Using Ontologies to Model Polysemy in Lexical Resources

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Outline

- In this presentation I will discuss the linking together of ontologies and lexica in order to study polysemy

- Outline of Presentation

  - motivation

  - polysemy

  - using the LSO model & default logics

  - further challenges in modelling polysemy using an ontology

  - conclusions

- The study of the connection between semantic meaning and ontological/world knowledge is a well-established part of lexical semantics

- Why are we looking at it again?

- Important motivation given by the popularity of linked open data

- The increased facility of interlinking different datasets opens up the possibilities for using semantic web ontologies to enhance the semantic structure of lexica

- Most popular current RDF-based model for linking together lexica and ontologies is the ***lemon*** model

lemon (McCrae et al 2011)

- We need a way of mapping lexical entries in a lexicon and map them to ontological items

- **lemon** represents a word sense as a reified pairing of a lexical entry with a ontological vocabulary item

- Lexical entries are mapped to their senses using the `lemon:sense` relation

- Each lexical sense is mapped to an ontological item using the `lemon:reference` relation

- In this talk we will use a more general model for linking up lexica and ontologies (for modelling meaning) called **LSO**

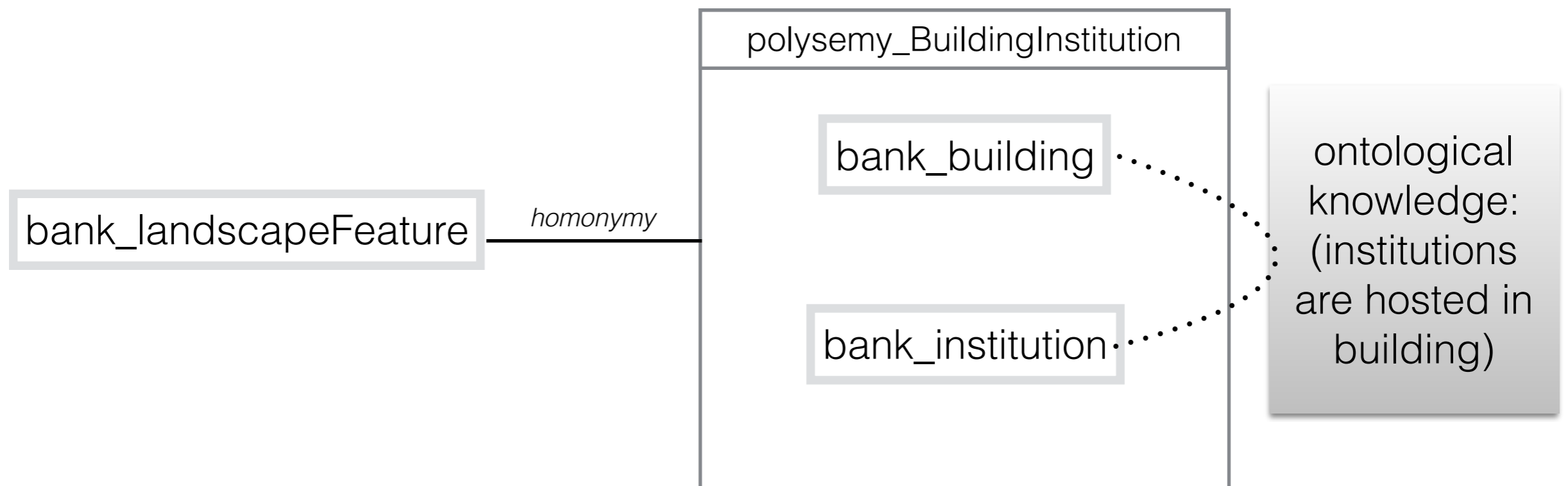# Ontological Modelling and Natural Language Meaning

- We have a better idea of the **differences between Ontological knowledge and Semantic knowledge**, and the viability of the distinction between the two

- Can assume that the structure of a well-designed **Ontology** will be **language-independent** to some degree

- thus it makes sense to distinguish between lexica (as semantic networks) and ontologies and to study how they maybe interfaced

- We take **polysemy** as a case study in how to **interface** a lexicon together with an ontology in order to model and analyse an important aspect of natural language meaning

Why regular polysemy?

"Bank":

- as in the bank of a river

- as in the Bank of England (institution)

- as in the bank down the road (building)

Regular polysemy is a linguistic phenomenon motivated by ontological knowledge

bank_landscapeFeature —*homonymy*—

polysemy_BuildingInstitution

bank_building

bank_institution

ontological knowledge: (institutions are hosted in building)

Regular Polysemy is productive

"Cows listening to Bach produce more milk than cows listening to Ozzy Osbourne..."

