Dragan's live session 1
Knowledge-based systems & Description Logic

Dragan Doder

Methods in AI Research

Outline

Quiz questions

Your questions

About exercises (briefly)

1 to 1 questions

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Quiz questions

Your questions

About exercises (briefly)

1 to 1 questions

Question 1

DL to English

The description logic concept

$$\forall reads.Comic$$

denotes the class of ...

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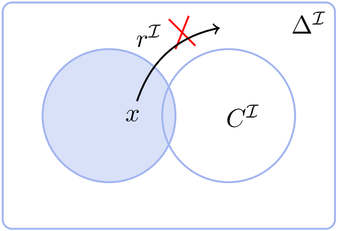
DL to English

The description logic concept

$$\forall reads.Comic$$

denotes the class of ...

- $\forall r.C$ – the set of those elements x such that all the elements with whom x is in relation r with are in C
- $=$ elements that are in relation r only with elements of C
- $(\forall r.C)^{\mathcal{I}} = \{x \mid r^{\mathcal{I}}(x) \subseteq C^{\mathcal{I}}\}$



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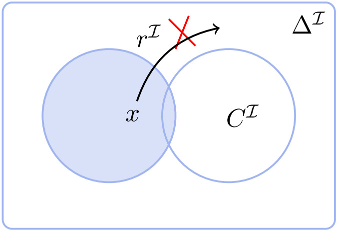

$\forall reads.Comic$ – the set of all elements in relation $reads$ only with elements of $Comic$

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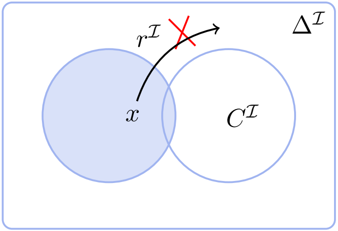

$\forall reads.Comic$ – the set of all elements in relation $reads$ only with elements of $Comic$

$=$ those who read only comics

Question 2

DL to FOL

Select the correct translation of Description logic statement

$$Vegan \equiv Person \sqcap \neg\exists eats.AnimalProduct$$

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$$Vegan \equiv Person \sqcap \neg \exists eats.AnimalProduct$$

Translation of concepts:

- $\sqcap, \sqcup, \neg \Longrightarrow \wedge, \vee, \neg$
- $r \Longrightarrow$ binary relation symbols
- $C \Longrightarrow$ unary relation symbol
- $\forall r.C \Longrightarrow \forall y(r(x,y) \to C(y))$
- $\exists r.C \Longrightarrow \exists y(r(x,y) \wedge C(y))$

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- $Vegan \implies$

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- $Vegan \implies Vegan(x)$

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- $Vegan \implies Vegan(x)$; $Person \implies Person(x)$

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- $Vegan \implies Vegan(x)$; $Person \implies Person(x)$
- $\exists eats.AnimalProduct \implies \exists y(eats(x, y) \wedge AnimalProduct(y))$
- $Person \sqcap \neg \exists eats.AnimalProduct \implies$
  $Person(x) \wedge \neg \exists y(eats(x, y) \wedge AnimalProduct(y))$

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- $Vegan(x)$
- $Person(x) \wedge \neg \exists y(eats(x, y) \wedge AnimalProduct(y))$

Translation of statements:

- $C \sqsubseteq D \Longrightarrow \forall x(C(x) \rightarrow D(x))$
- and therefore (since $C \equiv D$ abbreviates "$C \sqsubseteq D$ and $D \sqsubseteq C$"):
- $C \equiv D \Longrightarrow$

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$$\forall x(Vegan(x) \leftrightarrow Person(x) \land \neg\exists y(eats(x, y) \land AnimalProduct(y)))$$

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DL to FOL

Select the correct translation of Description logic statement

$$Vegan \equiv Person \sqcap \neg \exists eats.AnimalProduct$$

In English: Vegan is a person that does not eat any animal product

Question 2 – another way of translating DL to FOL

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Select the correct translation of Description logic statement

$$Vegan \equiv Person \sqcap \neg \exists eats.AnimalProduct$$

In English: Vegan is a person that does not eat any animal product

Rephrase: x is a vegan iff (x is a person and it is not the case that $\underline{x \text{ eats some animal product}}$).

