csc343 winter 2021
assignment #1: relational algebra
due February 12th, 4 p.m.

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relations

- Batch(<u>bID</u>, mID, productionDate, vialCount)
  Vaccine batch *bID*, manufacturer *mID*, was produced on *productionDate*, with *vialCount* vials in this batch.
- Vial(<u>vID</u>, bID, thawTime, dose_count)
  Vial *vID* from batch *bID* removed from cold storage at *thawTime*, with *dose_ count* doses remaining.[1]
- Manufacturer(<u>mID</u>, name, thawMax, intervalMin, intervalMax)
  Manufacturer *mID*, with company *name*, *thawMax* maximum hours vaccine is usable after being removed from cold storage, *intervalMin* minimum days to second dose, *intervalMax* maximum days to second dose (both zero for a single-dose vaccine).
- Tracking(<u>bID</u>, canadaDate, locationDate, locationName)
  Batch *bID* arrived in Canada on *canadaDate*, shipped to province or territory *locationName* on *locationDate*.
- Vaccination(<u>pID, date</u>, vID, adID, atID, reaction, covidStatus)
  Patient *pID* vaccinated on *date* from vial *vID*. The dose was administered by *adID*, the patient was attended by *atID*. At vaccination time the patient had infection status *covidStatus* and reaction to vaccine *reaction*.
- Patient(<u>pID</u>, latestPositiveTest)
  Patient *pID* had most recent positive Covid-19 test on *latestPositiveTest* (00:00:00, January 1st, 1970 if this never happened).
- Staff(<u>sID</u>, pID, specialty)
  Medical staff *sID* is also patient *pID*, and has medical specialty *speciality*.

our constraints

For each of the following constraints give a one sentence explanation of what the constraint implies, and why it is required.

[1] A timestamp of 00:00:00, January 1st, 1970 is recorded for any events that have not happened (yet).

- $\Pi_{pID} Staff - \Pi_{pID} Patient = \emptyset$

  Solution: Staff pID subset Patient pID. the vaccines administer by the staff to the patients (must belong in the patients Relation).

- $(\Pi_{adID} Vaccination \cup \Pi_{atID} Vaccination) \subseteq \Pi_{sID} Staff$

  Solution: Administrators and Attendants authorized to administer a vaccine must be staff. This is because patients can not administer vaccines on themselves without prior medical knowledge.

- $\Pi_{specialty} Staff \subseteq \{'RN','RPN','MD','Pharmacist'\}$

  Solution: Staff specialty must be RN or RPN or MD or Pharmacist. This is a requirement as the professions mentioned above are licensed professionals and can aid it diagnosing COVID.

- $\Pi_{pID} Vaccination \subseteq \Pi_{pID} Patient$

  Solution: Patients vaccinated must be present in the patients table. Patients who have had the most recent positive COVID test should get vaccinated to reduce this threat.

- $\Pi_{bID} Vial - \Pi_{bID} Batch = \emptyset$

  Solution: One cannot enter a vial from a batch that was not recorded in the batch table in the Vial table. This is because a vial must come from a registered batch produced by a manufacture.

- $\Pi_{covidStatus} Vaccination \subseteq \{'positive','negative'\}$

  Solution: Covid test can only have two vales i.e positive or negative. Covid status of the patients makes it easier to diagnose and store data in the database.

- $\Pi_{reaction} Vaccination \subseteq \{'true','false'\}$

  Solution: Reaction can be either true or false. This is because the even if the patient has one negative symptom this would classify the reaction as bad else it would be classified as good.

- $\Pi_{mID} Batch \subseteq \Pi_{mID} Manufacturer$

  Solution: Manufacture is the superset and all batches mId needs to come from the manufacturers. This is to ensure we can have adequate quality control.

- $\Pi_{bID} Tracking - \Pi_{bID} Batch = \emptyset$

  Solution: bId of tracking has to be a subset of Batches as they get shipped to different places and the difference between has to be 0 as bId is a key in both relations. This can used used as a quality control measure to make sure than no place has received unauthorized vaccines.

