University of Toronto
CSC343, Fall 2016

Assignment 1: Sample Solutions

Note that there are multiple correct answers to all of these questions.

1. Find all patients who (a) have had more than 2 different doctors write them a prescription, and (b) have had a narcotic prescribed to them by every doctor who has written them a prescription. A narcotic is a drug whose schedule is "narcotics". Report the patient's OHIP number.

   – patient has had more than 2 different doctors write them a prescription.

   two_doctors(patient) := $\Pi_{P1.patient}(\sigma_{P1.patient=P2.patient=P3.patient \wedge P1.doctor \neq P2.doctor \neq P3.doctor}(\rho_{P1}(Prescription) \times \rho_{P2}(Prescription) \times \rho_{P3}(Prescription)))$

   – drug is a narcotic.

   narcotics(drug) := $\Pi_{DIN}(\sigma_{schedule="narcotics"}Product)$

   – patient has had something prescribed by doctor.

   prescribed(patient, doctor) := $\Pi_{patient,doctor}(Prescription)$

   – patient has had a narcotic prescribed by doctor.

   prescribed_narcotic(patient, doctor) := $\Pi_{patient,doctor}(Prescription \bowtie narcotics)$

   – patient should have had a narcotic prescribed by this doctor (who gave patient a prescription)
   – in order to be in the result.

   should_have(patient, doctor) := $\Pi_{patient,doctor}(two\_doctors \bowtie (\Pi_{doctor}Prescription))$

   – patient did not having a narcotic prescribed by a doctor who gave patient a prescription.

   missed(patient) := $\Pi_{patient}(should\_have - prescribed\_narcotic)$

   – patient had a narcotic prescribed by *every* doctor who gave patient a prescription.

   every(OHIP) := $two\_doctors - missed$

2. Find every prescription from 2016 that has never been filled. Report the patient's OHIP number, the prescription ID, prescription date, and drug.

   Prescription_2016(RxID) := $\Pi_{RxID}(\sigma_{date.year=2016}Prescription)$

   Filled_2016(RxID) := $\Pi_{RxID}(Prescription\_2016 \bowtie Filled)$

   Not_Filled(RxID) := $Prescription\_2016 - Filled\_2016$

   Results(OHIP, RxID, date, drug) := $\Pi_{patient,RxID,date,drug}(Not\_Filled \bowtie Prescription)$

3. Find the pharmacist who has trained the most people. Report the pharmacist's OCP number and name.

   Cannot be expressed in RA.

4. The "narcotics prescription period" of a doctor for a patient is the time from the first prescription for narcotics from that doctor for that patient to the most recent one. (It would be zero if that doctor wrote only one prescription for narcotics for that patient.) Find all patients who have had narcotics prescribed by two or more doctors, and for whom the narcotics prescription periods never overlap. In other words, if they had narcotics prescribed by n different doctors,

$$[start_1..end_1] < [start_2..end_2] < ... < [start_n..end_n]$$

   where $start_i$ and end_i are the start and end of the narcotics prescription period of doctor i for that patient. Notice that we have written strictly less than. This means that if $end_i = start_{i+1}$ we do not consider that the periods overlap. Report the patient's OHIP number.

   narcotic_rx(patient, doctor, date) := $\Pi_{patient,doctor,date}$
   $(Product \bowtie_{DIN=drug \wedge schedule='narcotics'} Prescription)$

   not_first(patient, doctor, date) := $(\Pi_{P2.patient,P2.doctor,P2.date}$
   $(\sigma_{P1.patient=P2.patient \wedge P1.doctor=P2.doctor \wedge P1.date<P2.date}$
   $(\rho_{P1}(narcotic\_rx) \times \rho_{P2}(narcotic\_rx)))$

   first(patient, doctor, begin_date) := $narcotic\_rx - not\_first$

   not_last(patient, doctor, date) := $(\Pi_{P1.patient,P1.doctor,P1.date}$
   $(\sigma_{P1.patient=P2.patient \wedge P1.doctor=P2.doctor \wedge P1.date<P2.date}$
   $(\rho_{P1}(narcotic\_rx) \times \rho_{P2}(narcotic\_rx)))$

