Introduction to Databases

Relational Algebra

under bag semantics

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Problem 1. Under set semantics, the natural join of two expressions with the same sets of attributes is equivalent to their intersection, that is, $R \bowtie S \equiv R \cap S$ whenever R and S are over the same attributes. Under bag semantics, natural join is defined in precisely the same way as under sets (but multiplicities are taken into account, of course), but the above equivalence no longer holds. Your task here is to exhibit a database that witnesses this fact.

Problem 2. For relations R and S with disjoint sets of attributes, the (left) *semi-join operation* $R \ltimes_\theta S$ in Relational Algebra under bag semantics is defined as follows:

$$\bar{r} \in_k R \ltimes_\theta S \iff \bar{r} \in_k R \text{ and there is } \bar{s} \in S \text{ such that } \bar{r}\bar{s} \text{ satisfies } \theta$$

Intuitively, $R \ltimes_\theta S$ returns all records of R, with the multiplicity with which they occur in R, for which there is a record in S such that their concatenation satisfies the condition θ.

Write a Relational Algebra expression that, under bag semantics, is equivalent to the semi-join operation defined above, and uses only primitive operations (possibly including duplicate elimination).