CS 681 Fall 2008

Designing Expert Systems

11. Review Questions and Exercises: Part I

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Questions and Exercises

Briefly define and compare “data”, “information” and “knowledge”, with the help of an example of each of these concepts.

Which are the different uses of an expert system?

Why it is hard to build an expert system?

Describe very briefly 6 basic concepts elicitation methods. Which are the main strengths and weaknesses of these methods?

Describe briefly the card-sort elicitation method and specify its main strengths and weaknesses.

In its standard form, the card-sort method elicits a strict hierarchy of concepts. How could one modify this method to build a tangled hierarchy?

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Questions and Exercises

Analyze the following dialog and develop an ontology (concepts, feature definitions, instances and facts) suggested by it.

KE: Suppose you were told that a spill had been detected in White Oak Creek one mile before it enters White Oak Lake.
What would you do to contain the spill?

SME: That depends on a number of factors.
I would need to find the source in order to prevent the possibility of further contamination, probably by checking drains and manholes for signs of the spill material. And it helps to know what the spilled material is.

KE: How can you tell what it is?

SME: Sometimes you can tell what the substance is by its smell.
Sometimes you can tell by its color, but that's not always reliable since dyes are used a lot nowadays. Oil, however, floats on the surface and forms a silvery film, while acids dissolves completely in the water.
Once you discover the type of material spilled, you can eliminate any building that either don't store the material at all or don't store enough of it to account for the spill.

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Questions and Exercises

Briefly define “verification”, “validation” and “certification.”

Describe very briefly the main stages of building an expert system.

Briefly describe three limiting factors in building expert systems.

What is a expert system shell?

What is a learning system shell?

Specify the sequence of phases in the development of an expert system.

Specify the sequence of phases in the development of an expert system with the Disciple shell.

Briefly compare the classical approach to the development of an expert system with the approach based on using a learning agent shell.

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Questions and Exercises

What is an object ontology?

Which are the different uses of an object ontology in a knowledge-based learning agent?

Consider a knowledge-based agent. Compare the relative generality of its object ontology and its rules.

What is an instance?

What is a concept?

Give an intuitive definition of generalization.

What does it mean for concept A to be more general than concept B?

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Questions and Exercises

What are the possible relationships between two concepts A and B, from a generalization point of view? Provide examples of concepts A and B in each of these three situations.

How could one prove that A is more general than B?
Is this always a practical procedure?

How could one prove that A is not more general than B?
Is this a practical procedure?

Briefly describe the guidelines related to siblings for designing an ontology.

Design an ontology fragment (concepts, feature definitions, instances, and facts) to represent the following information: John Doe has written the “Windows of opportunities” book between 2005 and 2007.

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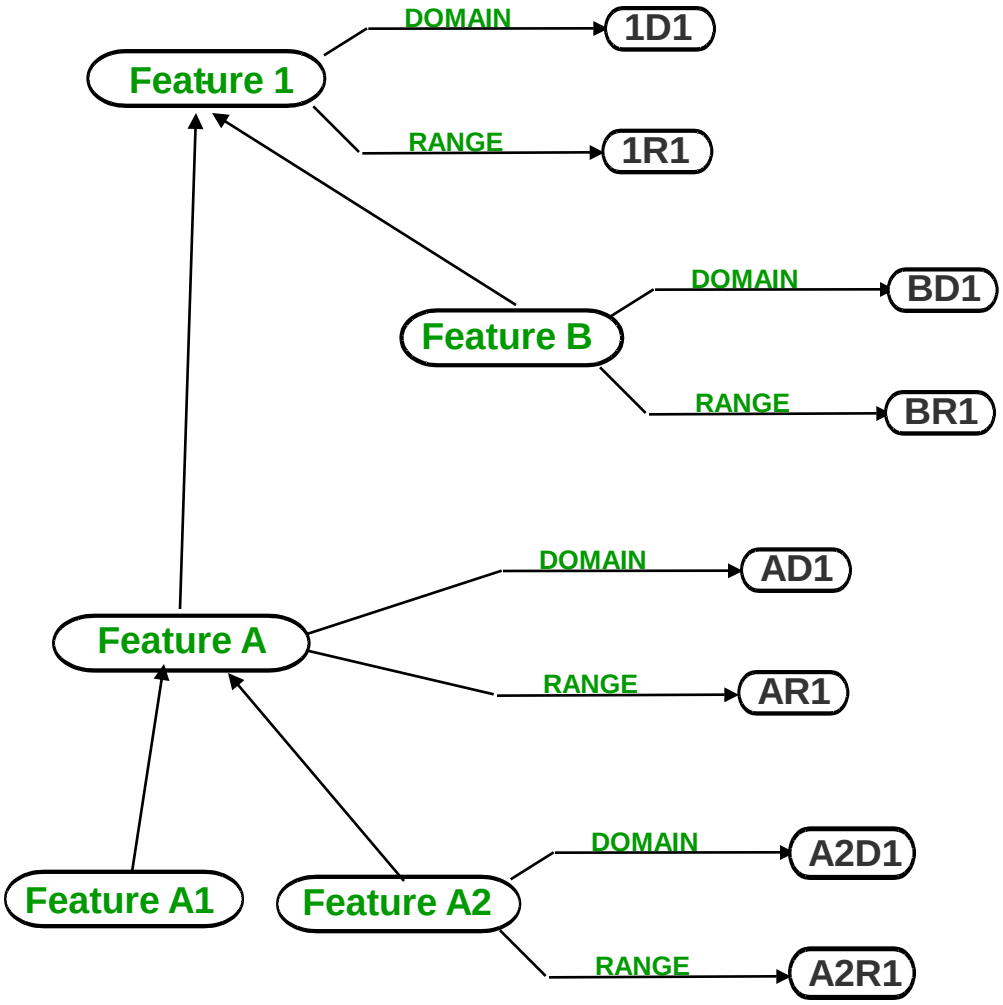
Exercise

Consider the following feature hierarchy:



Is there any necessary relationship between:

BD1 and 1D1?

BR1 and 1R1?

A2D1 and 1D1?

AD1 and BD1?

1D1 and 1R1?

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Questions and Exercises

Using the ontology design pattern for concepts and subconcepts, represent the following information (in a graphical form):

Support is a PhD advisor criterion. It has as basic subcriteria (i.e. criteria that do not have subcriteria) the following: advisor funding, advisee AY support, advisee summer support, advisee funding assistance, and advisee conference support.

Consider the “evaluation criterion” concept and one of its instances called “advisee AY support from John Doe during the AY08-09.” Represent in an ontology the various features of this instance, including the fact that this support is “very high.”

Briefly discuss, with the help of an example, why maintaining the consistency of the object ontology is a complex knowledge engineering activity.

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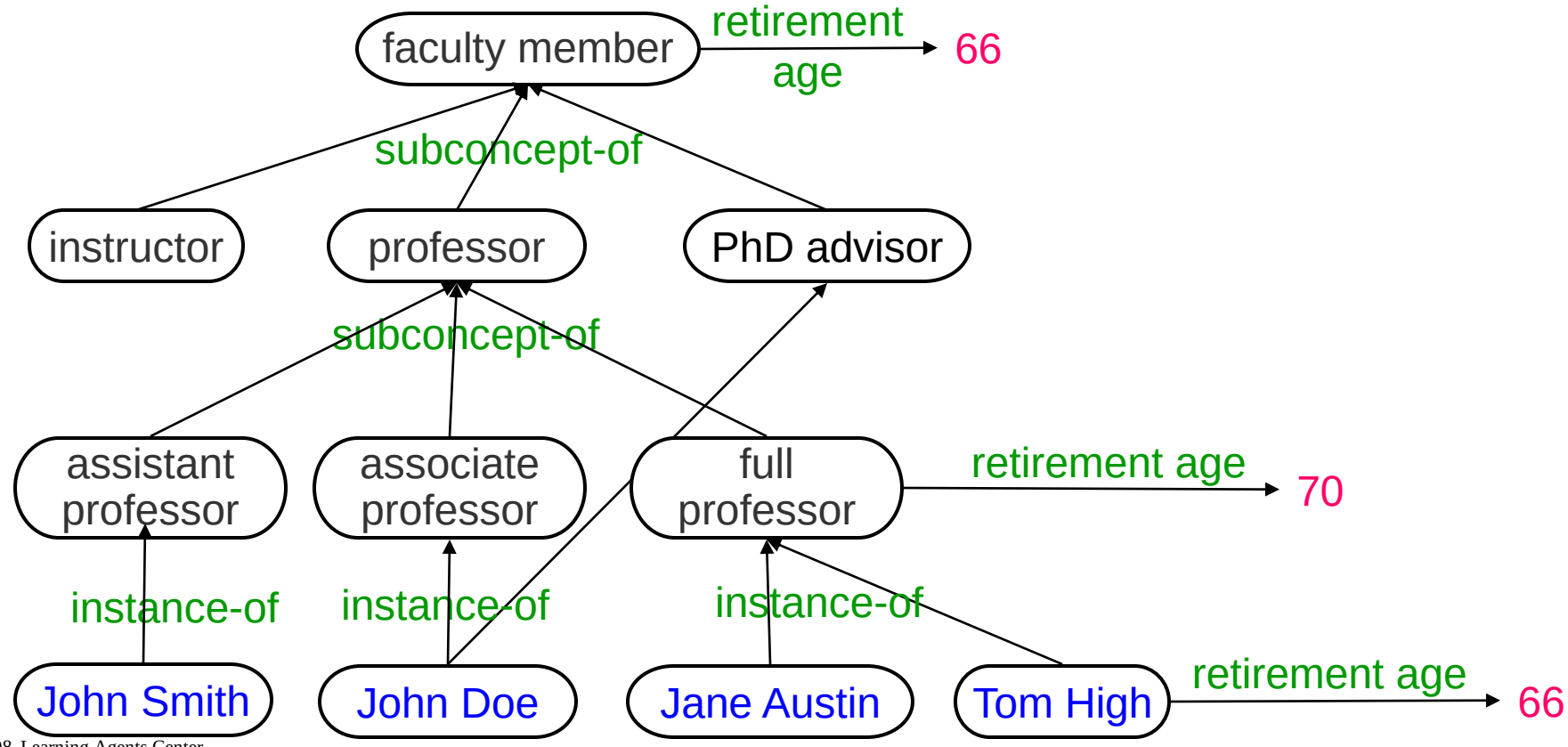
Questions and Exercises

Briefly explain how the following questions are asked, assuming the knowledge from the following ontology:

What is the retirement age of John Smith?

