Frames – A General Formal of Representations?

Kogwis 2010 Symposium

Potsdam

Formal Frame Theory for Concept Composition and Decomposition

Wiebke Petersen

Heinrich-Heine-Universität Düsseldorf
www.phil-fak.uni-duesseldorf.de/~petersen/

6.10.2010, Potsdam

outline

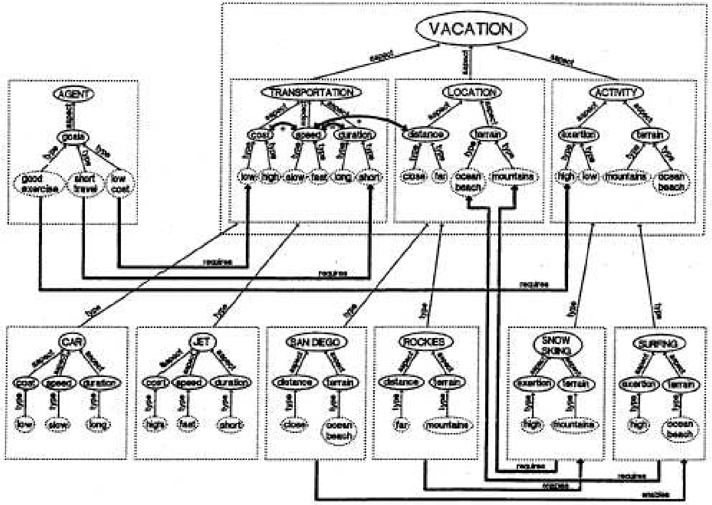
1. Frames
2. Attributes in frames
3. Concept composition

frames

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

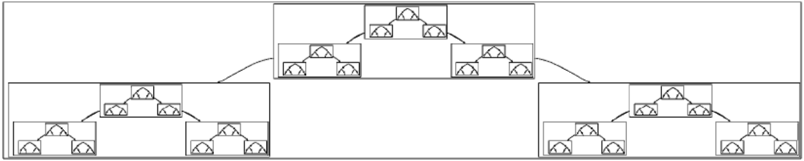
- Frames provide the fundamental representation of knowledge in human cognition.
- At their core, frames contain **attribute-value sets**.
- Frames further contain a variety of relations.
    - **Structural invariants** in a frame capture relations in the world that tend to be relatively constant between attributes.
    - **Constraints** capture systematic patterns of variability between attribute values.

Example: vacation frame with constraints (Barsalou 1992)

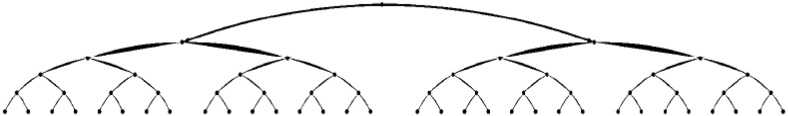


unlimited recursion in frames

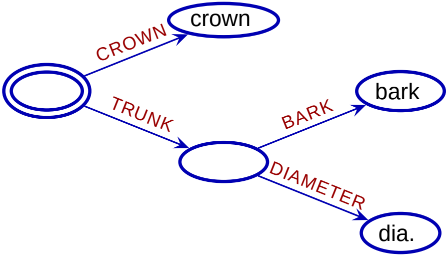
Self-similarity in Barsalou's frames (attributes are frames):



Recursion in classical feature structure theories:



frames as generalized typed feature structures

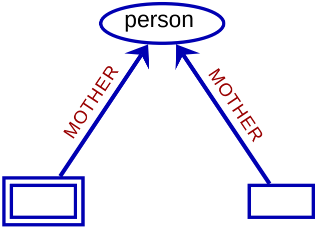


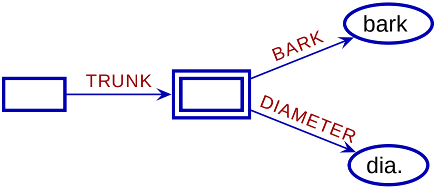
Typed feature structures (Carpenter 1992)

