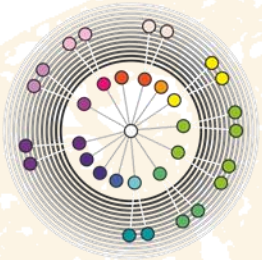

Enriching the Semantic
Network WordNet
with Conceptual Frames

Resolving Multiple Hyperonymy

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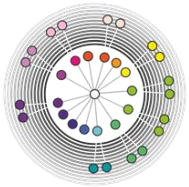


Enriching the Semantic Network WordNet with Conceptual Frames

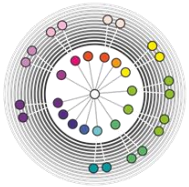
Introduction

WordNet

- A lexical semantic network that encodes human knowledge
- Nodes are the concepts, represented by sets of synonyms (synsets)
- Edges are the semantic relationships between concepts

Hyperonymy (and its inverse relation, hyponymy)

- Connects more general concepts to more specific ones
- Organises noun synsets in hierarchies
- The most abstract concept is at the root of the tree
- The most specific concepts are at the leaves of the tree



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Introduction

Hyperonymy forms a cycle-free directed connected graph whose root is an abstraction that is a hyperonym of all other synsets.

Hyperonymy is an **asymmetric** and **transitive** is-a relation:

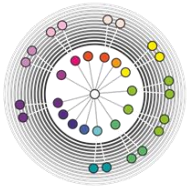
- A *parrot* is a *bird*.
- A *cockatoo* is a *parrot*.

Then:

- A *cockatoo* is a *bird*. (transitivity)

But not:

- A *bird* is a *parrot*. (asymmetry)



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Motivation

We want to use of semantic classes for nouns and their inheritance by hyponyms when encoding the syntagmatic combinations of verbs and nouns.

- Mapping Corpus Pattern Analysis (CPA) ontology to WordNet synsets
  - Adding 253 new semantic types to the 25 more generic WordNet semantic classes
  - Finding the highest-most synset (i.e., with no such hyperonyms) which represents a CPA type
  - Propagating the CPA type assignment to hyponyms
- Expectation
  - Each synset belongs to a specific CPA semantic type
- Discovery
  - Some sunsets were assigned multiple CPA classes due to multiple hyperonymy

Due to this, resolving the multiple hyperonymy is critical for this work.

Multiple hyperonymy

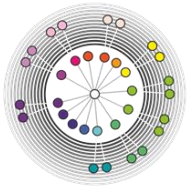
Multiple hyperonymy can be:

- Disjunctive (Exclusive)
  - *albino* is either *animal* or *human*
  - Connected to polysemy, should not exist in WordNet
- Conjunctive
  - *spoon* is both *cutlery* and *container*
  - often have a common hyperonym (different from *{entity:1}*)
  - different type of semantic relations can be defined, with only one hyperonymy
- Non-exclusive
  - *knife* can be *cutlery*, *weapon* or both
  - both a disjunctive and a conjunctive relations, should not exist in WordNet
  - *hatmaker* “someone who makes and sells hats” with hyperonyms *maker* and *merchant*

Multiple hyperonymy

Our aim is to investigate and resolve multiple hyperonymy relations in WordNet by:

- **defining** new relations in place of some hyperonymy relations
- **deleting** hyperonymy relations (if appropriate)
- + **specifying** new hyperonymy relation where necessary



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Data basis

Princeton WordNet 3.0 in XML encoding

Looking at all noun synsets with at least one non-instance hyperonymy relation

Noun synsets	Count
With hyperonyms	74,388
With instance hyperonyms	7,725
With no hyperonyms	1
Total	82,114

Data basis

Noun synsets with multiple hyperonymy relations

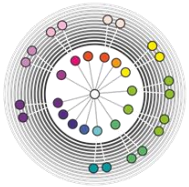
Multiple hyperonymy synsets	Count
With 2 hyperonyms	1,387
With 3 hyperonyms	30
With 4 hyperonyms	3
With 5 hyperonyms	1
Total	1,421

Data preparation

Grouping helps define rough semantic classes, for each of which the multiple hyperonymy resolution follows a pattern

Grouped based on common hyperonyms in 2 sets of groups:

- **Single** – all synsets with multiple hyperonyms that have a specific common hyperonym
- **Double** – all synsets with multiple hyperonyms that have a specific pair of common hyperonyms



