The Practitioner's Cookbook for Linked Lexical Resources

Iryna Gurevych & Judith Eckle-Kohler
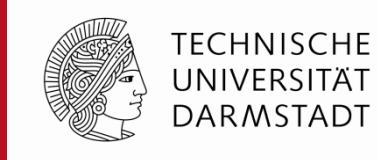
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UKP

Outline

Part 1: Ingredients and Techniques

Part 2: Recipes

Part 1: Ingredients and Techniques

Ingredients: Lexical Resources

Integration Technique: Automatic Sense Linking

Interoperability Technique: Standardizing

Part 1: Ingredients and Techniques

Ingredients: Lexical Resources

Elements of Lexical Resources

**Classic Lexical Resources**

Collaborative Lexical Resources

Integration Technique: Automatic Sense Linking

**Interoperability Technique: Standardizing**

Elements of Lexical Resources

Lexical Markup Framework
(LMF, ISO 24613:2008) – Core Package
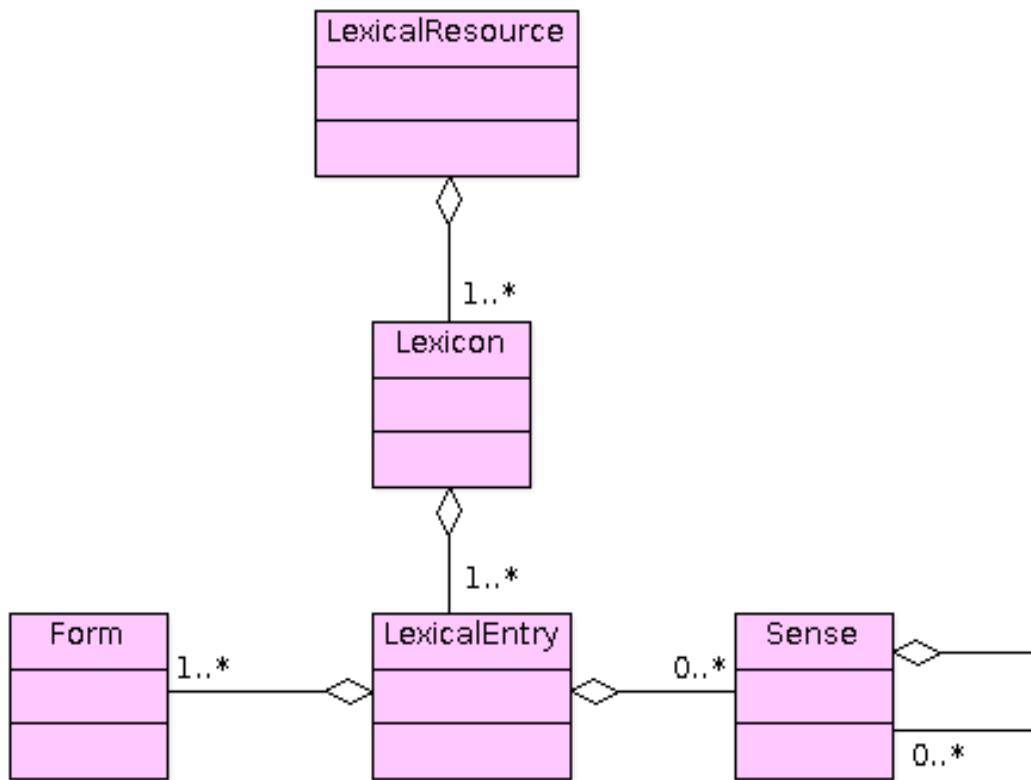
- A lexical resource consists of lexicons.

- A lexicon belongs to a particular language and consists of lexical entries.

- LexicalEntry is a class representing a lexeme in a given language.

- A lexeme is an abstract pairing of meaning and form (Jurafsky & Martin, 2008)

The Form Part of a Lexical Entry: Lemma and Word Form

```
┌─────────────────────┐              ┌─────────────────────┐
│  Lexical entry      │ ───────────► │  Lemma              │
│  POS: verb          │ ─┐           │  sing               │
└─────────────────────┘  │           └─────────────────────┘
                         │
                         │           ┌─────────────────────┐
                         ├─────────► │  Word Form          │
                         │           │  sang               │
                         │           └─────────────────────┘
                         │
                         │           ┌─────────────────────┐
                         └─────────► │  Word Form          │
                                     │  sung               │
                                     └─────────────────────┘
```
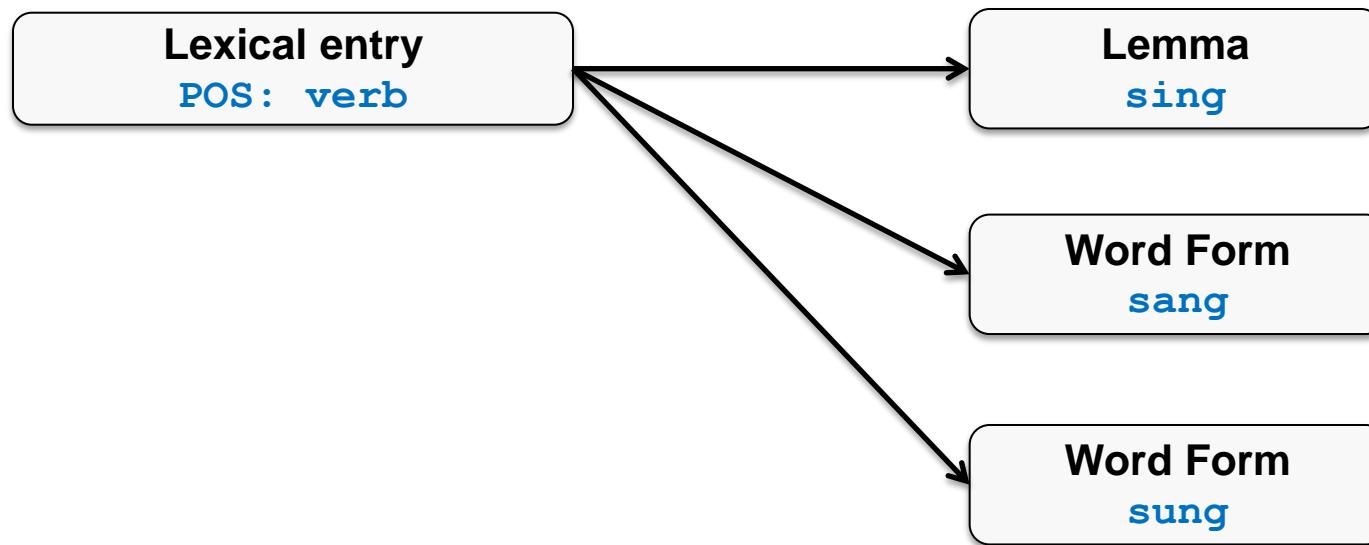
The Meaning Part of a Lexical Entry: Sense

- Lemmas can have several senses (**lexical ambiguity**)
- Colloquial: „*words can have several meanings*"
- Many lemmas are associated with more than one sense

to sing — 1. Produce tones with the voice

2. divulge confidential information or secrets

```
Lemma
to sing
```
→
```
Sense #1
Sing / produce tones
```

→
```
Sense #2
Sing / divulge secrets
```
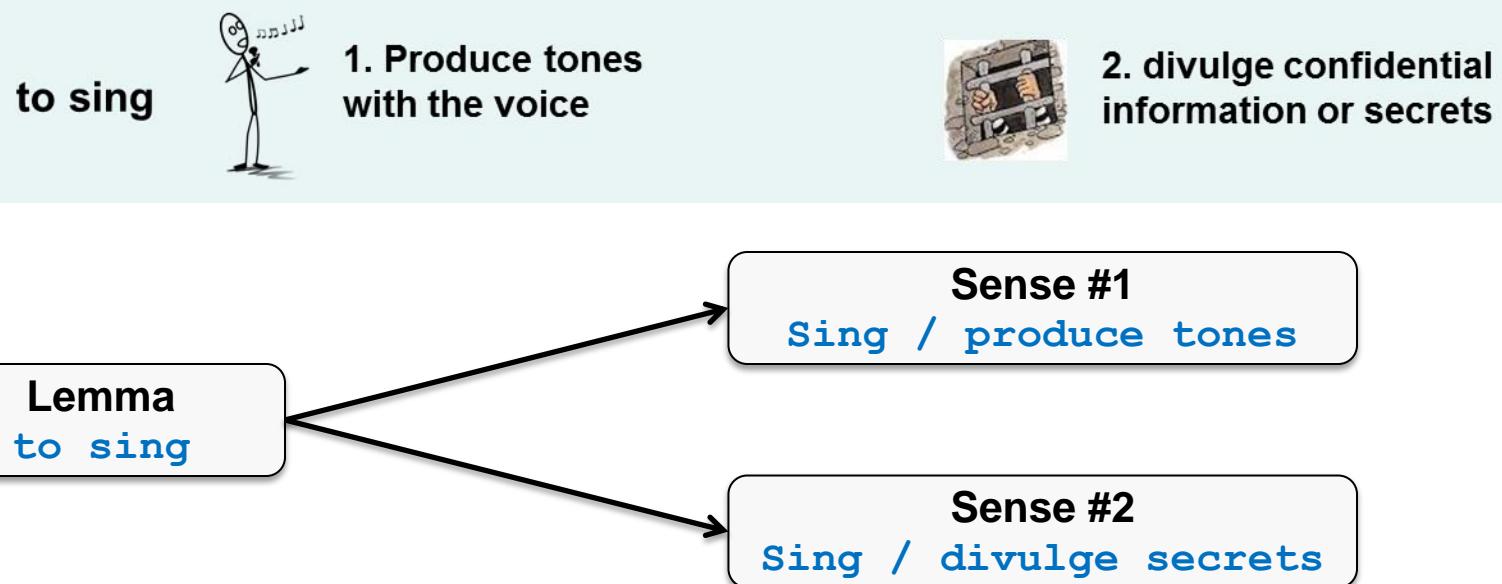
Lexical Information about Senses I

- **Definitions**: short summaries of the meaning of a sense, also called **glosses**. They are meant to define a meaning.

  - The lemma *sing* has a sense that can be defined as "Produce tones with the voice".

- **Sense examples**: Senses can also be described by example sentences. They illustrate a meaning.

  - Sense example for lemma *sing* in the sense "Produce tones with the voice": "*She was singing while she was cooking*."

Lexical Information about Senses II

- **Translations**
  - German translation of *to sing* : *singen*

- **Usage information,** e.g. register (informal, slang, …)
  - *sing / divulge secrets* has register slang

- **Semantic field**
  - e.g., in WordNet: animate, food, location, communication …
  - semantic field of *sing / produce tones:* creation

- **Domain**:
  - *sing / produce tones* has domain music

Lexical Information about Senses III

Morphologically Related Senses

- E.g. *sing / produce tones with the voice* (verb) – *singer* (noun)

Sense Relations

- Synonymy: equivalent senses are related by the synonymy relation
  - Colloquial: „*the same meaning can be expressed by different words*"

- Hypernymy / Hyponymy (noun senses): Also called the IS-A relation
  - singer is-a musician

- Many more sense relations …

Lexical Information about Senses IV

- **Syntactic behavior**: Subcategorization frames (SCFs)
- SCFs specifiy
  - syntactic categories (NP-nominative, NP-accusative, PP …) and
  - grammatical functions (subject, object, ...) of the arguments of a verbal, nominal or adjectival predicate.
- partly language-specific

She   *is singing.*
[subject, nominative]

She   *is singing*   *Christmas carols.*
[subject, nominative]   **[object,accusative]**

Relation of Sense and Subcategorization Frame

Example:

- *Sing / produce tones with the voice* can be used with NP-accusative:
  - *They sing Christmas carols.*

- *Sing / divulge secrets* is usually not used with NP-accusative:
  - *Just a matter of time before an informant sings.*

Grouping Related Senses –
Different Ways to Organize a Lexicon

In dictionaries and in the ISO standard LMF, senses are grouped into lexical entries that share the same lemma and part-of-speech.