Against "sense enumeration lexicons"

- A sense enumeration lexicon is one where each sense of a word is stored separately

- In this case, we might accept that the "Bach" as music reading is lexicalised in English, so that the lexicon contains:

  > Bach as person
  >
  > Bach as music

- but do we really want to do the same for Ozzy? and for all past, present and future musicians?

- Pustejovsky [95,96] argued that it is impossible to list all senses of words explicitly in a lexicon.

- We need a **rule that is able to generate the music sense from the musician sense** for all individuals of the class musicians.

Lexicon-Semantics-Ontology (LSO) -1

- We use a model of lexicon/ontology interaction that keeps the lexicon/ontology separation of *lemon* but is more general in some important respects:

- A lexicon **Lex** is a finite set of lexical entries; each entry can be associated with one or more senses in the set **Sense** of senses via the `sense` relation; homophonous words are considered separate entries and so the senses of a single entry are related

Lexicon-Semantics-Ontology (LSO) - 2

- An Ontology **O** is a theory in a logical language **L** with a vocabulary **V**; we use **O** to describe the extensions of words and phrases in **Lex**; we use **hasRef** to relate senses and ontological vocabulary items

- We use **hasRefSub** to relate together lexical entries with ontological items in the case that a given lexical entry has a sense with a reference that is subsumed by a given ontological item

Lexicon-Semantics-Ontology (LSO) - 3

- We do not adhere to the *lemon* principle of semantics by reference; for us the **semantics of a language exists in the interaction between the lexicon and an ontological/world knowledge layer**

- In effect we view the semantics of the lexicon as being determined by the interaction of the senses of the lexical entries (the sense layer) with an ontological layer
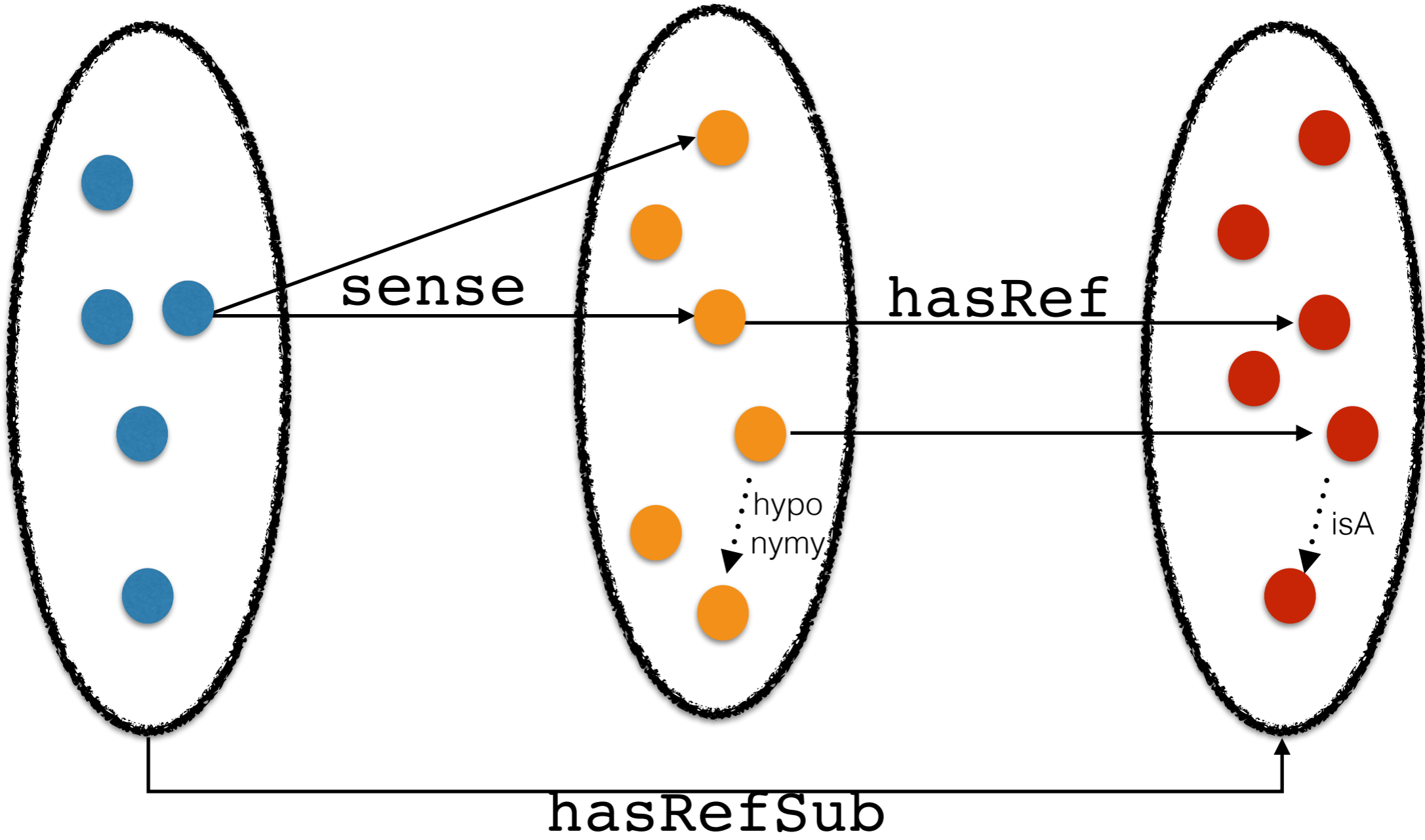
The Lexicon-Ontology Interface

