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Developing the Semantic Web via the Resolution of Meaning Ambiguities

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A theoretical framework for the treatment of meaning ambiguities in the Semantic Web

- Motivations: how to develop the Semantic Web?

- An ontological approach to the representation of n-ary relations (**PROL**)

- A unified approach to the study of different kinds of metaphors (e.g., *conventional vs novel*)

- Directionality and contextual elements

- Representation and measure of semantic *proximity*

How to develop the Semantic Web?

- Increasing human-machine interaction

- Providing a more faithful representation of a knowledge base expressed in natural language

- A mere translation of the intended meaning into the machine language (easy solution) would bypass the problem of machine understanding

- A simple ontology with a measure of semantic proximity should allow the machine to identify semantic ambiguous expressions

A unified approach to study different kinds of metaphors

- Standard approach: inference from a *source* conceptual domain to a *target conceptual domain.**

- The conceptual distance between source and target domains can vary, for ex. in *conventional* vs *novel* metaphors.**

- The *context* provides useful information to select the relevant properties attributed to the target.***

*GRICE P. (1989) STUDIES IN THE WAY OF WORDS, HARVARD UNIVERSITY PRESS, CAMBRIDGE (MA).
**CARSTON R. (2002) THOUGHTS AND UTTERANCES: THE PRAGMATIC OF EXPLICIT COMMUNICATION, BLACKWELL, OXFORD.
***INDURKHYA, B. (1992) METAPHOR AND COGNITION, KLUWER, DORDRECHT.

A unified approach to study different features of metaphor

- Linguistic structure of metaphors: *nominal* vs *verbal* metaphors.

Ex. «the actor is a dog» / «grasping an idea»

- *Directionality* of metaphors:* the direction of the attribution from the source to the target sometimes depends on the order of terms in the relation.

Ex. «the actor is a dog» / «the dog is an actor»

Our approach can deal with these features within a unified framework.

*TVERSKY, S (1977) FEATURES OF SIMILARITY, PSYCHOLOGICAL REVIEW, 84, PP. 327-352;
ORTONY, A. (1979). BEYOND LITERAL SIMILARITY, PSYCHOLOGICAL REVIEW, 86, 3, 161–180.

Expressive limits of RDF

- Declarative languages standardly used in the Semantic Web (RDF, RDFS, OWL) have strong limitations

- Only binary relations can be expressed in a natural way; unsatisfactory solutions given by the W3C for the representation of n-ary relations

-The only concepts represented in the related graph are classes, and the relations are represented as arrows

- The graph provides poor contextual information

PROL* (Parametric Relational Ontological Language)

- A simple RDF-based ontology design to formalize any n-ary relation ($n \geq 1$) as a *parametric pattern*

- A n-ary relation is formalized as a class of ordered tuples

- Relations are intended as *concepts*: much more semantic information is represented in the corresponding graph

* GIUNTI, M., SERGIOLI, G., VIVANET, G., PINNA, S. (2021). REPRESENTING N-ARY RELATIONS IN THE SEMANTIC WEB. LOGIC JOURNAL OF THE IGPL, 29(4), 697-717.

PROL (Parametric Relational Ontological Language)

- Parametric pattern: binary relation parametrized with respect to $n - 2$ arguments (i.e., all arguments except the first two).

- 6 terms:

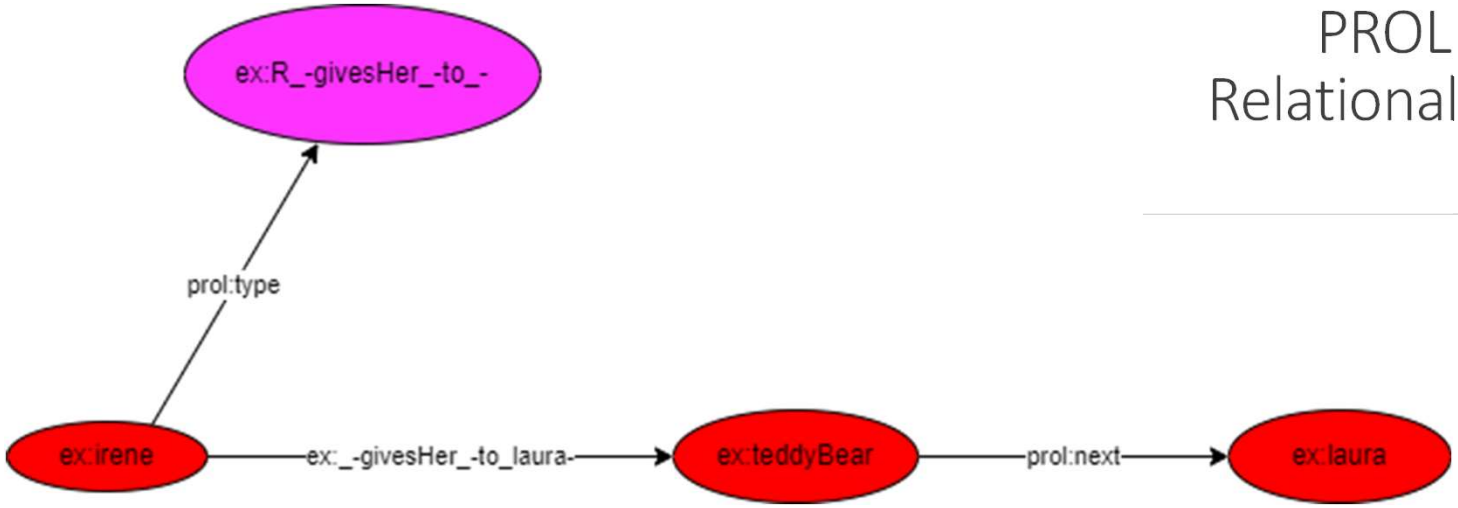
prol:Relation, prol:Domain, prol:hasPlaces, prol:represents;