- **UPDATED 6/2/21** $\Pi_{vID} Vaccination - \Pi_{vID} Vial = \emptyset$

  Solution: Every dose extracted from a vial to administer a vaccine must be a to the Vial relation (must be a subset). The vial used were those sent by authorized manufacturers.

You must use notations from this course and operators:

$$\pi, \sigma, \rho, \bowtie, \bowtie_{condition}, \times, \cap, \cup, -, =$$

queries

1. Rationale: Let's see how well we're doing.

   Query: Find pID of all patients who have received all required doses since the beginning of December 2020.

   Solution:

   - First, we check if the vIds for the Vials used to Vaccinate and vIds of the Vaccinated are the same and then display all the patients who vaccinated since the beginning of December 2020.

   - We also also for the patients that do not require any more vaccinations by setting dose count = 0.

   - We also assume that the Date follows the following format <ddmmyyhhmmss>.

   $\pi_{pID}\ \sigma_{Vacinnation.vId = Vial.vId \wedge\ date\ >\ 011220000000\ \wedge\ dose\_count\ =\ 0}(Vaccination \bowtie Vial)$

   Query: Find the names of all provinces or territories that have used vaccine from every manufacturer in their vaccinations.

   Solution:

   - First, we find all the manufacturers that have manufactured the distributed batches of vaccines.

   $allManu(bId) := \pi_{bID}\ \sigma_{Batch.mId\ =\ Manufacture.mId}\ (Batch \bowtie Manufacture)$

   - Then, we display all the location names that these batches were shipped too by comparing the batch Ids with the Tracking relation.

   $allShipped(locationname, bId) := \pi_{locationname, Tracking.bId} \sigma_{allManu.bId\ =\ Tracking.bId}(allManu \bowtie Tracking)$

   - Then, we find out which amongst the shipped batches of vaccines were used were used.

   $allUsed(bId) := \pi_{bId}\ \sigma_{Vial.vId\ =\ Vaccination.vId}\ (Vial \times Vaccination)$

   - And finally we display the names of all provinces or territories that have used vaccine from every manufacturer in their vaccinations.

   $\pi_{locationname}\ \sigma_{allUsed.bId\ =\ allShipped.bId}\ (allUsed \bowtie allShipped)$

2. Rationale: Let's see how badly we're doing.

   Query: Find pID of all patients who are still waiting for a subsequent dose more than the maximum number of days recommended by the manufacturer.

   Solution:

   Query: Find sID of all staff who administered a vaccination from a vial that had thawed longer than recommended by the manufacturer.

   Solution:

   - First, we find all the vaccines that were thawed longer than the recommended by the manufacturer.

   $thawLong(vId) := \pi_{vId}\ \sigma_{(date - thawtime)\ >\ thawmax}\ (Vial \bowtie Manufacture)$

   - Then, we find all the staff Ids of the staff that administered vaccines from the vials to patients.

   $vaccineAdmin(sId, vId) := \pi_{sId, vId}\ \sigma_{(Staff.pId\ =\ Vaccination.pId)}\ (Staff \bowtie Vaccination)$

   - Lastly we find all the sID of all staff who administered a vaccination from a vial that had thawed longer than recommended by the manufacturer using both thawLong and vaccineAdmin relations.

$\pi_{sId}\, \sigma_{(thawLong.vId = vaccineAdmin.vId)}\, (thawLong \bowtie vaccineAdmin)$

Query: Find vID of all vials with 4 or fewer doses used by the time they had exceeded the maximum time recommended by the manufacturer after thawing.

Solution:

- Similar to the last question, in addition to that we also check the remaining does count for the patients and display the results.

