CSE460/560 DATA MODELS AND QUERY LANGUAGES

Relational Algebra - 2

Cheng-En Chuang

(Slides Adopted from Jan Chomicki and Ning Deng)

University at Buffalo
Department of Computer Science and Engineering
School of Engineering and Applied Sciences

Outline

1. Projection π
2. Selection σ
3. Composability
4. Union ∪
5. Set Difference (−)
6. Cross Product(×)
7. Renaming(ρ)

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1. **Projection π**
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Example Instances

Student

FirstName,	GPA,	SID
[James,	3.9,	1701]
[Jean,	3.9,	1702]
[John,	3.0,	1703]
[Mary,	4.0,	1801]
[Mike,	4.0,	1805]

Club

President,	Name
[James,	C1]
[Mary,	C2]
[Tom,	C3]

MajorsIn

SID,	MID
[1701,	01]
[1701,	02]
[1805,	03]
[1801,	04]

Major

MID,	Name
[01,	CS]
[02,	EE]
[03,	Math]
[04,	ME]

Projection π

- Pick columns $A_1, \ldots, A_k$ which are distinct attributes of relation *R*, from *R*
  - arity($A_{A_1,\ldots,A_k}(R)) = k$
  - A tuple $t \in \pi_{A_1,\ldots,A_k}(R)$ iff for some $s \in R$
    - $t[A_1, \ldots, A_k] = s[A_1, \ldots, A_k]$
- Example
  - $\pi_{firstname,gpa}(Student)$
  - How about $\pi_{gpa}(Student)$?

FirstName,	GPA
[James,	3.9]
[Jean,	3.9]
[John,	3.0]
[Mary,	4.0]
[Mike,	4.0]

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Selection σ

- Select tuples/rows that satisfy the selection condition *c* from relation *R*
  - *c* is a condition on attributes of R and *c* is built from
    - Comparisons between operands which can be constants or attribute names
    - Boolean operators: $\land\ (AND), \lor\ (OR), \neg\ (NOT)$
  - $arity(\sigma_c(R)) = arity(R)$
  - A tuple $t \in \sigma_c(R)\ iff\ t \in R$ and *t* satisfies *c*
- Example
  - $\sigma_{gpa<3.5}(Student)$
  - $\sigma_{gpa<3.5}($ Student $) =$

Student

FirstName,	GPA,	SID
[James,	3.9,	1701]
[Jean,	3.9,	1702]
[John,	3.0,	1703]
[Mary,	4.0,	1801]
[Mike,	4.0,	1805]

FirstName,	GPA,	SID
[John,	3.0,	1703]

  - When does selection need to eliminate duplicates?

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Composing σ and π

- $\pi_{firstname}\left(\sigma_{GPA>3.5}(Student)\right)$

- $\pi_{firstname}\left(\sigma_{GPA>3.5}\left(\text{Student} \right)\right)$

Student

```
 FirstName,  GPA,   SID
[James,      3.9,  1701]
[Jean,       3.9,  1702]
[John,       3.0,  1703]
[Mary,       4.0,  1801]
[Mike,       4.0,  1805]
```

- Then?

- The is the schema of result of this query?

```
FirstName
[James ]
[Jane  ]
[Mary ]
[Mike ]
```

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Union ∪

- Takes two **compatible** relations
  - Returns all tuples in either relation
- Property
  - $arity(R_1 \cup R_2) = arity(R_1) = arity(R_2)$
  - $t \in R_1 \cup R_2 \; iff \; t \in R_1 or \; t \in R_2$
- Compatibility
  - $arity(R_1) = arity(R_2)$
  - The corresponding attribute domain in R_1 and $R_1 or \; t \in R_2$ are the same
  - Thus compatibility of two relations can be determined solely on their schemas
  - Can we do $Student \cup Club$?
  - How about $\pi_{firstname}\left(\sigma_{gpa=4.0}(Student)\right) \cup \sigma_{gpa<3.5}(Student))$?
    - What is this query doing?

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Set Difference (−)

- Takes two compatible relations
  - Compute all tuples that in the first relation
  - But not in the second relation
- Property
  - $arity(R_1 - R_2) = arity(R_1) = arity(R_2)$
  - $t \in R_1 - R_2 \ \ iff \ \ t \in R_1 \wedge t \notin R_2$
- Example
  - $\pi_{firstname}(Student) - \pi_{president}(Club)$
    - 🍭 What is this query doing?

Student

FirstName,	GPA,	SID
[James,	3.9,	1701]
[Jean,	3.9,	1702]
[John,	3.0,	1703]
[Mary,	4.0,	1801]
[Mike,	4.0,	1805]

Club

President,	Name
[James,	C1]
[Mary,	C2]
[Tom,	C3]

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Cross Product($\times$)

- Takes two relations
  - Pair each tuple $t_1 \in R_1$ with each tuple $t_2 \in R_2$
- Property
  - Given $arity(R_1) = k_1, arity(R_2) = k_2$
    - $arity\ (R_1 \times R_2) = k_1 + k_2$
    - $t \in R_1 \times R_2\ \ iff$:
      - The first k_1 components of *t* form a tuple in R_1
      - The next k_2 components of *t* form a tuple in R_2

Cross Product(×)

- Example
  - $Student \times MajorsIn$

Student

FirstName,	GPA,	SID
[James,	3.9,	1701]
[Jean,	3.9,	1702]
[John,	3.0,	1703]
[Mary,	4.0,	1801]
[Mike,	4.0,	1805]

×

MajorsIn

SID,	MID
[1701,	01]
[1701,	02]
[1805,	03]
[1801,	04]

=

FirstName,	GPA,	(SID),	(SID),	MID
[James,	3.9,	1701,	1701,	01]
[James,	3.9,	1701,	1701,	02]
[James,	3.9,	1701,	1805,	03]
[James,	3.9,	1701,	1801,	04]
[Jean,	3.9,	1702,	1701,	01]
[Jean,	3.9,	1702,	1701,	02]
[Jean,	3.9,	1702,	1805,	03]
[Jean,	3.9,	1702,	1801,	04]
[John,	3.0,	1703,	1701,	01]
[John,	3.0,	1703,	1701,	02]
[John,	3.0,	1703,	1805,	03]
[John,	3.0,	1703,	1801,	04]
[Mary,	4.0,	1801,	1701,	01]
[Mary,	4.0,	1801,	1701,	02]
[Mary,	4.0,	1801,	1805,	03]
[Mary,	4.0,	1801,	1801,	04]

… …

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Renaming (ρ)

- Givens a set of new attribute names as indicated in the list of $B_1, \ldots, B_n$ to *R*
- Property
  - Let $A_1, \ldots, A_n$ be the attributes of *R* before renaming
    - $arity\left(\rho_{B_1,\ldots,B_n}(R)\right) = arity(R) = n$
    - $t \in \rho_{B_1,\ldots,B_n}(R)\ \ iff$ for some $s \in R$
      - $t[B_1, \ldots, B_n] = s[A_1, \ldots, A_n]$
- Example
  - $\rho_{FirstName,GPA,Sid,Miid,Mid}(Student \times MajorsIn)$

```
FirstName,GPA, Sid,  Miid,  Mid
                ...
                ...
```

Set- and Bag- RA

Which operators behaviors differently in Set- and Bag- RA?

Select (σ)	No
Projection (π)	Yes
Cross-product ($\times$)	No
Set-difference ($-$)	No
Union ($\cup$)	Yes

Recommended Reading

Database Systems: The Complete Book
Chapter 2.4, 5.2