prol:type, prol:next

- Example: Irene gives her Teddy Bear to Laura

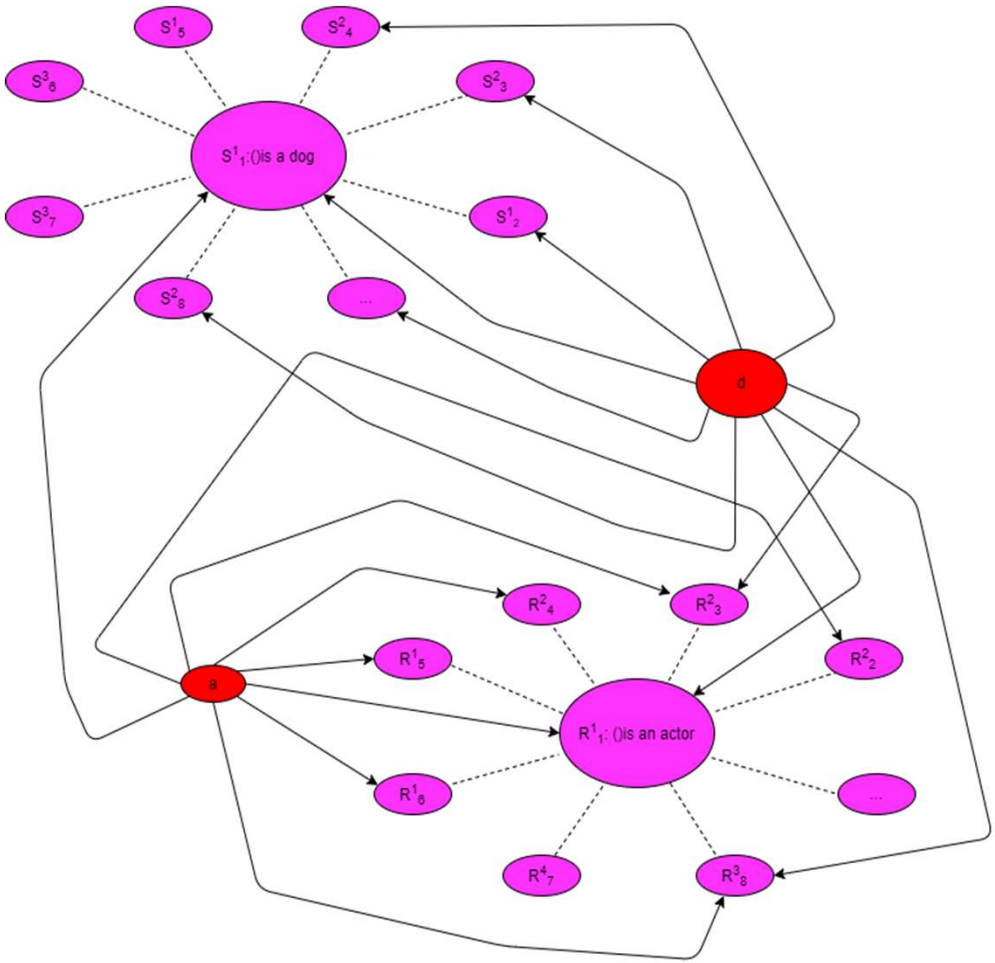
→ Instance of the relation *()gives her()to()*

PROL (Parametric Relational Ontological Language)



The choice of the right parametric path is determined by the definition in PROL of the parametric property that represents the n-ary relation:

ex:_-givesHer_-to_Laura- prol:represents ex:R:_-givesHer_-to_-.
ex:R:_-givesHer_-to_- rdf:_3 ex:Laura.



