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Information Systems

Ontologies

Group 07

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1. Introduction

In this document is presented the solution for the assignment 4 of Information Systems course, which involves reasoning about ontologies. Since it does not involve any coding, the entire solution is presented in this document. Given a tree structure of states and transitions, the requirements are simple and straightforward, as follows: firstly a LTS should be made as a formalisation of the presented ontology and secondly, some sets should be calculated for some given syntactical ontologies.

2. Solution

In this chapter is presented the solution for the requirements described in chapter 1.

1. LTS

It is known an LTS states for labelled transitions system and which consists of the following:

- Set of states = {Ann, Karl, Bob, Math, horse, bike, Poetry}
- Set of actions = {knows, rides, teaches, reads}
- A transition relation between states, labelled with actions, that is shown below

$\text{Ann} \xrightarrow{\text{knows}} \text{Karl}$ $\quad$ $\text{Ann} \xrightarrow{\text{knows}} \text{Bob}$

$\text{Karl} \xrightarrow{\text{rides}} \text{horse}$ $\quad$ $\text{Karl} \xrightarrow{\text{rides}} \text{bike}$ $\quad$ $\text{Karl} \xrightarrow{\text{teaches}} \text{Math}$

$\text{Bob} \xrightarrow{\text{rides}} \text{bike}$ $\quad$ $\text{Bob} \xrightarrow{\text{reads}} \text{Poetry}$

2. Ontologies

For the ontologies, the reasoning is done from right to left. In case an ontology starts with true (tt), all states are considered, if it starts with false (ff) it is started with the empty set. Moreover, the P<**α**>Q operation is referred as diamond and indicates that at there is at least one transition **α** from P to Q, where P and Q are sets of states. Also, the P[**α**]Q operations is referred to as diamond and indicates that all **α** transitions from P go to Q, or none of them.

a) [knows]<rides>tt

Step 1: tt = {Ann, Karl, Bob, Math, horse, bike, Poetry}, as mentioned above, all states are included

Step 2: <rides>tt = {Karl, Bob} ⇔ all states in the LTS from which **at least one** *rides* transition can be performed, leading to a state from the set shown at Step 1.
Only from the states *Bob* and *Karl* there can be performed at least one *rides* transition that takes into *bike* or *horse* states, so they make the result for Step 2.

Step 3: [knows]<rides>tt = {Ann, Karl, Bob, Math, horse, bike, Poetry} ⇔ all states in the LTS from which **all or none** *knows* transitions can be performed, leading to a state shown at Step 2.
All *knows* transitions from state *Ann* lead to a state that belongs to the set {*Karl, Bob*}, therefore the state *Ann* should be part of the final result. In addition, from the other states, that are { Karl, Bob, Math, horse, bike, Poetry} there cannot be performed any *knows* transitions that lead to the states from Step 2, thus they are also part of the final result.

b) **[knows]<teaches>tt**

Step 1: tt = {Ann, Karl, Bob, Math, horse, bike, Poetry}

Step 2: <teaches>tt = {Karl} ⇔ all states in the LTS from which **at least one** *teaches* transition can be performed, leading to a state from the set shown at Step 1.
Only from the state *Karl* there can be performed at least one *teaches* transition which takes into *Math* state, so it makes the result for Step 2.

Step 3: [knows]<rides>tt = {Karl, Bob, Math, horse, bike, Poetry} ⇔ all states in the LTS from which **all or none** *knows* transitions can be performed, leading to a state shown at Step 2.
Not all *knows* transitions from state *Ann* lead to the state {*Karl*}, therefore the state *Ann* should not be part of the final result. In addition, from the other states, that are { Karl, Bob, Math, horse, bike, Poetry} there cannot be performed any *knows* transitions that lead to the state from Step 2, thus they are part of the final result.

c) **<knows><teaches>tt**

Step 1: tt = {Ann, Karl, Bob, Math, horse, bike, Poetry}

Step 2: <teaches>tt = {Karl} ⇔ all states in the LTS from which **at least one** *teaches* transition can be performed, leading to a state from the set shown at Step 1.
Only from the state *Karl* there can be performed at least one *teaches* transition which takes into *Math* state, so it makes the result for Step 2.

