Universität des Saarlandes
Fachrichtung 6.2 – Informatik
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7th Theoretical Assignment in Artificial Intelligence (WS 2006/2007)
Solutions

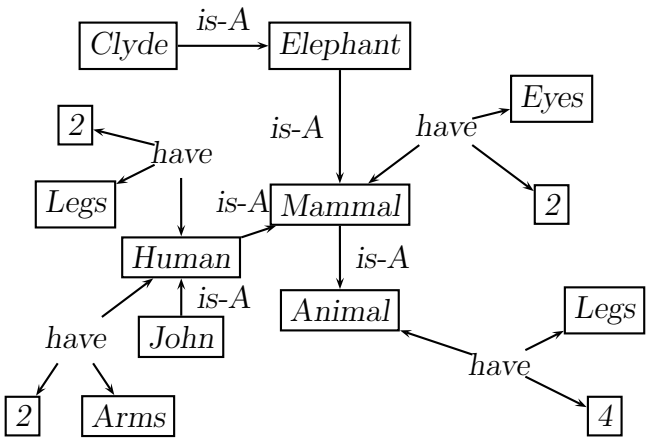
Exercise 7.1 Consider the following statements:

Clyde is an elephant. Elephants are mammals. Mammals are animals. Humans are mammals. John is a human. Animals are four-legged. Humans are two-legged (biped). Mammals have two eyes. Humans have two arms.

- Represent these statements in a semantic net (in shortform).
- Represent these statements as formulas in first-order predicate logic (such that it can be derived that John has two legs and not four!)
- Represent these statements as frames.

Solution:

- *The semantic net in shortform:*



- *We treat individual objects like* Clyde *and* John *as constants, and concepts like* Elephant *and* Mammal *as predicates.*
  - $Elephant(Clyde)$
  - $\forall x(Elephant(x) \Rightarrow Mammal(x))$
  - $\forall x(Mammal(x) \Rightarrow Animal(x))$
  - $\forall x(Human(x) \Rightarrow Mammal(x))$

- $Human(John)$
- $\forall x(Animal(x) \wedge \neg Human(x) \Rightarrow FourLegged(x))$
- $\forall x(Human(x) \Rightarrow Biped(x))$
- $\forall x(Mammal(x) \Rightarrow TwoEyed(x))$
- $\forall x(Mammal(x) \Rightarrow TwoArmed(x))$

Different representations are possible, for example an alternative representation of the sixth statement is:

- $\forall x(Animal(x) \wedge \neg Human(x) \Rightarrow \exists l_1, l_2, l_3, l_4(Leg(l_1) \wedge Leg(l_2) \wedge Leg(l_3) \wedge Leg(l_4) \wedge l_1 \neq l_2 \neq l_3 \neq l_4 \wedge Have(x, l_1) \wedge Have(x, l_2) \wedge Have(x, l_3) \wedge Have(x, l_4)))$

- *Frame representation:*

$$\left[\begin{array}{ll} CLYDE & \\ Self: & (\textit{element-of ELEPHANTS}) \end{array}\right]$$

$$\left[\begin{array}{ll} ELEPHANTS & \\ Self: & (\textit{subset-of MAMMALS}) \end{array}\right]$$

$$\left[\begin{array}{ll} MAMMALS & \\ Self: & (\textit{subset-of ANIMALS}) \\ eyes: & 2 \end{array}\right]$$

$$\left[\begin{array}{ll} ANIMALS & \\ legs: & 4 \end{array}\right]$$

$$\left[\begin{array}{ll} JOHN & \\ Self: & (\textit{element-of HUMANS}) \end{array}\right]$$

$$\left[\begin{array}{ll} HUMANS & \\ Self: & (\textit{subset-of MAMMALS}) \\ legs: & 2 \\ arms: & 2 \end{array}\right]$$

Exercise 7.2
Consider the following statement:

John tells Mary a secret on Valentine's day.