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x eats some animal product: there exists an animal product such that x eats it

there exists y such that y is an animal product and x eats y

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$\exists y(eats(x,y) \wedge AnimalProduct(y))$

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Now we incorporate this in the sentence above:

$\forall x(Vegan(x) \leftrightarrow Person(x) \wedge \neg \exists y(eats(x, y) \wedge AnimalProduct(y)))$

Question 3

DL: concepts and statements

What is the main difference between concepts and statements in Description logic?

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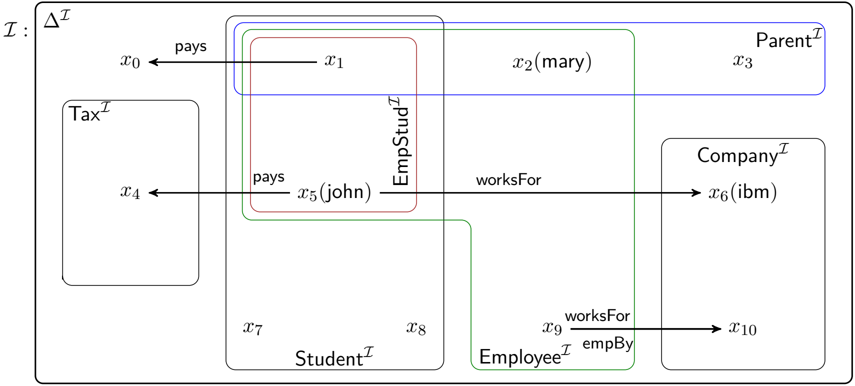
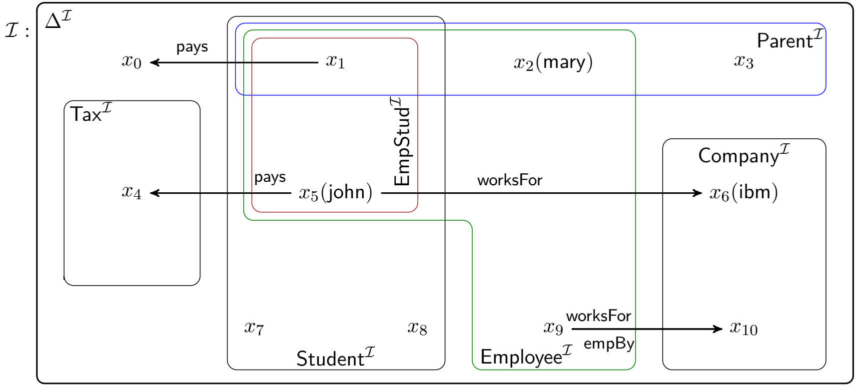
- mostly correct answers
- A couple of remarks:
  - both are DL notions
  - both are logical expressions (just not of the same type)

Question 4



- $(\mathsf{Tax} \sqcup \exists \mathsf{pays}.\mathsf{Tax})^{\mathcal{I}} = ?$

Question 4



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- Answer: $\{x_4, x_5\}$

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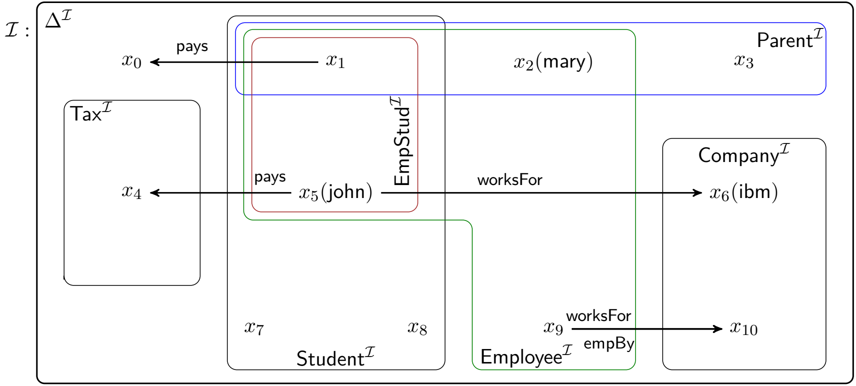

