Frames for sortal, relational, and functional concepts

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CTF 2007, Düsseldorf

outline

outline

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1. **Classification of concepts (Löbner)**
2. **Frames**
   - Definition of frames
   - Classification of frames
3. **Attributes and type signatures**
   - Attributes and functional concepts
   - Type signatures and minimal upper attributes

concept classification

person, pope, house, verb, sun, Mary, wood, brother, mother, meaning, distance, spouse, argument, entrance

concept classification: relationality

non-relational	person, pope, house, verb, sun, Mary, wood
relational	brother, mother, meaning, distance, spouse, argument, entrance

Löbner

concept classification: uniqueness of reference

	non-unique reference	unique reference
non-relational	person, house, verb, wood	Mary, pope, sun
relational	brother, argument, entrance	mother, meaning, distance, spouse

Löbner

concept classification

	non-unique reference	unique reference
non-relational	**sortal concept**	**individual concept**
relational	**proper relational concept**	**functional concept**

Löbner

concept classification

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Löbner

outline

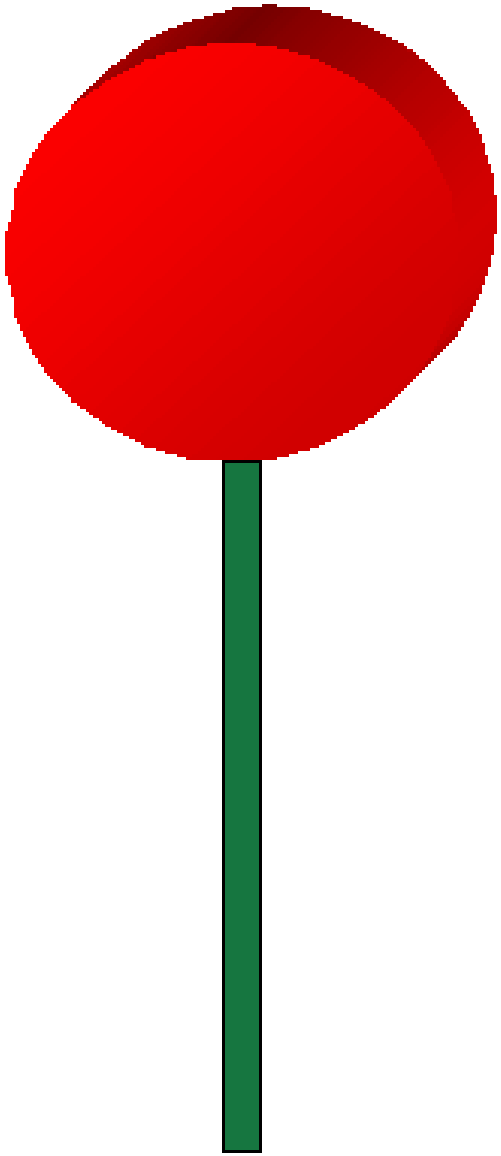
frames

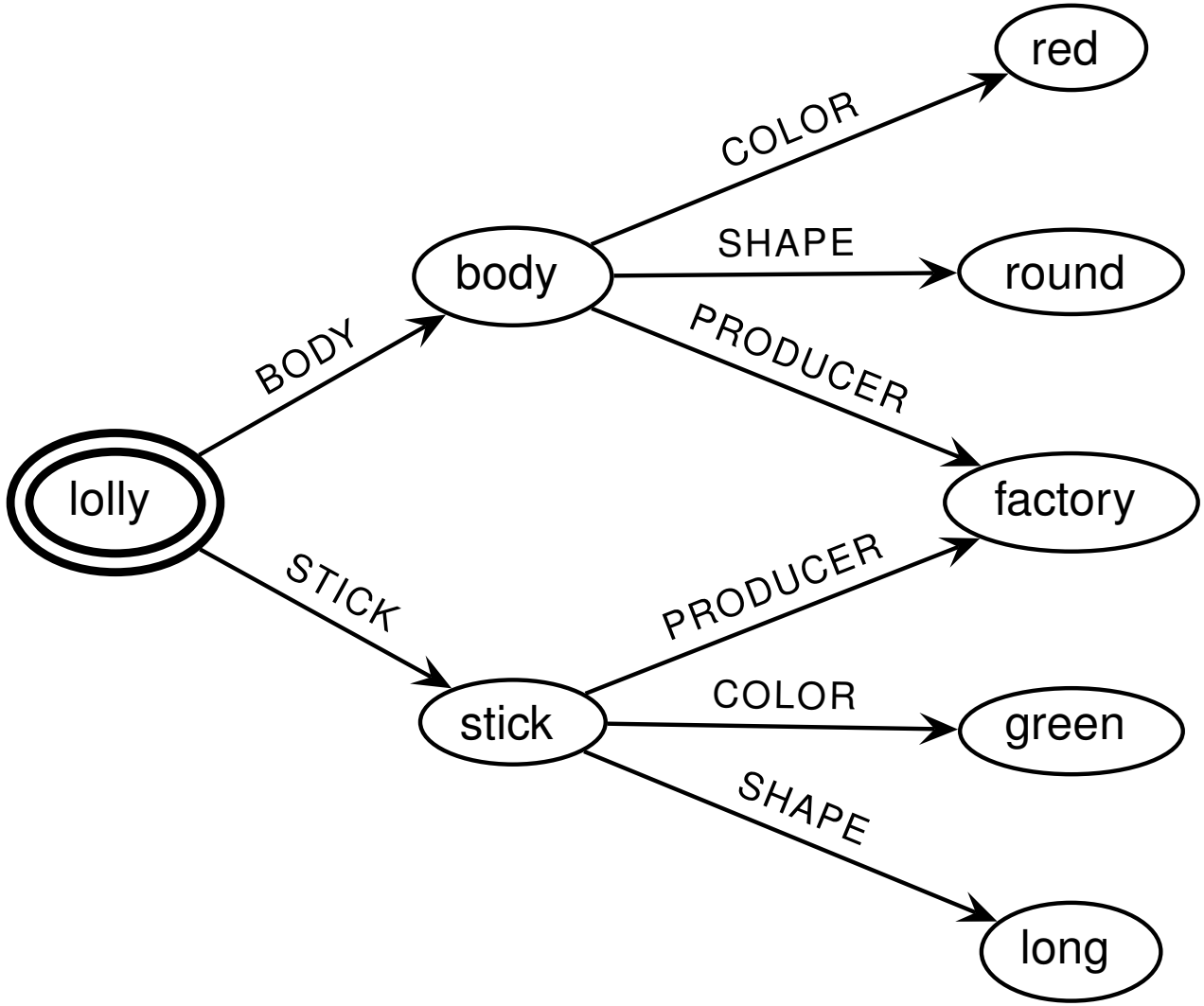
Barsalou (1992) *Frames, Concepts, and Conceptual Fields*

- Frames provide the fundamental representation of knowledge in human cognition.
- At their core, frames contain **attribute-value sets**.

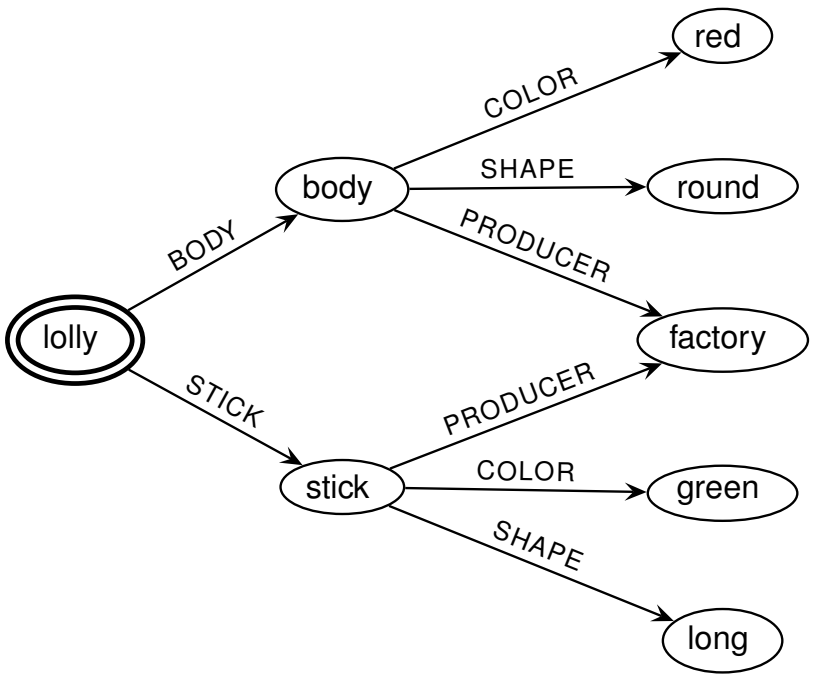
example:passport frame

lolly-frame




red
COLOR
body
SHAPE
round
PRODUCER
BODY
lolly
factory
STICK
PRODUCER
stick
COLOR
green
SHAPE
long