   last(patient, doctor, last_date) := $narcotic\_rx - not\_last$

   pres_begin_end(patient, doctor, begin_date, end_date) := $first \bowtie last$

   overlapping(patient) := $\Pi_{P1.patient}$
   $(\sigma_{P1.patient=P2.patient \wedge P1.doctor \neq P2.doctor \wedge P1.end\_date \geq P2.begin\_date \vee P1.begin\_date \leq P2.end\_date}$
   $(\rho_{P1}(pres\_begin\_end) \times \rho_{P2}(pres\_begin\_end)))$

   result(OHIP) := $\Pi_{patient}(pres\_begin\_end) - overlapping$

5. Find all pharmacists who have never filled a prescription for a drug product whose active ingredient is "codeine". Report their OCP number and every schedule for which they *have* filled a prescription. Put the information into a relation with attributes "OCP" and "schedule".

   codeine_drug(drug) := $\Pi_{DIN}(\sigma_{name="codeine"} ActiveIngredient)$

   prescription_codeine(RxID) := $\Pi_{RxID}(Prescription \bowtie codeine\_drug)$

   pharmacist_filled_codeine(OCP) := $\Pi_{pharmacist}(Filled \bowtie prescription\_codeine)$

not_filled_codeine(OCP) := $\Pi_{OCP} Pharmacist - pharmacist\_filled\_codeine$

pharmacist_filled_drugs(OCP, DIN) := $\Pi_{pharmacist,drug}(\sigma_{Filled.RxID=Prescription.RxID}(Filled \times Prescription))$

all_pharmacist_schedule(OCP, schedule) := $\Pi_{OCP,schedule}(pharmacist\_filled\_drugs \bowtie Product)$

Results(OCP, schedule) := $all\_pharmacist\_schedule \bowtie not\_filled\_codeine$

6. Lets say a minor trainer is a pharmacist who has trained no more than two people. (They may have trained none.) Find all pharmacists who have trained 2 or more minor trainors. (They may have trained other pharmacists who were not minor trainors.) Report the pharmacist's OCP number.

   not_minor(OCP) := $\Pi_{T1.P2}(\sigma_{T1.P2=T2.P2 \wedge T1.P2=T3.P2 \wedge T1.P1 \neq T2.P1 \wedge T1.P1 \neq T3.P1 \wedge T2.P1 \neq T3.P1}$
   $(\rho_{T1}(TrainedUnder) \times \rho_{T2}(TrainedUnder) \times \rho_{T3}(TrainedUnder)))$

   minor(P1) := $\Pi_{OCP} Pharmacist - not\_minor(OCP)$

   minor_trained(P1, P2) := $\Pi_{P1,P2}(minor \bowtie TrainedUnder)$

   Results(OCP) := $\Pi_{T1.P2}(\sigma_{T1.P2=T2.P2}(\rho_{T1}(minor\_trained) \times \rho_{T2}(minor\_trained)))$

7. Find the most junior pharmacist: the pharmacist whose first time filling a prescription has the latest date. Report the pharmacist's OCP number, the prescription ID for the first prescription they filled, the date on which it was written, and the date on which it was filled.

   filling_dates(OCP, date) := $\Pi_{pharmacist,date} Filled$

   not_first_filling_date(OCP, date) := $\Pi_{F2.pharmacist,F2.date}$
   $(\sigma_{F1.pharmacist=F2.pharmacist \wedge F1.date<F2.date}(\rho_{F1}(filling\_dates) \times \rho_{F2}(filling\_dates)))$

   first_filling_date(OCP, date) := $filling\_dates - not\_first\_filling\_date$

   not_junior(OCP, date) := $\Pi_{F2.OCP,F2.date}$
   $(\sigma_{F1.date<F2.date}(\rho_{F1}(first\_filling\_date) \times \rho_{F2}(first\_filling\_date)))$

   junior(pharmacist, date) := $\Pi_{OCP}(first\_filling\_date - not\_junior)$

   prescribed_date(RxID, date_written) := $\Pi_{RxID,date} Prescription$

   Result(OCP, RxID, date_written, date_filled) := $\sigma_{pharmacist,RxID,date\_written,date}(prescribed\_date \bowtie Filled \bowtie junior)$