However, senses can also be **grouped differently**:

- Grouping of senses that are related by some sense relation
  - e.g., synonymy

- Grouping of senses that share the same syntactic behavior
  - e.g., subcategorization frame

Part 1: Ingredients and Techniques

Ingredients: Lexical Resources

Elements of Lexical Resources

Classic Lexical Resources

Collaborative Lexical Resources

Integration Technique: Automatic Sense Linking

Interoperability Technique: Standardizing

WordNet

- Domain-independent, broad-coverage lexical-semantic network of English nouns, verbs and adjectives

- Realized at Princeton University by George Miller's team (started in 1985)

- Widely used for many NLP tasks and applications

- http://wordnet.princeton.edu/wordnet/

WordNet is Organized in Synsets

Synonymous senses are grouped into synsets.

spill the beans#1
let the cat out of the bag#1
talk#5
tattle#2
blab#1
peach#1
babble#4
sing#5
babble out#1
blab out#1

Synset ,
Synset ID: (1){00939238}

WordNet Synsets

Synonymous senses are grouped into synsets.

spill the beans#1
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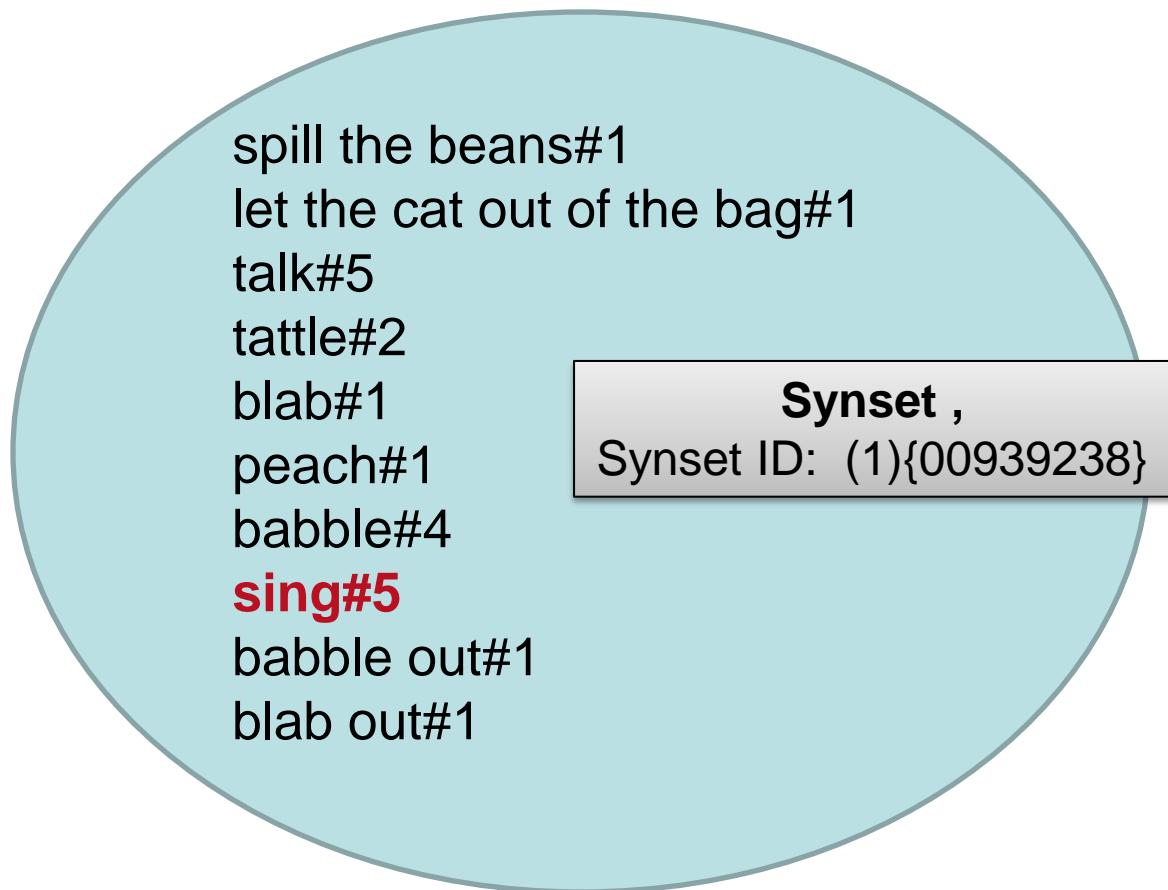
Synset ,
Synset ID: (1){00939238}
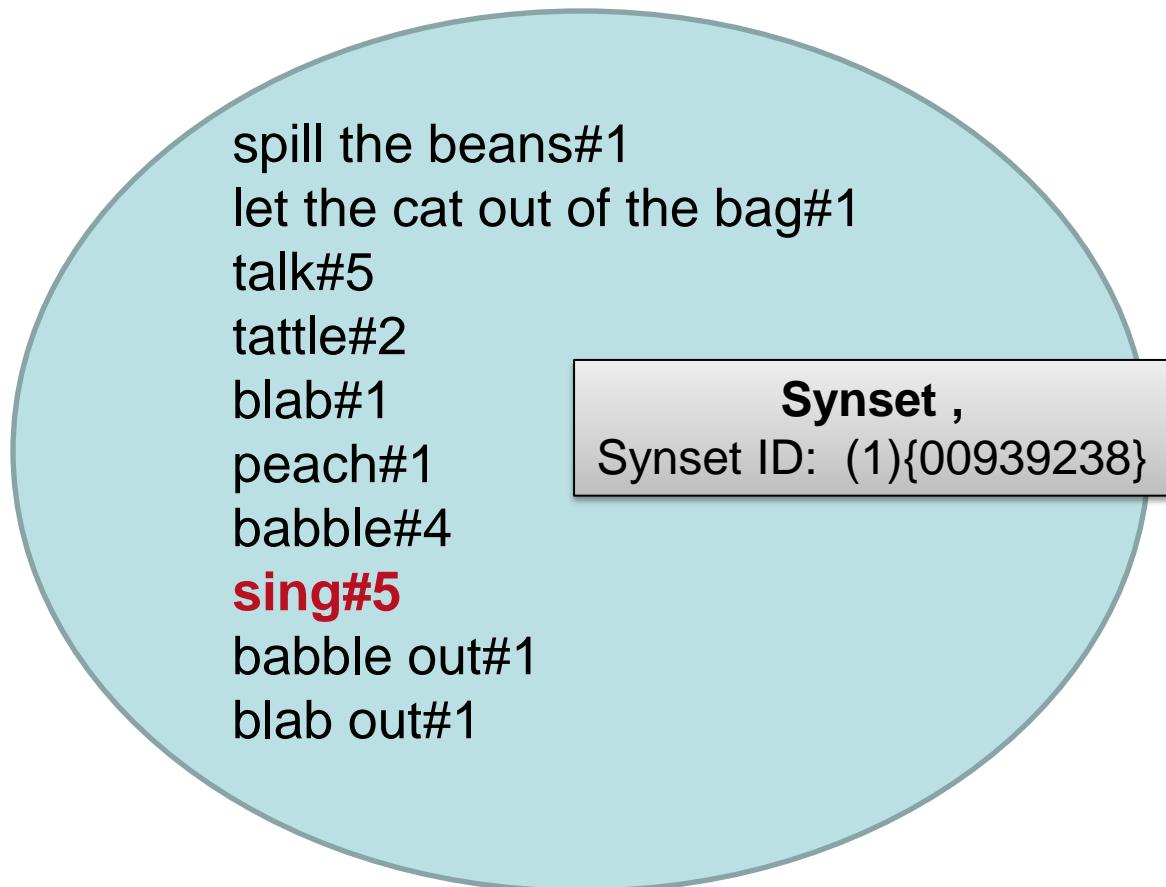
Members of a synset
- are senses,
- are represented by their lemma.

All synset members belong to the same word class (e.g., noun, verb).

Synset Definitions (Glosses)

Synsets have glosses, i.e. definitions/short summaries of their meaning.

- The meaning of a synset is expressed in its gloss.
- The meaning of a synset can alternatively be captured by the list of its member synonyms.

Synset , Synset ID: (1){00939238}

Gloss: "divulge confidential information or secrets"

Members:
sing (Sense ID: sing%2:32:01::)
spill the beans (Sense ID: spill_the_beans%2:32:00::)

Sense Examples

Senses, i.e., members of a synset, are illustrated by sense examples – sentences illustrate a meaning.

Synset , Synset ID: (1){00939238}
Gloss: "divulge confidential information or secrets"

Members:
sing (Sense ID: sing%2:32:01::)
Sense Example: *"Just a matter of time before an informant sings."*

spill the beans (Sense ID: spill_the_beans%2:32:00::)
Sense Example: *"They had planned it as a surprise party, but somebody spilled the beans."*

VerbNet

- Domain-independent, broad-coverage lexicon of English verbs

  - lexical-syntactic and lexical-semantic information for verbs
  - 3962 verb lemmas in VerbNet 3.1

- http://verbs.colorado.edu/~mpalmer/projects/verbnet.html

VerbNet is Organized in Verb Classes

Verbs are grouped into **verb classes**, based on Levin's classification of English verbs:

- 470 verb classes, hierarchically structured
- **VerbNet sense** = pair of verb lemma and verb class

chant chatter chirp chortle
chuckle cluck coo croak … scream screech shout shriek sibilate
sigh simper
sing smatter smile snap
snarl snivel
snuffle …

manner_speaking-37.3
Members: 103, Frames: 14

VerbNet Verb Classes

VerbNet verb classes group verbs that share the same predicate-argument structure, i.e.

- subcategorization frame,
- semantic roles and selectional preferences,
- semantic predicate based on the event decomposition of Moens and Steedman (1988).

Although the resulting verb classes are semantically coherent, the semantic relatedness of verb senses in a VerbNet class is **distant** compared to WordNet synsets.

- e.g., the verbs *believe, swear and doubt* are in the same verb class.

VerbNet – Information types

VERB: sing

EXAMPLE: "Susan whispered about the party."