What is the retirement age of Tom High?

What is the retirement age of Jane Austin?



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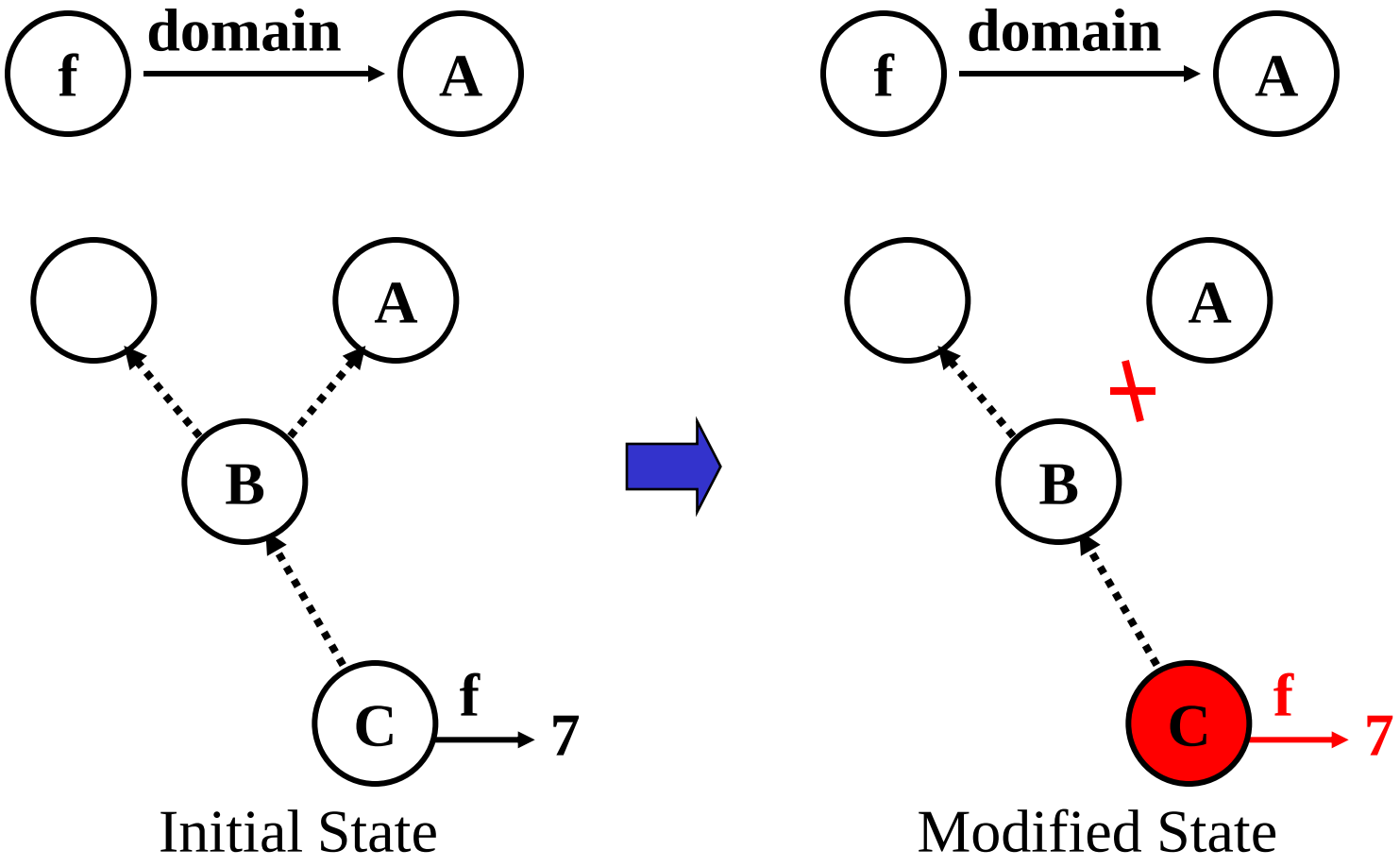
Questions and Exercises

Consider the following modification of an ontology. Explain why if we delete the “subconcept of” relationship between B to A, C can no longer have the feature f.



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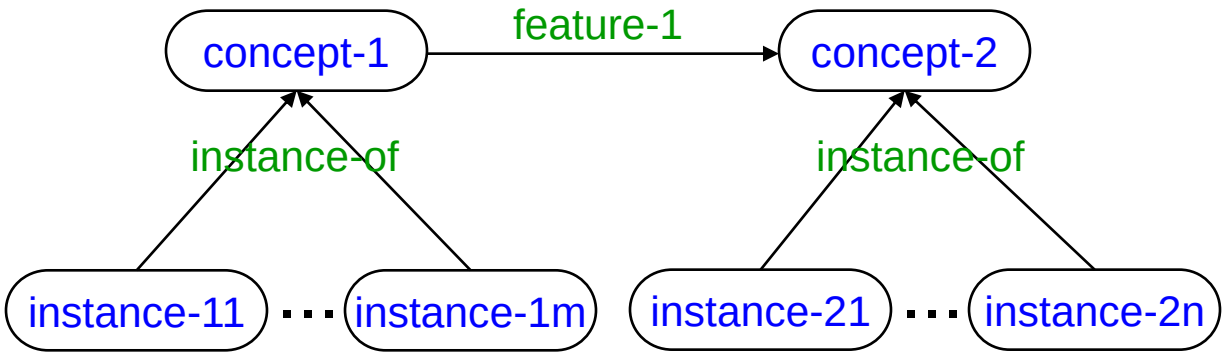
Questions and Exercises

Consider the following representation:



Which are all the facts that can be inferred from it?

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Questions and Exercises

Develop an object ontology that represents the following information:

Puss is a calico.

Herb is a tuna.

Charlie is a tuna.

All tunas are fishes.

All calicos are cats.

All cats like to eat all kinds of fish.

Cats and fishes are animals.

Hint: You should define object concepts, object features and instances.

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Questions and Exercises

Develop an object ontology that represents the following information:

The government of US is a representative democracy.
The government of Britain is a parliamentary democracy.
George W. Bush is the head of the government of US.
George W. Bush has a critical role in setting objectives for US.

You should define object concepts, object features and instances, keeping in mind that you will need to extend this ontology with new knowledge in the future.

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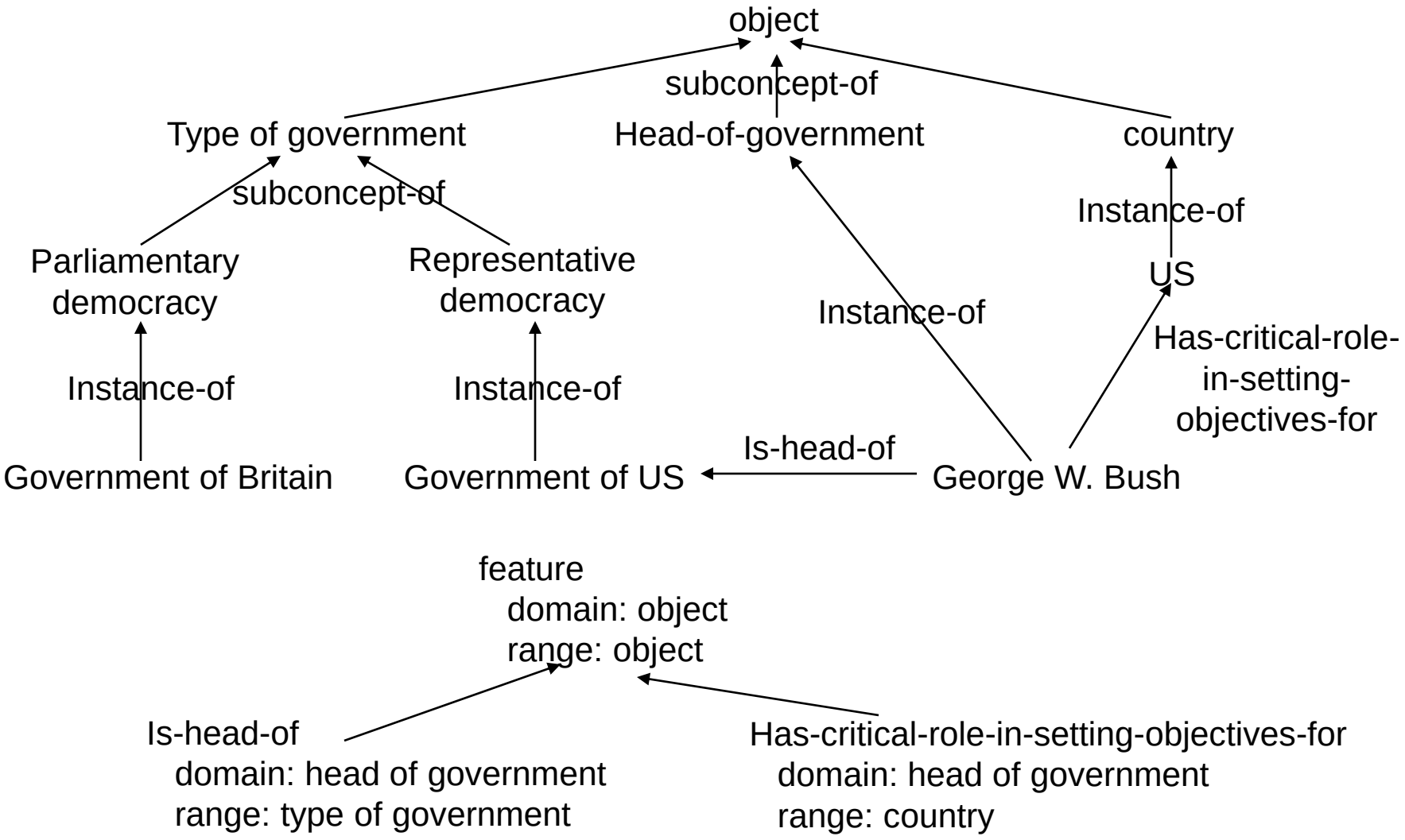
Questions and Exercises