8. Find every patient who has had a prescription for a homeopathic drug product filled, that is, a product whose schedule is "homeopathic", but has never had a prescription filled for a drug product with any other schedule.

filled_Rx(RxID) := $\Pi_{RxID} Filled$

all_prescribed(patient, DIN) := $\Pi_{patient,drug}(Prescription \bowtie filled\_Rx)$

prescribed_schedule(patient, schedule) := $\Pi_{patient,schedule}(all\_prescribed \bowtie Product)$

different_schedule(patient) := $\Pi_{P1.patient}$
$(\sigma_{P1.patient=P2.patient \wedge P1.schedule \neq P2.schedule \wedge P1.schedule=\text{“}homepathic''}$
$(\rho_{P1}(prescribed\_schedule) \times \rho_{P2}(prescribed\_schedule)))$

Result(patient) := $\Pi_{patient} prescribed\_schedule - different\_schedule$

9. Find all patients who have had at least two prescriptions for narcotics that have a single active ingredient, whose units are mg, and for whom the dosage of the ingredient in these prescriptions never decreased from one prescription to the next. Report their OHIP number.

not_single_ingredient(DIN) := $\Pi_{A1.DIN}(\sigma_{A1.DIN=A2.DIN \wedge A1.name \neq A2.name}(\rho_{A1}(ActiveIngredient) \times \rho_{A2}(ActiveIngredient)))$

single_ingredient(DIN) := $\Pi_{DIN} Product - not\_single\_ingredient$

mg_narcotics_ingredient(DIN) := $\Pi_{DIN}(\sigma_{unit='mg' \wedge schedule='narcotics'}$
$(single\_ingredient \bowtie ActiveIngredient \bowtie Product))$

at_least_two(patient, RxID, drug, dosage) := $\Pi_{P1.patient,P1.RxID,P1.drug,P1.dosage}$
$(\sigma_{P1.patient=P2.patient \wedge P1.drug=M1.DIN \wedge P2.drug=M1.DIN \wedge P1.RxID \neq P2.RxID}$
$(\rho_{P1}(Prescription) \times \rho_{P2}(Prescription) \times \rho_{M}(mg\_narcotics\_ingredient)))$

non_decreasing(patient) := $\Pi_{A1.patient}$
$(\sigma_{A1.patient=A2.patient \wedge A1.drug=A2.drug \wedge A1.date<A2.date \wedge A1.dosage>A2.dosage}$
$(\rho_{A1}(at\_least\_two) \times \rho_{A2}(at\_least\_two))$
result(OHIP) := $\Pi_{patient} Prescription - non\_decreasing$

10. Report the OCP number of the pharmacist who has had the greatest number of other pharmacists train under him or her.

Cannot be expressed by RA.

11. For each pharmacist who has trained anyone, report their OCP number, the OCP number of the first person to complete training under them, and the OCP number of the last person to complete training under them. Your resulting relation should have three attributes: “OCP”, “first” and “last”.

not_first(P2, P1) := $\Pi_{T2.P2,T2.P1}(\sigma_{T1.P2=T2.P2 \wedge T1.completed)<T2.completed)}(\rho_{T1} TrainedUnder \times \rho_{T2} TrainedUnder))$

first(P2, first) := $\Pi_{P2,P1} TrainedUnder - not\_first$

not_last(P2, P1) := $\Pi_{T1.P2,T1.P1}(\sigma_{T1.P2=T2.P2 \wedge T1.completed)<T2.completed)}(\rho_{T1} TrainedUnder \times \rho_{T2} TrainedUnder))$

last(P2, last) := $\Pi_{P2,P1} TrainedUnder - not\_last$

Result(OCP, first, last) := $\Pi_{P2,first,last}(first \bowtie last)$

12. Find all people who have, at least twice, had more than one prescription filled in a year, but haven't had one filled since 2014. Report the person's OHIP number and the last date on which they had a prescription filled.