frame definition

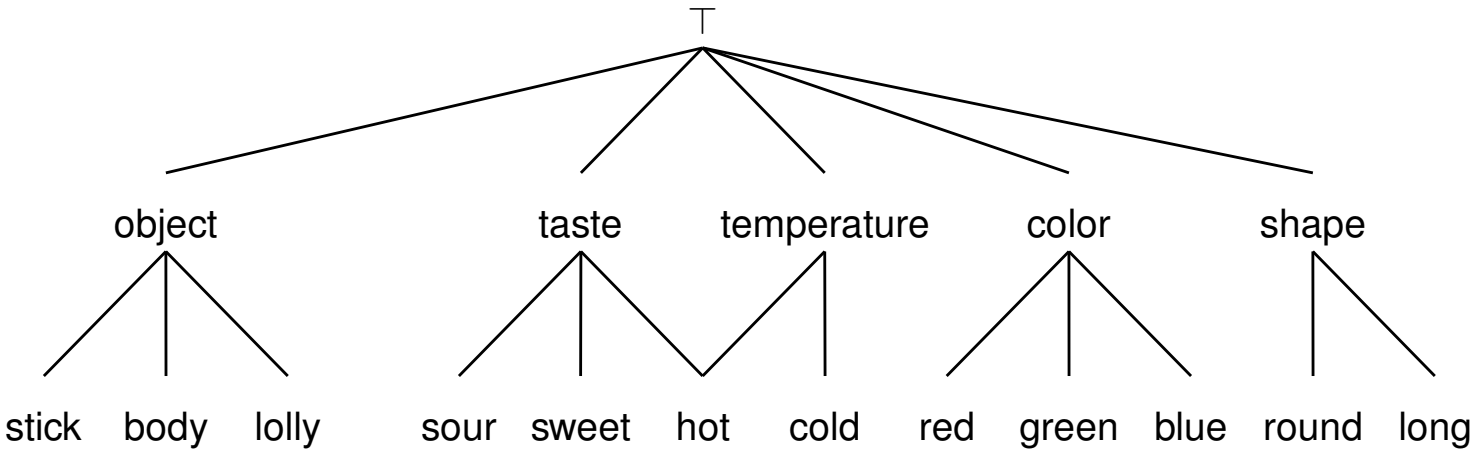


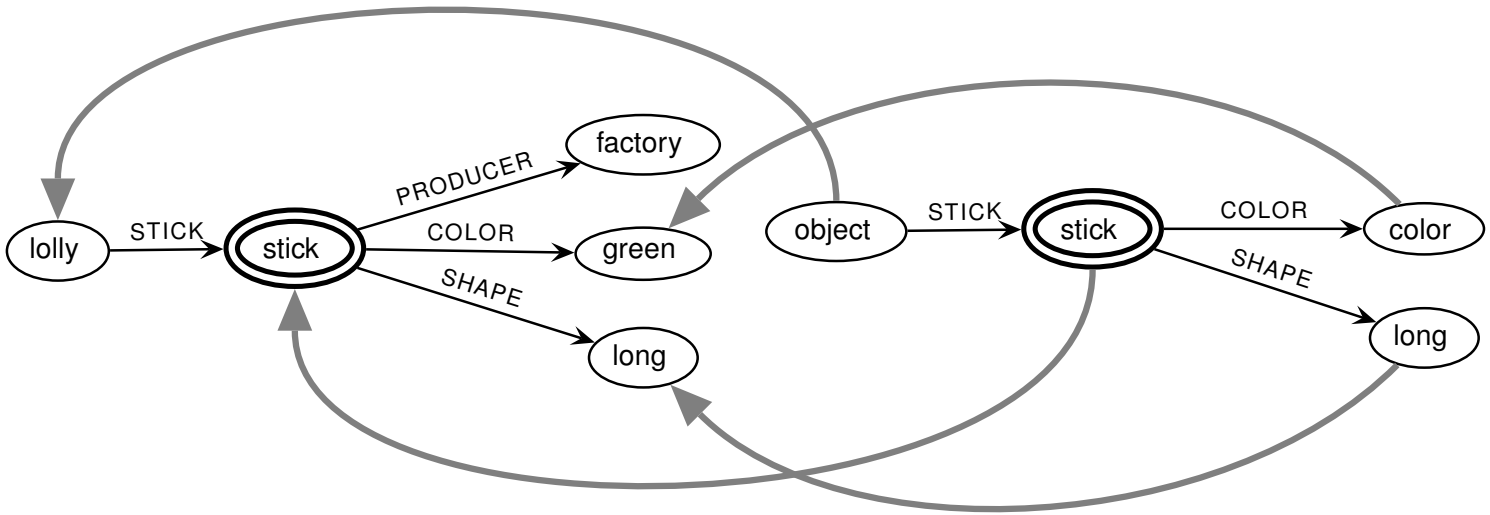
Definition

Frames are rooted, connected, directed graphs with

- one central node (here: double-encircled)
- nodes labeled with types
- arcs labeled with attributes
- no node with two equally labeled outgoing arcs

type hierarchy and frame subsumption





terminology

Definition

A node is a root of a frame if all other nodes can be reached from it by a path of directed arcs.

terminology

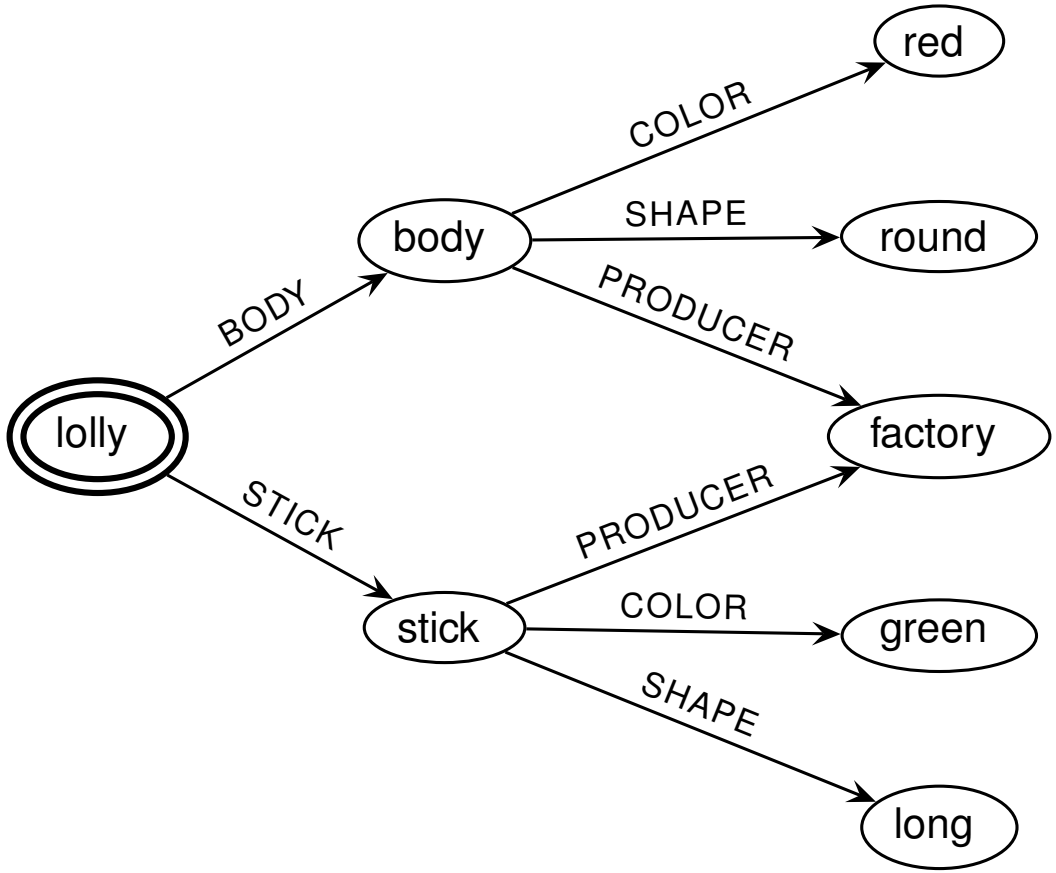
Definition

A node is a root of a frame if all other nodes can be reached from it by a path of directed arcs.

Definition

A node is a source if it has no incoming arc.

lolly-frame (sortal concept)



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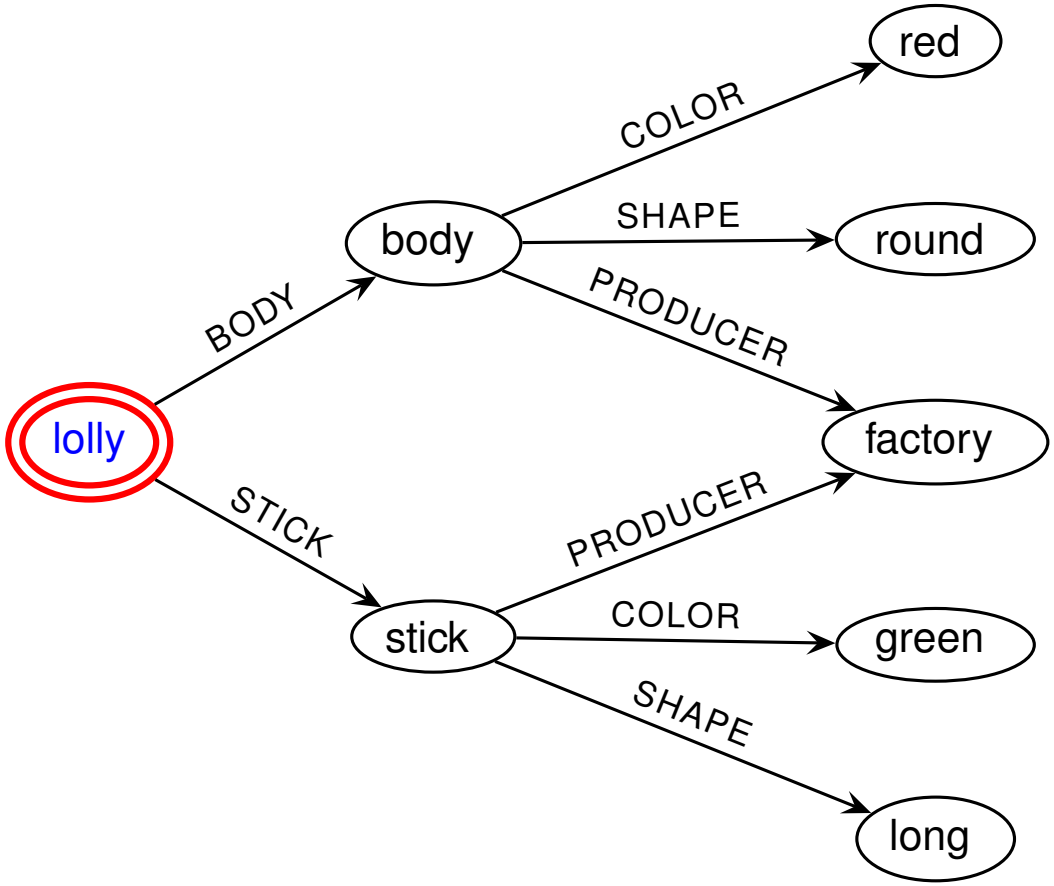
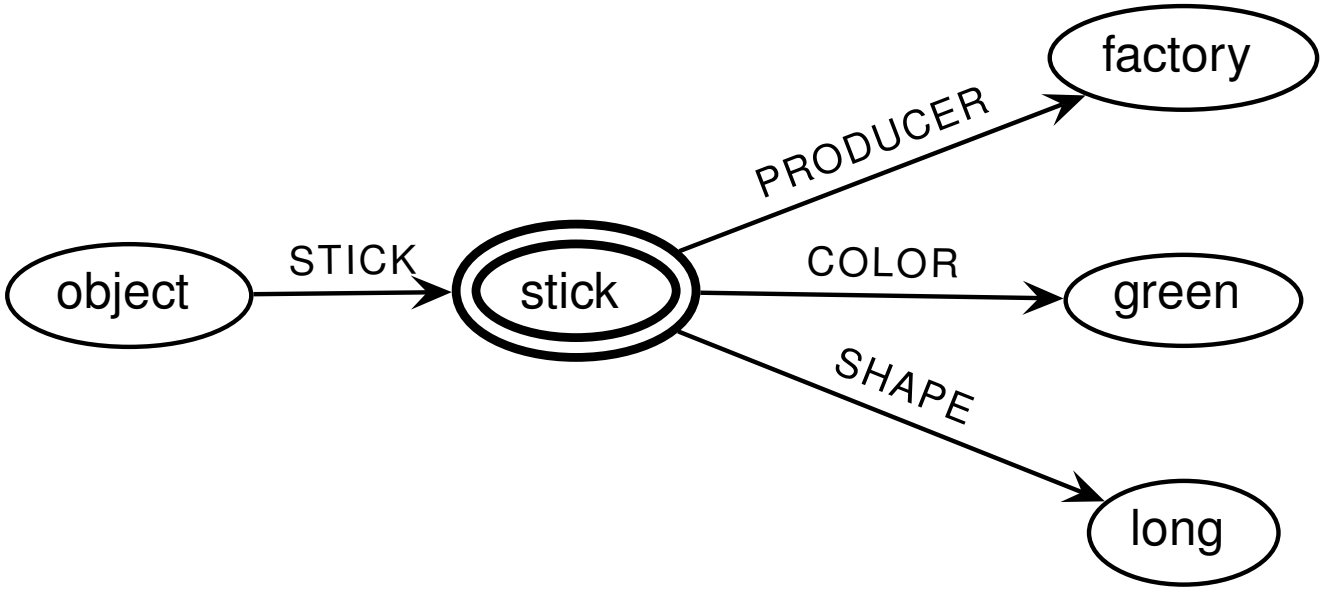


central node = root = source

stick-frame (functional concept)