$\pi_{vId}\, \sigma_{(date-thawtime) > thawmax \wedge dose\_count <= 4}\, (Vial \bowtie Manufacture)$

3. Rationale: Trace exposures.

   Query: Staff sID_1 is exposed to covid-positive staff sID_2 if:

   (a) staff sID_2 administered or attended staff sID_1's vaccination,

   (b) staff sID_1 administered or attended staff sID_2's vaccination,

   (c) or if some staff exposed to sID_2 administered or attended sID_1's, or had a vaccination administered or attended by sID_1. vaccination.

   Find sID of all staff exposed to covid-positive staff sID 42.

   Solution:

   -Staff that attended or administered patient 42's vaccination.

   $patient42Staff := \pi_{Staff.sID}(\sigma_{(Vaccination.adID=Staff.sID) \vee (Vaccination.atID=Staff.sID)}$
   $(\pi_{adID,atID}(\sigma_{pID=42}(Vaccination)) \times Staff))$

   -Staff whose vaccination was either administered or attended by patient 42.

   $patient42isStaff := \pi_{sID}(((\sigma_{adID=42 \vee atID=42}((\pi_{pID}(Staff) \bowtie Vaccination)))) \bowtie Staff)$

   -All staff exposed to COVID staff sID 42.

   $patient42Staff \cup patient42isStaff$

4. Rationale: Find versatile staff.

   Query: Find all staff who have worked to both administer vaccines and attend patients (not necessarily at the same vaccination).

   Solution:

   - All staff who attended vaccines.

   $atID := \pi_{atID}(Vaccination)$

   - All staff who administered vaccines.

   $adID := \pi_{adID}(Vaccination)$

   - All staff that have both administered and attended a vaccination

   $atID \cap adID$

5. Rationale: Quality control.

   Query: Find the staff who gave the most recent Moderna vaccine that had a bad ('true') reaction. Keep ties.

   Solution:

   - Moderna's mID

   $modernaMID := \pi_{mID}\ (\sigma_{name='Moderna'}(Manufacturer))$

   - All batches produced by moderna

   $modernaBatches := \pi_{bID}\ (Batch \bowtie modernaMID)$

   - All vials associated with moderna

   $modernaVials := \pi_{Vial.vID}\ (Vial \bowtie modernaBatches)$

   - All administered moderna vaccines where reaction is bad

   $modVacBadReac := \sigma_{reaction='true'}\ (Vaccination \bowtie modernaVials)$

   - All moderna vaccinations that were administered earliest (earliest by date in relation to the time they arrived)

   $earliestDates := \pi_{v2.date}(\sigma_{v1.date>v2.date}(\rho_{v1}\ modVacBadReac \times \rho_{v2}\ modVacBadReac))$

   - Recently administrated Moderna Vacs

   $mostRecentVacs := modVacBadReac.date - earliestDates$

   - Staff who gave most recent Moderna vaccination

   $\pi_{adID}\ Vaccination \bowtie mostRecentVacs$

   Query: Find all patients who did not have a positive covid status when they were vaccinated in Ontario, but did have a positive test at some later date (possibly in a different province or territory).

   Solution:

   - Batches associated with Ontario

   $ontarioBatches := \pi_{bID}\ (\sigma_{locationName='Ontario'}\ (Tracking))$

   - Vials associated with Onatrio

   $ontarioVials := \pi_{Vial.vID}\ (Vial\ \bowtie\ ontarioBatches)$

   - Ontario based patients with negative stats

   $negativeOntarians := \pi_{pID}\ (\sigma_{covidStatus='negative'}\ (Vaccination\ \bowtie\ ontarioVials))$

   - Onatrio patients who tested positive elsewhere after they tested negative in Ontario

   $positiveafterON := \pi_{negativeOntarians.pID}$
   $(\sigma_{Vaccination.covidStatus='positive' \wedge Vaccination.date > negativeOntarians.date}(Vaccination \bowtie negativeOntarians))$
   $positiveafterON\ \cup\ negativeOntarians$

your constraints

For each of these constraints you should derive a relational algebra expression of the form $R = \emptyset$, where R may be derived in several steps, by assigning intermediate results to a variable. If the constraint cannot be expressed in the relational algebra you have been taught, write "cannot be expressed."