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Data preparation

Grouping result:

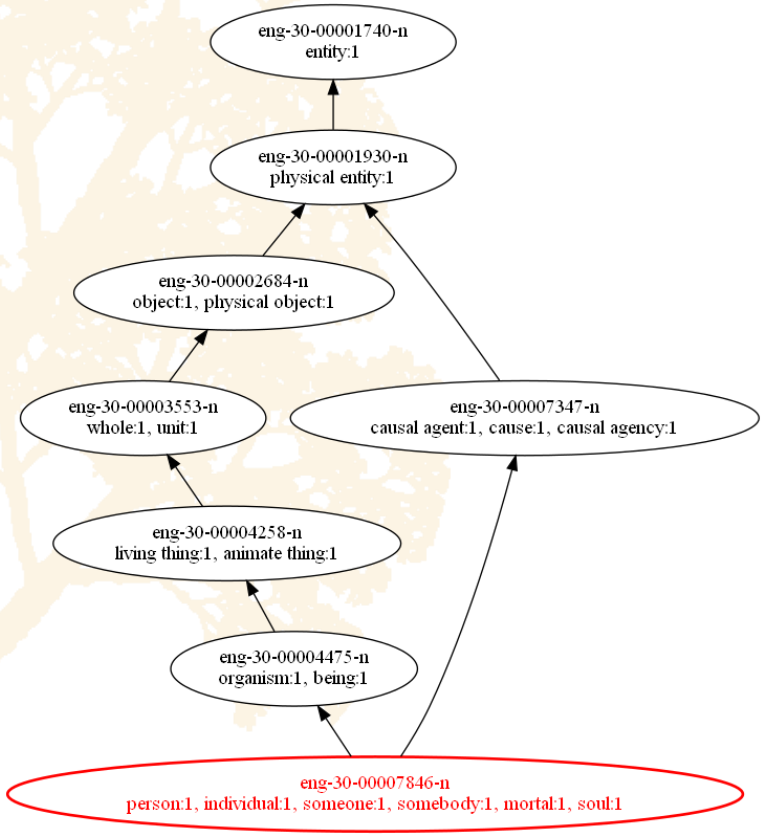
- 1,814 single groups
  - 512 with 2 or more members
  - 66 with 5 or more members
- 1,305 double groups
  - 121 with 2 or more members
  - 40 with 3 or more members

Using large single (5+ members) and double (3+ members) as starting point for multiple hyperonymy resolution

Data preparation

Visualisation of the hyperonymy graphs of synset with multiple hyperonymy

- Aid for editors and reviewers
- Displaying all direct and indirect hyperonyms up to *{entity:1}*
- Visualisation of post-editing graphs with changes
  - Dotted lines where deleted
  - Dashed lines where changed or added
  - Solid line for no changes



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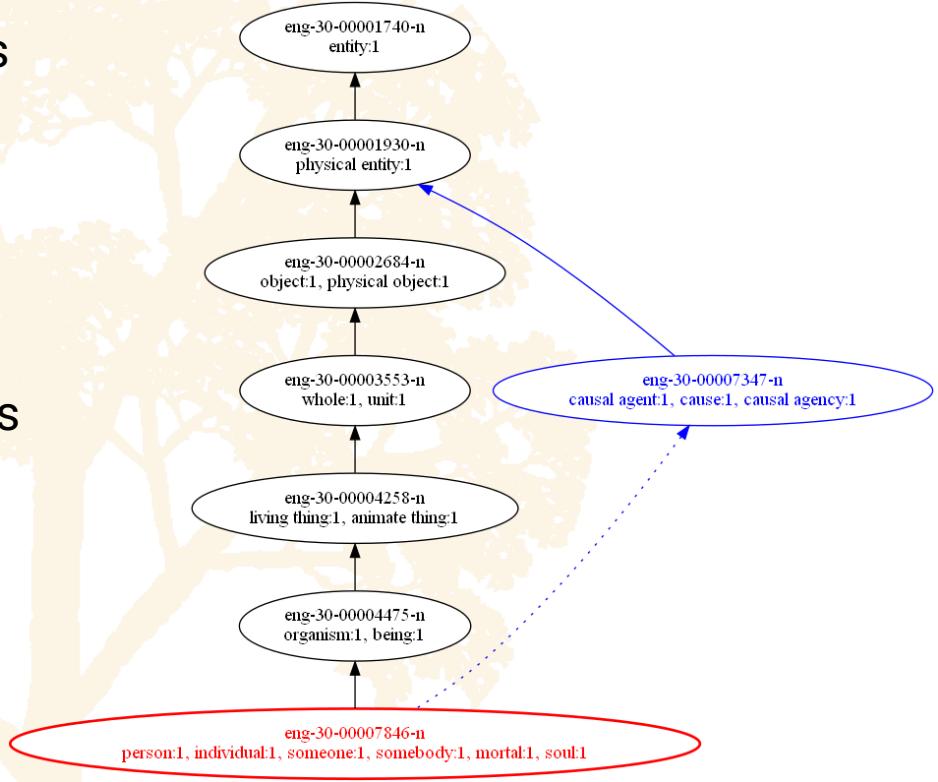
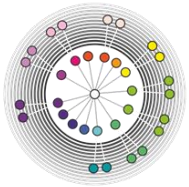