Typed feature structures
are connected directed graphs with

- one central node
- nodes labeled with types
- arcs labeled with attributes
- no node with two outgoing arcs with the same label
- and such that each node can be reached from the central node via directed arcs.

frames as generalized typed feature structures





Frames (Petersen 2007)

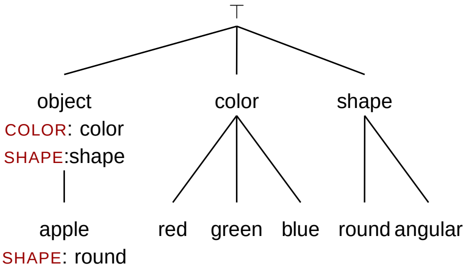
Frames
are connected directed graphs with

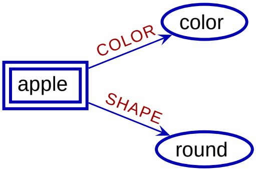
- one central node
- nodes labeled with types
- arcs labeled with attributes
- no node with two outgoing arcs with the same label

Open argument nodes are marked as rectangular nodes.

Frames relate to unrooted feature structures.

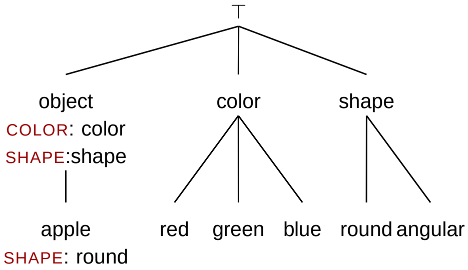
type signatures and constraints

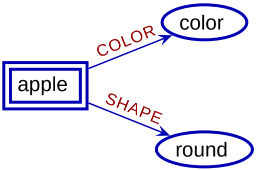




redundancy in attribute and type labeling

type signatures and constraints





redundancy in attribute and type labeling

attributes in frames

Barsalou, 1992

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

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 $m \in \delta(\text{mother})$.

interpretation of functional concepts

denotational interpretation

A functional concept denotes a set of entities:

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

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

relational interpretation

A functional concept has also a relational interpretation:

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

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

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 $m \in \delta(\text{mother})$.

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.

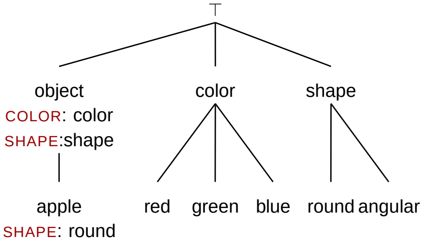
If $(p, m) \in \varrho(\text{mother})$, then $m \in \delta(\text{mother})$.

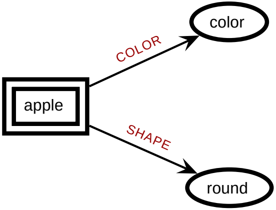
attributes in frames

thesis:

Attributes in frames are relationally interpreted functional concepts!

- attributes are not frames themselves
- attributes are unstructured
- the possible values of an attribute are subconcepts of the denotationally interpreted functional concept





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. The attribute set should be a subset of the type set: $\mathcal{ATTR} \subseteq \mathcal{TYPE}$.

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. The attribute set should be a subset of the type set: $\mathcal{ATTR} \subseteq \mathcal{TYPE}$.

attributes in frames

thesis:

Attributes in frames are relationally interpreted functional concepts!