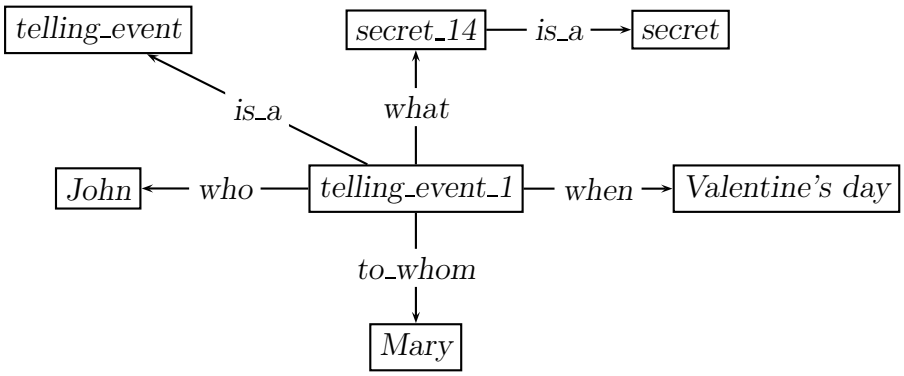
Represent this statement as a semantic net (in shortform). Use only binary relations.

Solution:
First we identify the relation:
- *tells(John, Mary, "secret", "Valentine's day")*

Then we transform this 4-ary relation into 4 binary relations:
- *who(tell_event_1, John)*

- *to_whom(tell_event_1, Mary)*
- *what(tell_event_1, "secret")*
- *when(tell_event_1, "Valentine's day")*

The resulting semantic net looks like that:



Exercise 7.3
Express the following information

1. in an appropriate logic,
2. as a semantic net,
3. and as frames:

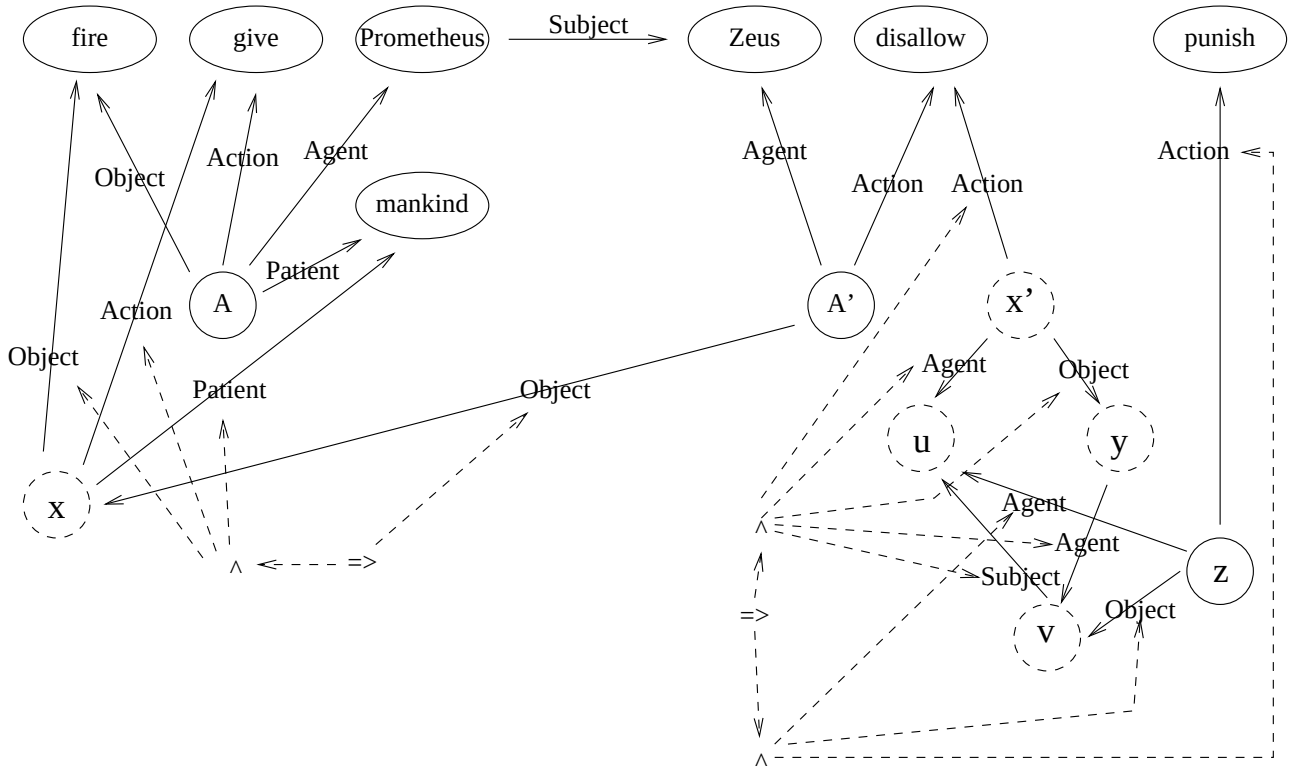
A is an action of type *give* with agent *Prometheus*, object *fire*, and patient *mankind*. *Prometheus* is a subject of *Zeus*. A' is an action of type *disallow* with agent *Zeus*. The object of A' is any action of giving fire to mankind. If the ruler disallows an action, which will be performed by one of his subjects, another action takes place, in which the ruler punishes the subject.