Step 3: <knows><rides>tt = {Ann} ⇔ all states in the LTS from which **at least one** *knows* transition can be performed, leading to a state shown at Step 2.
From the state *Ann* there is one *knows* transition leading to the state {*Karl*}, therefore the state *Ann* should be part of the final result. In addition, from the other states, that are { Karl, Bob, Math, horse, bike, Poetry} there cannot be performed *knows* transition that leads to the state from Step 2, thus they are not part of the final result.
The result is clear, as Ann is the only one that knows someone who can ride something,a s she knows Bob and Karl and each of them can ride something.

d) **<knows>[teaches]ff**

Step 1: ff = ∅

Step 2: [teaches]ff = {Ann, Bob, Math, horse, bike, Poetry} ⇔ all states in the LTS from which *teaches* transitions cannot be performed.

Step 3: <knows>[teaches]ff = {Ann} ⇔ all states in the LTS from which **at least one** *knows* transition can be performed, leading to a state shown at Step 2.
From the state *Ann* there is one *knows* transition leading to the state {*Karl*}, therefore the state *Ann* should be part of the final result. In addition, from the other states, that are { Karl, Bob, Math, horse, bike, Poetry} there cannot be performed at least one *knows* transition that leads to a state from the set shown at Step 2, thus they are not part of the final result.
The expression can be read as "*she knows someone who does not teach*", and Ann knows Karl who teaches Math.

e) <knows>[rides]ff

Step 1: ff = ∅

Step 2: [rides]ff = {Ann, Math, horse, bike, Poetry} ⇔ all states in the LTS from which *rides* transitions cannot be performed.

Step 3: <knows>[rides]ff = ∅⇔ all states in the LTS from which **at least one** *knows* transition can be performed, leading to a state shown at Step 2.
From the state *Ann* there are 2 *knows* transitions leading to the states {*Karl, Bob*}, but these states are not part of the set shown at Step 2, therefore the state *Ann* should be part of the final result. In addition, from the other states, that are { Karl, Bob, Math, horse, bike, Poetry} there cannot be performed at least one *knows* transition that leads to a state from the set shown at Step 2, thus they are not part of the final result.
Also, the result is clear as the expression can be read as "*she knows someone who does not ride something*", but all she knows are Bob and Karl and both ride something.

f) [knows]<rides>tt ∧ <knows>[teaches]ff = E1 ∧ E2

Step 1: Expression E1 is computed at point a) and its result is E1 = {Ann, Karl, Bob, Math, horse, bike, Poetry}
Step 2: Expression E2 is computed at point d) and its result is E2 = {Ann}
Step 3: The final result is the intersection of the sets which satisfy the expressions E1 and E2.
{Ann, Karl, Bob, Math, horse, bike, Poetry} ∧ {Ann} = {Ann}
The expression can be read as "*everyone she knows rides something and she knows somebody who does not teach*". Clearly, only Ann satisfies this.

g) [knows](<teaches>tt ∨ <reads>tt) = [knows]<teaches>tt ∨ [knows]<reads>tt = E3 ∨ E4

Step 1: Expression E3 is computed at point b) and its result is E3 = {Karl, Bob, Math, horse, bike, Poetry}
Step 2: Expression E4 is computed at below:

Step 2.1: tt = {Ann, Karl, Bob, Math, horse, bike, Poetry} ⇔ start with all states

Step 2.2: <reads>tt = {Bob} ⇔ all states in the LTS from which **at least one** *reads* transition can be performed, leading to a state from the set shown at Step 2.1.

Step 2.3: [knows]<reads>tt = {Karl, Bob, Math, horse, bike, Poetry} $\Leftrightarrow$ all states in the LTS from which **all or none** *knows* transitions can be performed, leading to a state shown at Step 2.2.

Not all *knows* transitions from Ann leads to Bob, so Ann should not be part of the result. In addition, from the other states, that are { Karl, Bob, Math, horse, bike, Poetry} there cannot be performed any *knows* transitions that lead to the state from Step 2.2, thus they are part of the final result.

Step 3: The final result is the union of the sets which satisfy the expressions E3 and E4.
{Karl, Bob, Math, horse, bike, Poetry} $\vee$ {Karl, Bob, Math, horse, bike, Poetry} = {Karl, Bob, Math, horse, bike, Poetry}
The expression can be read as "*everyone she knows teaches something or everyone she knows reads something*". Clearly, Ann does not satisfy this.