    pres(RxID, patient) := $\Pi_{RxID,patient} Prescription$

    filled_pres(patient, date, RxID) := $\Pi_{patient,date,RxID}(\sigma_{date.year<2014}(pres \bowtie Filled))$

    more_than_one(patient, year) := $\Pi_{F1.patient,F1.date.year}$
    $(\sigma_{F1.date.year=F2.date.year \wedge F1.patient=F2.patient \wedge F1.RxID \neq F2.RxID}(\rho_{F1}(filled\_pres) \times \rho_{F2}(filled\_pres)))$

    at_least_twice(patient) := $\Pi_{patient}(\sigma_{M1.patient=M2.patient \wedge M1.year \neq M2.year}$
    $(\rho_{M1}(more\_than\_one) \times \rho_{M2}(more\_than\_one)))$

    qualified_patients(patient, date) := $filled\_pres \bowtie at\_least\_twice$

    not_last(patient, date) := $\Pi_{Q2.patient,Q2.date}(\sigma_{Q1.patient=Q2.patient \wedge Q1.date>Q2.date}$
    $(\rho_{Q1}(qualified\_patients) \times \rho_{Q2}(qualified\_patients)))$

    results(patient, last_date) := $qualified\_patients - not\_last$

Part 2: Additional Integrity Constraints

Express the following integrity constraints with the notation $R = \emptyset$, where R is an expression of relational algebra. You are welcome to define intermediate results with assignment and then use them in an integrity constraint.

1. A pharmacist can only train under someone who registered with the Ontario College of Physicians before they did.

   trainer(P2, date2) := $\Pi_{OCP,registered} Pharmacist$

   trainee(P1, date1) := $\Pi_{OCP,registered} Pharmacist$

   $\sigma_{date1<date2}(trainee \bowtie TrainedUnder \bowtie trainer) = \emptyset$

2. A doctor can't prescribe a controlled substance (a product with schedule "narcotics") until after they have prescribed three different over-the-counter drug products (products with schedule "OTC").

   – get all over the counter drugs and controlled substances (i.e., narcotics)

otc(drug) := $\Pi_{DIN}(\sigma_{schedule=\text{“}OTC\text{”}} Product)$
narcotics(drug) := $\Pi_{DIN}(\sigma_{schedule=\text{“}narcotics\text{”}} Product)$

– get all prescriptions for over the counter drugs and narcotics

otc_prescription(doctor, drug, date) := $\sigma_{doctor,drug,date}(otc \bowtie Prescription)$
narcotics_prescription(doctor, drug, date) := $\sigma_{doctor,drug,date}(narcotics \bowtie Prescription)$

– find the earliest narcotic prescription for each doctor

not_first_narcotic(doctor, date) := $\Pi_{N1.doctor,N1.date}$
$(\sigma_{N1.doctor=N2.doctor \wedge N1.date>N2.date}(\rho_{N1}(narcotic\_prescription) \times \rho_{N2}(narcotic\_prescription)))$
first_narcotic(doctor, narcotic_date) := $\Pi_{doctor,date}(narcotic\_prescription) - not_first_narcotic$

– find all doctors with at least three over the counter prescriptions

at_least_three(doctor, date1, date2, date3) := $\Pi_{P1.doctor,P1.date,P2.date,P3.date}$
$(\sigma_{(P1.doctor=P2.doctor \wedge P1.doctor=P3.doctor \wedge P1.drug \neq P2.drug \wedge P1.drug \neq P2.drug \wedge P2.drug \neq P3.drug)}$
$(\rho_{P1}(otc\_prescription) \times \rho_{P2}(otc\_prescription) \times \rho_{P3}(otc\_prescription)))$

– filter down to doctors with three over the counter prescriptions prior to first narcotic prescription

three_otc_before_narc(doctor) := $\Pi_{doctor}(\sigma_{date1<narcotic\_date \wedge date2<narcotic\_date \wedge date3<narcotic\_date}($
$at\_least\_three \bowtie first\_narcotic))$

– get any doctors that don't have three prescriptions prior to first narcotic prescription. note that this may include doctors who have never prescribed a narcotic, but that is addressed in the final step

less_than_three_otc(doctor) := $\Pi_{doctor} Prescription - three\_otc\_before\_narc$

– find the doctors with a narcotic prescription, but less than three over the counter prescriptions prior to it

$less\_than\_three\_otc \bowtie narcotics\_prescription = \emptyset$