

Assignment #3: Relational Algebra

Release: Sept. 19, 2019

Due: 8:00 PM, Wednesday, Sept. 25, 2019

Goal

Gain familiarity with the theoretical foundations of relational algebra.

Description

- Assume the relational database schema that records information related to US forests used in HW2 and shown below:
 - $\text{FOREST} = (\text{Forest_No}, \text{Name}, \text{Area}, \text{Acid_Level}, \text{MBR_XMin}, \text{MBR_XMax}, \text{MBR_YMin}, \text{MBR_YMax})$
 - $\text{STATE} = (\text{Name}, \text{Abbreviation}, \text{Area}, \text{Population})$
 - $\text{COVERAGE} = (\text{Forest_No}, \text{State}, \text{Percentage}, \text{Area})$
 - $\text{ROAD} = (\text{Road_No}, \text{Name}, \text{Length})$
 - $\text{INTERSECTION} = (\text{Forest_No}, \text{Road_No})$
 - $\text{SENSOR} = (\text{Sensor_Id}, \text{X}, \text{Y}, \text{Last_Charged})$
 - $\text{REPORT} = (\text{Sensor_Id}, \text{Report_Time}, \text{Temperature})$
 - $\text{WORKER} = (\text{SSN}, \text{Name}, \text{Age}, \text{Rank})$
- Note: For outer joins, the following symbols are used:
 - \bowtie left outer join
 - \ltimes right outer join
 - \Join full outer join
- Answer the following questions [for a total of 100 points]:
 1. [20 points total] Assuming that the relations ROAD and INTERSECTION have 6 and 11 tuples, respectively, find the *arity* and *cardinality* of the following relations: (For those whose accurate values can not be determined, give the min and max values)
 - (a) $\pi_{\text{Road_No}}(\text{Road})$
 - (b) $\pi_{\text{Road_No}}(\text{Intersection})$
 - (c) $\text{Road} * \text{Intersection}$
 - (d) $(\sigma_{\text{Length} > 100}(\text{Road})) \bowtie_{\text{Road.Road_No} = \text{Intersection.Road_No}} (\text{Intersection})$
 - (e) $(\text{Intersection}) \ltimes (\text{Road})$

2. [12 points total] Write the *relational algebra* expression to answer each of the following queries in nesting notation:

- (a) List the names of all forests that have acid_level over 75%.
- (b) Retrieve the names of all forests, each of which has at least 50% of its area in Pennsylvania.

3. [12 points total] Write the *relational algebra* expression to answer each of the following queries in sequence notation:

- (a) Find the names of all roads in the forest whose name is “Allegheny National Forest”.
- (b) Find the Locations (i.e., X, Y coordinates) of all sensors in “Allegheny National Forest” that have issued a report between Jan. 9, 2019 and Jan. 11, 2019.

4. [40 points total] Write the *relational algebra* expression in either nested or sequence form to answer each of the following queries:

- (a) Find the names of all forests such that no sensors in those forests reported anything between Jan. 9, 2019 and Jan. 11, 2019.
- (b) For each forest, find its average temperature and number of sensors.
- (c) Find the locations of sensors that reported the highest temperature.
- (d) Find the State with largest area of forests (assuming that forests do not overlap).
- (e) List the pairs of states only once that share at least one forest (i.e., cover parts of the same forests).

5. [16 points total] Given relation R with attributes A, B, C, and relation S with attributes C, D, E, provide:

- an instance of relation R with 7 tuples,
- an instance of relation S with 6 tuples, and
- an instance of relation $R \bowtie_{R.C=S.C} S$,

such that relation $R * S$ has 4 tuples, and relation $R \bowtie_{R.C=S.C} S$ has 6 tuples.

Feel free to assume any type for attributes A, B, C, D, E in your relation instances/examples. You do not need to provide $R * S$ or $R \bowtie_{R.C=S.C} S$.

To submit your assignment

1. Create a single file named `hw3-<pitt_user_name>` in PDF (.pdf) (e.g. `hw3-pitt01.pdf`), containing your answers to all the questions. *Hand-written and scanned answer files will not be accepted/graded.* **Do not forget to include your name and `pitt_user_name` at the top of the file.**
2. Submit your assignments through the Web-based submission interface (go to the class web page <http://db.cs.pitt.edu/courses/cs1555/current.term/> and click the Submit button). **It is your responsibility to make sure the assignment was properly submitted.**
3. Submit your assignment by the due date (8:00 PM, Wednesday, Sept. 25, 2019). There is no late submission.
4. If you have trouble generating any of the relational algebra symbols, for example $R \bowtie_{A=B} S$, use a descriptive word, e.g., `R Join(A=B) S`.

Academic Honesty

The work in this assignment is to be done *independently*. Discussions with other students on the assignment should be limited to understanding the statement of the problem. Cheating in any way, including giving your work to someone else will result in an F for the course and a report to the appropriate University authority.