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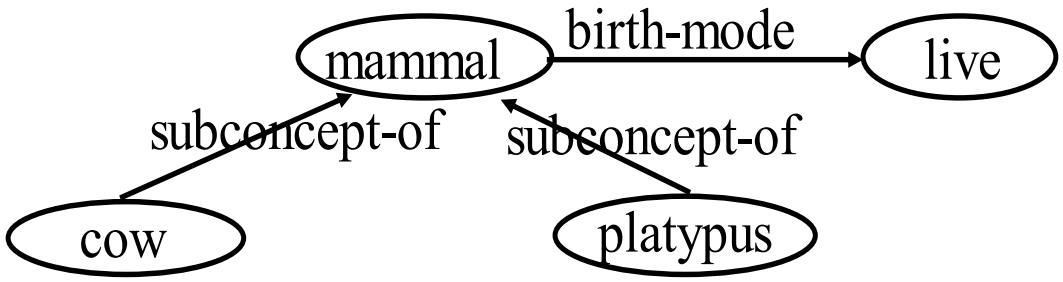
Questions and Exercises

Insert the additional knowledge that platypus lays eggs into the following object ontology:



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Questions and Exercises

What is a positive example of a concept?

What is a negative example of a concept?

What is a generalization rule? What is a specialization rule? What is a reformulation rule?

Name all the generalization rules you know.

Briefly describe and illustrate with an example the “turning constants into variables” generalization rule.

Define and illustrate the dropping conditions generalization rule.

Indicate three different generalizations of the sentence “History books in the Fenwick Library” and demonstrate that each of them is more general than the given sentence.

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Questions and Exercises

Define and illustrate the following generalization rule: climbing generalization hierarchies

Solution

An expression can be generalized by replacing a concept with a more general concept from a generalization hierarchy. For instance, the statement “GMU PhD students are hard working” can be generalized to “GMU graduate students are hard working”, by replacing the concept “GMU PhD students” with the more general concept “GMU graduate students”.

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Questions and Exercises

Define and illustrate the following:

a) generalization of two concepts;
b) minimally general generalization of two concepts;
c) maximally general specialization of two concepts.

What is a negative exception?

What is a positive exception?

Draw a picture representing a plausible version space, as well as a positive example, a negative example, a positive exception and a negative exception. Then briefly define each of these elements.

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Questions and Exercises

Define and illustrate the least general generalization of two concepts. Does it always exist?

Answer

G is the least general generalization of two concepts A and B if and only if G is a generalization of A and B and G is less general than any other generalization of A and B.

Two concepts may not have a least general generalization. In such a case there are several minimal generalizations of A and B, but none of them is less general than all the others.

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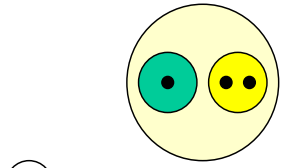
Questions and Exercises

Consider the cells consisting of two bodies, each body having two attributes, color (which may be yellow or green) and number of nuclei (1 or 2). The relative position of the bodies is not relevant because they can move inside the cell. You should assume that any generalization of a cell is described as a single pair ((s t) (u v)).

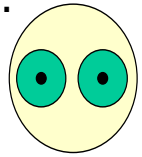
a) Indicate all the possible generalizations of the following cell, and the generalization relations between them:



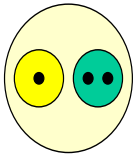
+ ((1 green) (2 yellow))

b) Determine the number of the distinct sets of instances and the number of concept descriptions for this problem.

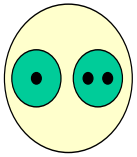
c) Given the following cell descriptions



((1 green) (1 green))



((1 yellow) (2 green))



((1 green) (2 green))

Determine the following minimal generalizations: g(E1, E2), g(E2, E3), g(E3, E1), g(E1, E2, E3)

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Questions and Exercises

Which is the set of instances represented by the following concept?

?O1	*instance of*	*PhD student*
	is interested in	*?O2*
?O2	*instance of*	*PhD research area*

Indicate such an instance.

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Questions and Exercises

What does the following concept represents?

?O1	*instance of*	*course*
	has as reading	*?O2*
?O2	*instance of*	*publication*
	has as author	*?O3*
?O3	*instance of*	*professor*

Which is an instance?

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Questions and Exercises

What does the following concept represents?

$?O_1$	instance of	PhD student
	is interested in	$?O_2$
$?O_2$	instance of	PhD research area
Except When		
$?O_2$	instance of	PhD research area
	requires	"programming"

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Questions and Exercises

Indicate several generalizations of the following sentence:
“Students who have majored in Computer Science at George Mason University between 2003 and 2004.”

Provide another example of a concept and indicate some of its generalizations.

Indicate several specializations of the following sentence:
“Students who have majored in Computer Science at George Mason University between 2003 and 2004.”

Provide another example of a concept and indicate some of its specializations.

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Questions and Exercises

Give an example of a natural language sentence C that has some concept interpretation.

Formulate a sentence G which is a generalization of C and use the generalization rules to demonstrate that G is a generalization of C.

Formulate a sentence S which is a specialization of C and use the generalization rules to demonstrate that S is a specialization of C.

Formulate a sentence D which is neither a generalization of C nor a specialization of C.

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Questions and Exercises

Demonstrate that C is more general than C1

C1:

?O1 is assistant professor
number of publications 10
is employed by George Mason University

C:

?O1 is professor
number of publications ?N1
?N1 is in [10 .. 35]

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Questions and Exercises

Demonstrate that C is a generalization of C1 and C2

C1:

?O1 is assistant professor
number of publications 10
is employed by George Mason University

C2:

?O1 is associate professor
number of publications 35

C:

?O1 is professor
number of publications ?N1
?N1 is in [10 .. 35]

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Questions and Exercises

Consider the following examples:

E_1

$?O_1$	instance of	graduate research assistant
	is interested in	$?O_2$
$?O_2$	instance of	PhD research area

E_2

$?O_1$	instance of	teaching assistant
	is interested in	$?O_2$
$?O_2$	instance of	PhD research area

Determine their minimally general generalizations, assuming the ontology from the next slide. Determine a common generalization which is not a minimally general generalization. Is there a least general generalization?

Consider the following generalizations:

G_1

$?O_1$	instance of	university employee
	is interested in	$?O_2$
$?O_2$	instance of	research area

G_2

$?O_1$	instance of	graduate student
	is interested in	$?O_2$
$?O_2$	instance of	research area

Determine their maximally general specializations, assuming the ontology from the next slide. Determine a common specialization which is not a maximally general specialization.