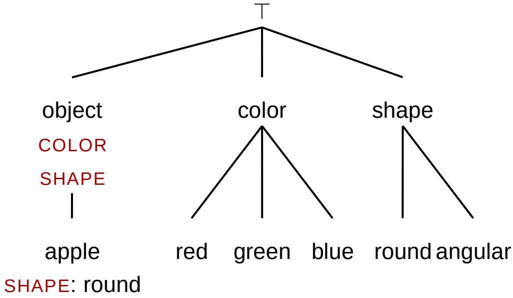
consequence (1):

Frames decompose concepts into relationally interpreted functional concepts!

consequence (2):

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

type signature



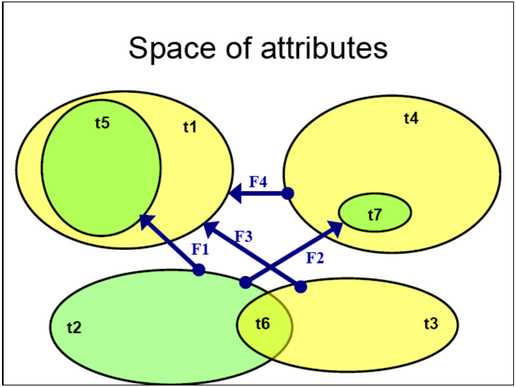
Barsalou, 1992: *Frames, Concepts, and Conceptual Fields*

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

attributes in frames

alternative thesis:

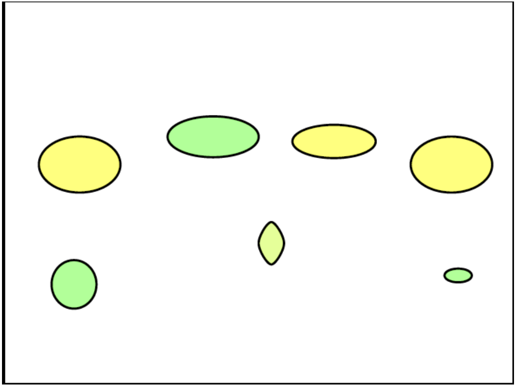
Types are definable by the range and domain of attributes!



attributes in frames

alternative thesis:

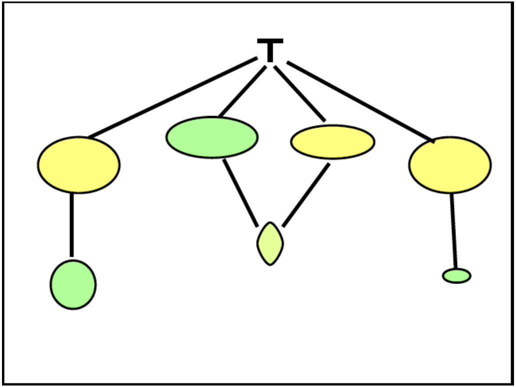
Types are definable by the range and domain of attributes!



attributes in frames

alternative thesis:

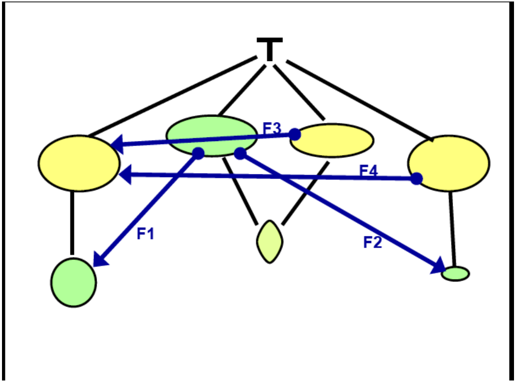
Types are definable by the range and domain of attributes!



attributes in frames

alternative thesis:

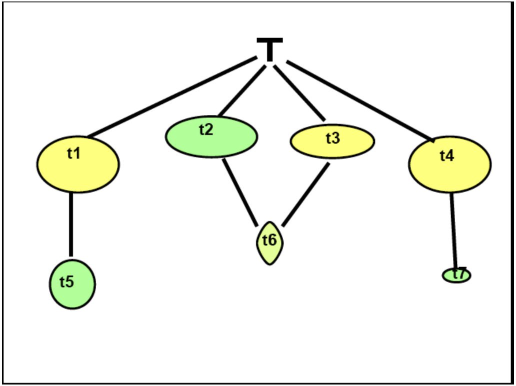
Types are definable by the range and domain of attributes!



attributes in frames

alternative thesis:

