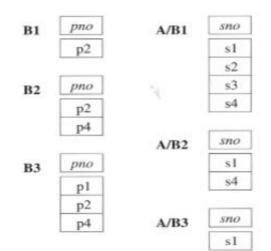
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sno	pno
s1	pl
s1	p2
s1	p3
s1	p4
s2	p1
s2	p2
s3	p2
s4	p2
s4	p4



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Module Summary

• Relations *r*, *s*:

Α	В	
а	1	
а	2	
а	3	
β	1	
γ	1	
δ	1	
δ	3	
δ	4	
€	6	
€	1	
β	2	

1 2 s

 $\begin{array}{c|c}
A \\
\hline
a \\
\beta
\end{array}$ 

e.g. A is customer name B is branch-name 1 and 2 here show two specific branch-names (Find customers who have an account in all branches of the bank)



# Division Example (5)

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Module Summary

• Relations r, s:

Α	В	С	D	E
а	а	а	а	1
а	а	γ	а	1
а	а	γ	b	1
β	а	γ	а	1
α β β γ	а	γ	b	3
γ	а	γ	а	1
γ	а	γ	b	1
γ	а	β	b	1

Α	В	С
а	а	γ
ν	а	ν

r ÷ s:

D	Ε
a b	1 1
8	6

e.g. Students who have taken both "a" and "b" courses, with instructor "1"

(Find students who have taken all courses given by instructor 1)

Source: db.fcngroup.nl/silberslides/Divsion Database Management Systems



## Module Summary

Module 16

Module Summary

• Discussed relational algebra with examples

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