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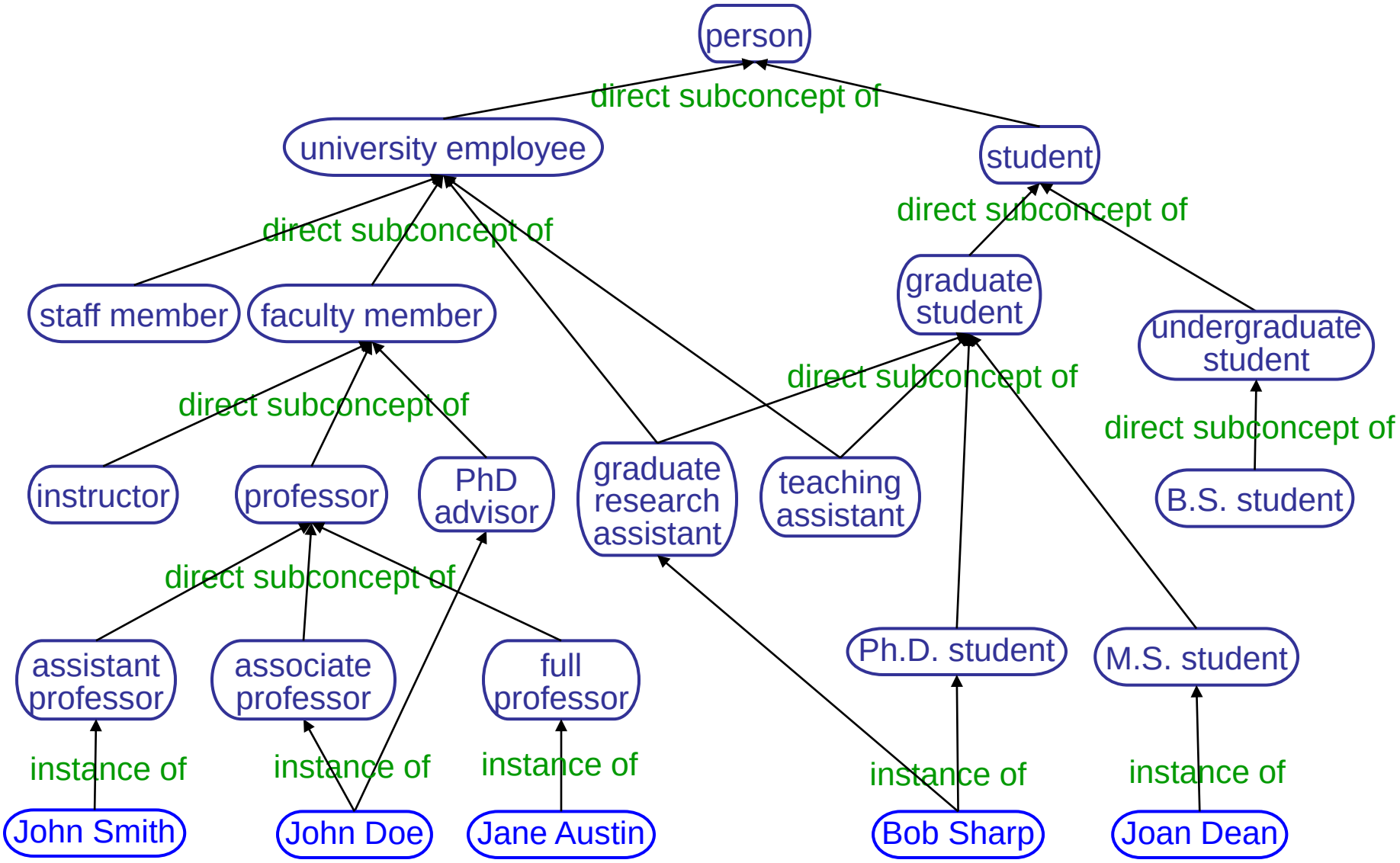
Questions and Exercises



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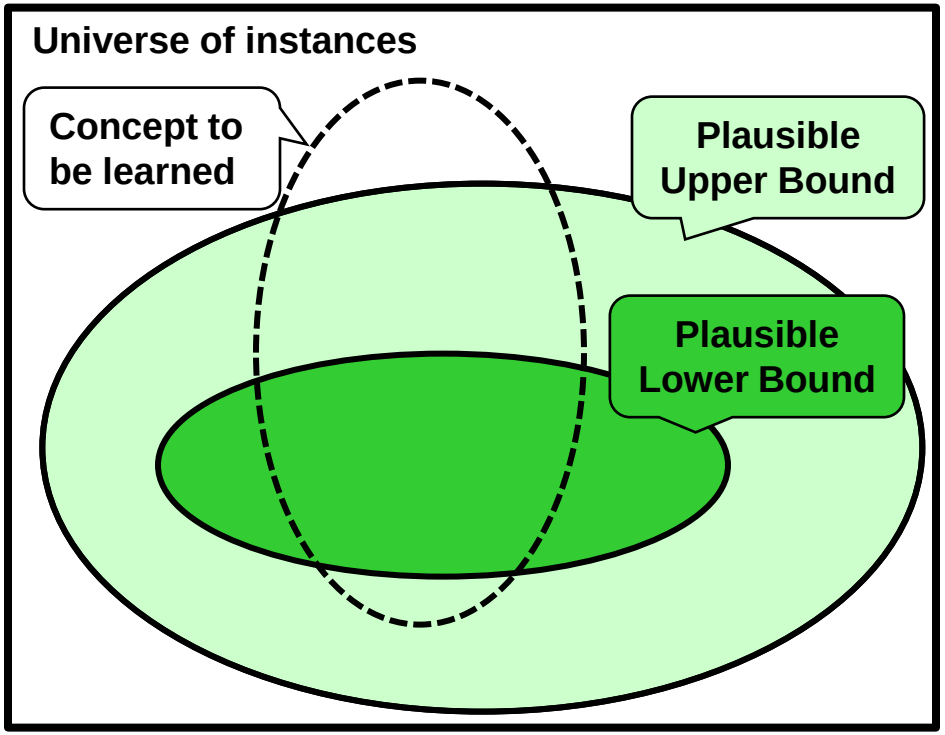
Questions and Exercises

Which are some concepts included in this version space?



Plausible Upper Bound

$?O_1$	instance of	{faculty member, student}
	is interested in	$?O_2$
$?O_2$	instance of	research area

Plausible Lower Bound

$?O_1$	instance of	{associate professor, graduate student}
	is interested in	$?O_2$
$?O_2$	instance of	PhD research area

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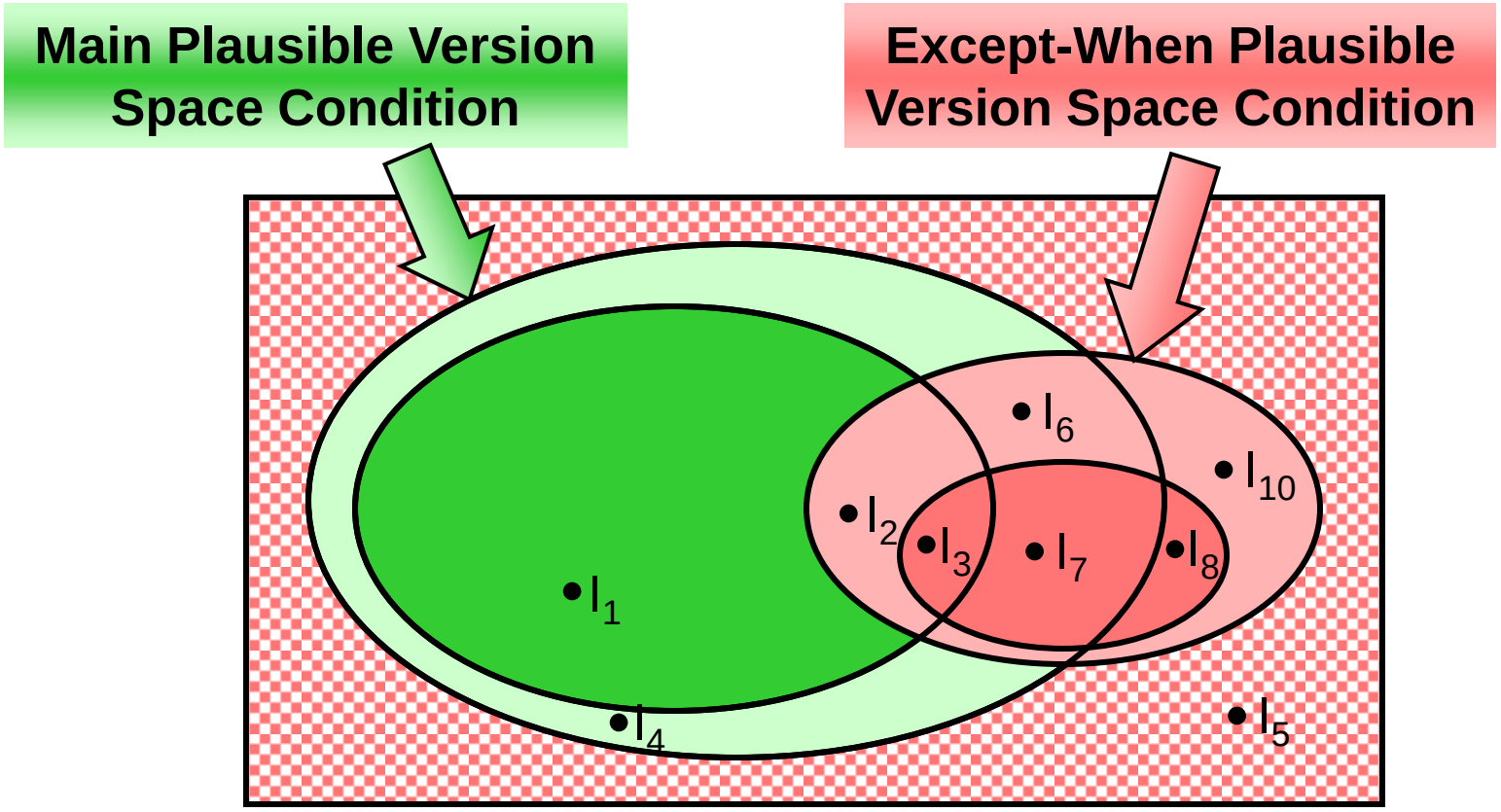
Questions and Exercises

Consider the following partially learned concept and 10 instances:



Order the instances by the plausibility of being positive examples of this concept and justify the ordering.