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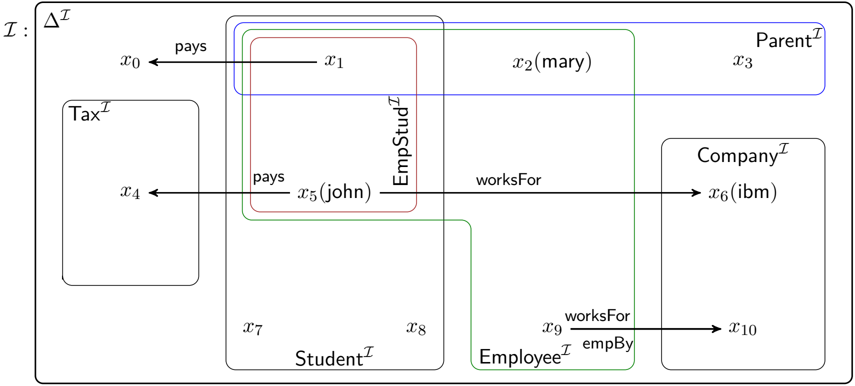
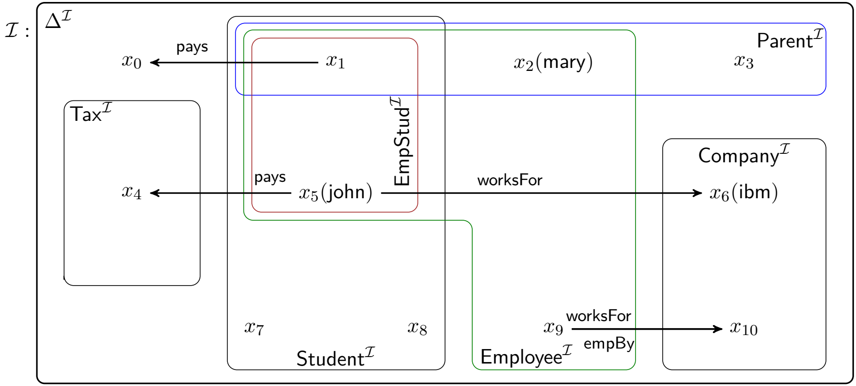


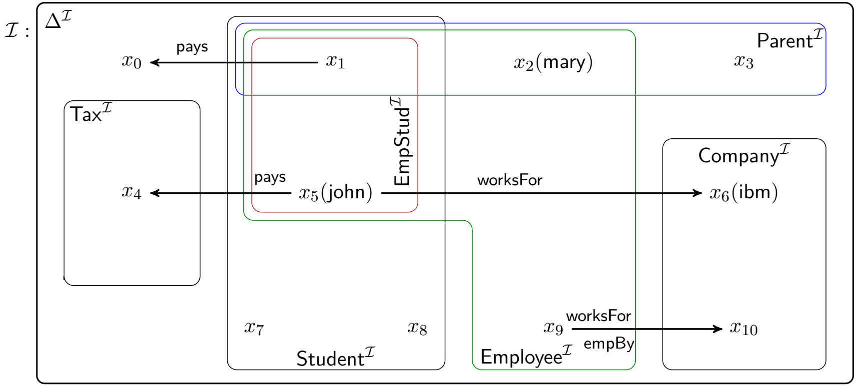
- $(\text{Tax} \sqcup \exists \text{pays}.\text{Tax})^{\mathcal{I}} = ?$
- Answer: $\{x_4, x_5\}$ not x_1
- $\exists r.C$ – all those elements that are in relation with some element form C

Exercise



- $(\text{Student} \sqcup \neg\exists \text{pays}.\top)^{\mathcal{I}} = ?$

Exercise



- $(\text{Student} \sqcup \neg\exists \text{pays}.\top)^{\mathcal{I}} =?$ All the elements form the domein of $\mathcal{I}$