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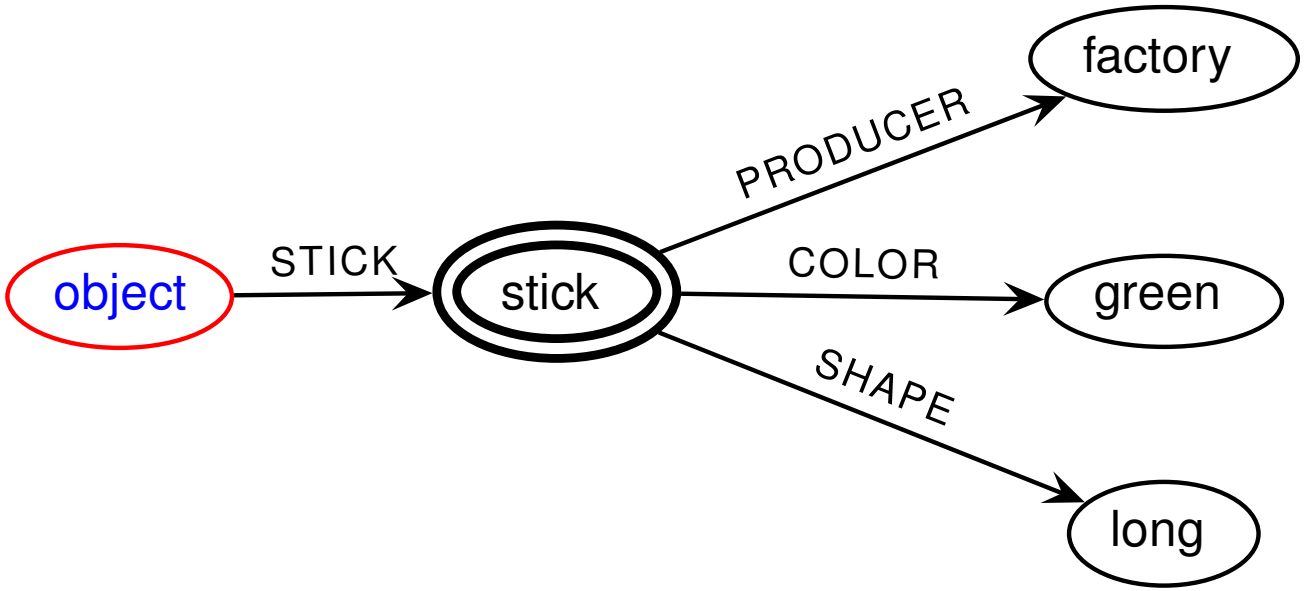
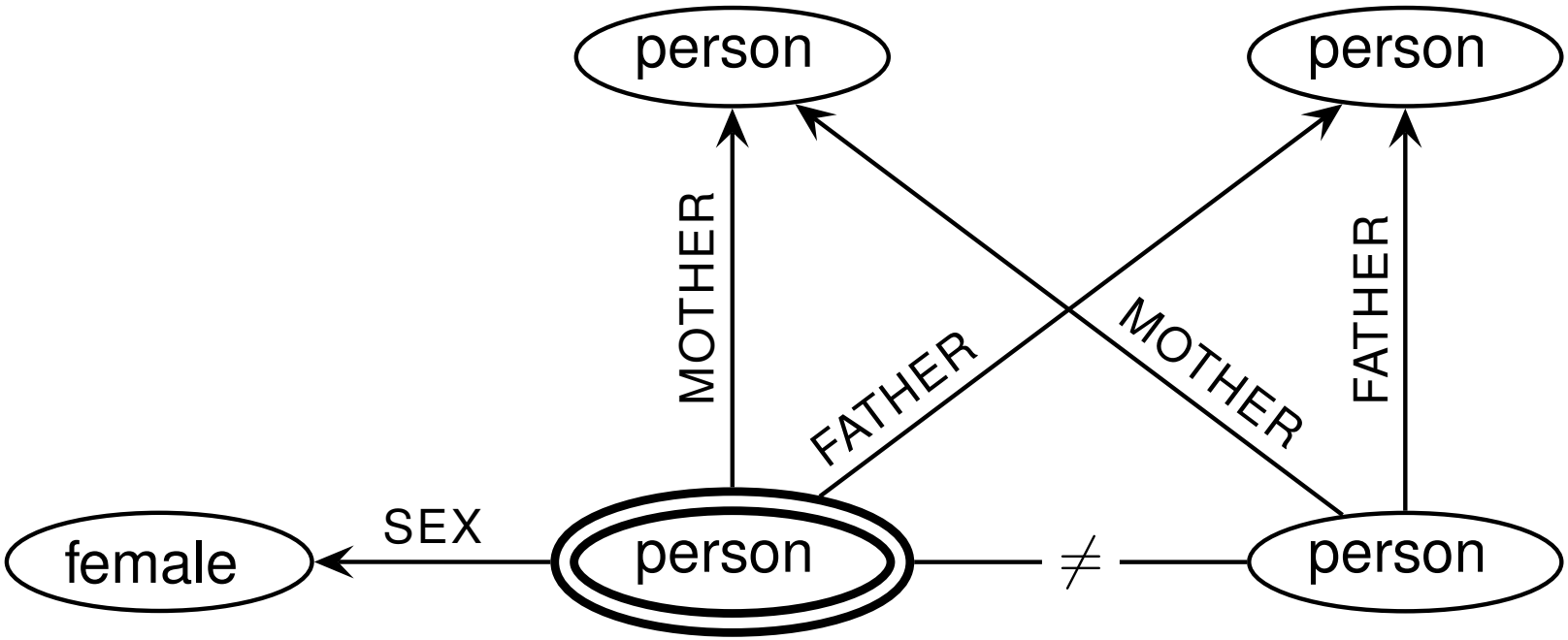
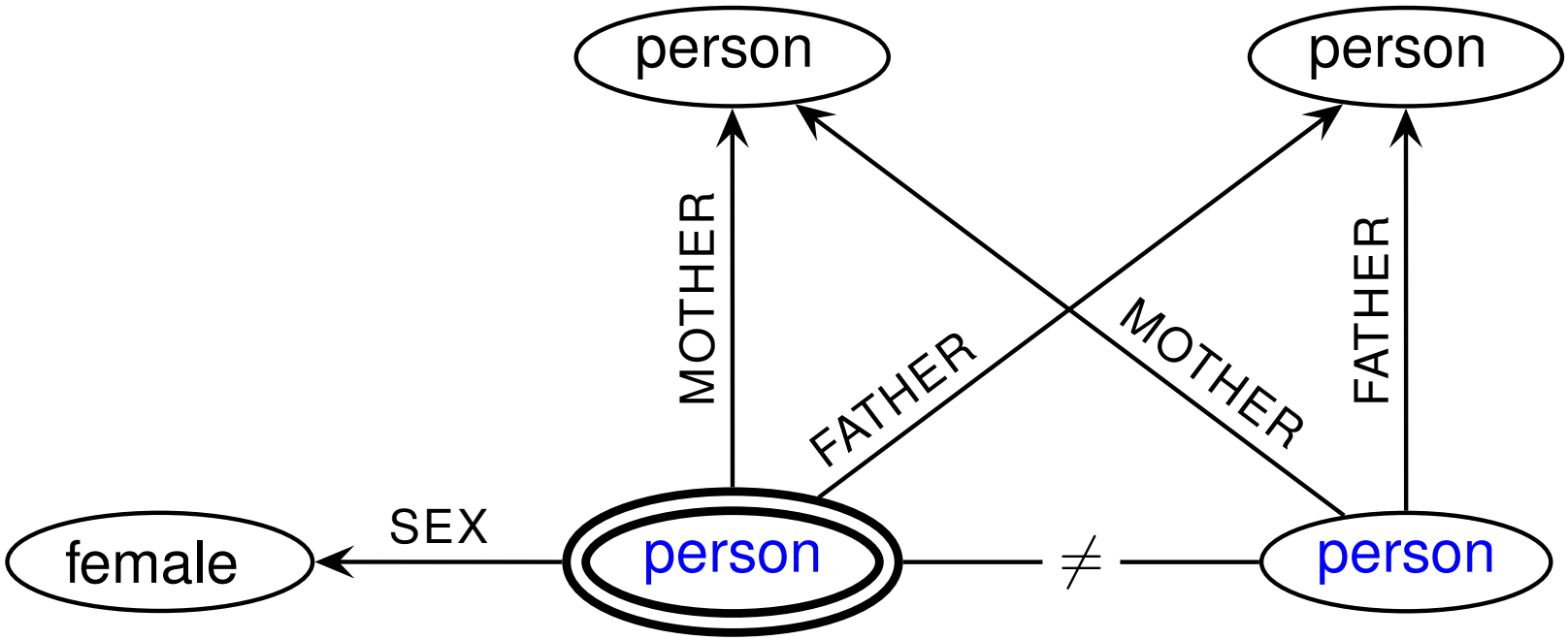


central node $\neq$ root $=$ source

sister-frame (proper relational concept)



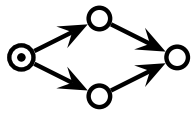
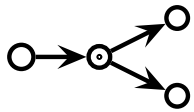
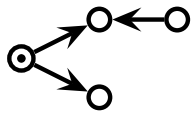
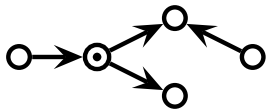
sister-frame (proper relational concept)



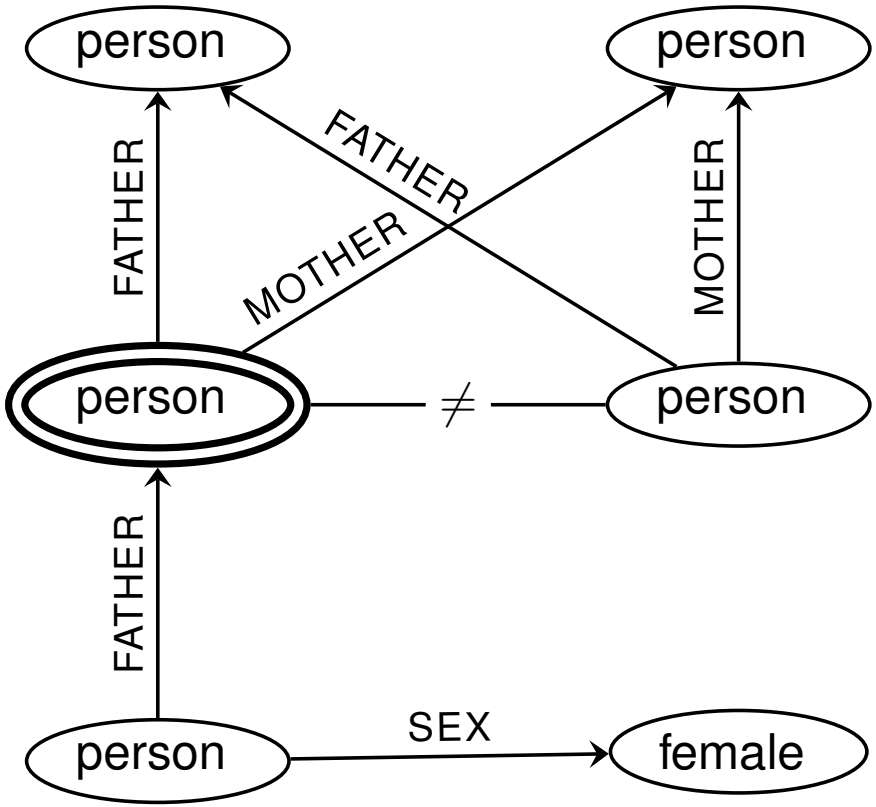
no root & central node = source

classification of acyclic frame graphs

C: central node, R: root, S: source

$C = R$	$C = S$	$\exists R$	$\exists S$	typical graph	frame class
+	+	+	+		sortal
−	−	+	+		functional
−	+	−	+		proper relational
−	−	−	+		???