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Questions and Exercises

Define the state-based representation of a problem.

Define the reduction representation of a problem.

What are some of the complementary abilities of humans and computers?

What are some of the complementary abilities of humans and computer assistants in the context of webpage believability assessment?

What is mixed-initiative reasoning?

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Questions and Exercises

What is a problem-reduction rule?

What is a solution-synthesis rule?

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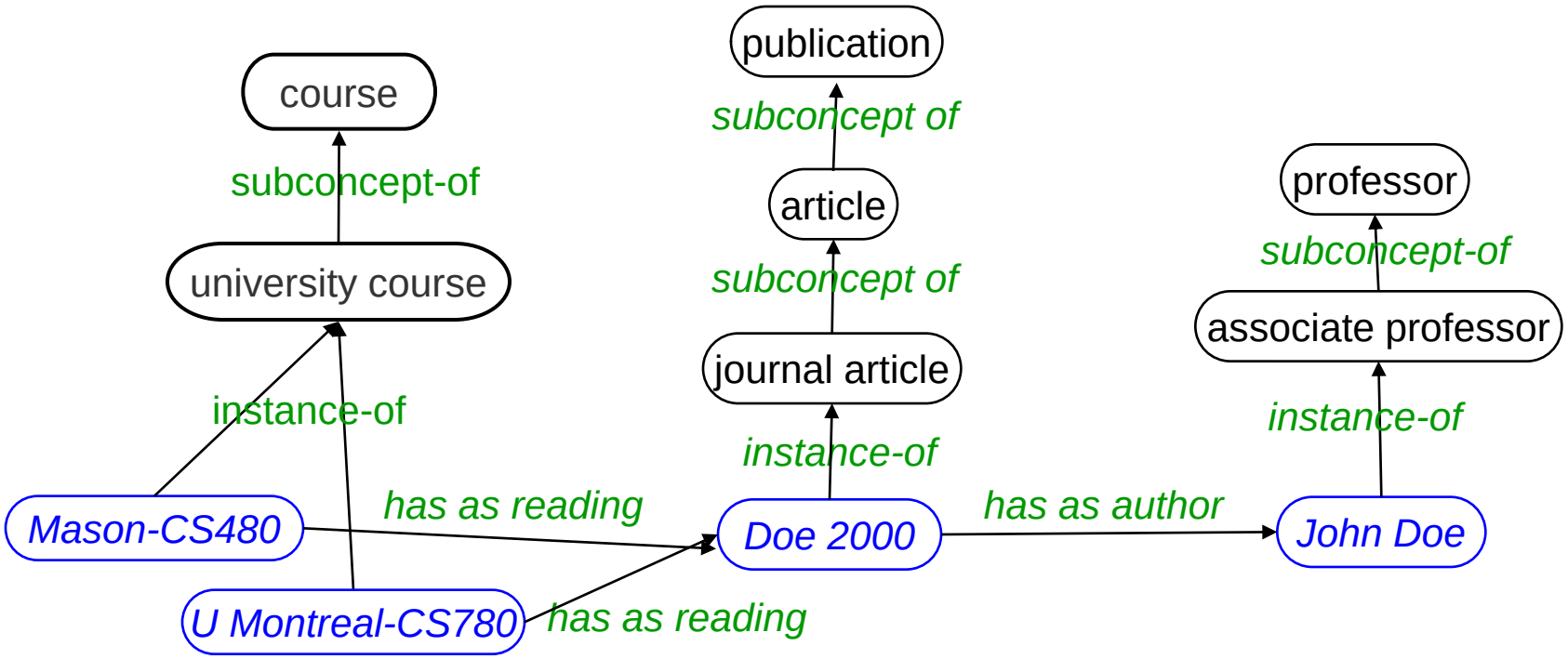
Questions and Exercises

Consider the following ontology fragment:



Explain how the following question will be answered:

Is there a course that has as reading a publication by a professor?

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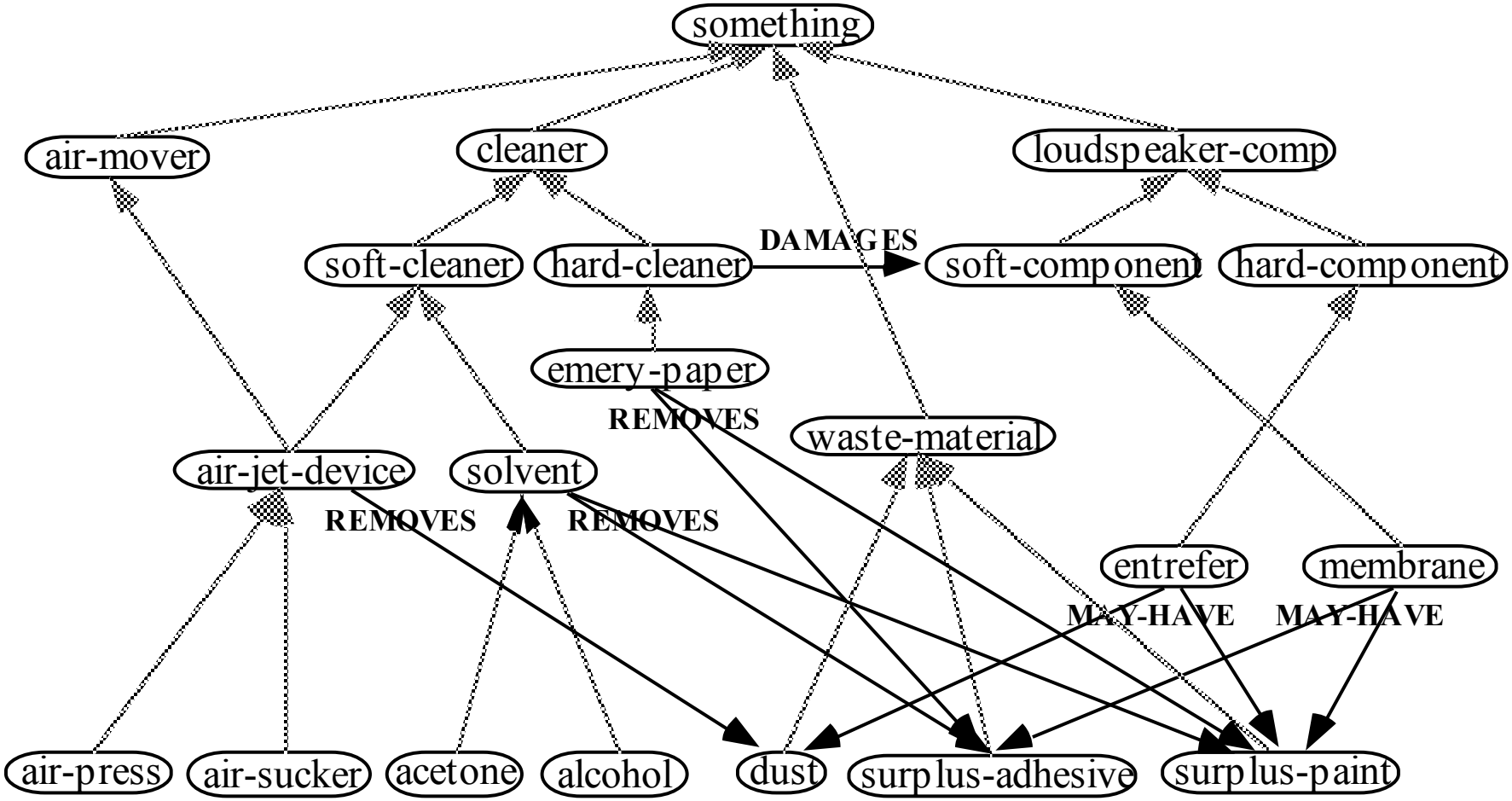
Questions and Exercises

Consider the following ontology fragment, where the unlabelled links are instance-of or subconcept-of links:



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Questions and Exercises

Consider the following question “Is there a cleaner X that removes dust?”

Represent the question as a network fragment.

Find all possible answers to the question based on the information from the above ontology fragment.

In order to answer the question, the agent would need to use several reasoning operations. Which are these operations?