SCF including obligatory lexemes

Semantic Roles

SYNTAX:

Agent[+animate|+organization] V {about}

Topic[+communication]

Selectional Preferences

Semantic Predicate

SEMANTIC PRED:

transfer_info(during(E), Agent, ?Recipient, Topic) cause(Agent, E)

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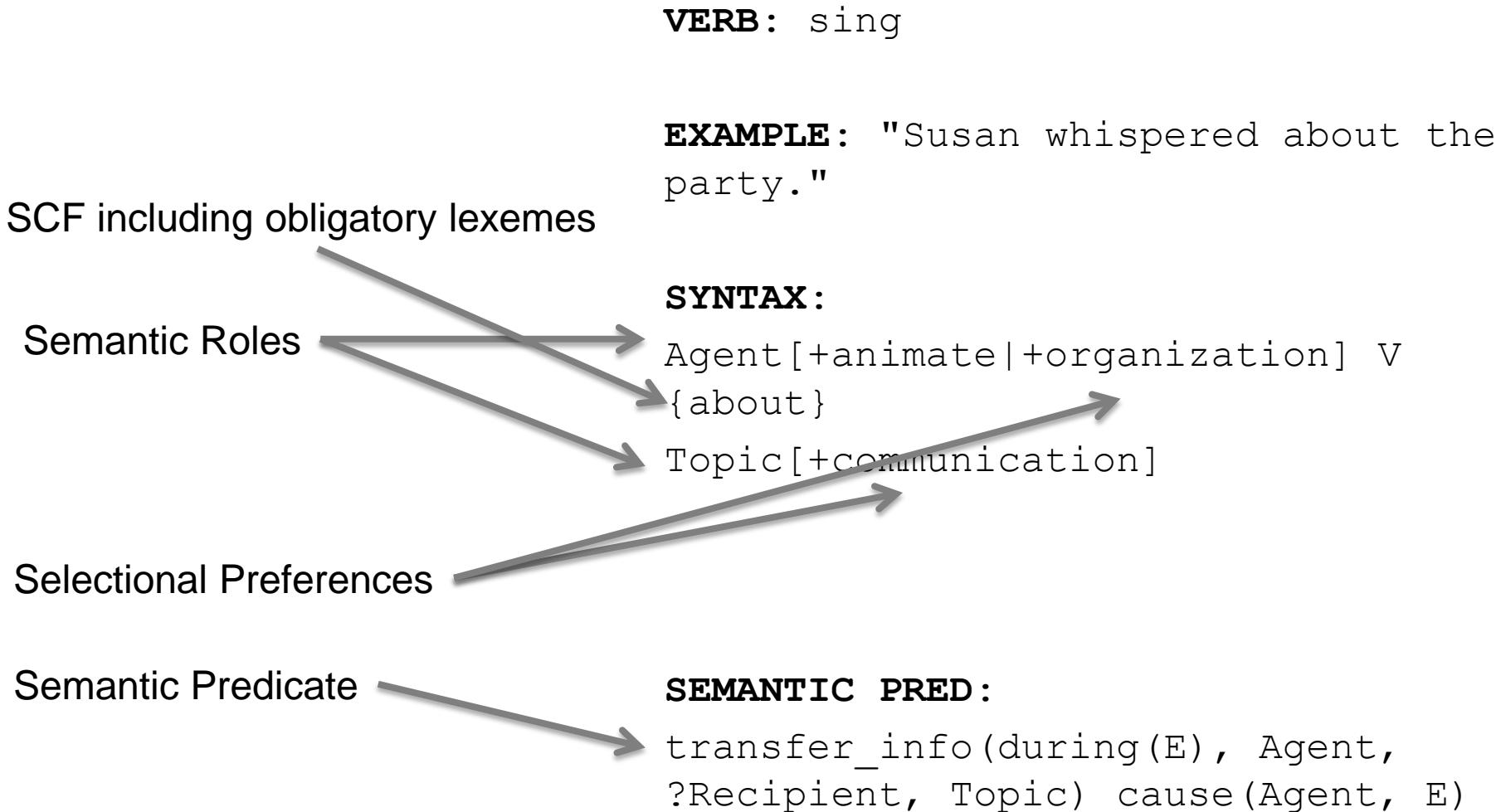
FrameNet

FrameNet is a lexical resource of English verbs, nouns, adjectives.

FrameNet 1.5 contains:

- 1,019 frames,
- 9,423 lemmas,
- 11,942 lexical units
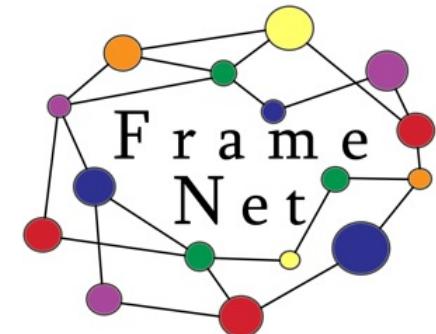
http://framenet.icsi.berkeley.edu/

FrameNet is Organized in Frames

- Senses are grouped into **frames** based on Fillmore's Frame Semantics (Fillmore 1976, Fillmore et al. 2003).

- In FrameNet, senses are called lexical units.

babble.v, bluster.v, chant.v, chatter.v, drawl.v, gabble.v, gibber.v, jabber.v, lisp.v, mouth.v, mumble.v, mutter.v, natter.v, prattle.v, rant.v, rave.v, shout.v, simper.v, **sing.v**, slur.v, stammer.v, stutter.v, whisper.v

Communication_manner

FrameNet Frames

- A **frame** represents a conceptual structure, or a prototypical situation with a (frame-specific) set of **roles** that identify the participants involved in the situation.

- Frames group senses which **evoke** the same kind of situation with participants taking over particular roles.

- Senses in a FrameNet frame are **semantically related, but not synonymous**; e.g., the verbs *love* and *hate* are both in the same FrameNet frame.

Frame Evoking Word Classes

Frame evoking word classes are

- **verbs**, they are the prototypical frame-evoking word classes

- **predicate-like** nouns and adjectives

  - e.g. nouns denoting events (*development*), relations (*brother*), states (*height*)

Example:

COMMUNICATION_MANNER frame:

[They]$_{Speaker}$ all *sang* [Happy Birthday]$_{Message}$

Coverage Issues in FrameNet

Low lexical coverage compared to WordNet
- 9,423 lemmas in FrameNet 1.5
- 156,584 lemmas in WordNet 3.0

- The focus of FrameNet is on verbs and predicate-like nouns and adjectives.
  - Many nouns and adjectives evoke uninteresting frames, e.g., nouns denoting artifacts and natural kinds; adjectives denoting colors.
  - Hence, few of them have been included [Baker and Fellbaum 2009].

- Senses encountered in a corpus may have no corresponding sense in FrameNet, e.g.

  Sing / produce tones with the voice → Frame Communication_manner

  Sing / divulge secrets → No frame available

Part 1: Ingredients and Techniques

Ingredients: Lexical Resources

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Collaborative Lexical Resources

Integration Technique: Automatic Sense Linking

Interoperability Technique: Standardizing

Wikipedia, a Multilingual Encyclopedia

- Wikipedia is a freely licensed encyclopedia written by thousands of volunteers in many languages.

- Free license allows others to freely copy, redistribute, and modify the work commercially or non-commercially.

- Founded January 15, 2001

- 6th most visited site according to Alexa (Feb. 2010)

http://www.wikipedia.org

(Jimmy Wales)

Wikipedia – Information Types

Title

Redirects

Introduction (first paragraph)

Headers

Categories

Infoboxes

Hyperlinks

Wikipedia – Disambiguation pages

- Sense inventory, including domain specific senses

Forest (disambiguation)

From Wikipedia, the free encyclopedia

A forest is a large area covered by trees.

Forest can also mean:

- Royal forest, an area set aside for hunting

Forest may also be:

- In Windows networking, the collection of every object, their attributes and rules in an Activ
- In graph theory, a disjoint union of trees
- *Forest* (album), an album by George Winston
- "Forest" (song), a song by the band System of a Down

The Forest may refer to:

- *The Forest*, a video game
- *The Forest*, a 2002 film

JWPL
Java-based Wikipedia Programming Library

Highlights

- High performance access to Wikipedia content

- Parser for the WikiMedia syntax

- Articles, discussion pages, categories as Java objects

- Access to information nuggets

- Redirects, links, link anchors, interlanguage links, sections, first paragraph, etc.

- Supports all Wikipedia language editions

Available open source: http://code.google.com/p/jwpl/

Wiktionary, a Multilingual Machine Readable Dictionary

Français
Le dictionnaire libre
856 000 + articles

English
The free dictionary
841 000+ articles

Tiếng Việt
Từ điển mở
227 000+ mục từ

Türkçe
Özgür sözlük
208 000+ madde

a multilingual free encyclopedia

Wiktionary
[ˈwɪkʃənrɪ] n.,
a wiki-based Open Content dictionary
Wiktio [ˈwɪʃ kəʒɪ]

Русский
Свободный словарь
137 000+ статей

Ido
La libera vortaro
137 000+ artikli

中文
自由的多语言词典
116 000+ 条词条

Ελληνικά
Το Ελεύθερο Λεξικό
107 000+ λήμματα

102 000+

Polski
Wolny słownik
93 000+ stron

http://www.wiktionary.org/

Wiktionary – Information Types

- Language
- Etymology
- Pronunciation
- Part of speech
- Morphology
- Derived terms, related terms
- Abbreviations
- Collocations
- Word senses
- Glosses
- Sense examples
- Synonyms, antonyms, hypernyms, hyponyms
- Translations
- Quotations
- …

JWKTL
Java-based **W**iktionary **L**ibrary

Highlights:

- efficient and structured access to the information encoded in the English, the German, and the Russian Wiktionary language editions
- sense definitions
- part of speech tags
- etymology
- example sentences
- translations
- semantic relations
- … and many other lexical information types.

Available open source: http://code.google.com/p/jwktl/

OmegaWiki, a Multilingual Lexical-Semantic Resource

- A free, **multilingual** resource
- Over 420.000 expressions in 255 languages
- Over 40.000 **language-independent** concepts
- Around 3,000 users
- **Goals**
  - Overcome Wiktionary's structural inconsistencies
  - Create a resource for translations/synonyms which is easily accessible and maintainable
- **Consequence:** a fixed database schema
  - Users can only contribute if they stick to the predefined structure
    - …but the price is a loss in expressiveness

http://www.omegawiki.org/

JOWKL
Java-based OmegaWiki Library

Highlights:

- Fast and efficient access to OmegaWiki
- Direct access to OmegaWiki database dumps, no preprocessing necessary
- Language independent

Available open source: http://code.google.com/p/jowkl/

Part 1: Ingredients and Techniques

Ingredients: Lexical Resources

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Lexical Resource Integration – Motivation

Lexical resources are largely different

- Different coverage of words/word senses
- Different information types
  - Encyclopedic vs. linguistic knowledge
  - Syntactic vs. semantic knowledge
  - …
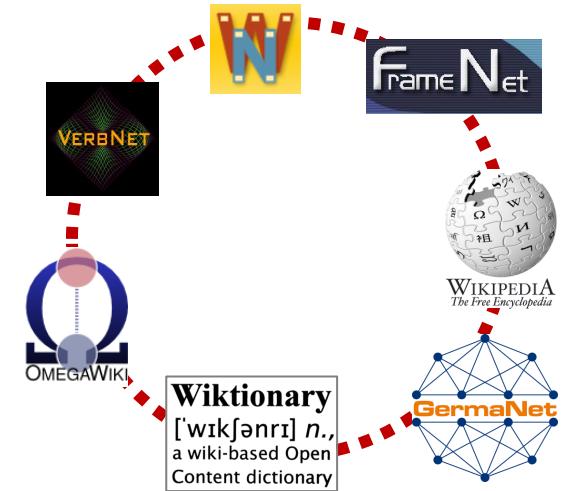
This can significantly influence the performance of an NLP system – Instead of choosing only one (best performing):

Why not combine multiple resources and benefit from all their knowledge?