4th frame class: not lexicalized?



relational concept: father of a niece

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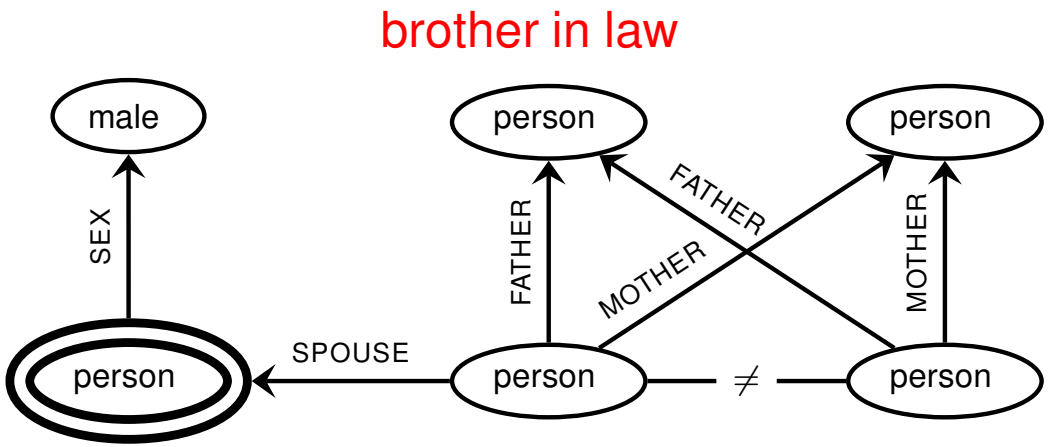

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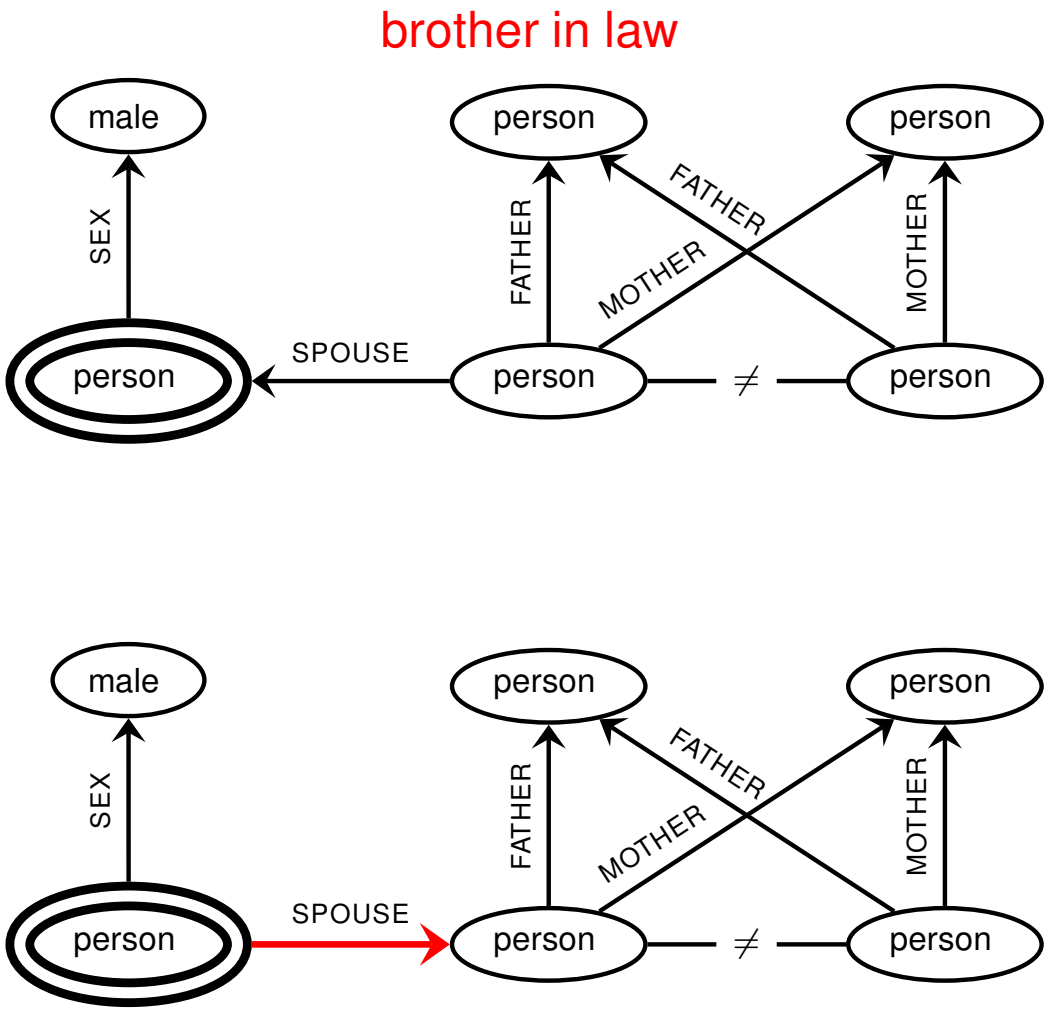
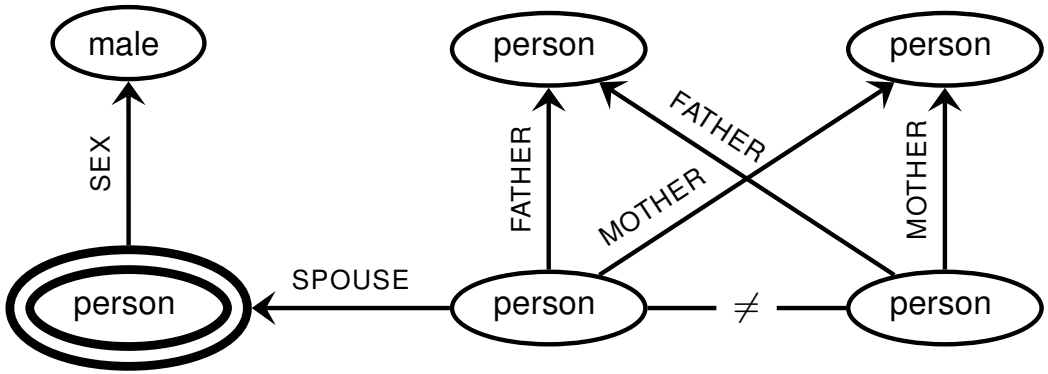
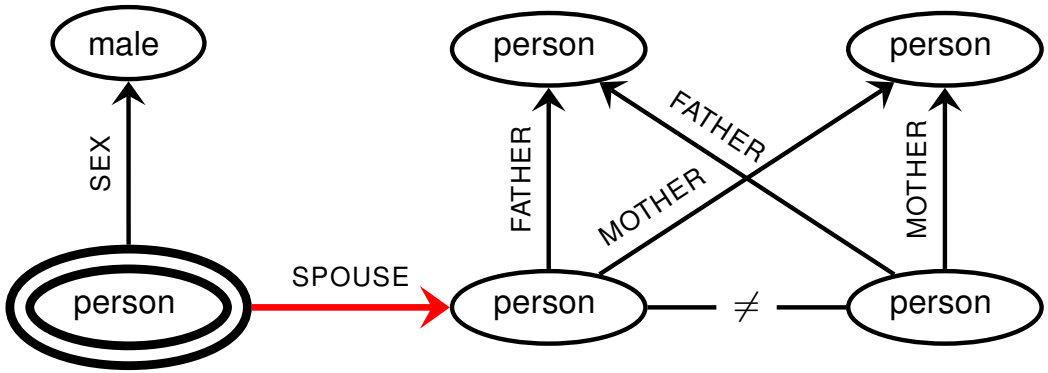


4th frame class: not lexicalized?

brother in law



“male person who is the spouse of someone who has a sibling”



“male person whose spouse has a sibling”

concept classification and frame graphs

relationality

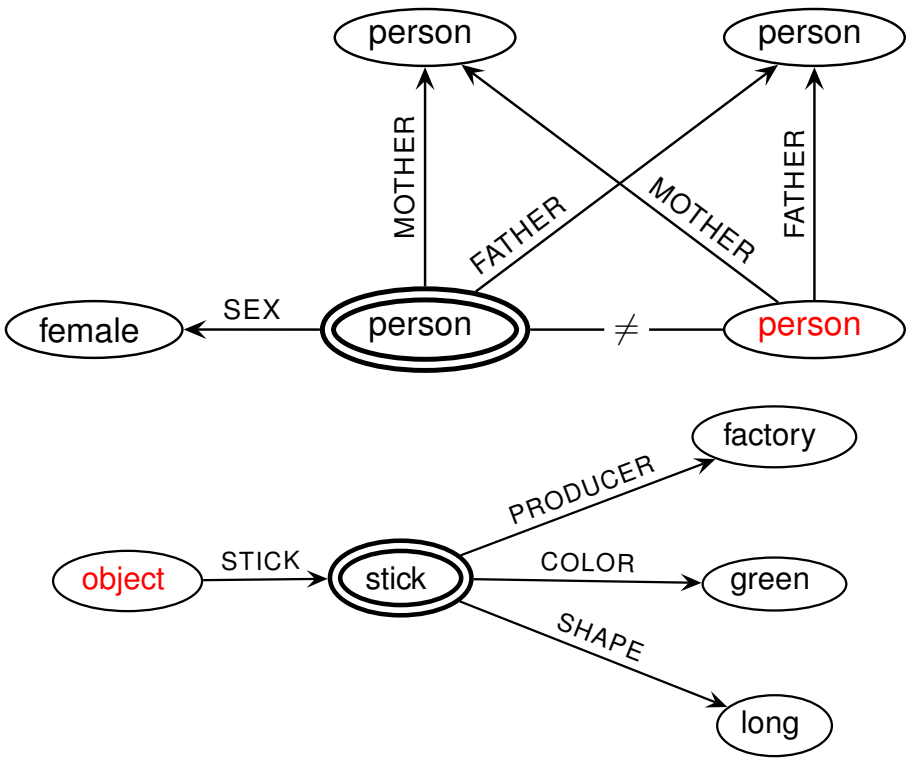
The arguments of relational concepts are modeled in frames as sources that are not identical to the central node.

functionality

The functionality of functional concepts is modeled by an incoming arc at the central node.

conclusion

The concept classification is reflected by the properties of the frame graphs.



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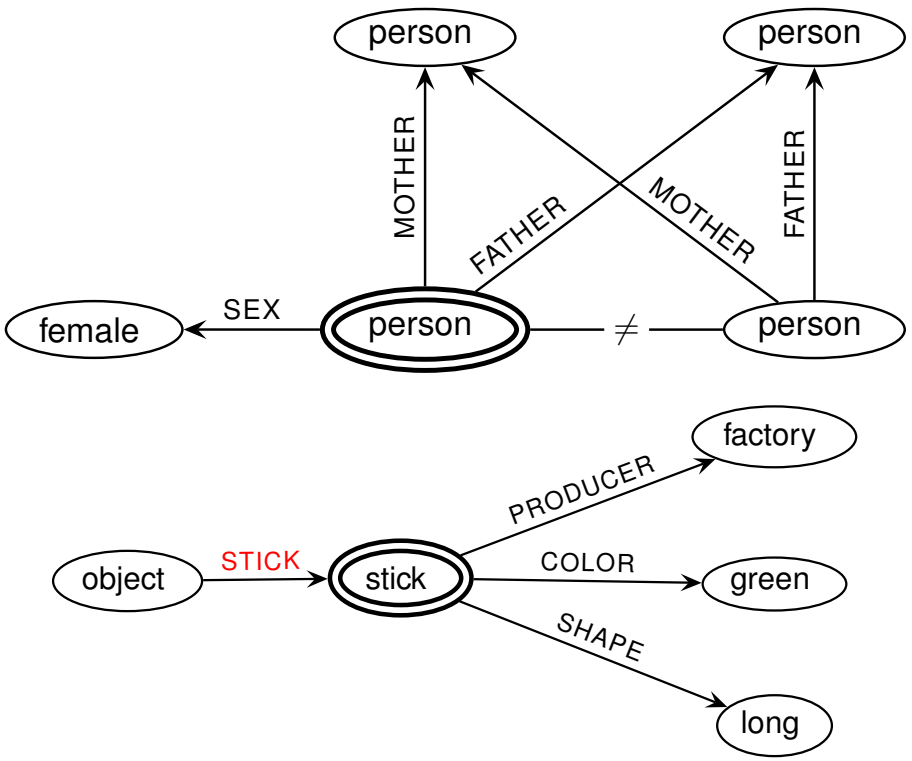

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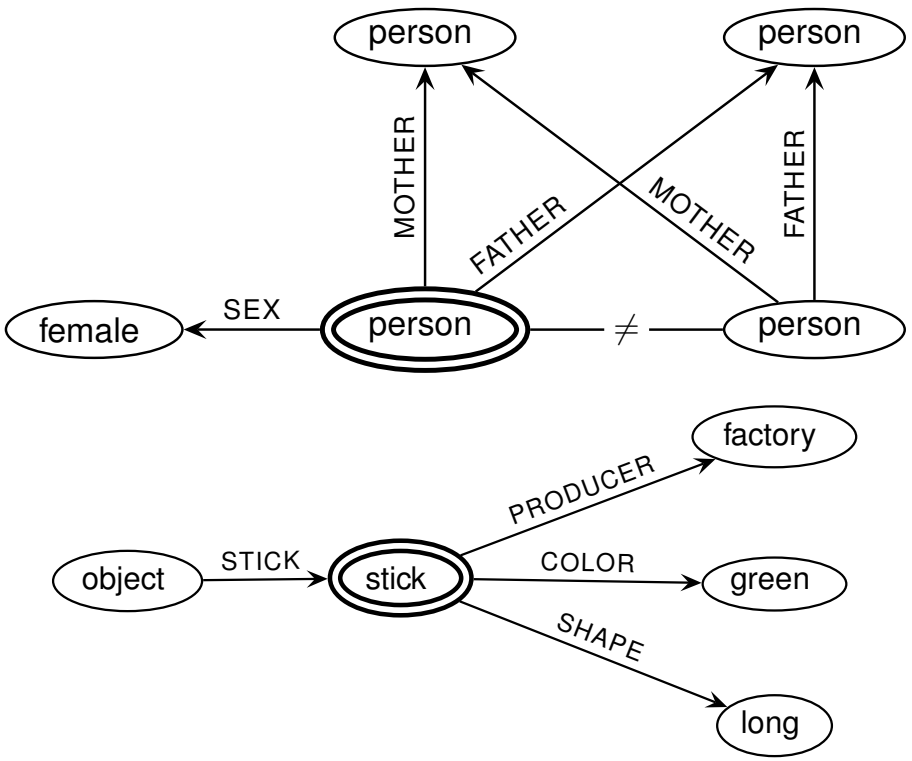

outline

attributes in frames

Barsalou, 1992: *Frames, Concepts, and Conceptual Fields*

"I define an attribute as a **concept** that describes an aspect of at least some category member."