Enriching the Semantic Network WordNet with Conceptual Frames

Process

Starting point (proof of concept):

- All large 40 double groups with 3+ members
- Some large single groups with 5+ members
- 150 synsets with multiple hyperonymy

Scope expansion:

- All double groups
- All single groups
- 1,421 synsets with multiple hyperonymy

Process

Stage 1:

- 2 editors, working on non-overlapping parts of the initial scope
- No prescribed relations - editors identify possible new relations
- Identified 9 new and 1 existing possible alternative relations

Stage 2:

- 2 editors, working on non-overlapping parts of the full scope
- Working with previously identified relations
- Cross-review of work for completeness and consistency
- Review of relation set, changed to 6 new and 3 existing in 3 groups

Process

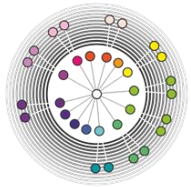
Delete, **add** or **change** hyperonymy relation to one of the following relations:

- Property (new)
  - **characteristic** – what distinguishes an entity
  - **origin** – what is the origin of an entity
  - **form** – what is the form of existence of an entity
- Application (new)
  - **function** – what is the function of an entity
  - **purpose** – what is the purpose of an entity
  - **use** – what is an entity used for
- Composition (existing)
  - **member, part, portion** – what is the composition of an entity

Examples

{chemical element:1, element:6} – 18 members in single group

+ *{noble gas:1, inert gas:1, argonon:1}* - 6 members in double group
+ *{halogen:1}* - 5 members in double group
+ *{gas:7}* - 6 members in double group
+ 3 members from other double groups



Enriching the Semantic Network WordNet with Conceptual Frames

Examples

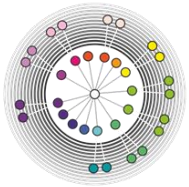
{chemical element:1, element:6} / *{noble gas:1, inert gas:1, argonon:1}* - 6 members

- **remove** the hyperonymy relation of group members to *{chemical element:1, element:6}*, as it is already a hyperonym of *{noble gas:1, inert gas:1, argonon:1}*

Examples

{chemical element:1, element:6} / *{halogen:1}* - 5 members

- **change** the hyperonymy relation of *{halogen:1}* from *{group:1, grouping:1}* to *{chemical element:1, element:6}*
- **remove** the hyperonymy relation of group members to *{chemical element:1, element:6}* as it is a hyperonym of *{halogen:1}*



Enriching the Semantic Network WordNet with Conceptual Frames

Examples

{chemical element:1, element:6} / *{gas:7}* - 6 members

- **change** the hyperonymy relation of group members to *{gas:7}* to the relation type **form**
- *{chlorine:1, Cl:2, atomic number 17:1}* and *{fluorine:1, F:6, atomic number 9:1}* are also members of the previous group - the rest of their multiple hyperonymy is already resolved