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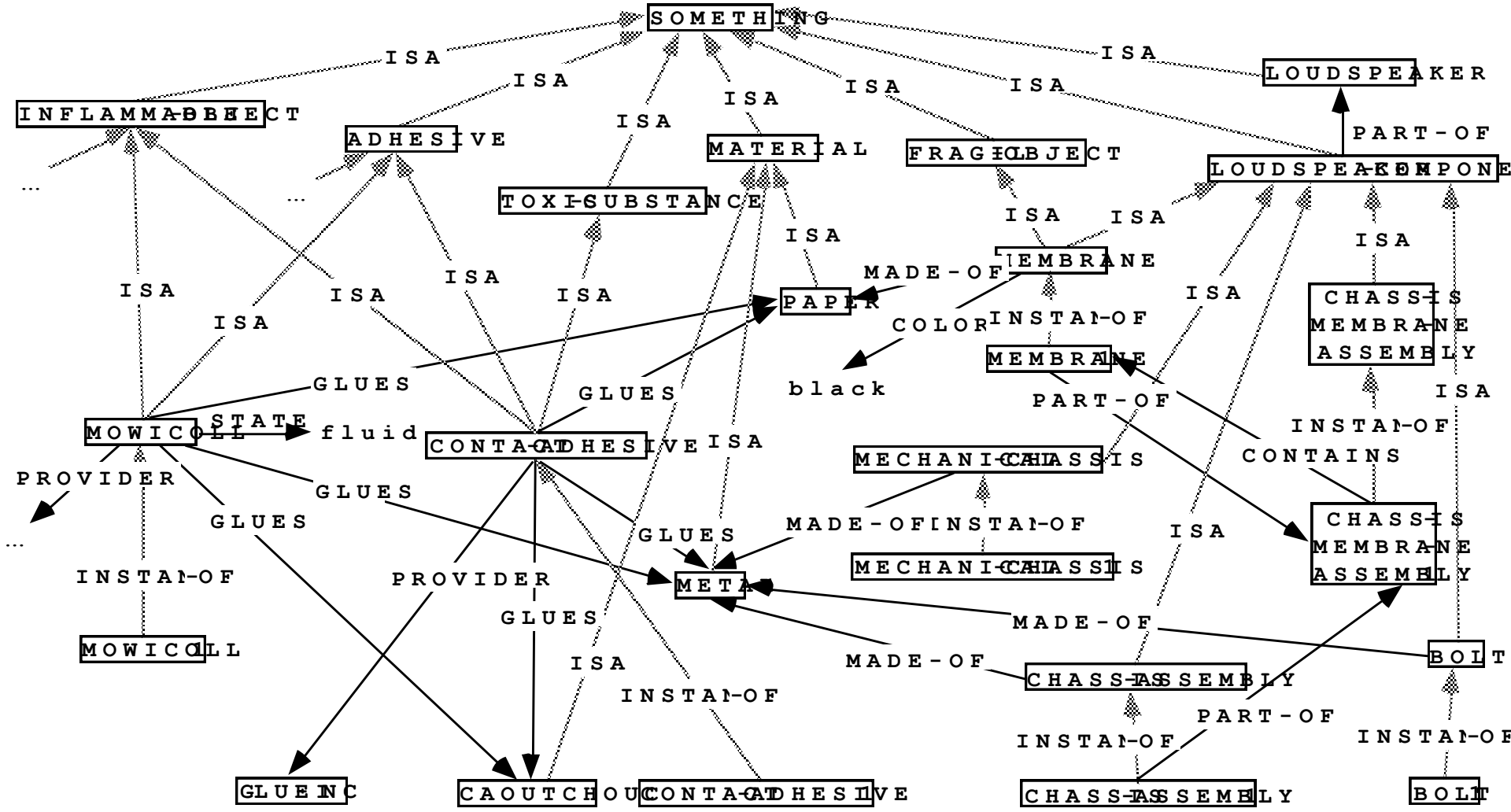
Questions and Exercises

Consider the following ontology fragment (where ISA means subconcept-of):



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Questions and Exercises

Consider the question:

"Is there a part of a loudspeaker that is made of metal?"

In the context of the object ontology from the previous slide.

a) Which are all the answers to this question?

b) Which are the reasoning operations that need to be performed in order to answer this question.

c) Consider one of the answers that requires all these operations and show how the answer is found.

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Questions and Exercises

Consider also the following expressions, in the context of the previous ontology fragment:

E1:	?X	IS	MEMBRANE		E2:	?X	IS	MECHANICAL-CHASSIS
		MADE-OF	?M				MADE-OF	?M
	?M	IS	PAPER			?M	IS	METAL
	?Z	IS	CONTACT-ADHESIVE			?Z	IS	MOWICOLL
		GLUES	?M				GLUES	?M
		STATE	fluid					

a) Find the minimally general generalizations of E1 and E2.

Solution

MGG1:

	?X	IS	LOUDSPEAKER-COMP
		MADE-OF	?M
	?M	IS	MATERIAL
	?Z	IS	INFLAMMABLE-OBJECT
		GLUES	?M

MGG2

	?X	IS	LOUDSPEAKER-COMP
		MADE-OF	?M
	?M	IS	MATERIAL
	?Z	IS	ADHESIVE
		GLUES	?M

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Questions and Exercises

b) Find two generalizations of E1 and E2 that are not minimally general generalizations.

G1:

?X	IS	SOMETHING
	MADE-OF	?M
?M	IS	MATERIAL
?Z	IS	INFLAMMABLE-OBJECT
	GLUES	?M

G2

?X	IS	SOMETHING
	MADE-OF	?M
?M	IS	SOMETHING
?Z	IS	SOMETHING
	GLUES	?M

c) Consider one of the generalizations found at b) and demonstrate why it is a generalization of E1 and E2 but it is not a minimally general generalization.

A MGG of E1 and E2 must not be more general than any other generalization of E1 and E2. G1 is not a MGG because is is more general than, for example, MGG1 from answer a). This is true because ?X=SOMETHING is more general in the semantic network than ?X= LOUDSPEAKER-COMPONENT.

d) Is there a least general generalization of E1 and E2?

No because the LGG is by definition the one and only MGG, and we have found MGG1 and MGG2.

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Questions and Exercises

e) Indicate a specialization of E1.

S1:	?X	IS	MEMBRANE
		MADE-OF	?M
	?M	IS	PAPER
	?Z	IS	CAOUTCHOUC
		GLUES	?M
		STATE	fluid

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Questions and Exercises

Consider the following rule and ontology fragment. Explain how the following problem is reduced: “Assess Bill Jones as a potential PhD advisor for Dan Moore.” Show the reasoning generated by the agent.

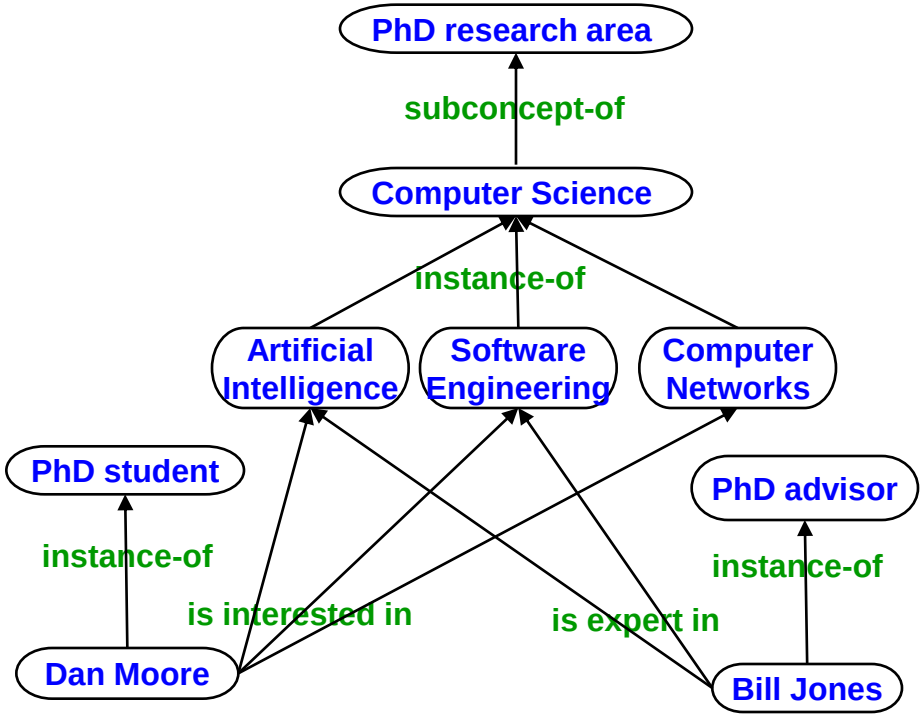
IF
Assess?O1 as a potential PhD advisor for ?O2

Question
Is ?O2 interested in the area of expertise of ?O1 ?

Answer
Yes, because ?O2 is interested in ?O3 which is the area of expertise of ?O1.

Condition
?O1 is PhD advisor
is expert in ?O3
?O2 is PhD student
is interested in ?O3
?O3 is PhD research area