Guarino, 1992: *Concepts, attributes and arbitrary relations*

"We define attributes as **concepts** having an associate relational interpretation, allowing them to act as conceptual components as well as concepts on their own."

interpretation of functional concepts

denotational interpretation

A functional concept denotes a set of entities:

$$\delta : \mathcal{R} \rightarrow 2^{\mathcal{U}}$$

$\delta(\text{mother}) = \{m \mid m \text{ is the mother of someone}\}$

relational interpretation

A functional concept has also a relational interpretation:

$$\varrho : \mathcal{R} \rightarrow 2^{\mathcal{U} \times \mathcal{U}}$$

$\varrho(\text{mother}) = \{(p, m) \mid m \text{ is the mother of } p\}$

consistency postulate (Guarino, 1992)

Any value of an relationally interpreted functional concept is also an instance of the denotation of that concept.

If $(p, m) \in \varrho(\text{mother})$, then $m \in \delta(\text{mother})$.

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attributes in frames

thesis:

Attributes in frames are relationally interpreted functional concepts!

consequence (1):

Frames decompose concepts into relationally interpreted functional concepts!

consequence (2):

The distinction between the attribute set and the type set is artificial: $\mathcal{ATTR} \subseteq \mathcal{TYPE}$.

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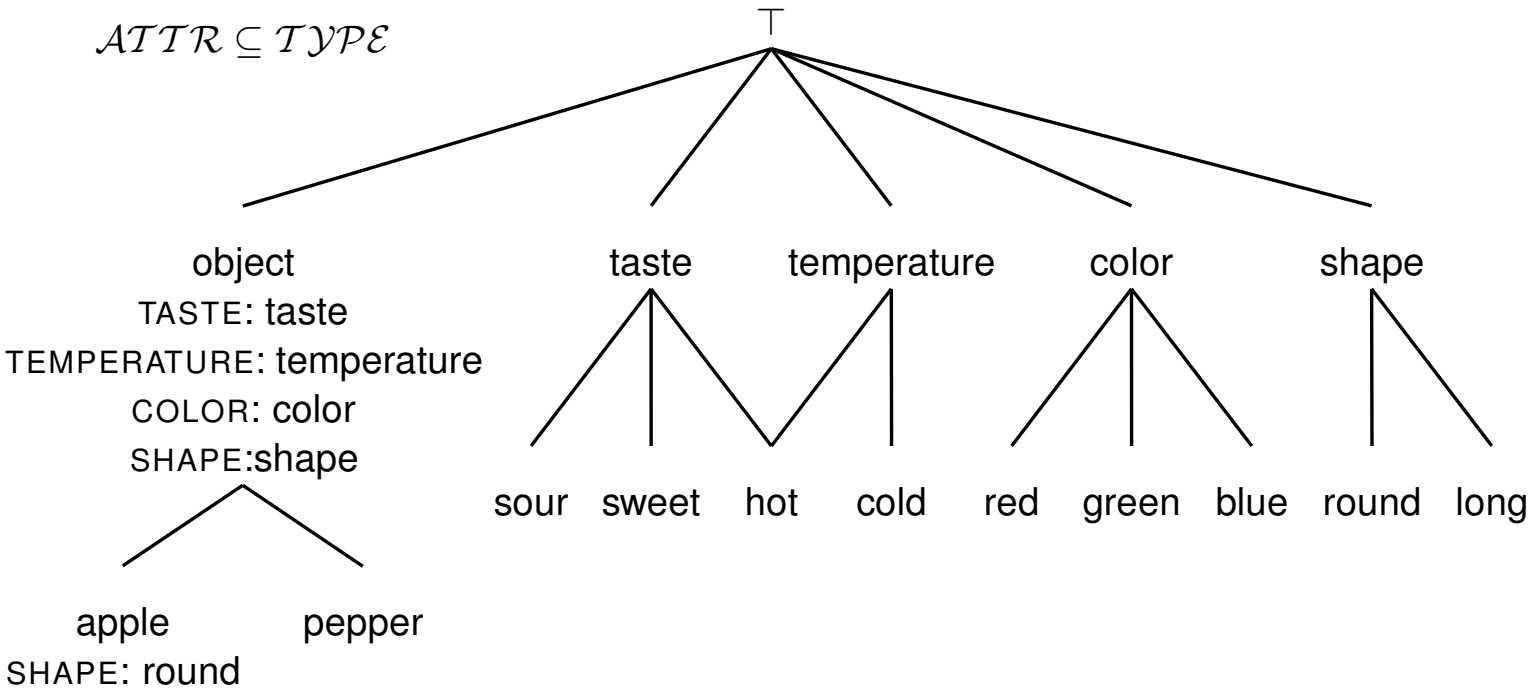
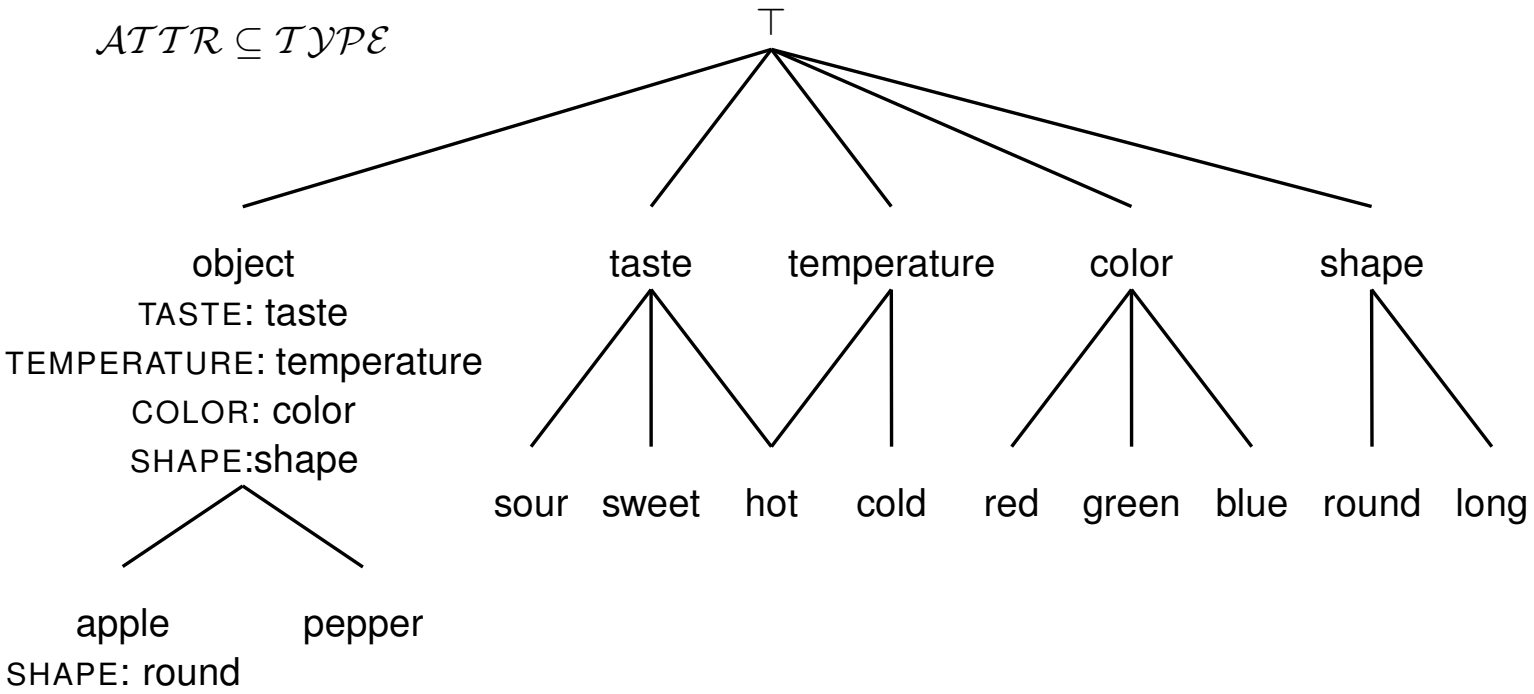
type signature and minimal upper attributes



Barsalou, 1992: *Frames, Concepts, and Conceptual Fields*

"I define an attribute as a **concept** that describes an aspect of at least some category member."
"Values are subordinate concepts of an attribute."

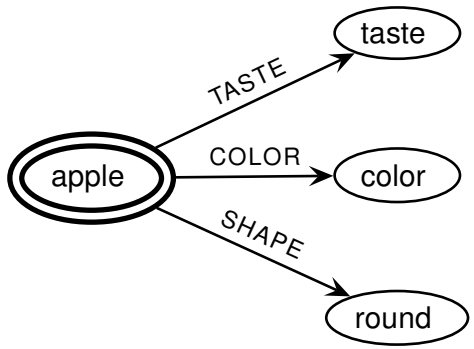
type signature and minimal upper attributes



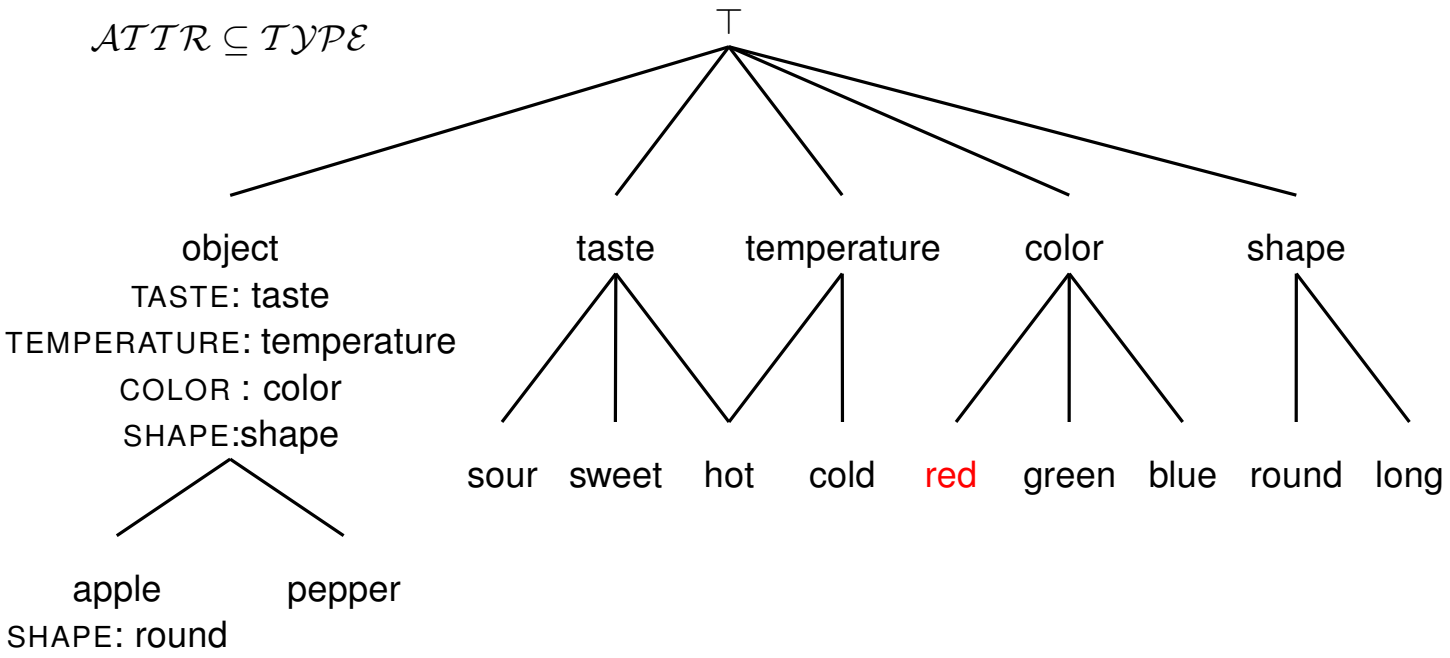
Definition

A minimal upper attribute of a type is a minimal element of the set of upper attributes of the type. Where an upper attribute of a type is an attribute which is a supertype of the type.