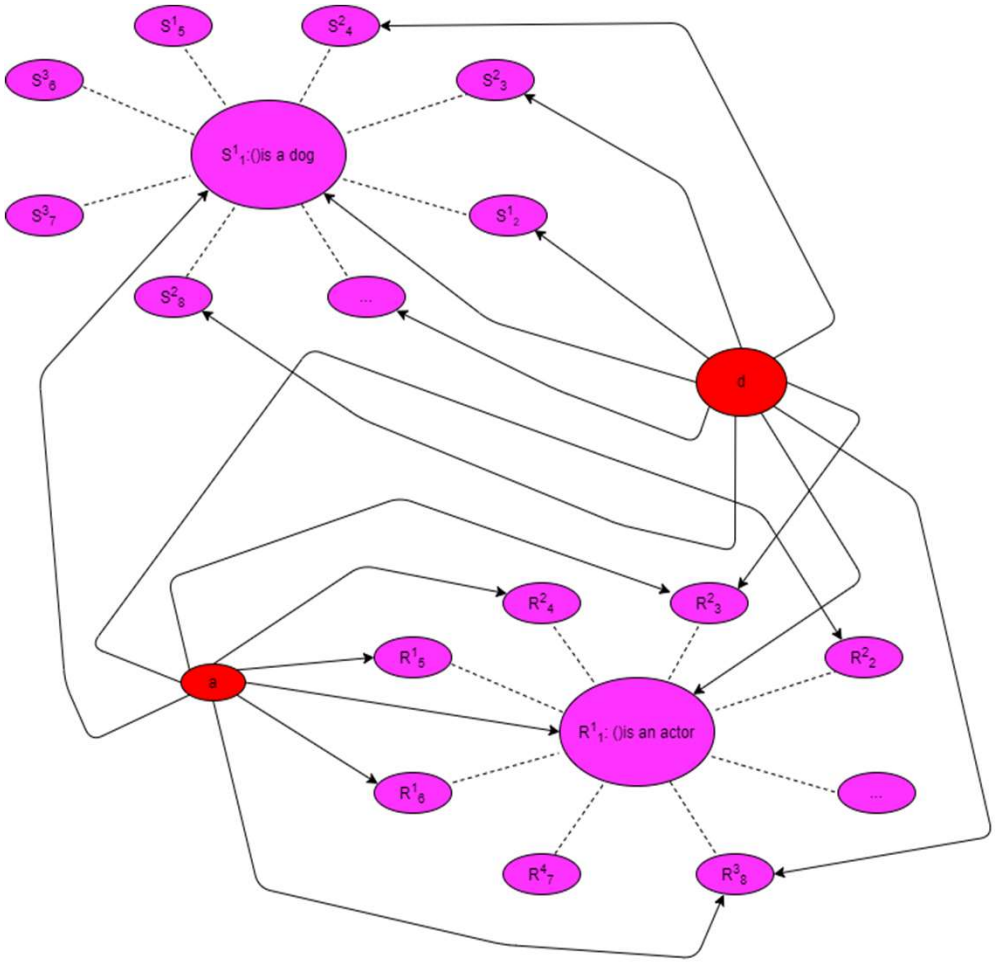
Example: disambiguation of the metaphoric expression «that actor is a dog» w.r.t. a non metaphoric one «that dog is an actor»

- Purple nodes: relations; red nodes: individuals.

- Dashed lines: paths whose intermediate nodes are only individuals.

- Arrows: an individual occurs in a tuple of a relation instance

Each unary relation (i.e., property) is surrounded by its semantic cloud.



Example: disambiguation of the metaphoric expression «that actor is a dog» w.r.t. a non metaphoric one «that dog is an actor»

Dog d is highly connected to both semantic clouds.

Actor a is highly connected to the cloud of actors, but only *abstractly* to the cloud of dogs.

The second situation indicates a metaphoric expression.

Verbal metaphors («grasping an idea») and novel ones («dog is an actor») may be treated in the same framework.

Contextual information and semantic proximity

- The representation with PROL (assuming very informative knowledge bases) provides a large amount of *contextual* information (relations as concepts).

- The relation beween different conceptual domains can be seen in terms of *semantic proximity.*

Measuring semantic proximity

Intuitively: semantic proximity of concept A to concept B ∝ likelihood that an instance of A is also an instance of B.

1) Semantic proximity of B *to* A (unary) :=

number of members of (A ∩ B) / number of members of A.

2) Semantic proximity of B *to* A (n-ary) := *as above, but:*

Let B (arity $n \geq 1$) and A (arity $m \geq 1$). *Members of A* : all the individuals belonging to some m-tuple which is an instance of A. *Members of B*: all the individuals belonging to some n-tuple which is an instance of B.

Conclusion

A method to solve meaning ambiguities in **PROL.**

A formal definition of semantic proximity that can be used to study verbal metaphors.

Metaphor is crucial for the development of the Semantic Web, as a way to (re)categorize and (re)organize conceptual knowledge.

General aim of the project: provide a better formal representation of natural language with no direct translation of its ambiguous aspects (loss of conceptual/cognitive content).