Databases

Lecture 7

Relational Algebra (II)

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- the *renaming* operator

$\rho(\mathrm{R}'(\mathrm{A}_1 \rightarrow \mathrm{A}_1{}', \mathrm{A}_2 \rightarrow \mathrm{A}_2{}', \mathrm{A}_3 \rightarrow \mathrm{A}_3{}'), \mathrm{E})$

  - E - relational algebra expression
  - the result, relation R', has the same tuples as the result of E
  - attributes A_1, A_2, and A_3 are renamed to $\mathrm{A}_1{}'$, $\mathrm{A}_2{}'$, and $\mathrm{A}_3{}'$, respectively

An Independent Subset of Operators

- independent set of operators M:
  - eliminating any operator *op* from M: there will be a relation that can be obtained using M's operators, but cannot be obtained with the operators in M-{*op*}
- for the previously described query language, with operators:

  $\{\sigma, \pi, \times, \cup, -, \cap, \otimes, *, \ltimes, \rtimes, \bowtie, \rhd, \lhd, \div\}$

an independent set of operators is $\{\sigma, \pi, \times, \cup, -\}$

- the other operators are obtained as follows (some expressions have already been introduced):
  - $R_1 \cap R_2 = R_1 - (R_1 - R_2)$
  - $R_1 \otimes_C R_2 = \sigma_C(R_1 \times R_2)$

- the other operators are obtained as follows (some expressions have already been introduced):
  - $R_1[\alpha], R_2[\beta], \alpha \cap \beta = \{A_1, A_2, \dots, A_m\}$, then:

    $$R_1 * R_2 = \pi_{\alpha \cup \beta}(R_1 \otimes_{R_1.A_1 = R_2.A_1 \ AND\ \dots\ AND\ R_1.A_m = R_2.A_m} R_2)$$

  - $R_1[\alpha], R_2[\beta], R_3[\beta] = \{(null, \dots, null)\}, R_4[\alpha] = \{(null, \dots, null)\}$

    $$R_1 \ltimes_C R_2 = (R_1 \otimes_c R_2) \cup (R_1 - \pi_\alpha(R_1 \otimes_c R_2)) \times R_3$$
    $$R_1 \rtimes_C R_2 = (R_1 \otimes_c R_2) \cup R_4 \times (R_2 - \pi_\beta(R_1 \otimes_c R_2))$$
    $$R_1 \bowtie_C R_2 = (R_1 \ltimes_C R_2) \cup (R_1 \rtimes_C R_2)$$