Question 5

FOL models

If P is an unary relation symbol, then for an arbitrary model M of the formula

$$(\exists x P(x)) \wedge \exists x \neg P(x)$$

we know that M

- has at least two elements
- has at most one element
- such M does not exist, since $P(x)$ cannot be both true and false in one model
- there is only one element of the domain for which P holds

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$M \models \exists x P(x)$ – there is some element with the property P
$M \models \exists x \neg P(x)$ – there is an element of M that does not have property P
Therefore, there are at least two elements

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$M \models \exists x P(x)$ – there is some element with the property P
$M \models \exists x \neg P(x)$ – there is an element of M that does not have property P
Therefore, there are at least two elements
$(\exists x P(x)) \land \exists x \neg P(x)$ is the same as $(\exists x P(x)) \land \exists y \neg P(y)$
$(\exists x \alpha(x)) \land \exists x \beta(x)$ is NOT the same as $\exists x(\alpha(x) \land \beta(x))$

Question 6

Logic models

For any formula F, let $M(F)$ denote the set of all models of F.
If A, B, C are formulas such that $A \models B \vee C$, which statement is necessarily true?

- $M(B) \cap M(C) \subseteq M(A)$
- $M(A) \subseteq M(B) \cup M(C)$
- $M(A) \subseteq M(B) \cap M(C)$
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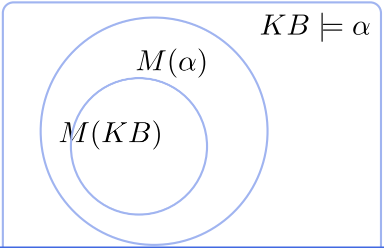
- $M(B) \cup M(C) \subseteq M(A)$

- $KB \models \alpha$ iff $M(KB) \subseteq M(\alpha)$
- $M(A) \subseteq M(B \vee C)$
-
-



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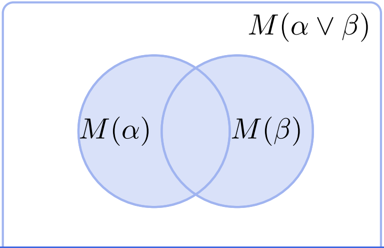
- $M(A) \subseteq M(B) \cap M(C)$
- $M(B) \cup M(C) \subseteq M(A)$

- $KB \models \alpha$ iff $M(KB) \subseteq M(\alpha)$
- $M(A) \subseteq M(B \vee C)$
- Finally, $M(B \vee C) = M(B) \cup M(C)$
- so $M(A) \subseteq M(B) \cup M(C)$



Outline

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Questions and comments:

I feel a bit difficult to remember all these conceptions and symbols in a short time.
And DL is a bit different from logic things I have learnt before.
(Just to feedback this, I think I need some time to absorb these stuff.)

Questions 1

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I feel a bit difficult to remember all these conceptions and symbols in a short time.
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(Just to feedback this, I think I need some time to absorb these stuff.)

Questions and comments:

Could you please provide more information about the difference between entailment and inference? I find it a little bit confusing. Could you maybe provide an example where alpha can be inferenced from KB but can not be entailmented? (not sure if that makes sense)
And also on the slide 39 from lecture 11 entailment symbol is in the place where it is hard for me to interpret this.
$\beta \models \alpha$ iff $\models \beta \to \alpha$
not sure how to interpret the second entailment symbol. Thank you
validity = holds in every model

Questions 2

Questions and comments:

1. Can you maybe provide the explanations for the exercises earlier? Because then I can check my answers and ask when an answer is unclear to me.
2. 'if a formula is valid then its negation is non satisfiable, again if a formula is satisfiable its negation is not valid'. I do not understand the second part of this statement. Also, if a formula is valid its negation is not valid?
3. Please explain more about the use of entailment and derivative. You've mentioned them shortly but there is more about it.

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3. Please explain more about the use of entailment and derivative. You've mentioned them shortly but there is more about it.

