Tutorial 7: Basic Relational Algebra

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February 2018

Consider a database consisting of the relations, where the primary key of each relation is underlined.

sailors(sid, sname, rating, age)
boats(bid, bname, color)
reserved(sid, bid, date)

1. Find the names of sailors who have reserved at least two different boats with the same color.

    - **RA**
      $rb \leftarrow \pi_{sid,bid,color}(reserved \bowtie boats)$
      $good \leftarrow \pi_{sid}(rb \bowtie_{rb.sid=rb2.sid \ \wedge \ rb.bid \neq rb2.bid \ \wedge \ rb.color=rb2.color} \rho_{rb2}(rb))$
      $answer \leftarrow \pi_{sname}(good \bowtie sailors)$

    - **Datalog**
      $rb(S, B, C) \leftarrow reserved(S, B, \_), \ boats(B, \_, C)$
      $good(S) \leftarrow rb(S, B, C), \ rb(S, B', C), \ B \neq B'$
      $answer(N) \leftarrow good(S), \ sailors(S, N, \_, \_)$

2. Find the names of sailors who have reserved all red boats.

    - **RA**
      $allred \leftarrow \pi_{bid}(\sigma_{color='red'}boats)$
      $good \leftarrow (\pi_{sid,bid}reserved) \div allred$
      $answer \leftarrow \pi_{sname}(good \bowtie sailors)$

    - **Datalog**
      $allred(B) \leftarrow boats(B, \_, \ 'red')$
      $witness(S, B) \leftarrow reserved(S, B, \_), \ allred(B)$
      $bad(S) \leftarrow sailors(S, \_, \_, \_), \ allred(B), \ \neg witness(S, B)$
      $good(S) \leftarrow reserved(S, \_, \_), \ \neg bad(S)$
      $answer(N) \leftarrow sailors(S, N, \_, \_), \ good(S)$

3. Find the name and color of boats which are reserved by all sailors rated above 7.

   - **RA**
     $above7 \leftarrow \pi_{sid}(\sigma_{rating>7} sailors)$
     $witness \leftarrow \pi_{sid,bid}(above7 \bowtie reserved)$
     $bad \leftarrow \pi_{bid}(above7 \times \pi_{bid}reserved - witness)$
     $good \leftarrow \pi_{bid}reserved - bad$
     $answer \leftarrow \pi_{bname,color}(good \bowtie boats)$

   - **Datalog**
     $above7(S) \leftarrow sailors(S, \_, R, \_),\ R > 7$
     $witness(S, B) \leftarrow reserved(S, B, \_),\ above7(S)$
     $bad(B) \leftarrow above7(S),\ reserved(\_, B, \_),\ \neg witness(S, B)$
     $good(B) \leftarrow reserved(\_, B, \_),\ \neg bad(B)$
     $answer(N, C) \leftarrow good(B),\ boats(B, N, C)$

4. Find the name(s) of sailors with the lowest rating.

   - **RA**
     $notlowest \leftarrow \pi_{sailors.sid}(sailors \bowtie_{sailors.rating>sailors2.rating} \rho_{sailors2}(sailors))$
     $lowest \leftarrow \pi_{sname}((\pi_{sid}sailors - notlowest) \bowtie sailors)$

   - **Datalog**
     $notlowest(S) \leftarrow sailors(S, \_, R, \_),\ sailors(S', \_, R', \_), R > R'$
     $lowest(N) \leftarrow sailors(S, N, \_, \_),\ \neg notlowest(S)$

5. Find the name and rating of the oldest sailor(s).

   - **RA**
     $notoldest \leftarrow \pi_{sailors.sid}(sailors \bowtie_{sailors.age<sailors2.age} \rho_{sailors2}(sailors))$
     $oldest \leftarrow \pi_{sname,rating}((\pi_{sid}sailors - notoldest) \bowtie sailors)$

   - **Datalog**
     $notoldest(S) \leftarrow sailors(S, \_, \_, A),\ sailors(S', \_, \_, A'),\ A < A'$
     $oldest(N, R) \leftarrow sailors(S, N, R, \_),\ \neg notoldest(S)$

6. Find the names of sailors who have reserved every boat reserved by those with a lower rating. E.g., if Bob is a sailor rated at 6, Pete and Rick being sailors rated below 6, then Bob must have reserved every boat reserved by Pete as well as those reserved by Rick. Can you express this query using RA's division operator? Explain your answer.

   Answer

   We cannot express this query using RA's division operator. Because the denominator is the set of boats that are reserved by those with a lower rating. For each sailor, the set of sailors with a lower rating can vary, thus the set of boats reserved can vary. RA's division can only express fixed denominator so it does not work.

- **RA**
  $map \leftarrow \rho_{sailors2.sid \rightarrow sid2}(sailors \bowtie_{rating > sailors2.rating} \rho_{sailors2}(sailors))$
  $allcombo \leftarrow \pi_{sid,bid}(map \bowtie_{map.sid2=reserved.sid} reserved)$
  $witness \leftarrow \pi_{sid,bid}(map \bowtie_{map.sid=reserved.sid} reserved)$
  $bad \leftarrow \pi_{sid}(allcombo - witness)$
  $good \leftarrow \pi_{sname}((\pi_{sid}reserved - bad) \bowtie sailors)$

  note:
    - we don't have to explicitly say $sailos.sid \neq sailors2.sid$ because
      we take a strict "greater-than" in rating; for the same sailor the
      rating is the same so he or she won't be selected
    - map are all the (sid, sid2) pairs where the first sailors rating is
      greater than the second's
    - $allcombo$ are, e.g., all the boats that Pete and Rick have reserved,
      i.e., Bob should reserve
    - $witness$ are, e.g., the boats that Bob has reserved

- **Datalog**
  $witness(S, B) \leftarrow reserved(S, B, \_)$
  $bad(S) \leftarrow sailors(S, \_, R, \_), sailors(S', \_, R', \_), R > R', \neg witness(S, B), witness(S', B')$
  $good(N) \leftarrow sailors(S, N, \_, \_), \neg bad(S)$