Linking Lexical Resources at the Word Sense Level
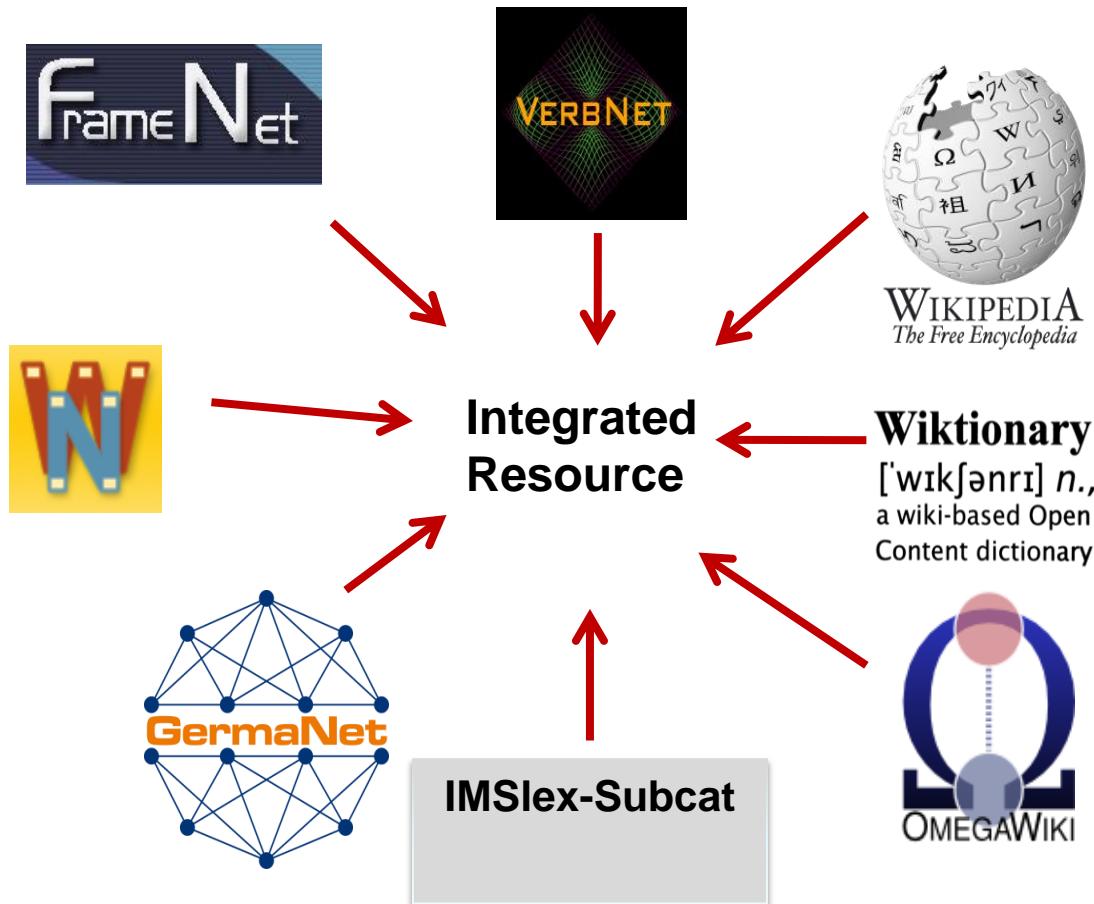
Linking at the word sense level:

sense alignment of resources

= linking of equivalent senses

Previous Work on Linking Lexical Resources

Linked Lexical Resources:

- Meaning Multilingual Central Repository, Atserias et al. (2004)
- Yago, Suchanek et al. (2007)
- SemLink (Palmer, 2009)
- Universal Wordnet (UWN), Gerard de Melo and Gerhard Weikum (2009)
- eXtended WordFrameNet, Laparra and Rigau (2010)
- BabelNet, Navigli and Ponzetto (2010)
- NULEX, McFate and Forbus (2011)
- UBY, Gurevych et al. (2012)
- … many more, e.g., on the Semantic Web

Linking at the Word Sense Level: Example

Wiktionary [ˈwɪkʃənrɪ] *n.,* a wiki-based Open Content dictionary

to sing
1. To produce musical or harmonious sounds with one's voice.
2. To express audibly by means of a harmonious vocalization.
3. To confess under interrogation.

to sing
1. Produce tones with the voice
2. divulge confidential information or secrets

to sing
1. To produce harmonious sounds with one's voice.

singen
1. Mit der Stimme harmonische Töne erzeugen.

Case Study: Automatic Word Sense Alignment of Wiktionary and WordNet

Goal:

Create a word sense alignment between Wiktionary and WordNet that comes with

(1) Increased coverage

(2) Enriched sense representations

Meyer, Gurevych (2011)

Wiktionary vs. WordNet: Differences

WordNet

Wiktionary [ˈwɪkʃənrɪ] *n.,* a wiki-based Open Content dictionary

Noun

plant (*plural* **plants**)

1. An organism that is not an animal, especially an organism...
   The garden had a couple of trees, and a cluster of...
2. (*botany*) An organism of the kingdom *Plantae*; now specifically, a living organism of the Embryophyte (and plants) of...
   b, or any organism closely related to such an organism.
3. (*ecology*) Now specifically, a multicellular eukaryote that includes chloroplasts in its cells, which have a cell wall.
4. A factory or other industrial or institutional building or facility.
5. An object placed surreptitiously in order to cause suspicion to fall upon a person.
   That gun's not mine! It's a plant! I've never seen it before!
6. Anyone assigned to behave as a member of the public during a covert operation (as in a police investigation).
7. A person, placed amongst an audience, whose role is to cause confusion, laughter etc.
8. (*snooker*) A play in which the cue ball knocks one (usually red) ball onto another, in order to pot the second; a set.

Noun

- S: (n) **plant**, works, industrial plant (buildings for carrying on industrial labor) *"they built a large plant to manufacture automobiles"*
- S: (n) **plant**, flora, plant life ((botany) a living organism lacking the power of locomotion)
- S: (n) **plant** (an actor situated in the audience whose acting is rehearsed but seems spontaneous to the audience)
- S: (n) **plant** (something planted secretly for discovery by another) *"the police used a plant to trick the thieves"; "he claimed that the evidence against him was a plant"*

Linking Wiktionary and WordNet at the Sense Level

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A two-step approach:
1. *Candidate extraction*
2. *Candidate disambiguation*

Wiktionary
[ˈwɪkʃənrɪ] *n.*,
a wiki-based Open
Content dictionary

plant
(organism)

plant
(factory)

bird
(animal)

plant
(person)

reddish
(color)

to fly
(move)

works
(factory)

…

works
(machine)

{plant, works, industrial plant}

WordNet **synsets**

Wiktionary **senses**

UKP

Linking Wiktionary and WordNet at the Sense Level

A two-step approach:
1. **Candidate extraction**
2. *Candidate disambiguation*

Wiktionary [ˈwɪkʃənrɪ] *n.,* a wiki-based Open Content dictionary

plant (organism)

plant (factory)

bird (animal)

plant (person)

reddish (color)

to fly (move)

{plant, works, industrial plant}

WordNet synsets

works (factory)

…

works (machine)
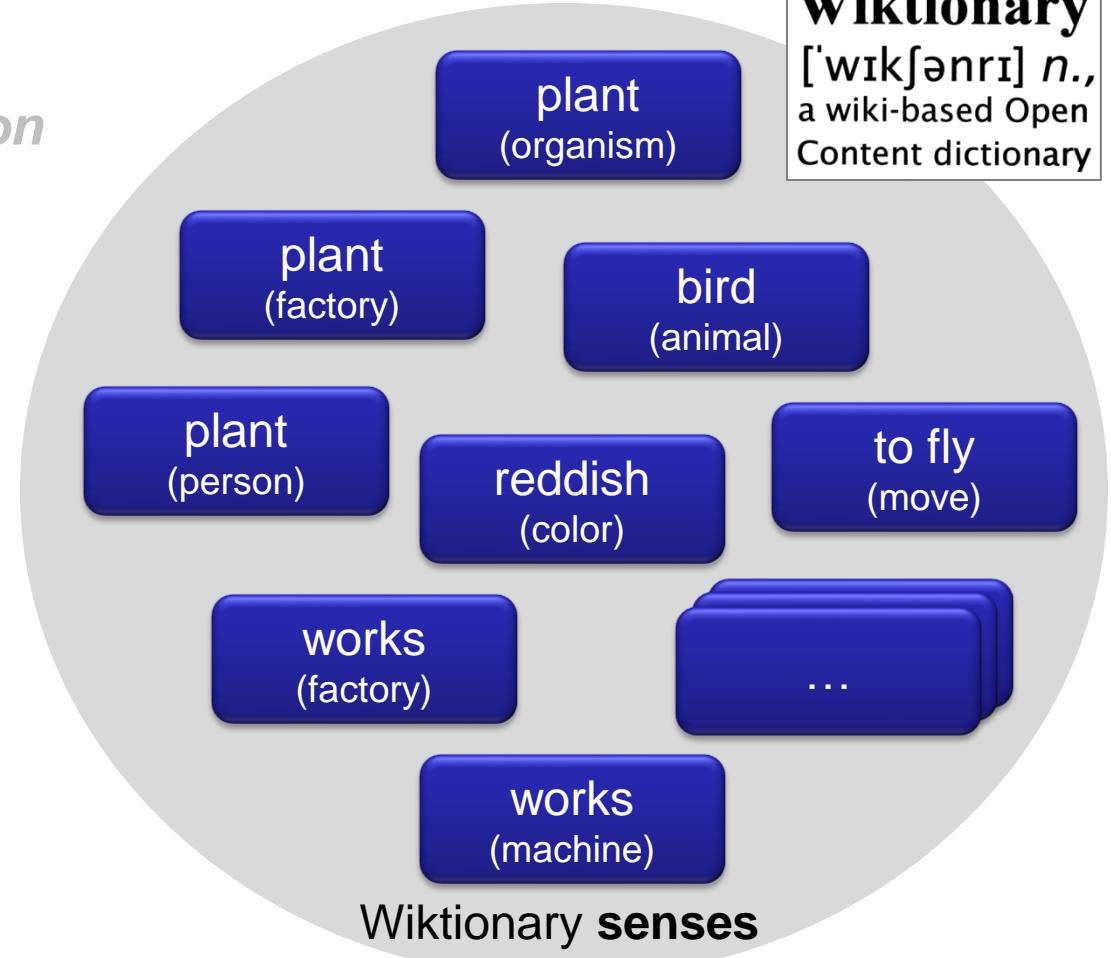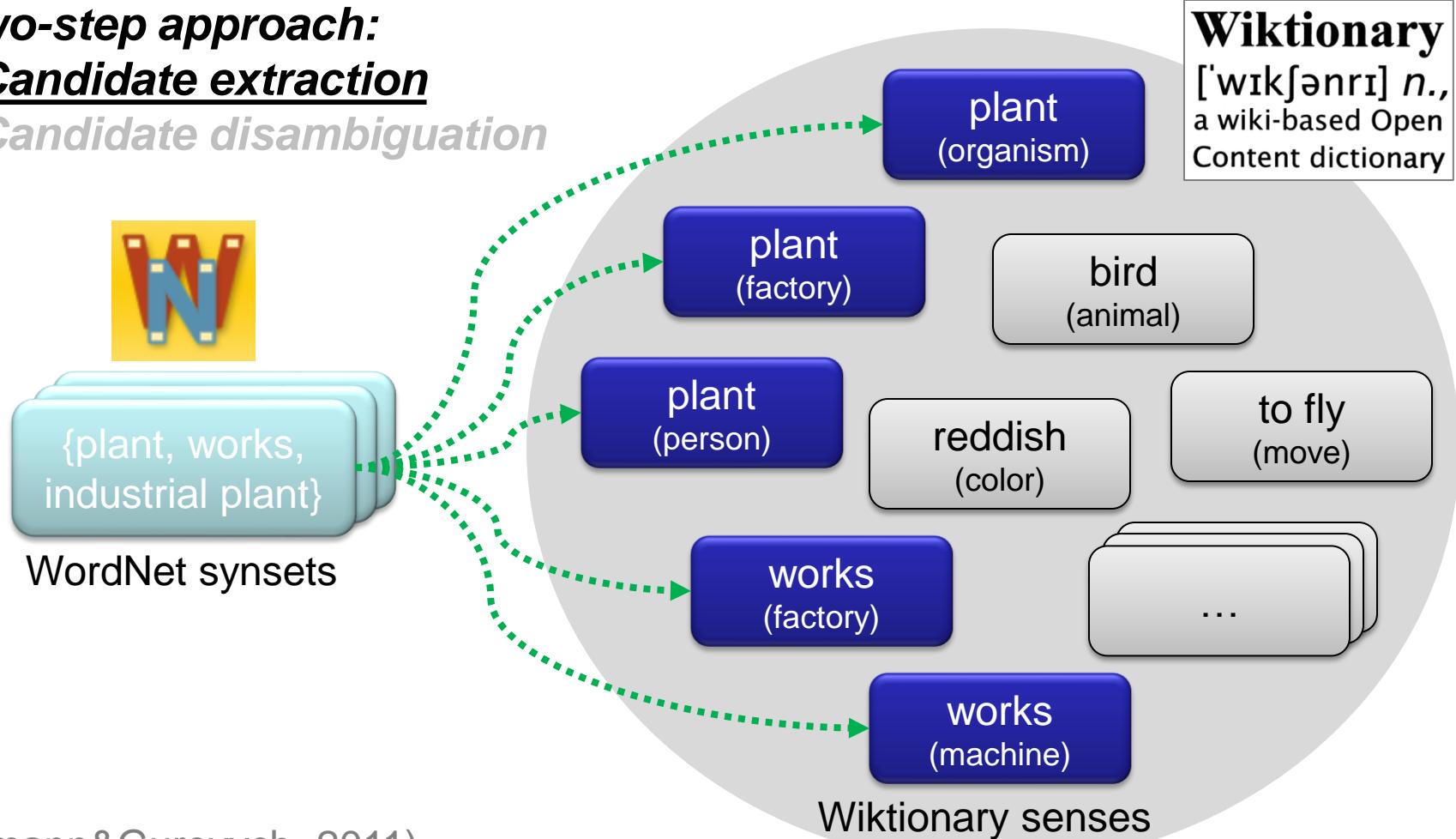
Wiktionary senses