red apple



$\mathcal{ATTR} \subseteq \mathcal{TYPE}$



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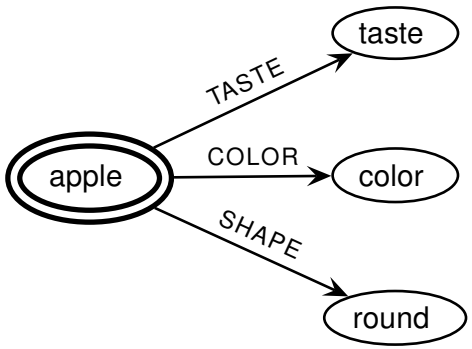
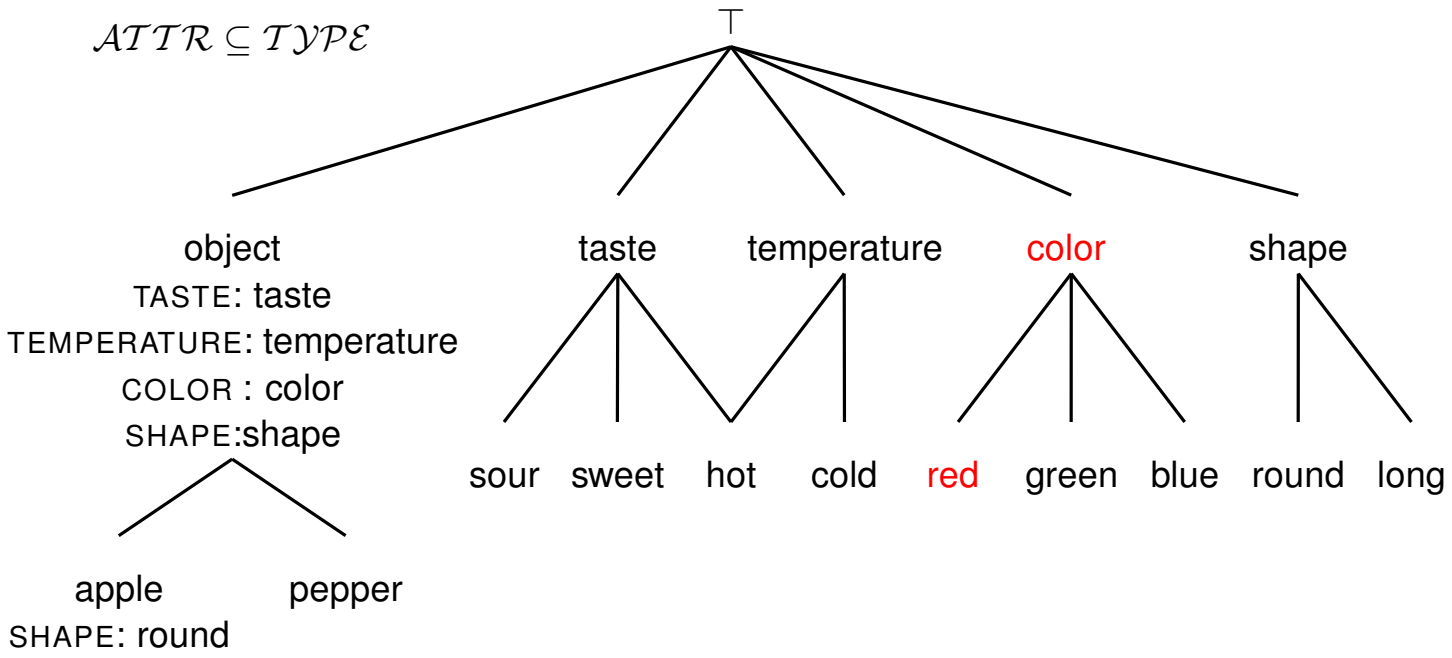
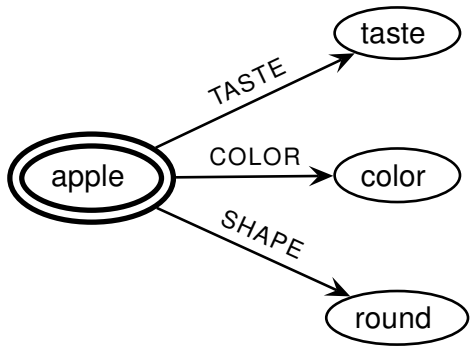



$\mathcal{ATTR} \subseteq \mathcal{TYPE}$
⊤
object
TASTE: taste
TEMPERATURE: temperature
COLOR : color
SHAPE:shape
taste
temperature
color
shape
sour
sweet
hot
cold
red
green
blue
round
long
apple
pepper
SHAPE: round

red apple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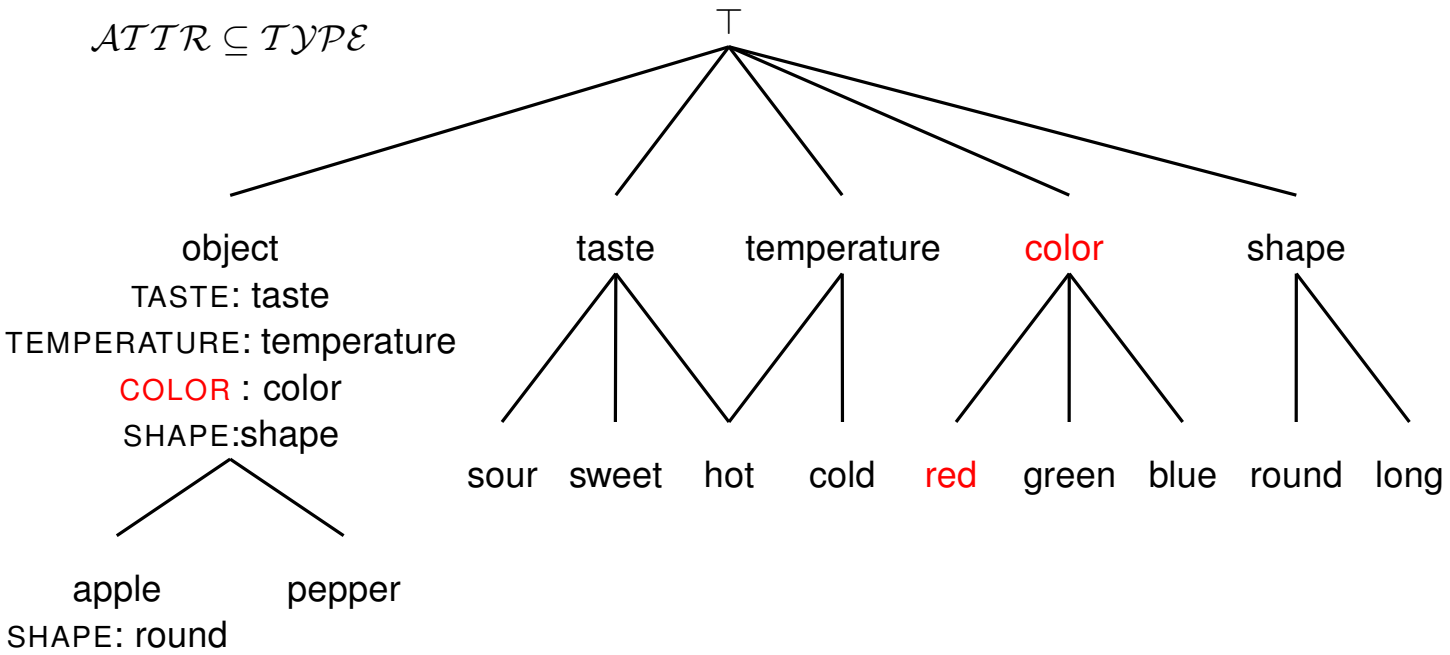
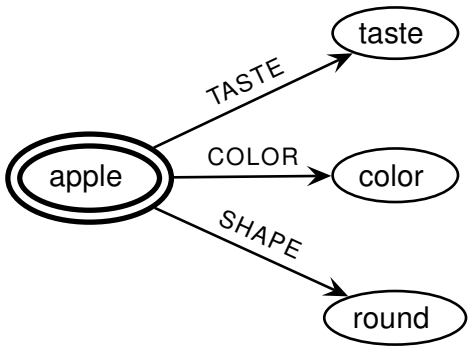


red apple



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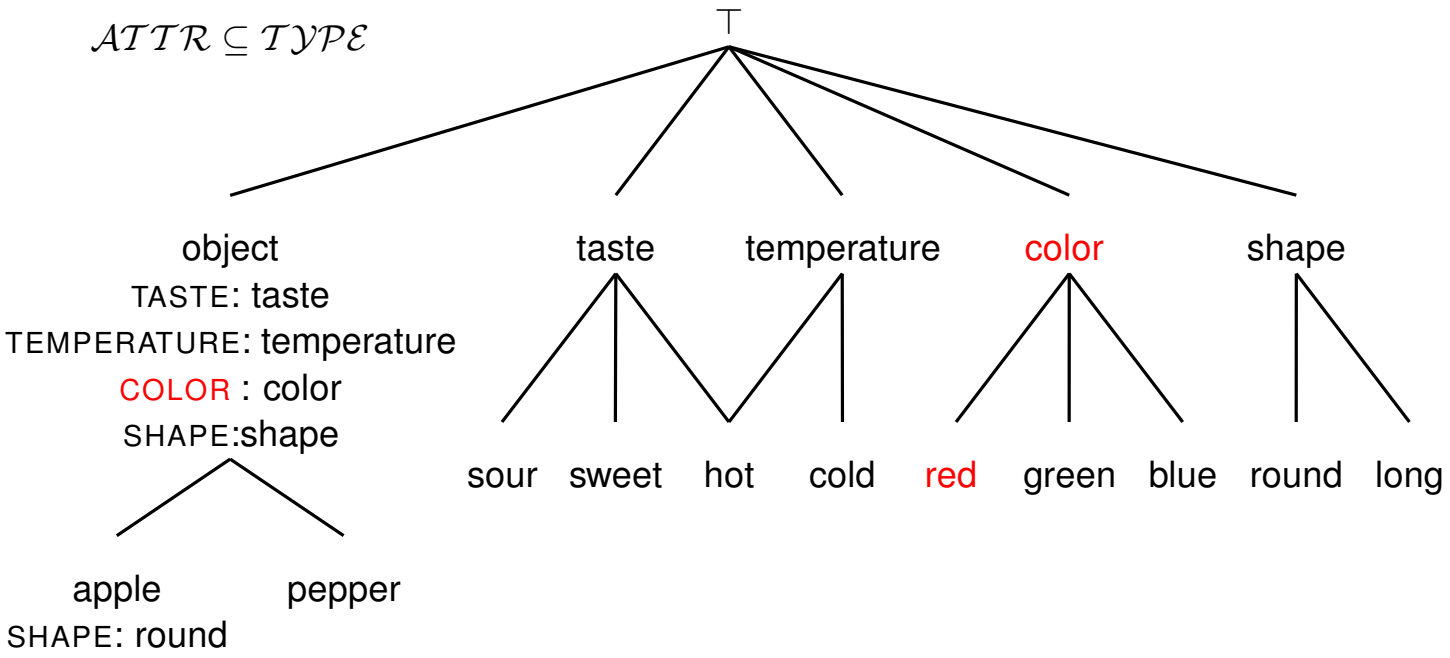