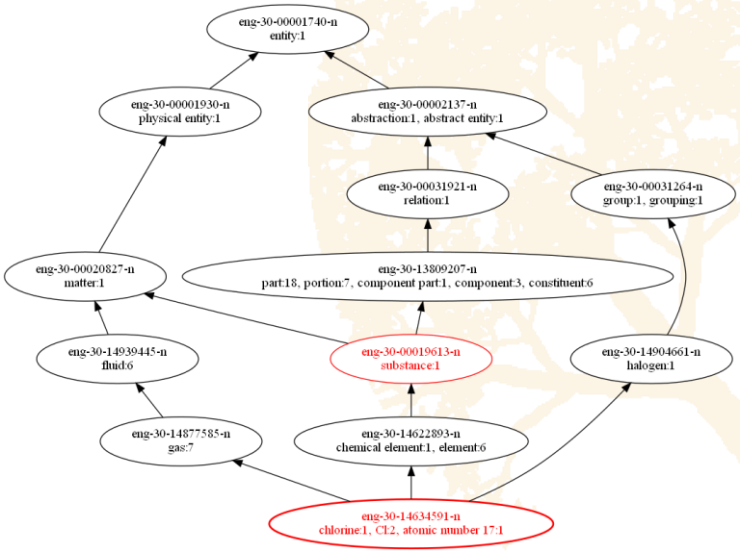
Examples

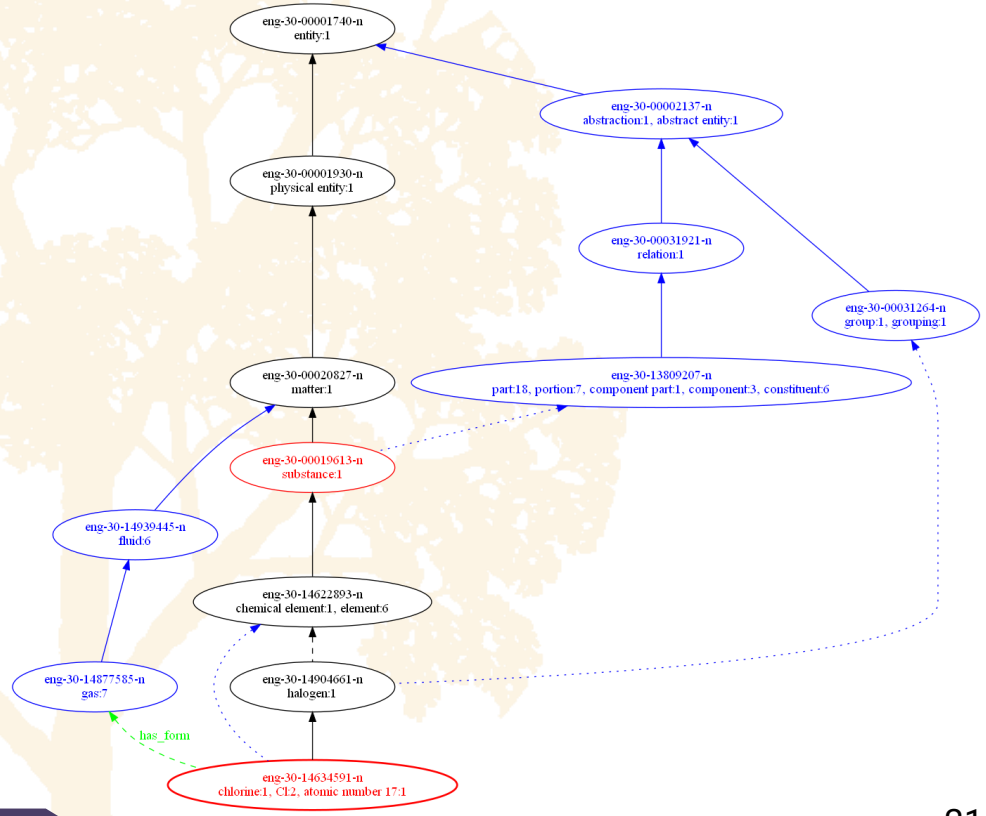
{chemical element:1, element:6} - other 3 members

- *{germanium:1, Ge:3, atomic number 32:1}* with hyperonyms:
  - *{chemical element:1, element:6}* and
  - *{semiconductor:2, semiconducting material:1}*, proposed change to **function**
- *{silicon:1, Si:2, atomic number 14:1}* with hyperonyms:
  - *{chemical element:1, element:6}* and
  - *{semiconductor:2, semiconducting material:1}*, proposed change to **function**
- *{selenium:1, Se:1, atomic number 34:1}* with hyperonyms:
  - *{chemical element:1, element:6}* and
  - *{antioxidant:1}*, proposed change to **function**