1. No vial is in two different batches.

   Solution:

   - Extract all the unique vIDs associated with batches.

   $vialIds(vId, bId) := \pi_{vId,bId}\,(Vial)$

   - Extract all the unique Batch Ids.

   $batchIds(bId) := \pi_{bId}\,(Batch)$

   - Extract all unique vids from the unique bids and store in a variable.

   $vIdfromBatches(vId, bId) := \pi_{vId,vialIds.bId}\,\sigma_{(vialIdad.bId = BatchIds.bId)}\,(vialIdad \bowtie BatchIds)$

   - Subtracting vIds from relations above will give an empty set.

   $\pi_{vId} vIdfromBatches\ -\ \pi_{vId} vialIds\ =\ \emptyset$

2. No patient receives vaccines from two different manufacturers.

   Solution:

   - Find all the patients that receive a vaccination from the vial

   $allPatients(pId, vId) :=\ \pi_{pID,Vial.vId}\,\sigma_{Vacinnation.vId = Vial.vId}(Vaccination \bowtie Vial)$

   - Extract all the unique vials from the batch

   $uniqueVials(vId, mId) :=\ \pi_{vID,mId}\,\sigma_{Batch.vId = Vial.vId}(Batch \bowtie Vial)$

   - Find the unique manufactures that produce these vials.

   $uniqueManufacturer(vId) := \pi_{vID}\sigma_{uniqueVials.mId = Manufacture.mId}(uniqueVials \bowtie Manufacture)$

   - Find the patients that have been vaccinated from the above mentioned vials

   $patientsVaccinatedByUniqueManu(pid) := \pi_{pID}\sigma_{Vaccination.vId = uniqueManufacturer.vId}(Vaccination \bowtie uniqueManufacturer)$

   - The difference between the two found patients should be an empty set

   $\pi_{pId}\,allPatients\ -\ patientsVaccinatedByUniqueManu\ =\ \emptyset$

3. No patient is vaccinated with more than two doses.

   Solution:

   - Assume maximum doses per patient is three

   $threeDoses := \pi_{v1.pID}$
   $(\sigma_{v1.pID = v2.pID \wedge v2.pID = v3.pID \wedge v1.pID = v3.pID \wedge v1.date\ != v2.date \wedge v2.date\ != v3.date \wedge v1.date\ != v3.date}$
   $(\rho_{v1} Vaccination\ x\ \rho_{v2} Vaccination\ x\ \rho_{v3} Vaccination))$

   - Obtaining two doses

   $twoDoses := \pi_{v1.pID}$
   $(\sigma_{v1.pID = v2.pID \wedge v1.date\ != v2.date})$
   $(\rho_{v1}\,Vaccination \times\ \rho_{v2}\,Vaccination)$

   - Constraint

   $threeDoses\ -\ twoDoses\ =\ \emptyset$

4. All staff receive at least one vaccination dose before they either administer, or attend, vaccinations.

   Solution:

   - Instances when staff are patient

   $whenStaffPatient := \pi_{Vaccination.date} Vaccination \bowtie Staff$

   - Instances when staff works

   $whenStaffWorks := \pi_{Vaccination.date}$
   $\sigma_{Staff.sID = vaccination.atID \vee Staff.sID = Vaccination.adID}(Vaccination \times Staff)$
   $whenStaffPatient - whenStaffWorks = \emptyset$

5. No vaccine is administered before it arrives in some Canadian territory or province.

   Solution:

   - Batch and associated with used vaccines

   $batchofUsedVials := \pi_{Vaccination.date\,,\,bID}\,(Vaccination \bowtie Vial)$

   - Arrival dates associated with Batches and their respective bID.

   $batchArrivalDate := \pi_{locationDate\,,\,bID}\,(Tracking)$
   $batchArrivalDate - batchofUsedVials = \emptyset$