Solution:

- *first order logic:*

$$
\begin{aligned}
&Action(A, give)\\
&Agent(A, Prometheus)\\
&Object(A, fire)\\
&Patient(A, mankind)\\
&Subject(Prometheus, Zeus)\\
&Action(A', disallow)\\
&Agent(A', Zeus)\\
&\forall x.Action(x, give) \wedge Object(x, fire) \wedge Patient(x, mankind) \Rightarrow Object(A', x)\\
&\forall x', y, u, v.Action(x', disallow) \wedge Agent(x', u) \wedge Object(x', y) \wedge Agent(y, v) \wedge Subject(v, u)\\
&\qquad \Rightarrow (\exists z.Action(z, punish) \wedge Agent(z, u) \wedge Object(z, v))
\end{aligned}
$$

- *semantic net:*



- *frames:*

$$\left[\begin{array}{l} A \\ Action : give \\ Agent : Prometheus \\ Object : fire \\ Patient : mankind \end{array}\right] \quad \left[\begin{array}{l} d_1 \\ Type : dependency \\ Subject : Prometheus \\ Ruler : Zeus \end{array}\right]$$

$$\left[\begin{array}{l} I_1 \\ Type : Implication \\ Precondition : x \\ Conclusion : A' \end{array}\right] \quad \left[\begin{array}{l} x \\ Action : give \\ Object : fire \\ Patient : mankind \end{array}\right] \quad \left[\begin{array}{l} A' \\ Action : disallow \\ Agent : Zeus \\ Object : x \end{array}\right]$$

$$\left[\begin{array}{l} I_2 \\ Type : Implication \\ Precondition : c \\ Conclusion : z \end{array}\right]$$

$$\left[\begin{array}{l} c \\ Type : Conjunction \\ Conjunct_1 : x' \\ Conjunct_2 : y \\ Conjunct_3 : d_2 \end{array}\right] \quad \left[\begin{array}{l} x' \\ Action : disallow \\ Agent : u \\ Object : y \end{array}\right] \quad \left[\begin{array}{l} y \\ Agent : v \end{array}\right] \quad \left[\begin{array}{l} d_2 \\ Type : dependency \\ Subject : v \\ Ruler : u \end{array}\right]$$

$$\left[\begin{array}{l} z \\ Action : punish \\ Agent : u \\ Object : v \end{array}\right]$$