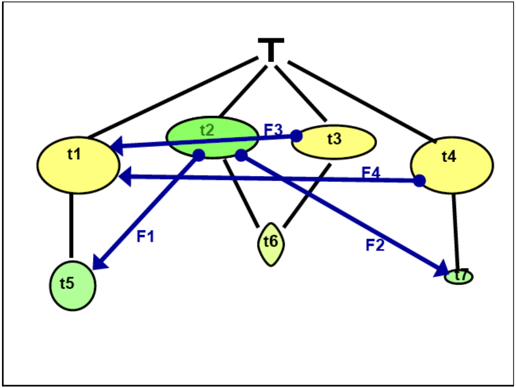
Types are definable by the range and domain of attributes!



attributes in frames

alternative thesis:

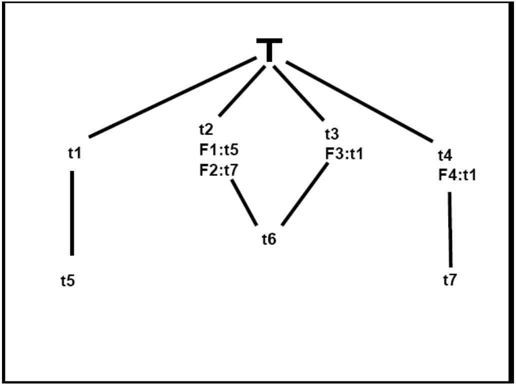
Types are definable by the range and domain of attributes!



attributes in frames

alternative thesis:

Types are definable by the range and domain of attributes!



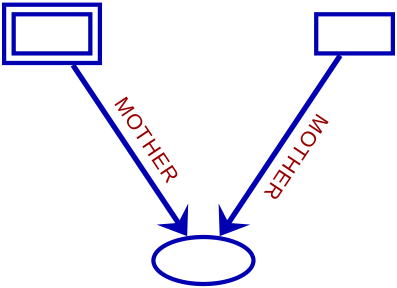
attributes in frames

alternative thesis:

Types are definable by the range and domain of attributes!

$$\Rightarrow \quad \mathcal{TYPE} = \bigcup_{A \subseteq \mathcal{ATTR}} \cap A$$

FC $\overset{\text{OF}}{\sqcup}$ RC $\mapsto$ RC: name OF sibling



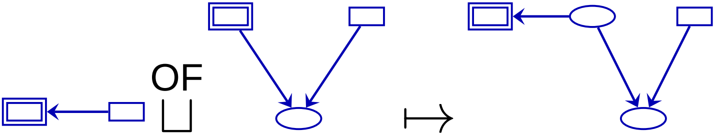
name

sibling

$\lambda y \lambda x.\ x = \text{NAME}(y)$

$\lambda y \lambda x.\ \text{MOTHER}(x) = \text{MOTHER}(y)$

$FC \overset{OF}{\sqcup} RC \mapsto$ RC: name OF sibling



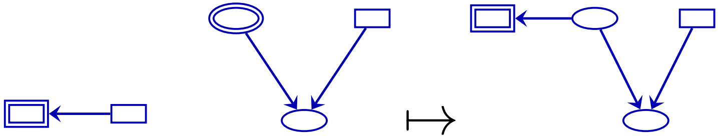
$\langle e, \langle e, t \rangle \rangle$ $\langle e, \langle e, t \rangle \rangle$ $\langle e, \langle e, t \rangle \rangle$

$\lambda y' \lambda x'.\, x' = f(y') \overset{OF}{\sqcup} \lambda y' \lambda x'.\, S(x', y') \mapsto \lambda y' \lambda x.\, x = f(\varepsilon u.\, S(u, y'))$

FC $\circ(\varepsilon\circ$ RC)

$\langle e, \langle e, t \rangle \rangle \circ (\langle \langle e, t \rangle, e \rangle \circ \langle e, \langle e, t \rangle \rangle) \mapsto \langle e, \langle e, t \rangle \rangle \circ \langle e, e \rangle \mapsto \langle e, \langle e, t \rangle \rangle$