(Niemann&Gurevych, 2011)

Linking Wiktionary and WordNet at the Sense Level

A two-step approach:

1. *Candidate extraction*
2. ***Candidate disambiguation***

Wiktionary
[ˈwɪkʃənɪ] *n.,*
a wiki-based Open
Content dictionary

plant
(organism) ✗

plant
(factory)

bird
(animal)

plant
(person) ✗

reddish
(color)

to fly
(move)

{plant, works,
industrial plant}

works
(factory)

…

WordNet synsets

works
(machine) ✗

Wiktionary senses

(Niemann&Gurevych, 2011)

UKP
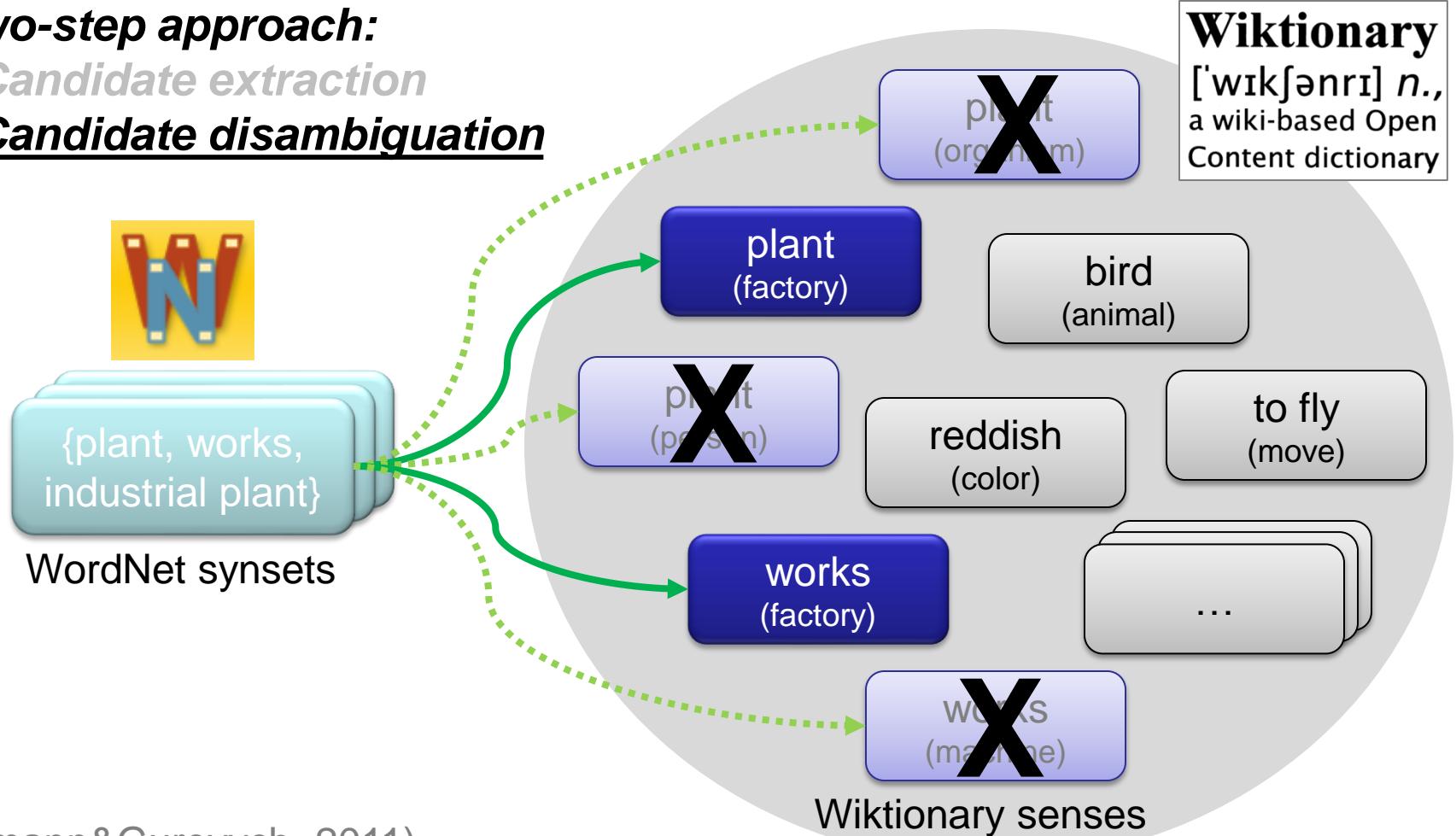
Disambiguation: BoW Representation

synset

hypernyms

hyponyms

hyper- &
hyponyms

word

gloss

usage
examples

Wiktionary
[ˈwɪkʃənrɪ] *n.*,
a wiki-based Open
Content dictionary

synonyms

bag-of-
words

bag-of-
words

Synsets are represented by synonyms, gloss, examples
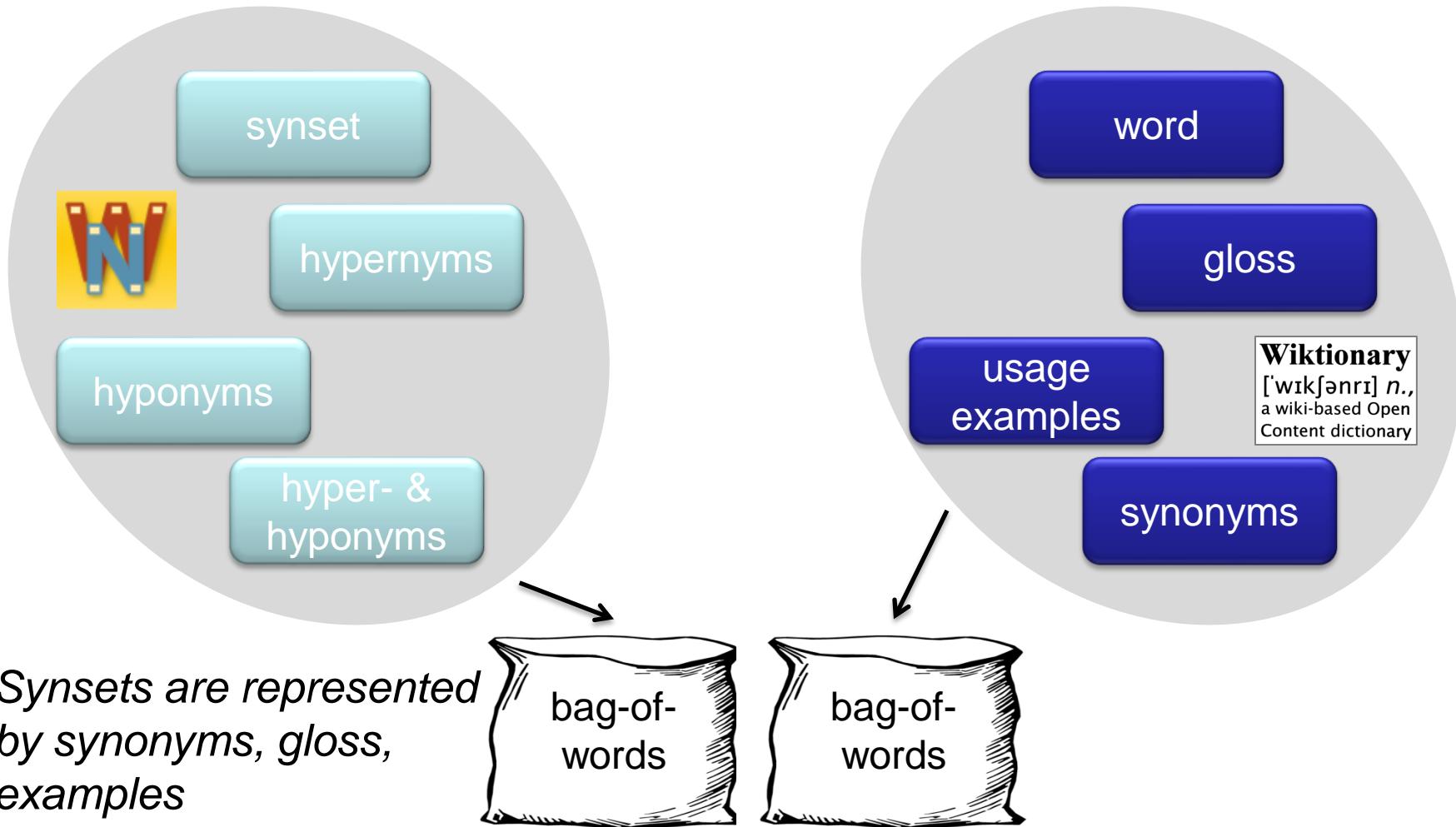
Disambiguation: Alignment Classification

bag-of-words → semantic relatedness measure ← bag-of-words

COS: Cosine similarity

PPR: Personalized PageRank
(Agirre&Soroa, 2009)

$s <$ threshold

$s \geq$ threshold

No alignment!