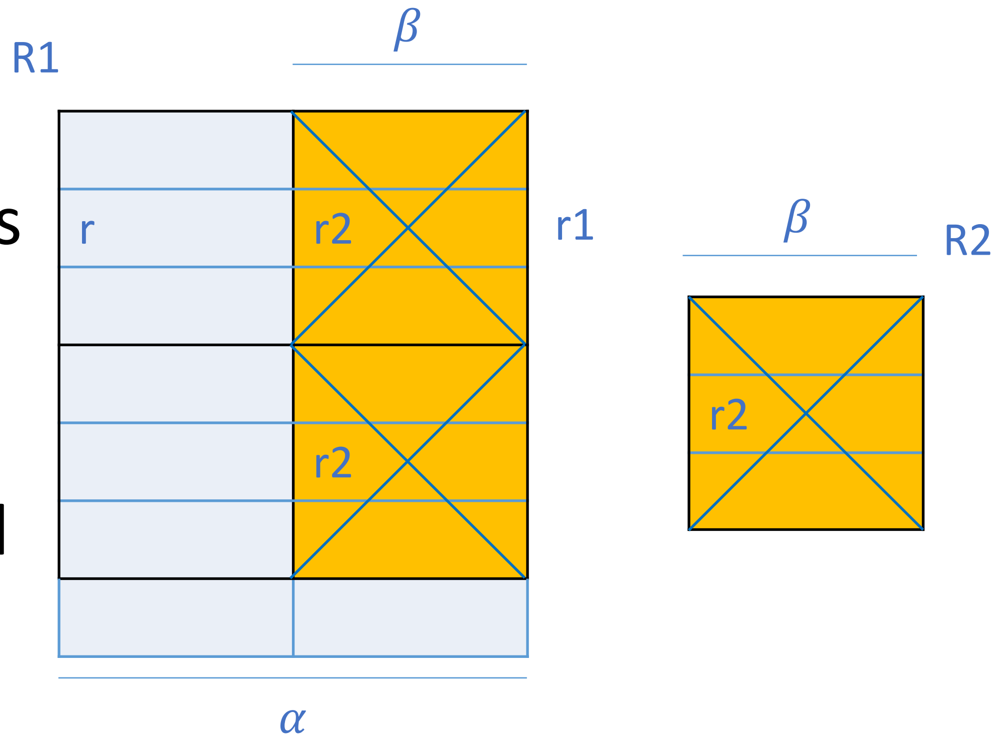
  - $R_1[\alpha], R_2[\beta]$

    $$R_1 \rhd R_2 = \pi_\alpha(R_1 * R_2)$$
    $$R_1 \lhd R_2 = \pi_\beta(R_1 * R_2)$$

- the other operators are obtained as follows (some expressions have already been introduced):
  - if $R_1[\alpha], R_2[\beta], \beta \subset \alpha$, then $r \in R_1 \div R_2$ if $\forall r_2 \in R_2, \exists r_1 \in R_1$ such that: $\pi_{\alpha-\beta}(r_1) = r$ and $\pi_{\beta}(r_1) = r_2$

  => r is in $\pi_{\alpha-\beta}(R_1)$, but not all the elements in $\pi_{\alpha-\beta}(R_1)$ are in the result

  - $(\pi_{\alpha-\beta}(R_1)) \times R_2$ contains all the elements with one part in $\pi_{\alpha-\beta}(R_1)$ and the second part in R_2
  - to obtain values that are disqualified, R_1 is subtracted from the obtained relation, and the result is projected on $\alpha - \beta$
  - the final expression:



$$R_1 \div R_2 = \pi_{\alpha-\beta}(R_1) - \pi_{\alpha-\beta}((\pi_{\alpha-\beta}(R_1)) \times R_2 - R_1)$$

* the next examples use the statements below:

- assignment

  $\text{R[list]} \coloneqq \text{expression}$

  - the expression's result (a relation) is assigned to a variable (R[list]), specifying the name of the relation [and the names of its columns]

- eliminating duplicates from a relation

  $\delta(\text{R})$

- sorting records in a relation

  $\text{S}_{\{\text{list}\}}(\text{R})$

- grouping

  $\gamma_{\{\text{list1}\}\ \text{group by}\ \{\text{list2}\}}(\text{R})$

  - R's records are grouped by the columns in *list2*
  - *list1* (that can contain aggregate functions) is evaluated for each group of records

```
students [id, name, sgroup, gpa, dob]

groups [id, year, program]

schedule [day, starthour, endhour, activtype, room, sgroup,
facultym_id]

faculty_members [id, name]
```

1. The names of students in a given group:

$$R \coloneqq \pi_{\{name\}}\left(\sigma_{sgroup='222'}(students)\right)$$

```
SELECT name
FROM students
WHERE sgroup='222'
```

2. The students in a given program (alphabetical list, by groups):

$$G \coloneqq \pi_{\{id\}}\left(\sigma_{program='IG'}(groups)\right)$$
$$R \coloneqq S_{\{sgroup,name\}}\left(\sigma_{sgroup\ is\ in\ G}(students)\right)$$

```
SELECT *
FROM students
WHERE sgroup IN
   (SELECT id
   FROM groups
   WHERE program='IG')
ORDER BY sgroup, name
```

```
students [id, name, sgroup, gpa, dob]
groups [id, year, program]
schedule [day, starthour, endhour, activtype, room,
  sgroup, facultym_id]
faculty_members [id, name]
```

3. The number of students in every group of a given program:

$$ST \coloneqq \sigma_{sgroup\ is\ in\left(\pi_{\{id\}}\left(\sigma_{program='IG'}(groups)\right)\right)}(students)$$

$$NR \coloneqq \gamma_{\{sgroup,\, count(*)\}\ group\ by\ \{sgroup\}}(ST)$$

```
SELECT sgroup, COUNT(*)
FROM (SELECT *
      FROM students
      WHERE sgroup IN
          (SELECT id
           FROM groups
           WHERE program='IG')
       ) t
GROUP BY sgroup
```

```
students [id, name, sgroup, gpa, dob]
groups [id, year, program]
schedule [day, starthour, endhour, activtype, room,
  sgroup, facultym_id]
faculty_members [id, name]
```