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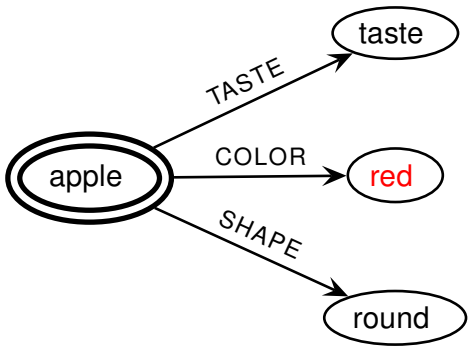
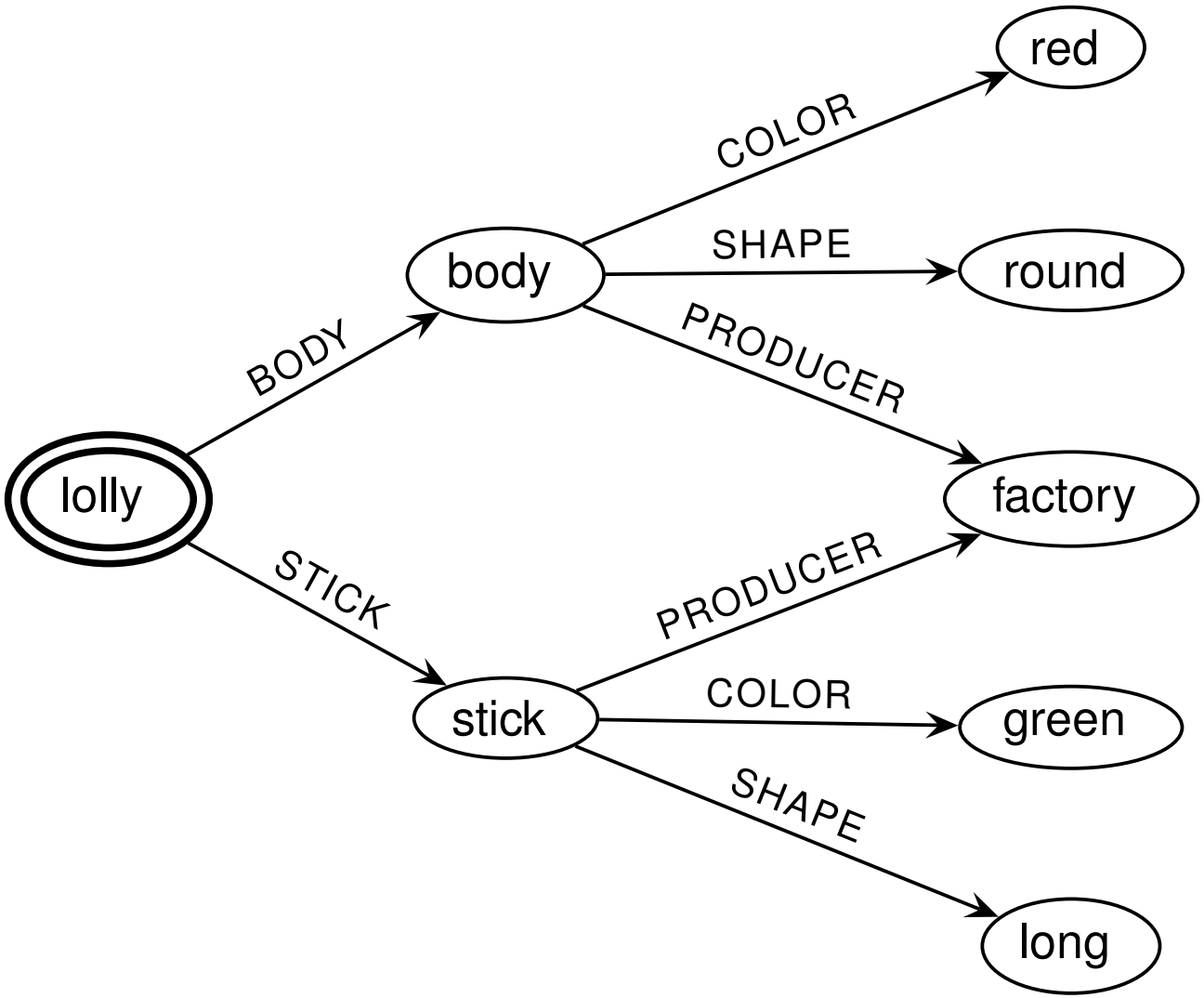


What is a red lolly?



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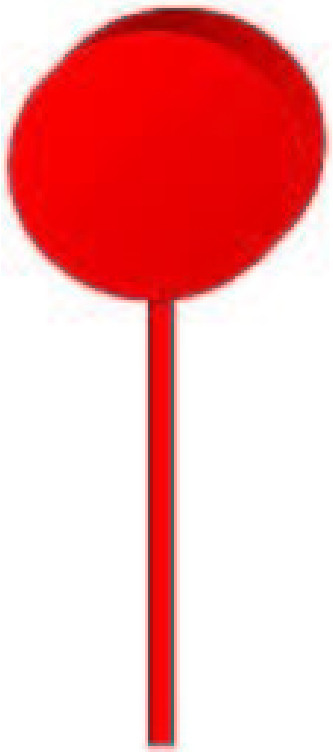

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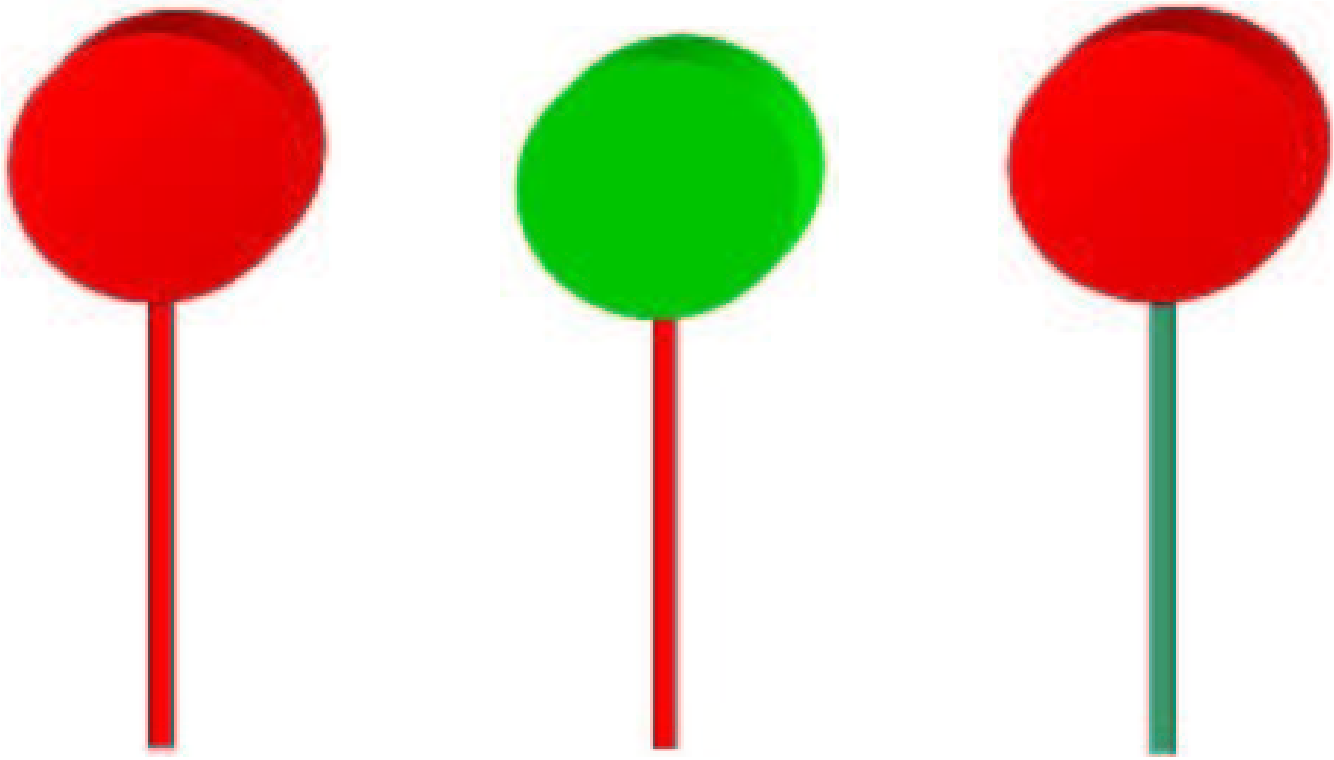

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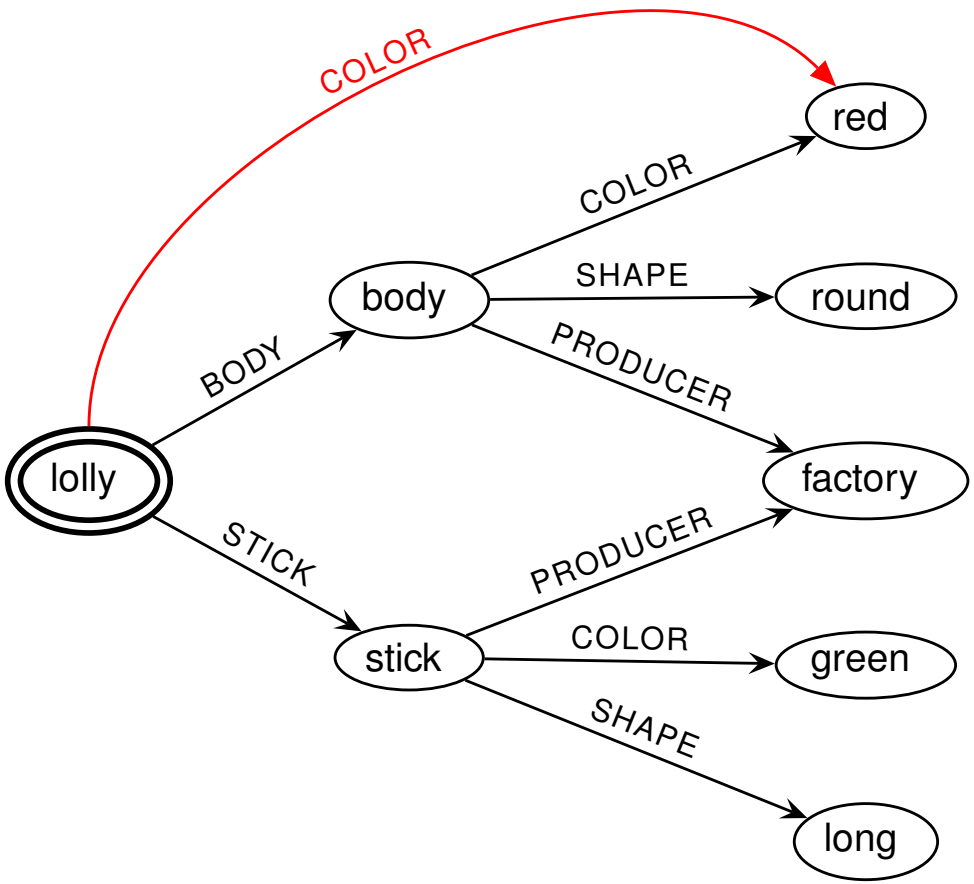