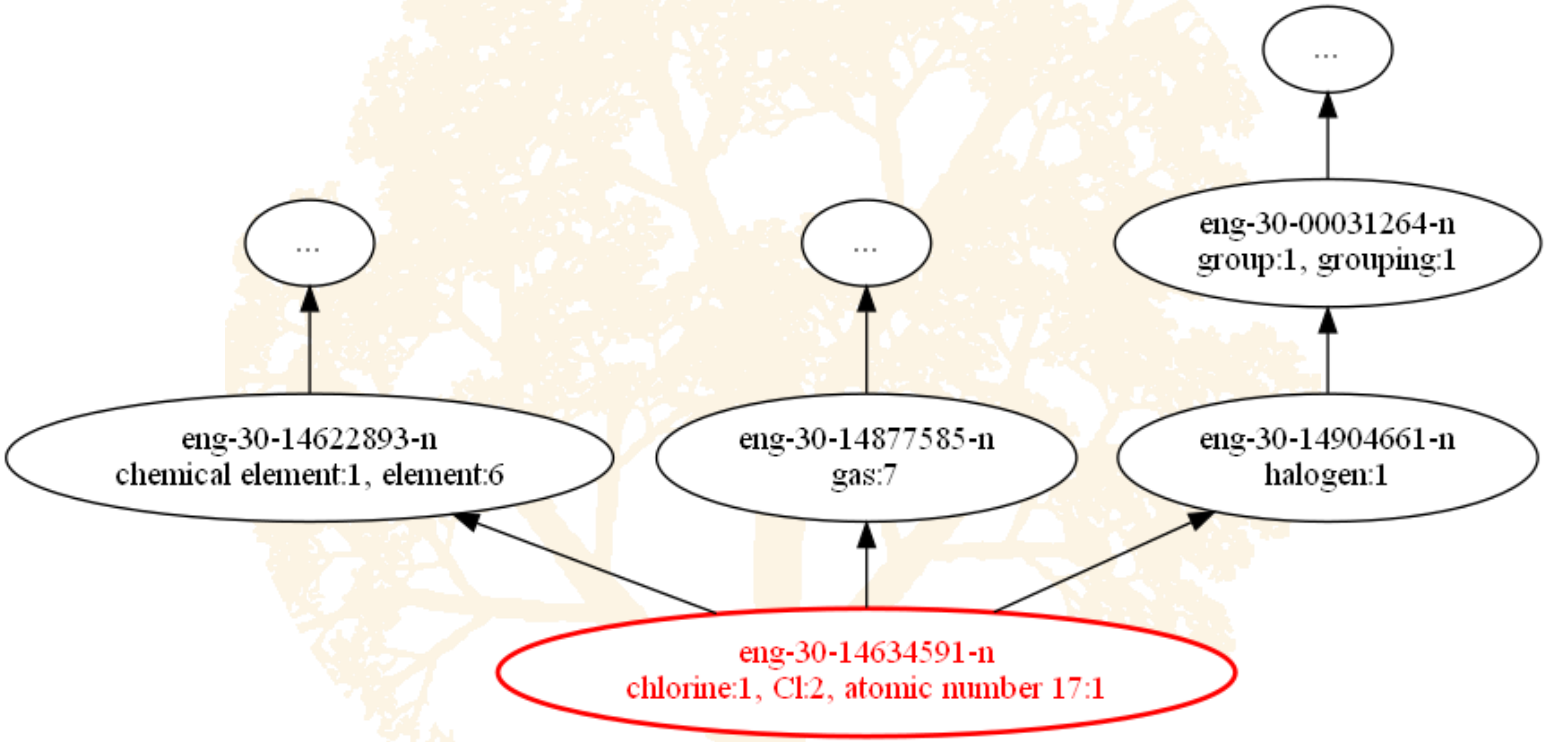
Examples

Before and after resolution of multiple hyperonymy for synset *{chlorine:1, Cl:2, atomic number 17:1}*