- In Generative Lexicon theory, (Pustejovsky 95) posits a (relatively) complex interaction between the lexicon and world knowledge

- This helps to **circumvent the need to explicitly store all word senses in a lexicon**, as well as explaining how words can be used in new and creative ways

- We need to think in terms of kinds of ontological knowledge that are more **easy to access** and more commonly manifested as phenomena in natural language such as polysemy

- We would also like to use computational lexica/ontologies to **model creativity in natural language** and the relationship between world knowledge and word knowledge

Semi-productivity

- Semi productivity is **one of the major issues** in modelling polysemy using rule

  - Usually in English the name of the meat of an animal is the same as the name of the animal itself, but not e.g. for **cow-beef**;

    - *I ate snake / * I ate cow*

  - Usually (in Italian) the name of a fruit bearing tree is the same name as the fruit itself, but this is not true for a sub-class of items undergoing the gender alternation

    - *La mora è molto dolce e cresce in montagna / La mela cresce sul melo.*
      (The blueberry is sweet and grows in the mountains / Apple tree produces the apple)

- In other words; in many cases a piece of ontological knowledge is reflected in a semantic regularity as a default that can be **cancelled in certain cases but is generally productive**

- Idea: **Use the default rule formalism**

Default Logic

- Non Monotonic Knowledge Representation formalism devised by Reiter 1987

- Uses rules to represent statements that hold by default, in addition to statements in classical logic

- Default rules are of the form:

$$\frac{\phi : \psi_1, \ldots, \psi_k}{\chi}$$

- where **φ** is the pre-requisite, the formulae **ψ1,....ψk** the justifications and X the consequent.

- We read the formula above as saying, if we know φ and it is consistent to assume that **ψ1,....ψk** is true then we can also assume the truth of **x**.

Default Logic

- A default theory is a pair **(D,W)** where **D** is a set of default rules and **W** is a set of classical first order sentences.

- Seems to correspond to the situation with the Sense-layer and Ontological layer: we can use the set **W** to describe the ontology and the set **D** to describe the sense layer

Example

$$\frac{hasRef(l,c) \wedge c \sqsubseteq \mathtt{Animal} \wedge \mathtt{fleshOf}(c',c) \wedge c' \sqsubseteq \mathtt{Edible} : hasRef(l,c')}{hasRef(l,c')}$$

The ANIMAL-MEAT alternation as a default rule.

Challenges - 1

- **DL** is useful for **representing the interface between sense-level and ontological knowledge** but implementation can present problems

- Adding default rules to description logic can **lead to undecidability**

- However there are kinds of default rules which we can add to description logics without incurring undecidability of the resulting logic

- But at the moment there aren't many tools publicly available for adding default rules to description logics and its not clear that these restricted versions of default rules are sufficiently expressive;

Challenges - 2

- What possibilities are there of using other, more tractable, non-monotonic formalisms? (or maybe we can use rules with numerical weights)

- …**On the other hand, the description of polysemy also seems to call for default information in the ontology itself**

When is polysemy likely to occur?

- Polysemy seems to occur when the association between two different entities/objects/parts of an object is very strong, so that it becomes efficient to use the the same expression for two different things

- E.g., take the example of **INFORMATION_OBJECTs** and **PHYSICAL_OBJECTs**

  - *The book had yellowed with age and gave off a musty odour*

  - *The book was thrilling and suspenseful*

- Seems to work with other information objects that are usually published or stored in a physical format:

  - *?The lecture is lying on the table*

  - *The lecture is on my hard drive/The lecture took an hour/The lecture was both enthralling and informative*

What kind of ontological information do we need to study polysemy?

- The foregoing examples, and others, seem to suggest that in order to represent instances of polysemy using ontological information, we should also have **information about what's commonly/ usually the case.**

- Certain institutions are usually associated with particular buildings

- It would be useful to have an ontology of social information too

Conclusion

- We have proposed a model for lexicon ontology interaction (LSO)

- We have proposed a formalism for generating polysemic senses from main ones and systematically dealing with exceptions

- We have discussed about possible examples and further issues about ontology modelling

Any questions?