Align this pair of WordNet synset and Wiktionary sense!
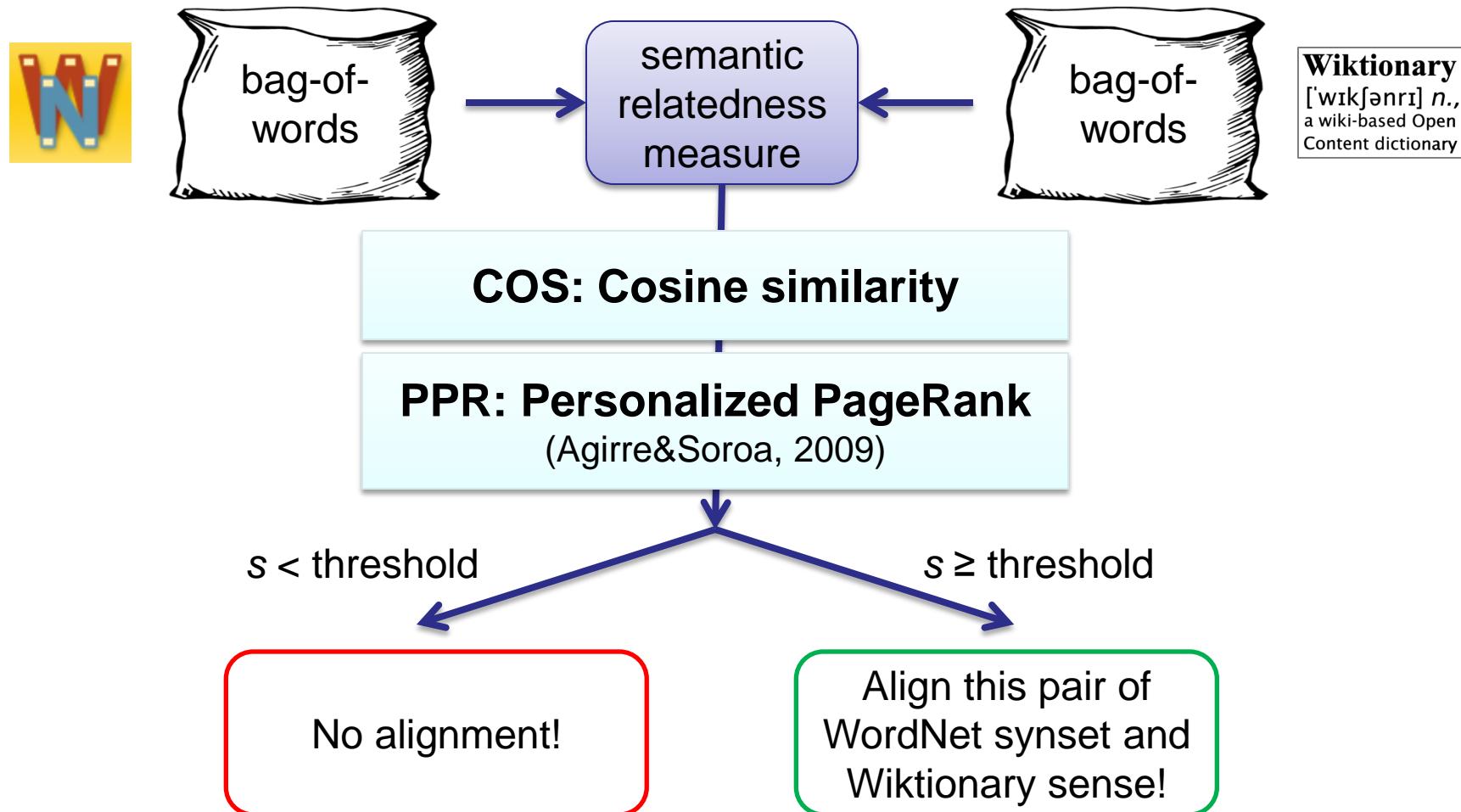
Evaluation

Evaluation of automatic word sense alignment of Wiktionary and WordNet:

- F1 ~ 0.66, Precision ~ 0.67, Recall ~ 0.65
- baseline results: F1 ~ 0.31 (random sense) and 0.4 (first sense)

Open issues to be addressed in future work:

- BoW representation is less suitable for verb senses
- Highly related senses are linked that are not covered by the Gold Standard data set, although these links might be very useful for many NLP applications

Increased Coverage: Domains

	Wiktionary AND WordNet	Only Wiktionary	Only WordNet
Biology	4,465	4,067	12,869
Chemistry	2,561	8,260	2,268
Engineering	1,108	940	1,080
Geology	2,287	2,898	2,479
Humanities	4,949	2,700	5,060
IT	439	3,032	557
Linguistics	1,249	1,011	1,576
Math	615	2,747	483
Medicine	3,613	3,728	3,058
Military	574	426	585
Physics	1,246	2,835	1,252
Religion	733	1,154	781
Social Sciences	3,745	2,907	4,458
Sport	905	2,821	807

Enriched Sense Representation

Access to complementary information

Synonyms

Gloss

Example sentence

Subsumption hierarchy

Synset organization

…

Wiktionary
['wɪkʃənrɪ] *n.,*
a wiki-based Open
Content dictionary

Pronunciation

Etymology

Usage

Quotations

Related terms

Translations

…

Sense Alignment of Multiple Resources

Matuschek & Gurevych (2013)

Hartmann & Gurevych (2013)

NLP Applications of Linked Lexical Resources
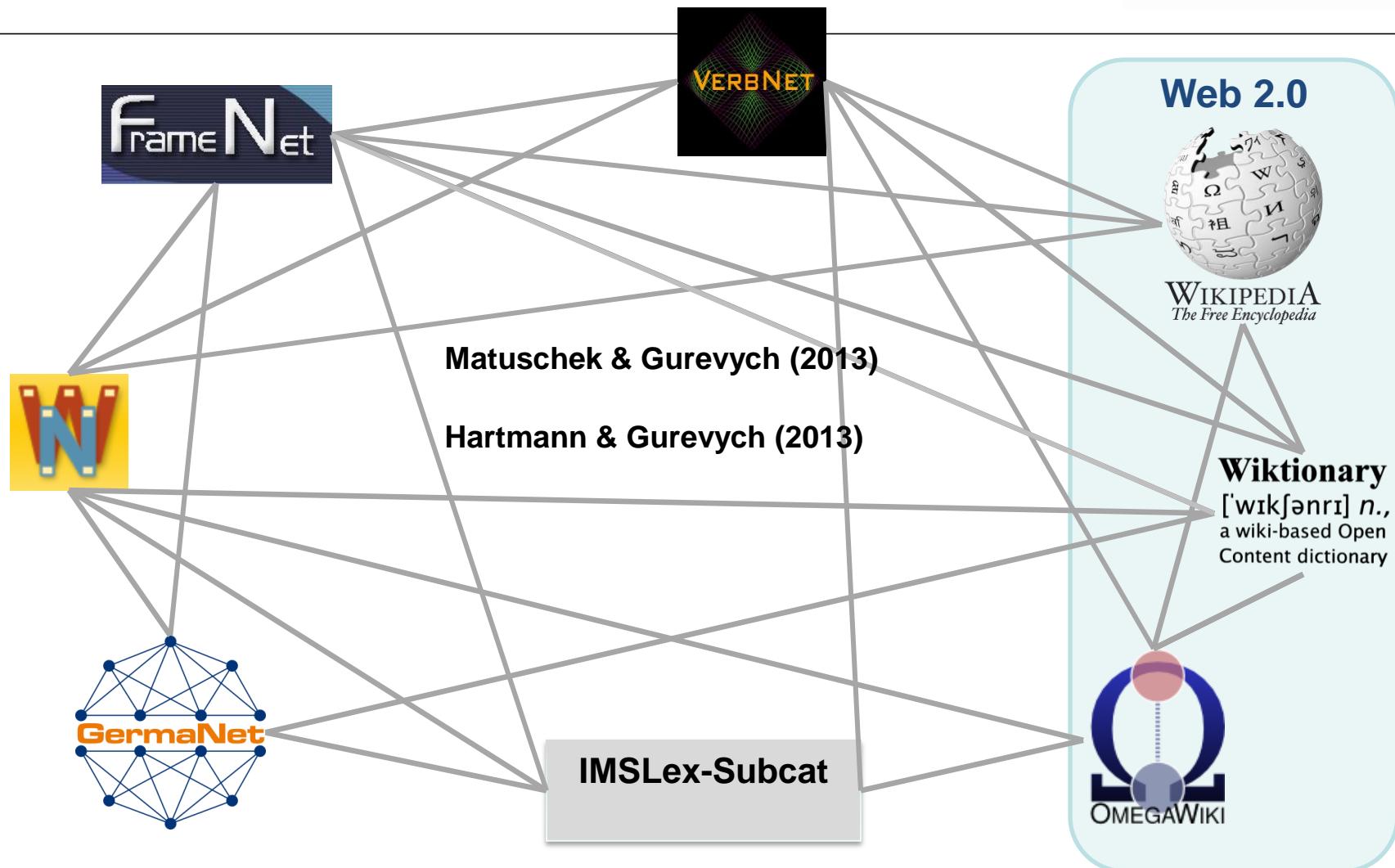
The increased coverage and the enriched sense representation yield synergies.

Previously shown:

- Linking FrameNet, VerbNet, and WordNet for semantic parsing (Shi and Mihalcea, 2005)

- Linking VerbNet, FrameNet and PropBank for semantic role labeling (Palmer, 2009)

- Linking WordNet and Wikipedia for word sense disambiguation (Navigli and Ponzetto, 2010)

- Linking WordNet and Wiktionary for measuring verb similarity (Meyer and Gurevych, 2012)

Future work:

- Semantic relatedness, information retrieval, information extraction,…

- Your application?

Part 1: Ingredients and Techniques

Ingredients: Lexical Resources

> **Elements of Lexical Resources**

> **Classic Lexical Resources**

> **Collaborative Lexical Resources**

**Integration Technique: Automatic Sense Linking**

Interoperability Technique: Standardizing

Interoperability – Motivation

- Different APIs …
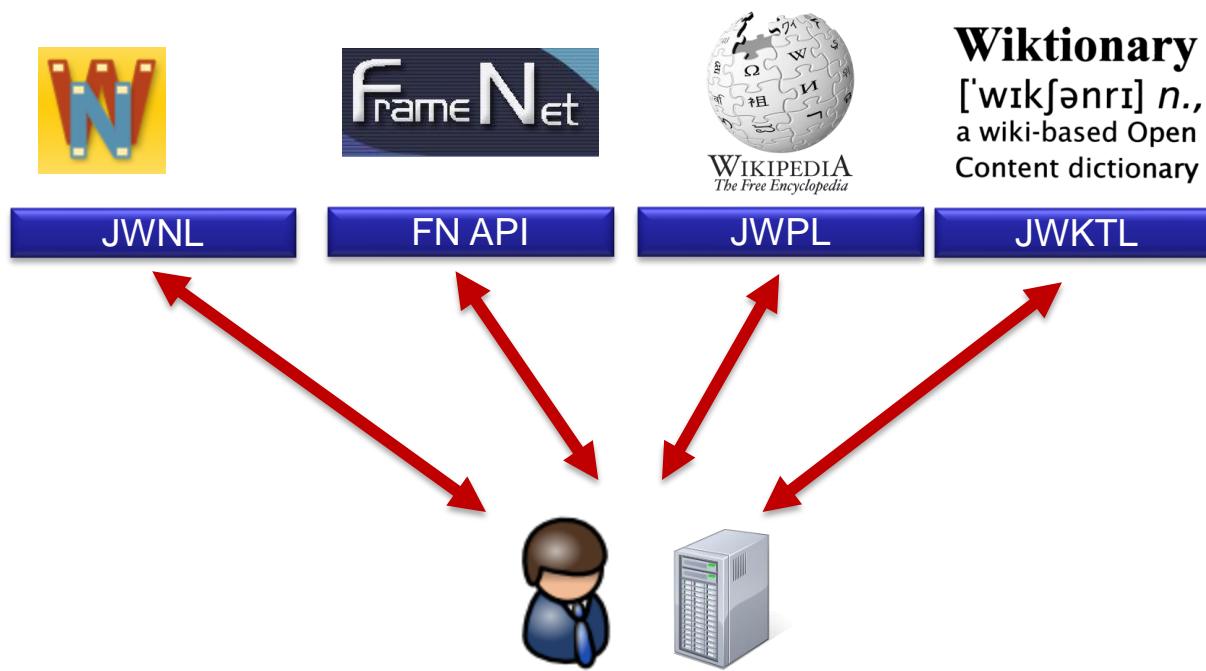
Integration of Lexical Resources at the Representation Level
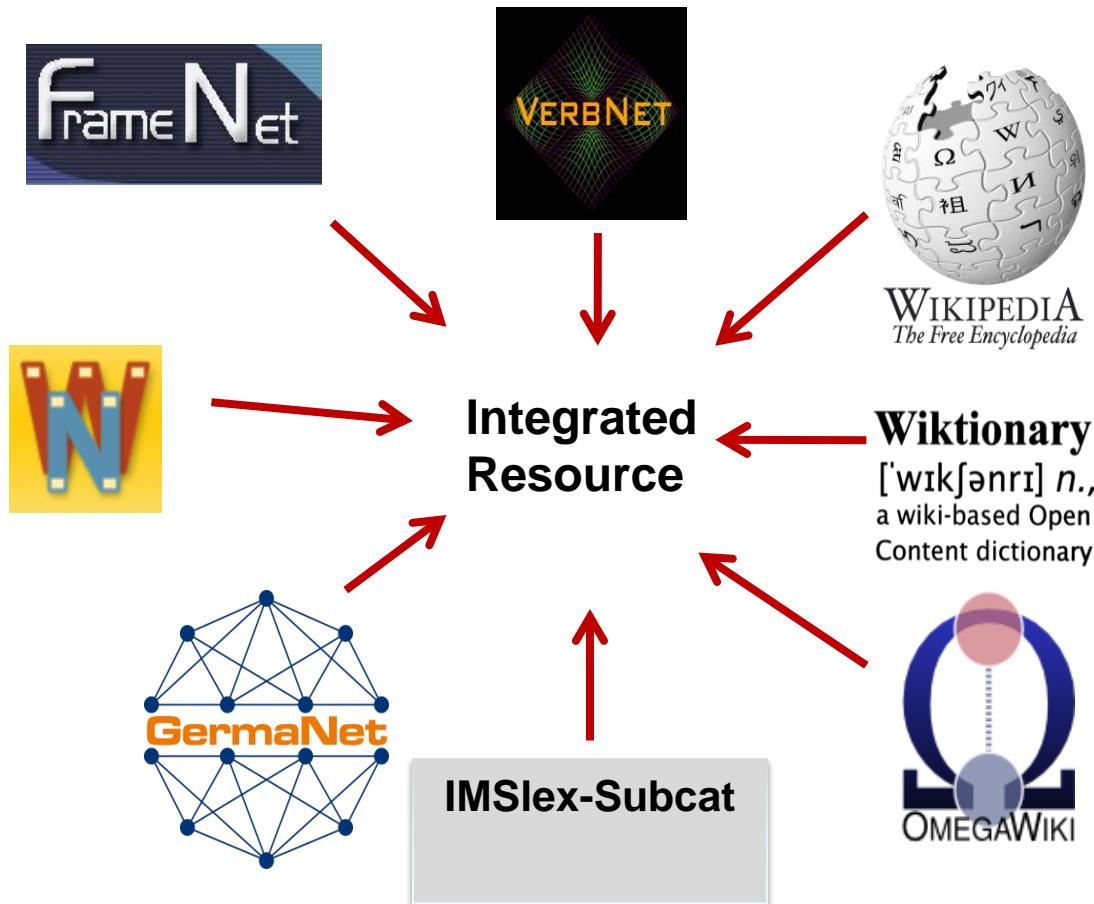
Integration at the representation level:

