

# Exercise sheet for Session 2

## Uncertain data management

Antoine Amarilli

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### 1 Exercise 1.

Consider a database schema that consists of the following tables:

- Class(**class**, **date**, **teacher**, **room**), indicating the planned classes
- Sick(**teacher**, **date**), indicating the dates at which a teacher is sick
- Unavail(**teacher**, **date**), indicating when a teacher is more generally unavailable
- Closed(**date**), indicating dates at which the entire school is closed
- Canceled(**class**, **date**), the occurrences of classes that have to be canceled.

Remember that a *tuple-generating dependency* is a rule of the form:

$$\forall \mathbf{x} \phi(\mathbf{x}) \Rightarrow \exists \mathbf{y} \psi(\mathbf{x}, \mathbf{y})$$

where  $\phi$  and  $\psi$  are conjunctions of atoms. An *inclusion dependency* is a tuple-generating dependency where  $\phi$  and  $\psi$  consist of a single atom without repeated variables.

**Question 1.** Write tuple-generating dependencies to express the following:

- When the school is closed, all planned classes on that day are canceled
- When a teacher is sick on a day, then they are unavailable on that day
- When a teacher is unavailable on a day, all classes that they planned to give on that day are canceled

**Question 2.** Which of these tuple-generating dependencies are inclusion dependencies?

**Question 3.** Write a conjunctive query  $Q$  that asks which classes are canceled on November 28th. (Do not assume that the Canceled table only contains classes; only return answers that occur in the Class table.) Write it in the relational calculus, and in the relational algebra.

**Question 4.** Consider the database instance that contains the following facts:

- John is sick on November 28th
- The class with **class** “UDM” is taught by Antoine on November 28th in room C017
- The class with **class** “FOO” is taught by John on November 28th in room C42
- The class with **class** “UDM” is taught by Antoine on December 5th in room C47
- The school is closed on December 5th

Construct the chase of this instance by the dependencies of Question 1.

**Question 5.** Evaluate  $Q$  on the chase. What can we deduce from this?

**Question 6.** The chase in Question 4 was finite. Would the chase by the dependencies of Question 1 be finite for any database instance? Why, or why not?

**Question 7.** Rewrite the query  $Q$  (in the relational calculus) to a union of conjunctive queries  $Q'$  such that, for any instance,  $Q'$  holds on the instance iff  $Q$  is entailed by the instance and the dependencies of Question 1.

## 2 Exercise 2.

Consider a database schema that consists of the following tables:

- Jedi(**jedi**), indicating the list of known Jedis
- Teach(**master, padawan**), indicating which Jedi trained which Jedi
- Light(**jedi**), indicating which Jedis are on the light side of the force
- Dark(**jedi**), indicating which Jedis are on the dark side of the force

**Question 1.** Write tuple-generating dependencies  $\Sigma$  that express the following:

- Anybody on the light side of the force is a Jedi
- Likewise for anybody on the dark side of the force
- If a master teaches a padawan, then both are Jedis
- Every Jedi was taught by some master
- Whenever some padawan is on the light side of the force and was taught by a master, then the master is on the dark side of the force.
- Conversely, when a padawan is on the dark side of the force, any master is on the light side of the force.

**Question 2.** Which one of these dependencies are inclusion dependencies? Which ones can be rewritten to be inclusion dependencies?

**Question 3.** Consider the instance  $I$  where the Jedis are Obi-wan (light side) and Anakin (dark side), and the first taught the second. Is the chase of this instance by  $\Sigma$  finite? Why?

Is the chase accurate with respect to the Star Wars movies?

**Question 4.** Is there an instance  $I$  whose chase by  $\Sigma$  is finite?

**Question 5.** Write a conjunctive query  $Q$  that asks whether a dark Jedi trained a dark Jedi. Write it both in the relational algebra and in the relational calculus.

**Question 6.** Is  $Q$  entailed by the instance  $I$  and tuple-generating dependencies  $\Sigma$ ? Why (not)?

**Question 7.** Is there an instance  $I'$  where  $Q$  does not hold, but such that  $I'$  entails  $Q$  under  $\Sigma$ ?

**Question 8.** Write a formula in first-order logic that asserts that a Jedi either follows the light side or the dark side, but not both. Can this be expressed as a tuple-generating dependency?