CS 186 Discussion Section
Week 7

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1 Relational Algebra and Calculus

These section notes are brought to you by the letters R and C, and the number π.

1.1 Relational Calculus

The relational calculus is a subset of the first-order predicate calculus, with variables ranging over domains that correspond to relations. Our textbook discusses both the domain and the tuple relational calculus: we'll be focusing on the latter.

The atoms of the TRC are:

1. $T \in Relation$
2. T.a Op Constant
3. T.x Op T.y

and the operators are one of $(>, <, =, <=, >=, !=)$.

$T \in Relation$ lets T range over tuples in the table Relation, T.a Op constant compares an attribute of a tuple to a constant (ie, Sailors.sid = 10), T.x = T.y compares one tuples attribute to another (in the same or another tuple; ie, Sailors.sid = Reserves.sid).

An utterance in the TRC is a formula in one of the following formats:

1. some atom a.
2. $\not p, p \wedge q, p \vee q, p \rightarrow q$
3. $\exists X(p(X))$
4. $\forall X(p(X))$

where p and q are formulae.

You can see from the first format that TRC formulae are recursively defined. An formula in the TRC evaluates to true or false, and the usual logical consequences follow for the boolean operators. $\exists$ is called the 'existential quantifier': it binds its variable over the enclosed formula, and evaluates to true if the enclosed formula is true for any substitution for the quantified variable allowed by the formula. $\forall$ is true only if the enclosed formula is true for all values of the quantified variable.

A query in the TRC is in this format:

$T|p(T)$

which can be read "return all tuples T such that p() holds for T."

Consider this schema:

```
Flight(_fno_, _dt_, from, to, aid)
- pk (fno,dt)
- fk aid->aircraft
Aircraft(_aid_, max_dist, pname)
- pk aid
Booking(_bid_, _passid_, fno, dt)
- pk bid
- fk (fno,dt) -> flights
```

1. Return all bookings for flights out of San Francisco

   $B|B \in Booking \wedge$
   $\exists F(F \in Flight \wedge F.fno = B.fno \wedge F.dt = B.dt \wedge F.from =' SanFrancisco')$

2. Return all the passengers who will fly on a 747:

   $P|\exists B(B \in Booking \wedge \exists F \exists A(F \in Flight \wedge A \in Aircraft \wedge F.fno = B.fno \wedge F.dt = B.dt \wedge F.aid = A.aid \wedge A.pname =' 747' \wedge P.passid = B.passid)$

3. Return cities that have outgoing flights for every type of aircraft.

   $C|\exists F(F \in Flight \wedge C.from = F.from \wedge \forall A(A \in Aircraft \wedge A.aid = F.aid))$

1.2 Relational Algebra

1.2.1 Basic Operators

1. π (Projection) retrieve some subset of the columns of a relation.
2. σ (Selection) retrieve some subset of the rows of a table.
3. X (Crossproduct) or "Cartesian product". given R X S, retrieve all combinations of concatenations of the rows of R and S.
4. $\cup$ (Union). Given $R \cup S$, concatenate the rows of R and S.
5. $-$ (Set minus). Given R - S, return those rows of R that do not occur in S.

1.2.2 Examples

Let's translate to (arbitrary, unoptimized) relational algebra:

1. $\sigma_{F.from='SanFrancisco'}(B \bowtie F)$ (not optimized)
2. $\pi_{B.passid}(\sigma_{A.pname='747'}(B \bowtie F \bowtie A)$
3. $\pi_{F.from}(F/\sigma_{aid}(A))$