standardization of resources

Heterogeneous Lexical Resources

Different information types

Linguistic terminology

Incompatible data formats

1. (n) [Adler]
   o [Adler]

GermaNet

Wikiwörterbuch
Wiktionary
['vɪkʃə,nɛʀi], *n*
Das freie Wörterbuch
ein Wiki-basiertes

Eintrag | Diskussion

Adler

WIKIPEDIA
Die freie Enzyklopädie

Artikel | Diskussion

Adler

Adler (v. mittelhochdt. *adelare*, urspr. *edelaar zu Aar*) steht fü

- Adler (Familienname), einen Familiennamen
- Adler (Biologie), Trivialbezeichnung für verschiedene Greifv

Hauptseite
Themenportale

Navigation
Meta:Main Page
Visual Dictionary
Random expression

Language: German ▽

RETURN HOME

No Comments

WordNet Search - 3.1
- WordNet home page - Glossary - Help

Word to search for: eagle   [Search WordNet]

Display Options: (Select option to change) ▾ [Change]

Key: "S:" = Show Synset (semantic) relations, "W:" = Show Word (lexical) relations
Display options for sense: (gloss) "an example sentence"
Display options for word: word (sense key)

Noun

- S: (n) **eagle** (eagle%1:05:00::), bird of Jove (bird_of_jove%1:05:00::) (any of various large keen-sighted diurnal birds of prey noted for their broad wings and strong soaring flight)
- S: (n) **eagle** (eagle%1:23:00::) ((golf) a score of two strokes under par on a hole)
- S: (n) **eagle** (eagle%1:21:00::) (a former gold coin in the United States worth 10 dollars)
- S: (n) **eagle** (eagle%1:10:00::) (an emblem representing power) *"the Roman eagle"*

Verb

- S: (v) **eagle** (eagle%2:35:00::), double birdie (double_birdie%2:35:00::) (shoot two strokes under par) *"She eagled the hole"*
- S: (v) **eagle** (eagle%2:33:00::) (shoot in two strokes under par)

MEMBERS

CRUISE (FN 1, 2, 3; WN 1
DRIVE (FN 1, 2, 3; WN 2,
FLY (FN 1, 2, 3, 4; WN 4
NAVIGATE (WN 2, 3; G
OAR

ROLES

- AGENT [+ANIMATE]
- THEME [+ANIMATE]
- LOCATION [+CONCRETE]

FRAMES

NP.AGENT V
  EXAMPLE "They rowed."
  SYNTAX AGENT V
  SEMANTICS MOTION(DURING(E), AGENT)
NP V PP.LOCATION
  EXAMPLE "They rowed along the canal."
  SYNTAX AGENT V {{+PATH}} LOCATION
  SEMANTICS MOTION(DURING(E), AGENT) PR

Frame: Self_motion

Definition:

COD: (of a winged creature or aircraft) move through the air under control.

Frame Elements and Their Syntactic Realizations

The Frame Elements for this word sense are (with realizations):

Frame Element	Number Annotated	Realization(s)
Area	(8)	AVP.Dep (2) PP[over].Dep (3) PP[about].Dep (1) PP[in].Dep (2) PP[through].Dep (1)
Depictive	(3)	PP[with].Dep (2) VPing.Dep (1)
Distance	(1)	NP.Dep (1)
Duration	(1)	Sub.Dep (1)

Dimensions of Interoperability

Structural Interoperability:

Uniform lexicon structure – given by the main organizational units

- e.g., harmonizing the *synset-based* organization (WordNet), the *headword-based* organization (Wiktionary) and the *frame-based* organization (FrameNet)

Interoperability at the level of linguistic terminology:

Uniform Data Categories – these are descriptions of the meaning of linguistic terms

- e.g., harmonizing the terms *lexical unit* (FrameNet) and *word sense* (Wiktionary)

Standardizing Lexical Resources

ISO Standards for lexical resources:

- ISO 24613:2008 **Lexical Markup Framework (LMF)**
- ISO 12620:2009 Data Category Registry: **ISOcat**

Standardization of lexical resources according to LMF makes them interoperable:

- at the structural level **LMF classes**

- at the level of linguistic terminology **ISOcat Data Categories**

ISO-LMF is an Abstract Standard …

- Classes are given in LMF, **but they have no attributes.**
- Attributes and their values = linguistic terminology

- In order to make use of ISO-LMF, attributes and their values have to be defined for each class.

- The result is **an instantiation of the abstract LMF standard** – **a lexicon model** that can be populated by lexicon data.
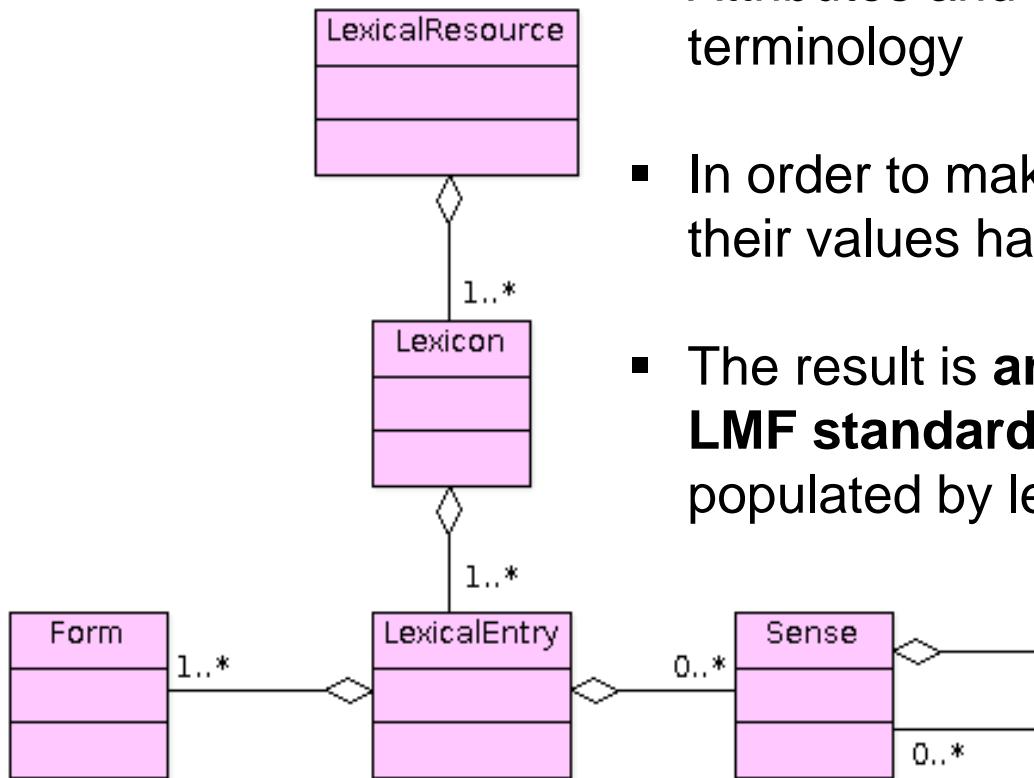
An Instantiation of LMF for NLP: UBY-LMF

UBY-LMF

- is an instantiation of LMF that is directly usable
- specifies attributes and their values for all LMF classes used
- extends the LMF standard by two classes: SemanticLabel and Frequency

Many different **types of lexical resources** in UBY-LMF:

- expert built vs. collaboratively constructed
- differently organized:
  - headword-based
  - wordnets
  - lexical resources based on frame semantics
  - subcategorization lexicons

Eckle-Kohler et al. (2013)

UBY-LMF – Design Principles

Extensibility

- further languages
- further lexicons
- automatically mined information types (e.g. domain labels)

No information loss

- including conflicting information
- e.g. keeping the original sense key in the `MonolingualExtRef` class

Implementation of UBY-LMF

- Definition of a lexicon model in UML (Unified Modeling Language)

- Implementation of the lexicon model in Java and as a DTD
- Conversion of lexical resources to UBY-LMF according to the lexicon model

- Import of converted resources into an SQL database based on an object-relational mapping using Hibernate
- Export format: XML