FC $\overset{\text{OF}}{\sqcup}$ RC $\mapsto$ RC: name OF sibling



$\langle e, \langle e, t \rangle\rangle$ $\quad$ $\langle e, e \rangle$ $\quad$ $\langle e, \langle e, t \rangle\rangle$

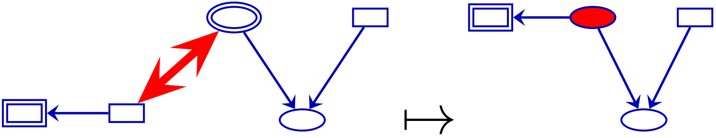
$\lambda y' \lambda x'.\, x' = f(y') \overset{\text{OF}}{\sqcup} \lambda y' \lambda x'.\, S(x', y') \mapsto \lambda y' \lambda x.\, x = f(\varepsilon u.\, S(u, y'))$

FC $\circ(\varepsilon\circ$ RC$)$

$\langle e, \langle e, t\rangle\rangle \circ (\langle\langle e, t\rangle, e\rangle \circ \langle e, \langle e, t\rangle\rangle) \mapsto \langle e, \langle e, t\rangle\rangle \circ \langle e, e\rangle \mapsto \langle e, \langle e, t\rangle\rangle$

1. $\varepsilon\circ$ RC: $\lambda y'(\lambda Q.\, \varepsilon u.\, Q(u)(\lambda x'.\, S(x', y'))) \rightarrow_\beta \lambda y'(\varepsilon u.\, \lambda x'.\, S(x', y')(u)) \rightarrow_\beta \lambda y'.\, \varepsilon u.\, S(u, y')$
2. FC $\circ(\varepsilon\circ$ RC$)$: $(\lambda y \lambda x.\, x = f(y)) \circ (\lambda y'.\varepsilon u.\, S(u, y')) \rightarrow \lambda y'(\lambda y \lambda x.\, x = f(y)(\varepsilon u.\, S(u, y'))) \rightarrow_\beta \lambda y' \lambda x.\, x = f(\varepsilon u.\, S(u, y'))$

$FC \overset{OF}{\sqcup} RC \mapsto$ RC: name OF sibling



$\langle e, \langle e, t \rangle \rangle$ $\langle e, e \rangle$ $\langle e, \langle e, t \rangle \rangle$

$\lambda y' \lambda x'.\, x' = f(y') \overset{OF}{\sqcup} \lambda y' \lambda x'.\, S(x', y') \mapsto \lambda y' \lambda x.\, x = f(\varepsilon u.\, S(u, y'))$

FC $\circ(\varepsilon\circ$ RC)

$\langle e, \langle e, t \rangle \rangle \circ (\langle \langle e, t \rangle, e \rangle \circ \langle e, \langle e, t \rangle \rangle) \mapsto \langle e, \langle e, t \rangle \rangle \circ \langle e, e \rangle \mapsto \langle e, \langle e, t \rangle \rangle$

1. $\varepsilon\circ$ RC: $\lambda y'(\lambda Q.\, \varepsilon u.\, Q(u)(\lambda x'.\, S(x', y'))) \rightarrow_\beta \lambda y'(\varepsilon u.\, \lambda x'.\, S(x', y')(u)) \rightarrow_\beta \lambda y'.\, \varepsilon u.\, S(u, y')$
2. FC $\circ(\varepsilon\circ$ RC): $(\lambda y \lambda x.\, x = f(y)) \circ (\lambda y'.\varepsilon u.\, S(u, y')) \rightarrow \lambda y'(\lambda y \lambda x.\, x = f(y)(\varepsilon u.\, S(u, y'))) \rightarrow_\beta \lambda y' \lambda x.\, x = f(\varepsilon u.\, S(u, y'))$

Outlook

- *Linguistics*: Frames, concept types and type shifts: the case of associative anaphora (Alexander Ziem)
- *History of medicine*: Evolution of Theories and Concepts (Heiner Fangerau)
- *Philosophy*: Grounded cognition: sensorimotor values in frames (Gottfried Vosgerau)