Examples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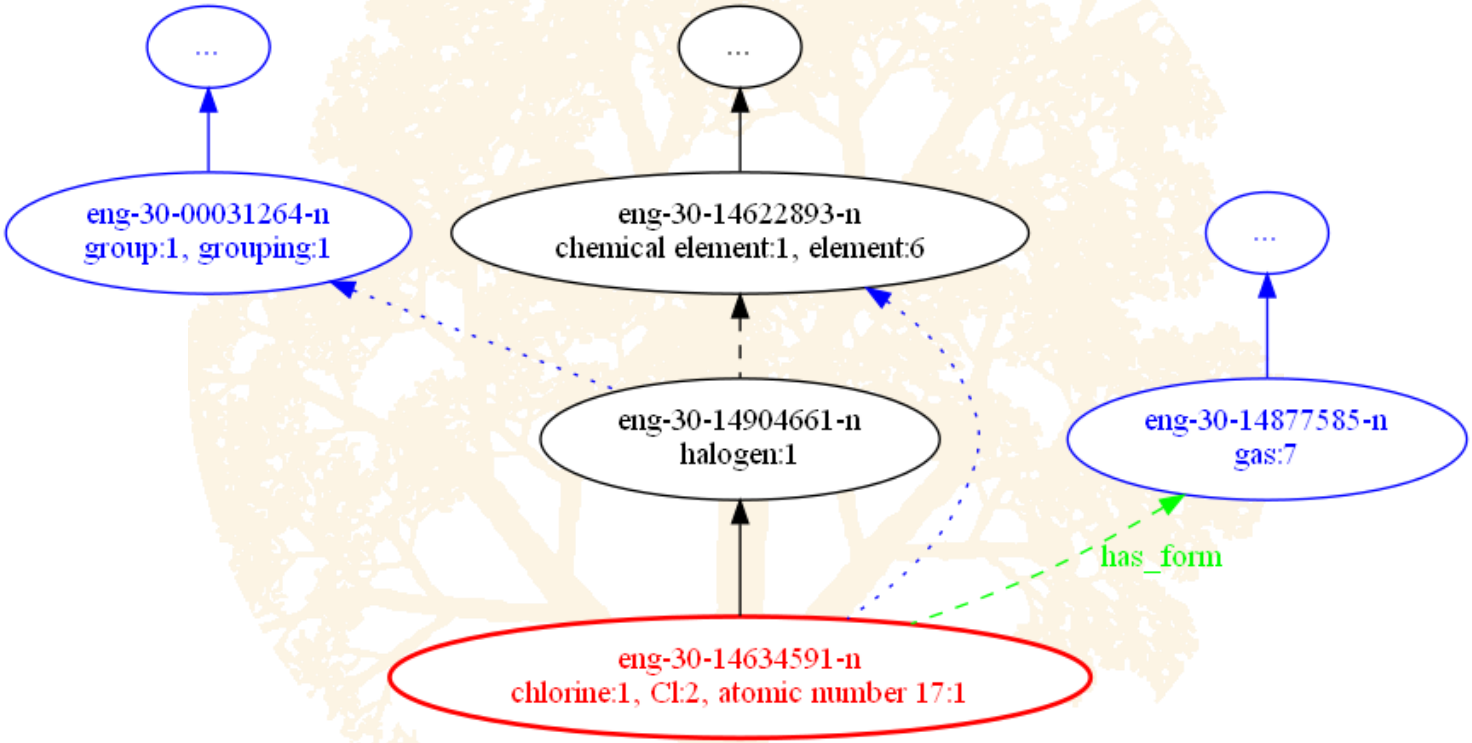
...
eng-30-00031264-n
group:1, grouping:1
eng-30-14622893-n
chemical element:1, element:6
eng-30-14877585-n
gas:7
eng-30-14904661-n
halogen:1
eng-30-14634591-n
chlorine:1, Cl:2, atomic number 17:1

