Written Assignment #1
CS 6530 Fall 2016

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1. **Problem 1.** Relational Algebra [28pts] Consider the dvdrental schema from the dvdrental database on our database server: `http://www.postgresqltutorial.com/postgresql-sample-database/`. Answer the following queries in relational algebra:

   a) Find the customer ids who have rented all films.

   The customer ids who have rented all films can be found by dividing a relation containing customer id and film rentals for the customer, by a relation containing all film ids. Let $R1$, $I1$ and $F1$ be instances of the rental, inventory and film relations. The following will give the customer ids who have rented all films.

   $$\pi_{customer\_id, film\_id}(R1 \bowtie_{R1.inventory\_id=I1.inventory\_id} I1) / \pi_{film\_id}(F1)$$

   b) Print the store id and the phone number for each store that has only one staff member.

   Let STO, ADR and STA be instances of the store, address and staff relations. In order to find stores with only one staff member, I will subtract the set of stores that have at least two staff members from the set of all stores. I am assuming that since each store has a manager staff id, each store will at least have one staff member who is a manager.

   The $StorePhone$ relation contains stores id and associated phone for all stores.

   $$\rho(StorePhone, \pi_{store\_id, phone}(STO \bowtie_{STO.address\_id=ADR.address\_id} ADR))$$

   The $StoreStaff$ relation contains all staff members associated with a store

   $$\rho(StoreStaff, \pi_{store\_id, phone, staff\_id}(StorePhone \bowtie_{StorePhone.store\_id=STA.store\_id} STA))$$

   The $StoresStaffPair$ relation contains the cross product of the $StoreStaff$ relation with itself.

$$\rho(StoresStaffPair(1 \to store\_id1, 2 \to phone1, 3 \to staff\_id1, 4 \to store\_id2, 5 \to phone2, 6 \to staff\_id2), StoreStaff \times StoreStaff)$$

The $PluralStaffStores$ relation contains stores ids and associated phone numbers of stores with at least two staff members.

$$\rho(PluralStaffStores, \pi_{store\_id1, phone1}(\sigma_{store\_id1=store\_id2 \land staff\_id1 \neq staff\_id2} StoresStaffPair))$$

The $StoresWithOneStaff$ relation is the difference between all stores and stores with at least two staff members. It will thus have the store id and associated phone numbers for stores having only one staff member.

$$\rho(StoresWithOneStaff, StorePhone - PluralStaffStores)$$

c) Find every pair of customer and staff who are from the same city, by listing their customer id and staff id.

This can be done by joining customer address and staff address on city id. Let CST, STF and ADR be instances of the customer, staff and address relations.

$$\rho(CustomerCity, \pi_{customer\_id, city\_id}(CST \bowtie_{CST.address\_id=ADR.address\_id} ADR)$$

$$\rho(StaffCity, \pi_{staff\_id, city\_id}(STF \bowtie_{STF.address\_id=ADR.address\_id} ADR)$$

The relations $CustomerCity$ and $StaffCity$ will contain the customer and staff ids respectively along with the city id of their address. If we do a natural join on these two relations, we can obtain a relation with customer id and staff id that are from the same city.

$$\pi_{customer\_id, staff\_id}(CustomerCity \bowtie StaffCity)$$

d) Find the customer ids who *have rented all and only those* films acted by Emily Dee.

First we find all the films acted by Emily Dee. $FACT$ and ACT are instances of relations film_actor and actor. The relation $EmilyDeeFilms$ will contain film ids of all films that Emily Dee acted in.

$$\rho(EmilyDeeFilms, \pi_{film\_id}(FACT \bowtie \pi_{actor\_id}(\sigma_{first\_name="Emily" \land last\_name="Dee"}(ACT))))$$

Next we find the relation containing all customer film rentals. INV and RNT are instances of the inventory and rental relations.

$$\rho(CustFilmRentals, \pi_{customer\_id, film\_id}(INV \bowtie_{INV.inventory\_id=RNT.inventory\_id} RNT))$$

The following relation will give the customer ids who have rented all and only those films acted by Emily Dee.

$$CustFilmRentals / EmilyDeeFilms$$

2. **Problem 2.** [28pts] Answer following queries using Tuple Relational Calculus.

a) Find the customer ids who have rented all films.

$$\{P \mid \exists C \in customer \; \exists R \in rental \; \exists I \in inventory \land \forall F \in film($$
$$C.customer\_id = R.customer\_id \land$$
$$R.inventory\_id = I.inventory\_id \land$$
$$I.film\_id = F.film\_id \land$$
$$P.customer\_id = C.customer\_id$$
$$)\}$$

b) Print the store id and the phone number for each store that has only one staff member.

$$\{P \mid \exists STO \in store \; \exists STA1 \in staff \; \exists STA2 \in staff \; \exists ADR \in address$$
$$\neg(STA1.store\_id = STO.store\_id \land$$
$$STA2.store\_id = STO.store\_id \land$$
$$STO.address\_id\_id = ADR.address\_id \land$$
$$STA1.staff\_id \neq STA2.staff\_id \land$$
$$P.store\_id = STO.store\_id \land$$
$$P.phone = ADR.phone)\}$$

c) Find every pair of customer and staff who are from the same city, by listing their customer id and staff id.

$$\{P \mid \exists C \in customer \; \exists S \in staff \; \exists A1 \in address \; A2 \in address$$
$$(C.address\_id = A1.address\_id \land$$
$$S.address\_id = A2.address\_id \land$$
$$A1.city\_id = A2.city\_id \land$$
$$P.customer\_id = C.customer\_id \land$$
$$P.staff\_id = S.staff\_id)\}$$

d) Find the customer ids who *have rented all* films acted by Emily Dee (slightly modified from Problem 1).

$$\{P \mid \exists R \in rental \; \exists I \in inventory \; \exists F \in film \; FA \in film\_actor \land \forall A \in actor$$
$$(R.inventory\_id = I.inventory\_id \land$$
$$I.film\_id = F.film\_id \land$$
$$F.film\_id = FA.film\_id \land$$
$$FA.actor\_id = A.actor\_id \land$$
$$A.first\_name = "Emily" \land$$
$$A.last\_name = "Dee" \land$$
$$P.customer\_id = R.customer\_id)\}$$