4. A student's schedule (the student is given by name):

$$T \coloneqq \sigma_{sgroup\ is\ in\left(\pi_{\{sgroup\}}\left(\sigma_{name='Ionescu\ M.\ Razvan'}(students)\right)\right)}(schedule)$$

5. The number of hours per week for every group:

$$F(no, sgroup) \coloneqq \pi_{\{endhour-starthour, sgroup\}}(schedule)$$

$$NoHours(sgroup, nohours) \coloneqq \gamma_{\{sgroup, sum(no)\}\ group\ by\ \{sgroup\}}(F)$$

```
students [id, name, sgroup, gpa, dob]

groups [id, year, program]

schedule [day, starthour, endhour, activtype, room, sgroup, facultym_id]

faculty_members [id, name]
```

6. The faculty members (their names) who teach a given student:

$$A \coloneqq (\sigma_{name='Ionescu\ M.\ Razvan'}(students)) \otimes_{students.sgroup=schedule.sgroup} schedule$$

$$B \coloneqq \pi_{\{facultym\_id\}}(A)$$

$$C \coloneqq faculty\_members \otimes_{faculty\_members.id=B.facultym\_id} B$$

$$D \coloneqq \pi_{\{name\}}(C)$$

```
students [id, name, sgroup, gpa, dob]
groups [id, year, program]
schedule [day, starthour, endhour, activtype, room, sgroup, facultym_id]
faculty_members [id, name]
```

7. The faculty members with no teaching assignments (i.e., not on the schedule):

$$C \coloneqq \pi_{\{name\}}(faculty\_members) - \pi_{\{name\}}(schedule \otimes_{schedule.facultym\_id = faculty\_members.id} faculty\_members)$$

* Is there a problem if two different faculty members have the same name?

```
students [id, name, sgroup, gpa, dob]
groups [id, year, program]
schedule [day, starthour, endhour, activtype, room, sgroup, facultym_id]
faculty_members [id, name]
```

8. Students with school activities on every day of the week (all days with school activities considered):

$$A \coloneqq \delta\left(\pi_{\{day\}}(schedule)\right)$$

$$B \coloneqq students \otimes_{students.sgroup=schedule.sgroup} schedule$$

$$C \coloneqq \delta(\pi_{\{name,day\}}(B))$$

$$D \coloneqq C \div A$$

* Is there a problem if two different students have the same name?

```
students [id, name, sgroup, gpa, dob]
groups [id, year, program]
schedule [day, starthour, endhour, activtype, room, sgroup, facultym_id]
faculty_members [id, name]
```

Milestone - review

- Databases Fundamentals
- The Relational Model
- SQL
- Functional Dependencies. Normal Forms
- Relational Algebra

See lecture problem (solved at the board)

- Create a database for a system that manages several funding portals, which bring together investors and entrepreneurs seeking funding for their startups. The entities of interest to the problem domain are: Funding Portals, Investors, Entrepreneurs, Startups, and Investments. A funding portal has a name and a website URL. An investor can offer funding through several portals, has a first name, last name, and date of birth. An entrepreneur has a first name, last name, and a startup success probability score; (s)he can own several startups. A startup has a name and description; it belongs to an entrepreneur. An investment is made by an investor for a startup through one of the funding portals the investor is registered on; it has a value (the invested amount of money) and a date. An investor can finance the same startup multiple times (through the same portal or through different portals).

References

- [Ta13] ȚÂMBULEA, L., Curs Baze de date, Facultatea de Matematică și Informatică, UBB, 2013-2014
- [Ra00] RAMAKRISHNAN, R., GEHRKE, J., Database Management Systems (2nd Edition), McGraw-Hill, 2000
- [Da03] DATE, C.J., An Introduction to Database Systems (8th Edition), Addison-Wesley, 2003
- [Ga08] GARCIA-MOLINA, H., ULLMAN, J., WIDOM, J., Database Systems: The Complete Book, Prentice Hall Press, 2008
- [Ra07] RAMAKRISHNAN, R., GEHRKE, J., Database Management Systems, McGraw-Hill, 2007, http://pages.cs.wisc.edu/~dbbook/openAccess/thirdEdition/slides/slides3ed.html
- [Ul11] ULLMAN, J., WIDOM, J., A First Course in Database Systems, http://infolab.stanford.edu/~ullman/fcdb.html