(2.) α is satisfiable iff there is a model m such that $m \models \alpha$ holds

A formula α is valid (notation $\models \alpha$) iff $m \models \alpha$ holds for every model m

$m \models \alpha$ iff $m \not\models \neg\alpha$

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(3.) α is a entailed by KB ($KB \models \alpha$) iff α is true in every model in which KB is true. (determined by the semantics)

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3. Please explain more about the use of entailment and derivative. You've mentioned them shortly but there is more about it.

(3.) α is a entailed by KB ($KB \models \alpha$) iff α is true in every model in which KB is true. (determined by the semantics)
α is inferred by KB $KB \vdash \alpha$ – depends on an inference mechanism (that tries to capture $\models$ - soundness and completeness)
If proof-based, given by a set of rules: α is inferred by KB if there is a sequence α_0, α_1,..., $\alpha_n = \alpha$, such that every member is either from KB or is derived by previous formulas by an application of a rule

Questions 3

Questions and comments:

Not a question, but a bit of feedback. There are almost 4 hours of pre-recorded lectures every week, even though there are only 2 hours planned for lectures for this course besides the live lectures. It is honestly a bit much to keep up with because you also have to prep and read the literature. Either schedule more time to watch the lectures (that it is at least feasible in the amount of time you have scheduled for the course) or reduce/spread out the lectures a bit better.

In the fourth video of 11th lecture, you say " if a formula is valid then its negation is unsatisfiable, again if a formula is satisfiable its negation is not valid". Did I hear that correctly and what does this exactly mean. Could you maybe demonstrate this with an example.

I want to give compliments on how structured these lecture and slidesets are. I was made very clear, thank you.

Questions 4

Questions and comments:

I do not have specific questions, only that description logic is still difficult to me. I would like to remark that the lectures keep getting longer every week, even though no extra time is scheduled for them. There is only 1:45h scheduled for the lectures, yet the lectures are now over 3 hours long. I planned for approximately 2 hours of lectures, but now I did not have time to watch all the lectures, only looking up parts for which I did not understand the slides well enough. I can only hope that reading the slides will be enough to understand this subject well enough for the exam, but currently description logic is still a challenge.

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Questions and comments:

Not for now, but I have to go over the lectures again, there is a lot to cover. I would like to know maybe if there is a "cheat sheet" type of document with all the possible concepts and operators and their usage for FOL and DL. Question 5 and 6 of the test were hard, can you explain them more?

Questions 5

Questions and comments:

Looking at the example of slide 20, in the green box: why is X is not quantified? I always note that when translating from description logic to FOL, the main X variable is never quantified, as if it was implied. However, if I am right, all FOL variables should be quantified when introduced, is not it?
I cant quite grasp the concept of soundness (and completeness), do we need to reproduce that on the exam or can you give a concrete example?
soundness and completeness will not be at the exam

DL: C, FOL: $C(x)$

DL: Concepts $\Rightarrow$ classes of elements

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DL: C, FOL: $C(x)$

DL: Concepts $\Rightarrow$ classes of elements

FOL: If all the variables are quantified, then the sentence has a truth value, if x is not quantified, then it needs μ to assign an element of the domain in order to determine truth

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Example: positive numbers

FOL: $x > 0$

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Looking at the example of slide 20, in the green box: why is X is not quantified? I always note that when translating from description logic to FOL, the main X variable is never quantified, as if it was implied. However, if I am right, all FOL variables should be quantified when introduced, is not it?

I cant quite grasp the concept of soundness (and completeness), do we need to reproduce that on the exam or can you give a concrete example?

soundness and completeness will not be at the exam

Example: positive numbers

FOL: $x > 0$

positive numbers $= \{x \mid x > 0\}$

Outline

Exercises Reasoning

Main questions and comments:

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2. DL is new, we need more time to work on it to understand what is not clear / to pose a question

3. Can you post the solution, then we can understand if we understand and pose a question?

4. More examples FOL?

5. some examples English to DL

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1.–3. (a) I will post the solutions; (b) next week more relaxed; (c) Next week we can come back to FOL and DL in Live session on 22nd
4.–5. I will add some more exercises

Outline

Quiz questions

Your questions

About exercises (briefly)

1 to 1 questions

I will be on Teams after the session.