Examples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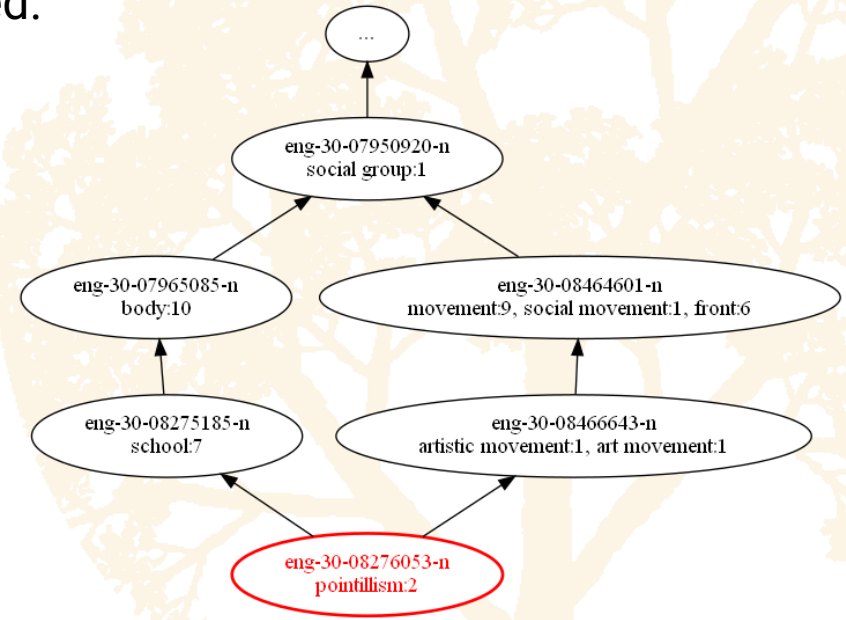
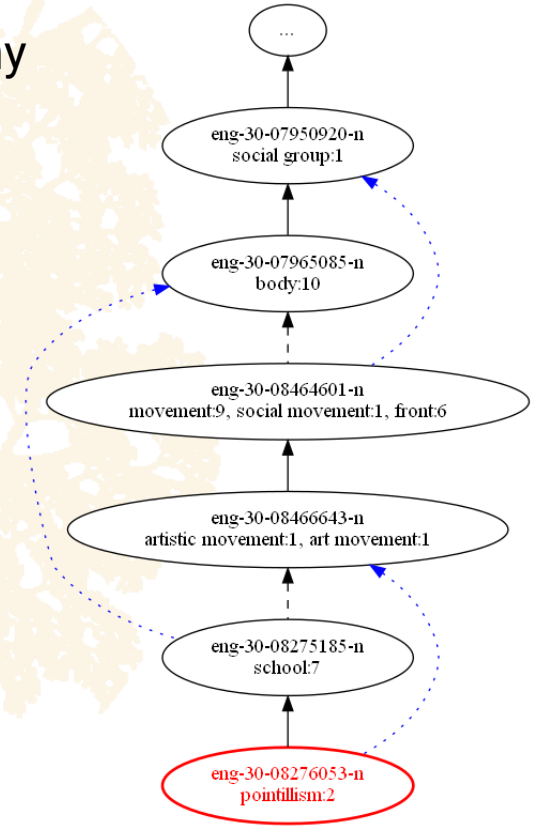
has_form
eng-30-14634591-n
chlorine:1, Cl:2, atomic number 17:1

Examples

In a few cases, additional restructuring of the hyperonymy tree was required.





Results

Action on synsets with multiple hyperonymy	Count
Remove relation	66
Change relation to **characteristic**	388
Change relation to **origin**	19
Change relation to **form**	122
Change relation to **function**	431
Change relation to **purpose**	117
Change relation to **use**	123
Change relation to **member**	13
Change relation to **part**	76
Change relation to **portion**	23
Add new hyperonymy relation	76
Total	1,454

Action on other synsets	Count
Remove relation	11
Change relation type	1
Add new relation	14
Total	26

Total number of actions: 1,480

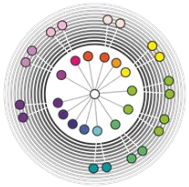
Results

- Noun graph defined by hyperonymy relations is now a **tree**
  - There is a single path from any synset to the root *{entity:1}*
- New relations are asymmetric and intransitive (inverse also defined)
- Observed dependency:

If the semantic primitives of multiple hyperonyms are different, a true hyperonym is the synset where the semantic primitive is the same with respect to the subordinate concept.

Conclusion

- Multiple hyperonymy represents several semantic relations which are only partially shown within WordNet
- Relations such as origin, form, function, etc. bear additional semantics and where they exist, they can be defined, regardless of whether multiple hyperonymy occurs
- Multiple hyperonymy resolution is necessary for cases which require proper inheritance



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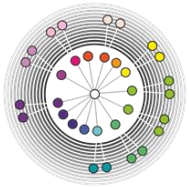
Future work

- The resulting tree structure is appropriate for semantic type classification of noun synsets using inheritance (CPA types mapping)
- This classification will further help the assignment of detailed PDEV sentence patterns to WordNet verb synsets, in turn expanding the verb-noun semantic relations
- A few cases of disjunctive multiple hyperonymy indicate a need for evaluation of possible polysemy in WordNet
- In the meantime, further evaluation and adjustment is required for the resulting WordNet relations and tree structure



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Thank you!

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