THEN
Assess ?O1 as a potential PhD advisor for ?O2 in ?O3



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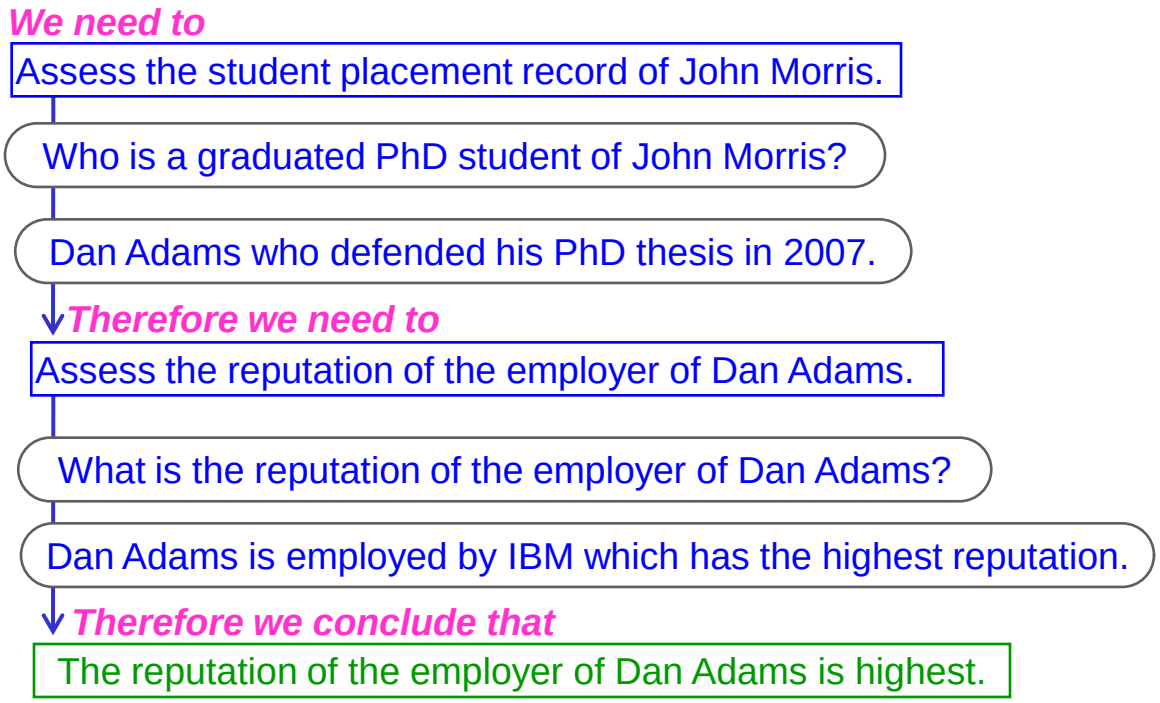
Questions and Exercises

Develop the ontology suggested by the following modeling:



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Questions and Exercises

Define the problem of inductive concept learning from examples.

What is abduction?
Give an example of abductive reasoning that was not discussed in class.
Provide two other explanations that are less plausible.
Specify a context when one of these alternative explanations would actually be more plausible.

See many questions and exercises in the lecture notes titled “Overview of Basic Machine Learning Strategies”.

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Questions and Exercises

What is multistrategy learning?
What is the motivation of a multistrategy approach to learning?
What are the learning strategies used by Disciple during Rule Learning and Rule Refinement?

Answers

Multistrategy learning denotes a type of learning that integrates several learning strategies, such as empirical learning from examples, explanation-based learning, neural network learning or learning by analogy.

The single-strategy learning methods have complementary strengths and weaknesses. For instance, empirical inductive learning from examples require many examples, but does not require background knowledge. In contrast, explanation-based learning requires only an example and complete background knowledge. Multistrategy learning methods integrate different learning strategies to take advantage of their complementary strengths to compensate for their relative weaknesses.

The rule learning and refinement methods of Disciple integrate learning from examples, learning from explanations and learning by analogy and experimentation.

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Questions and Exercises

Define the rule learning problem in Disciple.

Compare the rule learning process in the Disciple approach with the traditional knowledge acquisition approach where a knowledge engineer defines such a rule by interacting with a subject matter expert. Identify as many similarities and differences as possible, and justify the relative strengths and weaknesses of the two approaches, but be as concise as possible.

Define the rule refinement problem in Disciple.

Compare the rule refinement process in the Disciple approach with the traditional knowledge acquisition approach. Identify as many similarities and differences as possible, and justify the relative strengths and weaknesses of the two approaches, but be as concise as possible.

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Questions and Exercises

Consider the following example and associated explanation:

What rule will be learned from them, assuming the ontology from the next two slides?

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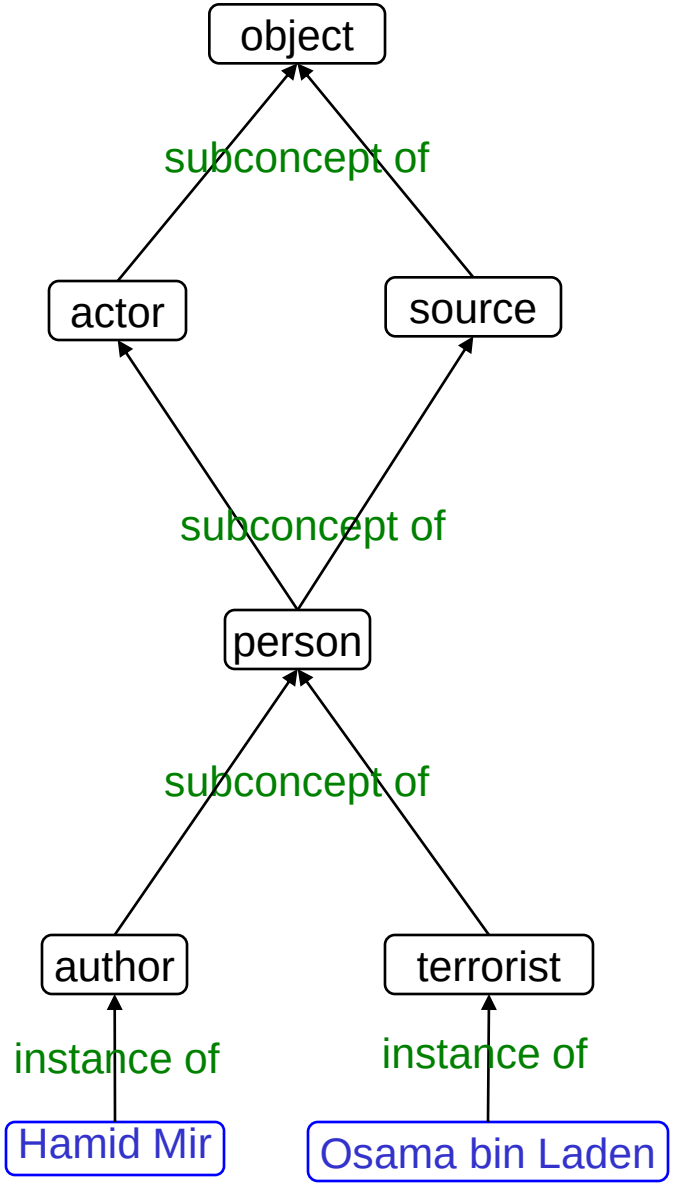
Questions and Exercises



is testimony by

domain: evidence

range: source

is testimony about

domain: evidence

range: evidence

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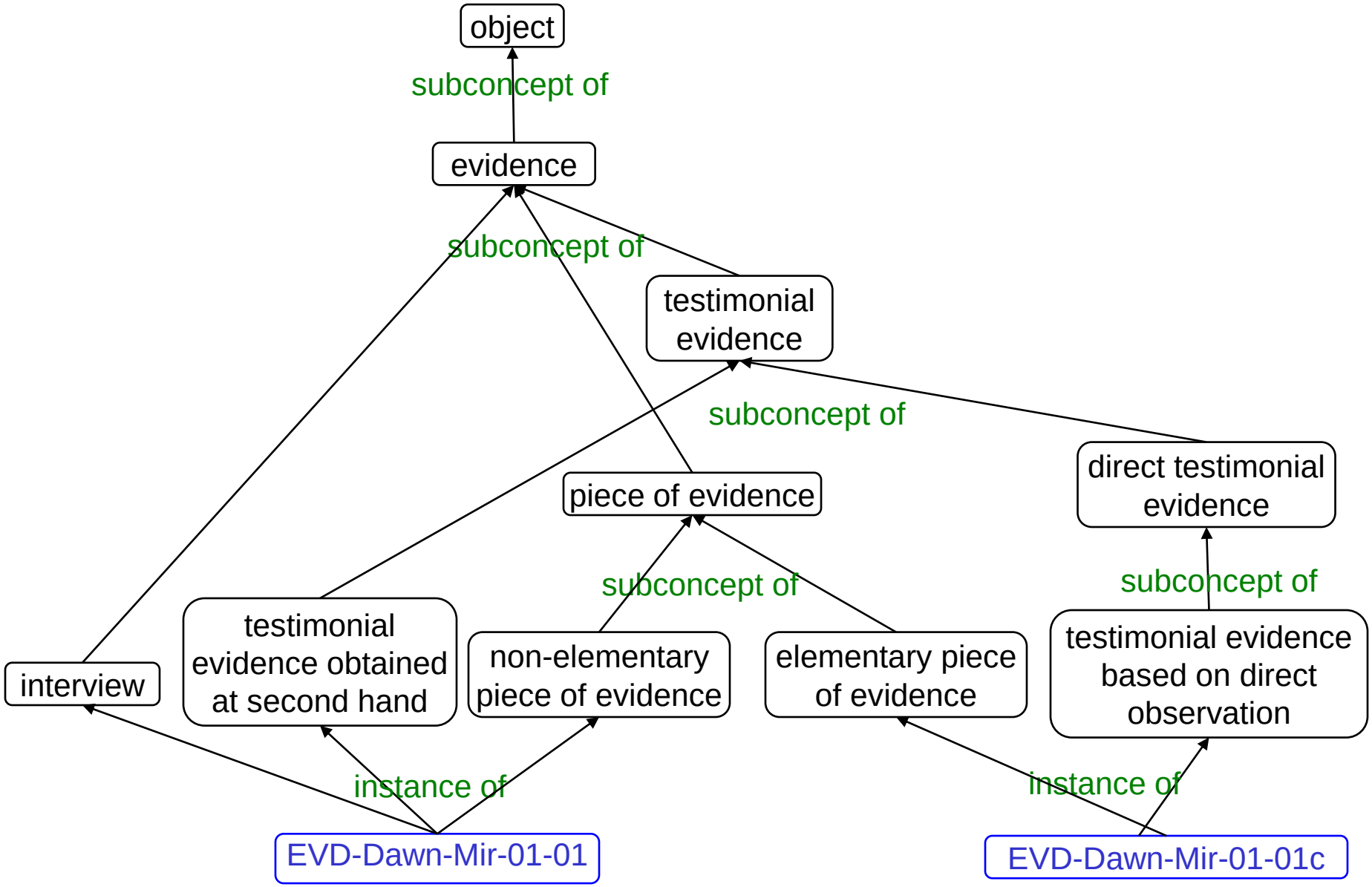
Questions and Exercises