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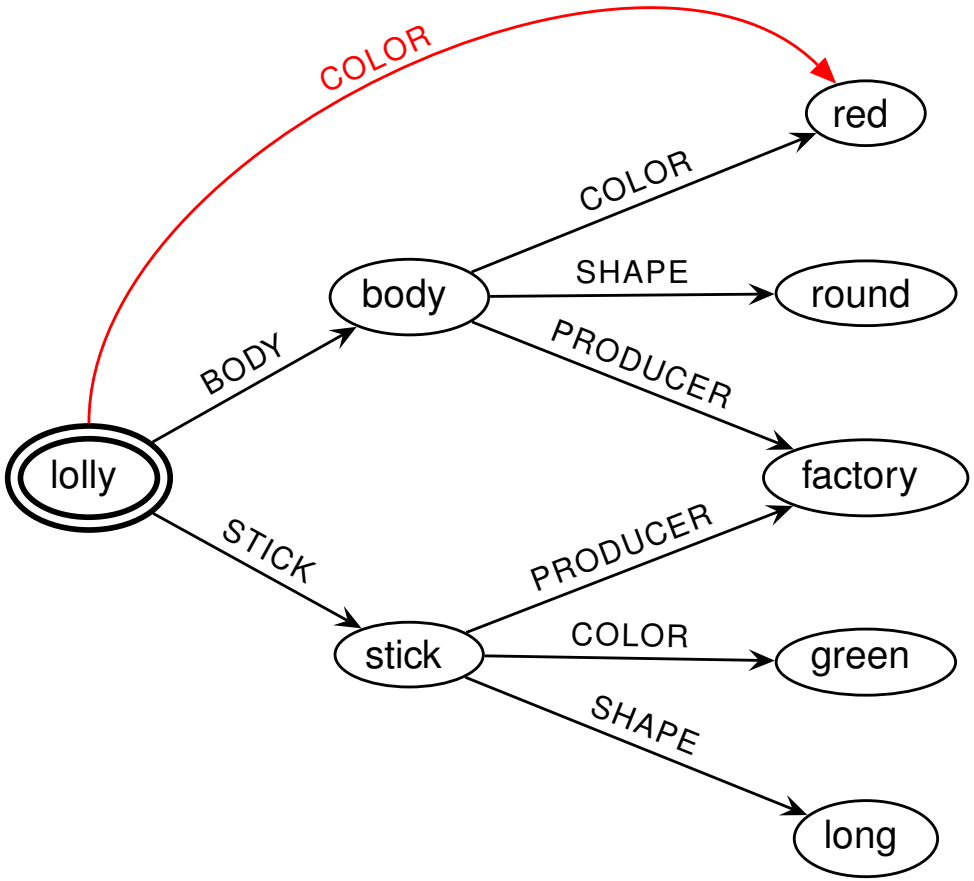
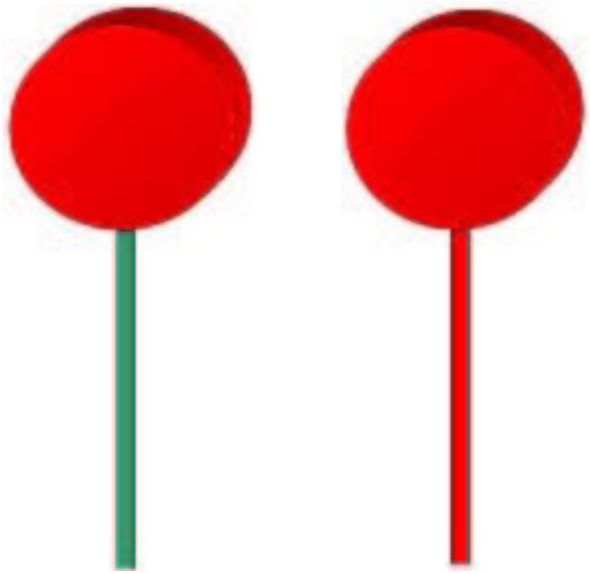
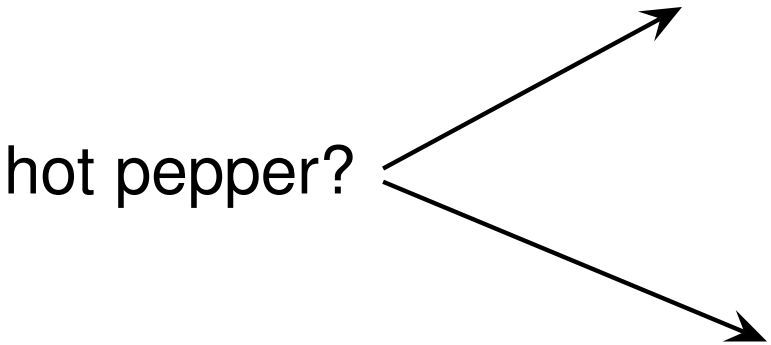




polysemy



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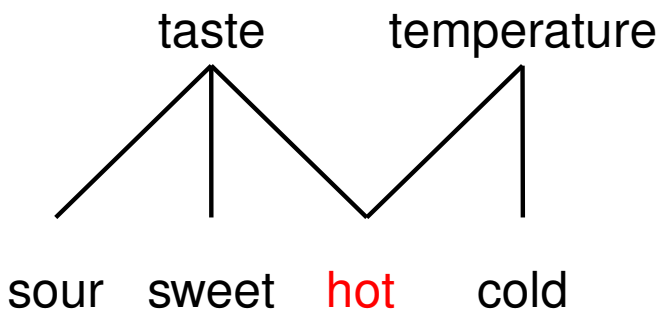

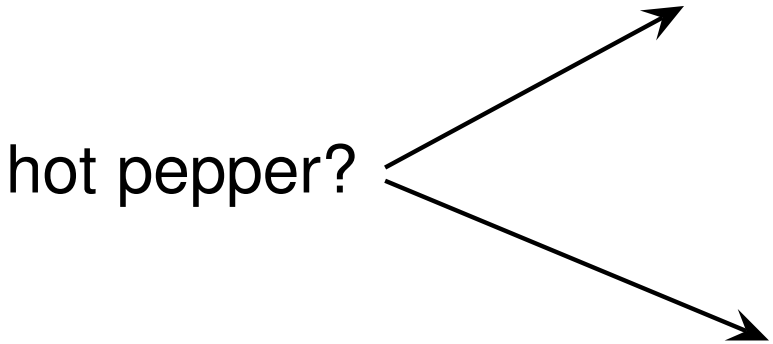

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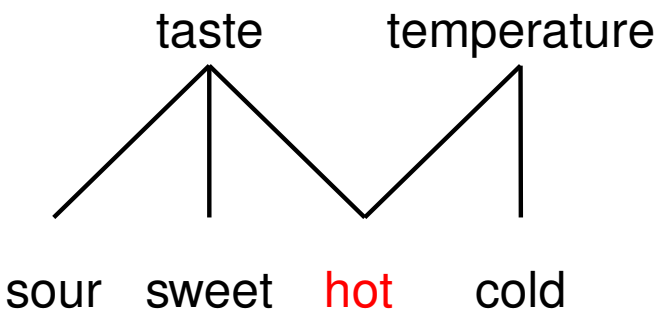
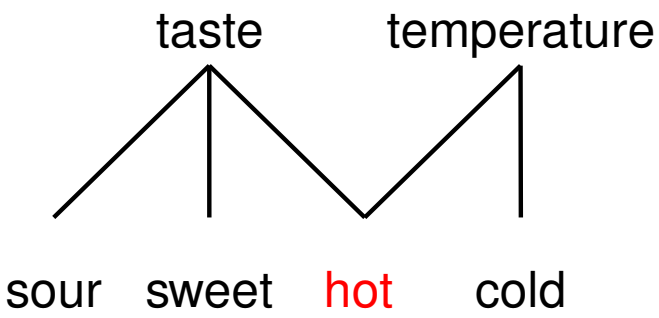


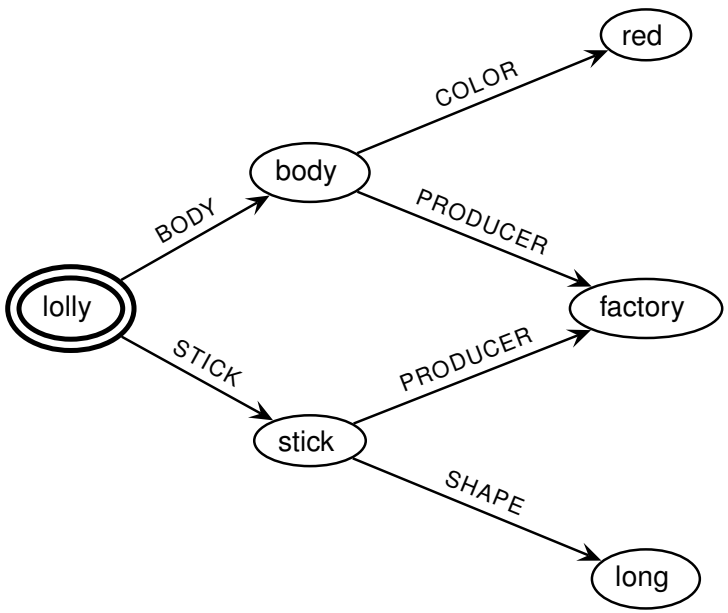
hot pepper?

polysemy



hot pepper?

logical reformulation of a frame



$$\lambda x \exists y_1 \exists y_2 \exists y_3 \exists y_4 \exists y_5$$
$$\text{lolly}(x) \wedge \text{body}(y_1) \wedge \text{stick}(y_2) \wedge \text{red}(y_3) \wedge$$
$$\text{long}(y_4) \wedge \text{factory}(y_5)$$
$$\wedge \text{BODY}(x) = y_1 \wedge \text{STICK}(x) = y_2$$
$$\wedge \text{COLOR}(y_1) = y_3 \wedge \text{SHAPE}(y_2) = y_4$$
$$\wedge \text{PRODUCER}(y_1) = y_5 \wedge \text{PRODUCER}(y_2) = y_5$$
$$\wedge \text{PRODUCER}(y_1) = \text{PRODUCER}(y_2)$$

$$\Leftrightarrow$$

$$\lambda x \ \text{lolly}(x) \wedge \text{body}(\text{BODY}(x)) \wedge \text{stick}(\text{STICK}(x)) \wedge$$
$$\text{red}(\text{COLOR}(\text{BODY}(x))) \wedge$$
$$\text{long}(\text{SHAPE}(\text{STICK}(x))) \wedge$$
$$\text{factory}(\text{PRODUCER}(\text{COLOR}(\text{BODY}(x)))) \wedge$$
$$\wedge \text{PRODUCER}(\text{BODY}(x)) = \text{PRODUCER}(\text{STICK}(x))$$

summary

- The concept classification is reflected by the graph-theoretical properties of the associated frame graphs.
- Attributes in frames are relationally interpreted functional concepts and therefore, frames decompose concepts by means of functional concepts.
- Type signatures provide a powerful tool for reducing redundancies in frame-based systems.

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literature

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origin of the pictures

- frames (title) `http://www.frames-by-the-case.com` (07/10/2006)
- passports: `http://travel.state.gov/images/non-e-passport.jpg` (17/08/2007) and `http://www.bundesdruckerei.de/pics/4_presse/fotoarchiv/aktuelle_fotos/ECC.jpg` (17/08/2007)
- root: `http://www.swiss.ai.mit.edu/~jaffer/TreeRoot.jpg` (17/08/2007)
- Düssel source: `http://upload.wikimedia.org/wikipedia/commons/8/84/` (17/08/2007)
- apple: `http://www.jonathanwald.com/800x600/images/Red-Apple.jpg` (17/08/2007)
- hot pepper (1): `http://www.sxc.hu/pic/m/a/an/anissa/39574_hot_pepper.jpg` (17/08/2007)
- hot pepper (2): `http://health.yahoo.com/media/prevention/image/picadillo_stuffed_peppers.jpg` (17/08/2007)