CS145 Mid-term Review

Peng Qi, Karthik Jagadeesh, Sophia Nguyen

August 14, 2014

Outline

- Relational Algebra
- SQL
- Relational Design Theory

Relational Algebra

- Relational Algebra is a MATHematical language

- Vocabulary (Relations, Operators)
- Grammar (Syntax)
- Dialects (Sets Model and Bags Model)

Relational Algebra: Vocabulary & Grammar – Basic Operators & Syntax

- Relations

$$R(A, B, C)$$

R

A	B	C
"CS145"	2014	"Firas"
"CS145"	2014	"Perth"
...	...	...

Column: Attribute
Row: Tuple

Relational Algebra: Vocabulary & Grammar – Basic Operators & Syntax

- Basic Operators

Name	Notation	Modifies
Union	$\cup$	Tuples
Difference	$-$	Tuples
Selection	σ	Tuples
Projection	π	Attributes
Rename	ρ	Attributes and relation
Cartesian Product	$\times$	Tuples and attributes

Relational Algebra: Vocabulary & Grammar – Basic Operators & Syntax

- Union ($\cup$)

R

A	B	C
1	2	3
4	5	6

S

A	B	C
4	5	6
7	8	9

$\Rightarrow$

$R \cup S$

A	B	C
1	2	3
4	5	6
7	8	9

Relational Algebra: Vocabulary & Grammar – Basic Operators & Syntax

- Difference ($-$)

R

A	B	C
1	2	3
4	5	6

S

A	B	C
4	5	6
7	8	9

$\Rightarrow$

$R - S$

A	B	C
1	2	3

Relational Algebra: Vocabulary & Grammar – Basic Operators & Syntax

- Selection (σ)

$$\sigma_{conditions}(R)$$

R

A	B	C
1	2	3
4	5	6
7	8	9

$\Rightarrow$

$\sigma_{A<5}R$

A	B	C
4	5	6
1	2	3

Relational Algebra: Vocabulary & Grammar – Basic Operators & Syntax

- Projection (π)

$$\pi_{attributes}(R)$$

R

A	B	C
1	2	3
4	5	6
7	8	9

$\Rightarrow$

$\pi_{A,C}R$

C	A
3	1
6	4
9	7

Relational Algebra: Vocabulary & Grammar – Basic Operators & Syntax

- Rename (ρ)

$$\rho_S(R)$$

$$\rho_{b_1,b_2,\ldots,b_n}(R)$$

$$\rho_{S(b_1,b_2,\ldots,b_n)}(R)$$

R

A	B	C
1	2	3
4	5	6

$\Rightarrow$

$\rho_{S(D,E,F)}R$

D	F	E
4	6	5
1	3	2

Relational Algebra: Vocabulary & Grammar – Basic Operators & Syntax

- Cartesian Product ($\times$)

R

A	B
1	2
4	5

S

C	D
5	6
8	9

$\Rightarrow$

$R \times S$

A	B	C	D
1	2	5	6
1	2	8	9
4	5	5	6
4	5	8	9

R

A	B
1	2
4	5

S

B	D
5	6
8	9

$\Rightarrow$

$R \times S$

A	R.B	S.B	D
1	2	5	6
1	2	8	9
4	5	5	6
4	5	8	9

Relational Algebra: Vocabulary & Grammar — Extended Operators & Syntax

- Natural Join ($\bowtie$)

$$R \bowtie S = \pi_{R.a_R, R.a_{R \cap S}, S.a_S} (\sigma_{R.a_{R \cap S} = S.a_{R \cap S}} (R \times S))$$

- Theta Join ($\bowtie_\theta$)

$$R \bowtie S = \sigma_\theta (R \times S)$$

- Extended Projection (π)

$$\pi_{b_1, b_2, \ldots, b_m, f_1(a) \to c_1, \ldots, f_p(a) \to c_p} (R)$$

- Outer Joins, ...

Relational Algebra: Dialects — Sets Model and Bags Model

- Just like the sets model is stemmed from set theory, the bags (multi-set) model is stemmed from the multi-set theory.
- What's different?

Relational Algebra: Dialects — Sets Model and Bags Model

- What's different (in the bags model)?
  - Union ($\cup$)
    $R(A)$ has m 1's, n 2's; and $S(A)$ has k 2's, p 3's
    What does $R(A) \cup S(A)$ look like?
    m 1's, $(n + k)$ 2's, and p 3's.
  - Difference ($-$)
    $R(A)$ has m 1's, n 2's; and $S(A)$ has k 2's, p 3's
    What does $R(A) - S(A)$ look like?
    m 1's, and $\max(n - k, 0)$ 2's.
  - Selection (σ)

Relational Algebra: Dialects — Sets Model and Bags Model

- What's different (in the bags model)?
  - Projection (π)
    $R(A, B)$ has m (1,2)'s, n (2,3)'s
    What does $\pi_A(\sigma_{A<B \vee (A<2 \wedge B>1)} R)$ look like?
    m 1's and n 2's.
  - Rename (ρ)
  - Cartesian Product($\times$)
    $R(A, B)$ has m (1,2)'s, n (2,3)'s
    What does $\pi_{S.A}(\sigma_{R.A=S.B}(R \times \rho_S(R)))$ look like?
    $R \times \rho_S(R)$: Schema: (R.A, R.B, S.A, S.B); tuples: m^2 (1,2,1,2)'s, mn (1,2,2,3)'s, nm (2,3,1,2)'s, and n^2 (2,3,2,3)'s.
    After selection and projection: mn (1)'s.

Relational Algebra: Dialects — Sets Model and Bags Model

- Anything new?
  - Duplicate Eliminator (δ)

$$\delta(R)$$

  - Grouping (γ) and aggregation (`MIN`, `MAX`, `SUM`, `COUNT`, `AVG`)

$$\gamma_{GroupingAttributes, AggregateFunctions \rightarrow NewNames}(R)$$