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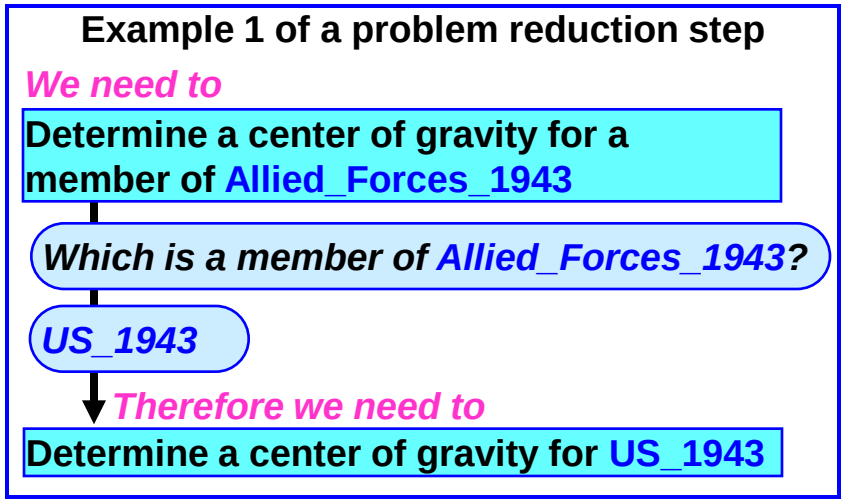
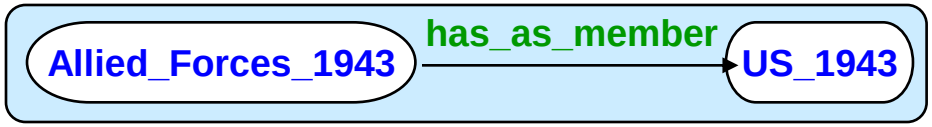
Questions and Exercises

Consider the following example and associated explanation:





What rule will be learned from them, assuming the ontology from the next slide?

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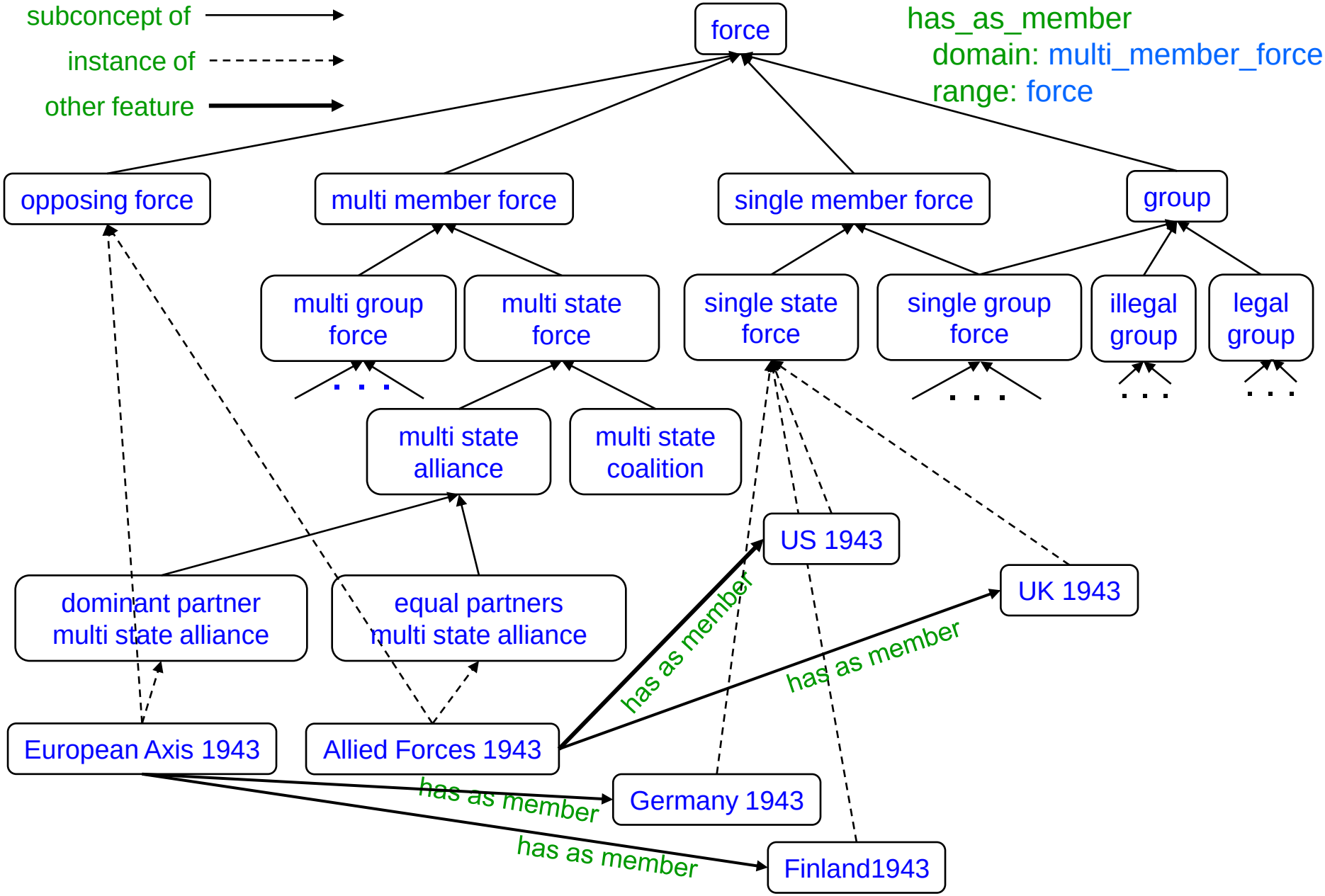
Questions and Exercises



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Questions and Exercises

Consider the additional positive example:

We need to

Determine a center of gravity for a member of *European_Axis_1943*

Therefore we need to

Determine a center of gravity for *Germany_1943*

Indicate the refined rule.

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Questions and Exercises

Consider the following negative example, its failure explanation, and the additional ontological knowledge:

Negative Example #3:

We need to

Determine a center of gravity for a member of European_Axis_1943

Which is a member of European_Axis_1943?

Finland_1943

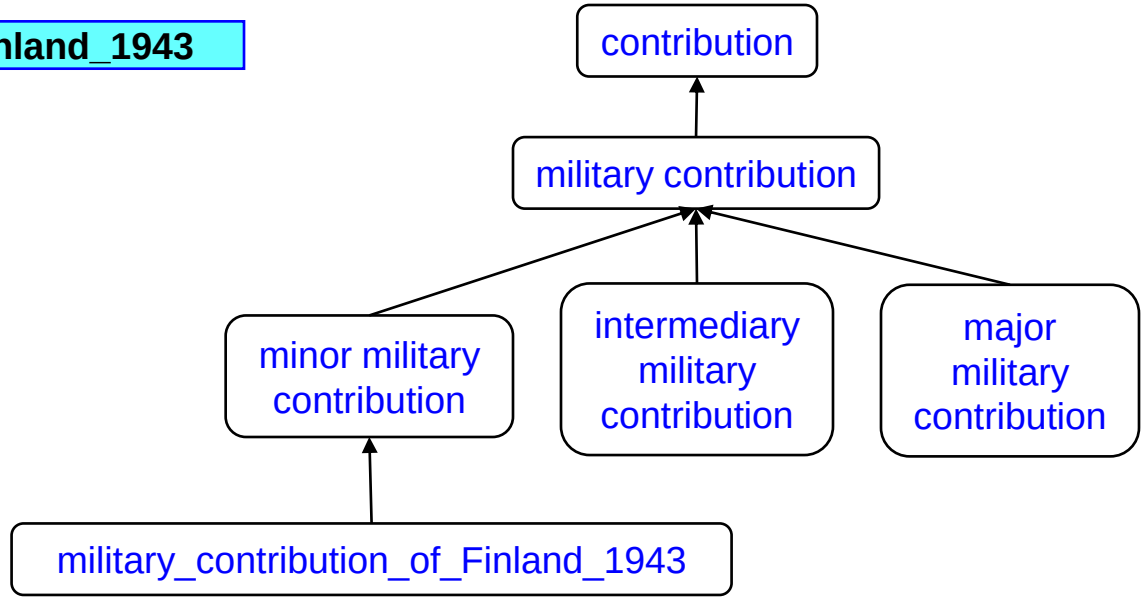
Therefore we need to

Determine a center of gravity for Finland_1943

FAILURE EXPLANATION

Finaland_1943 has_as_military_contribution military_contribution_of_Finland_1943 is minor_military_contribution

has_as_military_contribution
domain: force
range: military contribution



Indicate the refined rule.

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