Example: SCFs in UBY-LMF – Fine-grained Specification of Syntactic Arguments
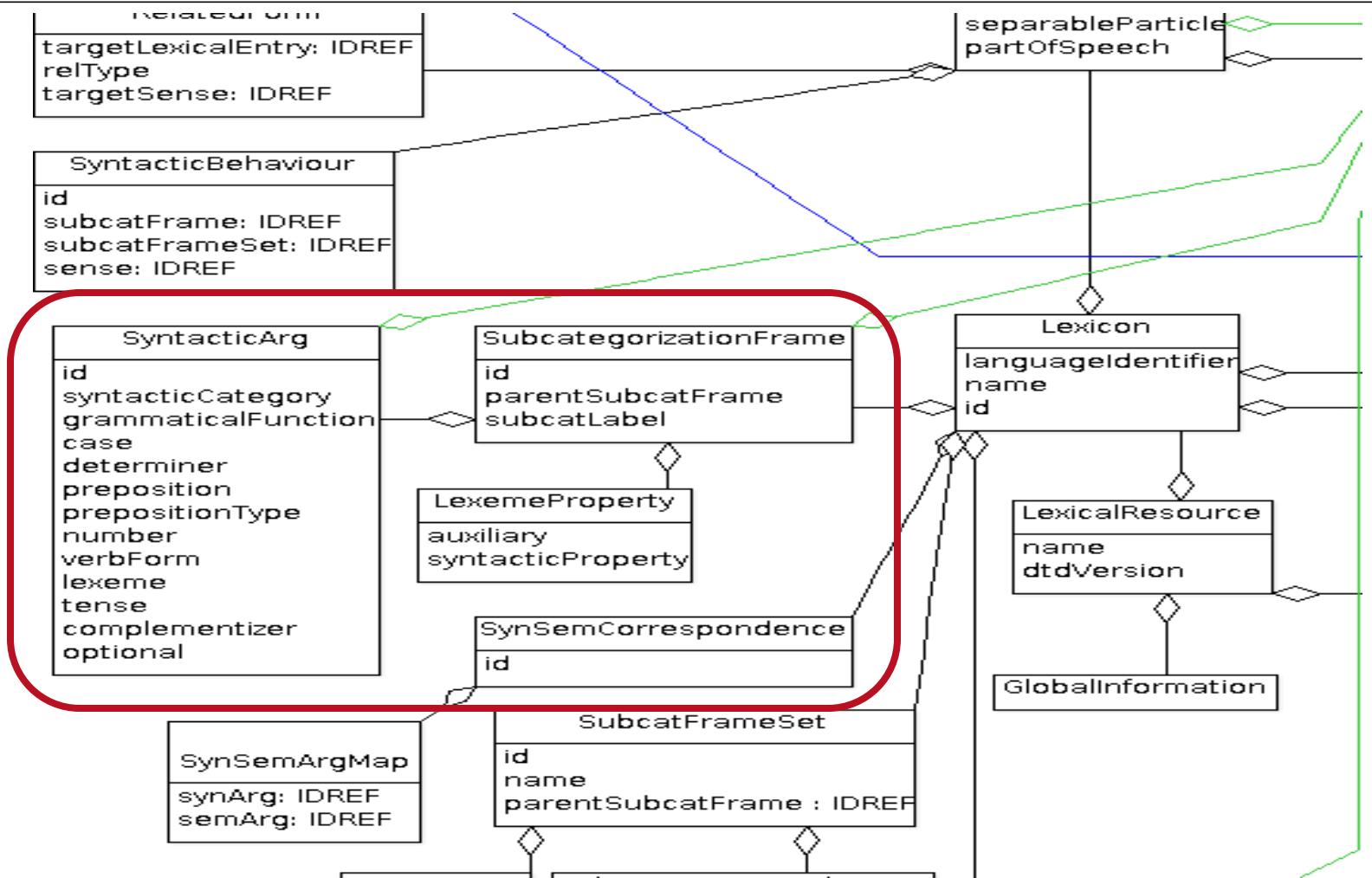
SCFs in UBY-LMF – Example

lachen

NN.Pp

laugh

NP V PP {about}

SCFs in UBY-LMF

GermaNet Syntactic Arguments	VerbNet Syntactic Arguments
syntacticCategory: nounPhrase grammaticalFunction: subject	syntacticCategory: nounPhrase grammaticalFunction: subject
syntacticCategory: prepositionalPhrase	syntacticCategory: prepositionalPhrase
grammaticalFunction: prepositionalComplement	grammaticalFunction: prepositionalComplement
Preposition: -	Preposition: about

Interoperable Lexical Resources

Lexicon model UBY-LMF

ISO-Standard Lexical Markup Framework

Preserves variety of lexical information

Extensible

Outline

Part 1: Ingredients and Techniques

Part 2: Recipes

UBY – the Main Ingredient
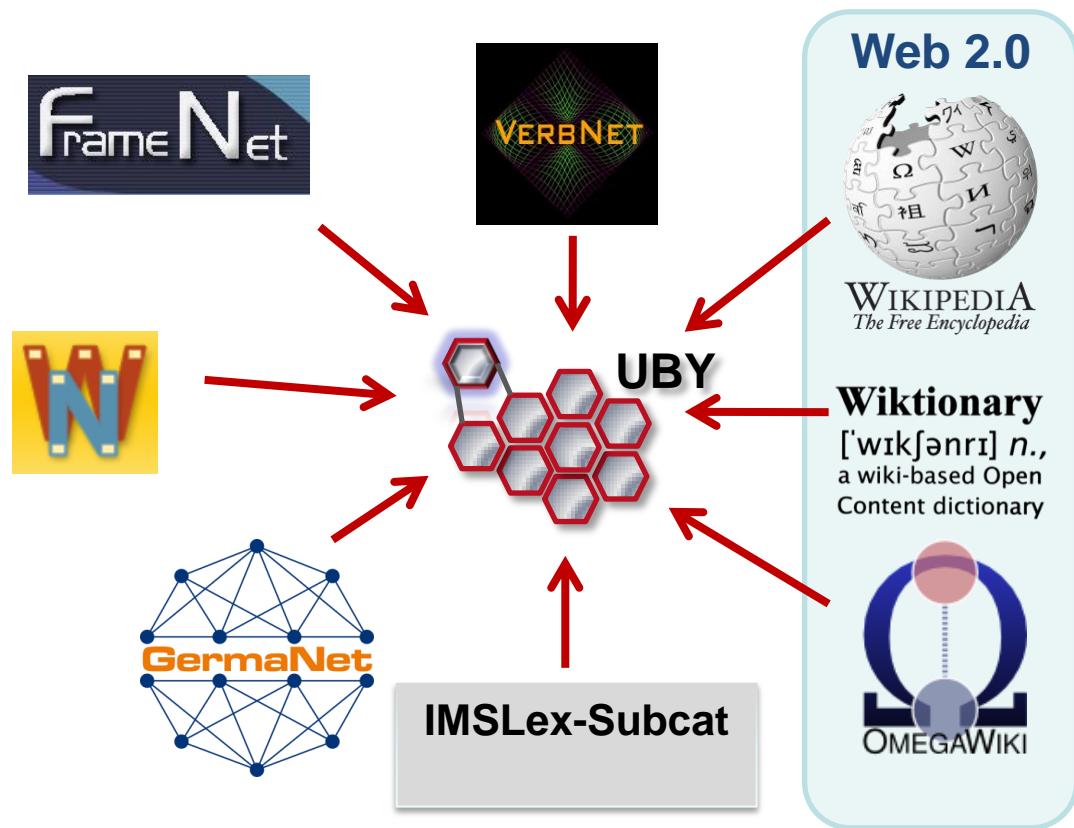
Goal: to exploit wide variety of lexical knowledge

The People Behind UBY – UKP Lab and Beyond

UKP Lab, TU Darmstadt

- Iryna Gurevych
- Judith Eckle-Kohler
- Kostadin Cholakov
- Richard Eckart de Castilho
- Silvana Hartmann
- Michael Matuschek
- Christian M. Meyer
- Yevgen Chebotar

Former group members:

- Zijad Maksuti, Tri-Duc Nghiem, Christian Wirth, Than-Le Ha

Beyond UKP:

- Christian Chiarcos (ACoLi, Goethe-University Frankfurt am Main)
- John McCrae (CITEC, Universität Bielefeld)

Part 2: Recipes

Tools and Planning Guide: What UBY has to offer

Mixed Starters: How to query UBY (for WSD)

Appetizer: UBY as UIMA resource

Main Dish: UBY for UIMA-based Semantic Tagging

Dessert: Cross-lingual verb sense linking

What UBY has to offer

Tools

UBY – Data and Tools

UI Redesign

Web Interface

https://uby.ukp.informatik.tu-darmstadt.de/webui/

Database Dumps

UBY

http://uby.ukp.informatik.tu-darmstadt.de/uby/

Open Source API (JAVA)

http://code.google.com/p/uby/

UBY Java API

The UBY API is **open source** at Google Code:
http://code.google.com/p/uby/

Getting Started:

1. Download a UBY database dump
2. Import the dump into a MySQL database
3. Start using the UBY API

The UBY API is work in progress!

Many API methods need to be added – consider contributing!

UBY Database Dumps

Downloads:

http://uby.ukp.informatik.tu-darmstadt.de/uby/

- Resources with **open licenses**
- database dumps in two different sizes:
  - all UBY resources along with pairwise alignments (without GermaNet, IMSLex), `uby_open_<version>`
  - all UBY resources along with pairwise alignments without Wikipedia, GermaNet, IMSLex, `uby_medium_<version>`

UBY API – Getting Started

- Recommended: using the UBY API with Maven
- Currently, it is necessary to use a specific **settings.xml** that configures the access to the public Maven repository maintained by UKP Lab.
- We plan to deploy the UBY API on Maven Central soon!

```xml
<dependency>
  <groupId>de.tudarmstadt.ukp.uby</groupId>
  <artifactId>de.tudarmstadt.ukp.uby.lmf.api-asl</artifactId>
  <version>0.3.0</version>
  <type>jar</type>
  <scope>compile</scope>
</dependency>
```

UBY API – Based on UBY-LMF

UBY-LMF has been implemented in Java. An object-relational mapping by means of the Hibernate framework allows mapping any instance of UBY-LMF to a SQL database.

UBY is an instance of the UBY-LMF lexicon model:

LexicalResource
name: UBY

Lexicon
name:

Lexicon
name:

Lexicon
name:

Lexicon
name: WikipediaDE

Lexicon
name: WiktionaryDE

Lexicon
name: OmegaWikiDE

Lexicon
name: IMSLex

Lexicon
name: GermaNet

Lexicon
name:

Lexicon
name: V

Lexicon
name: OmegaWikiEN

Lexicon
name: WikipediaEN

UBY API – Based on UBY-LMF

UBY (as instance of the LexicalResource class) aggregates instances of the Lexicon class.

- Lexicon instances: WordNet, FrameNet, Wiktionary, Wikipedia, …

- Example: querying the names of UBY lexicons

```
Uby uby = new Uby(dbConfig);

List<String> lexiconNames = uby.getLexiconNames();
```

UBY API – Uniform Access to UBY Resources

The uniform representation of resources allows querying across all UBY lexicons.

- Option to filter by POS

- Example: querying lexical entries for a given lemma and POS **across all UBY lexicons** (here: noun "album")

```
Uby uby = new Uby(dbConfig);

List<LexicalEntry> nounEntries =
uby.getLexicalEntries("album", EPartOfSpeech.noun, null);
```

UBY API – Uniform Access to UBY Resources

Individual UBY lexicons are queried the same way:

- First, retrieve the lexicon to be queried
- Option to filter by POS

- Example: querying UBY WordNet for the lexical entry of the noun "album"

```
Uby uby = new Uby(dbConfig);

Lexicon wordNet = uby.getLexiconByName("WordNet");

List<LexicalEntry> lexEntries =
uby.getLexicalEntries("album", EPartOfSpeech.noun, wordNet);
```

Good to Know – Extraction of Bulk Data from UBY

To extract **all instances** of LexicalEntry, Sense, SenseAxis, always use the **Iterator** methods.

- Example: `lexicalEntryIterator`
  - Option to filter by POS and Lexicon

```
Iterator<LexicalEntry> lexicalEntryIterator =
        uby.getLexicalEntryIterator(null,lex);


while (lexicalEntryIterator.hasNext()) {
        LexicalEntry le = lexicalEntryIterator.next();
        for (Sense s: le.getSenses()) {
                System.out.println(
                        s.getLexicalEntry().getLemmaForm());
        }
}
```

What UBY has to offer

Planning Guide

# Increased Coverage of Lemmas (and their Senses)

UBY lexicons contain different, complementary lemmas:
over 3 million unique lemma-POS combinations for English

EN Lexicons	noun	verb	adjective
5	1	699	-
4	1,630	1,888	430
3	8,439	1,948	2,271
2	53,856	4,727	12,290
1	2,900,652	50,209	41,731
Σ (unique EN)	3,080,771		

Enriched Senses Based on Sense Alignments

Definition

SenseExample

SemanticLabel semanticField

Synset

Subcategorization-Frame

WordNet sense

Wiktionary sense

Definition

SenseExample

SemanticLabel register

Equivalent
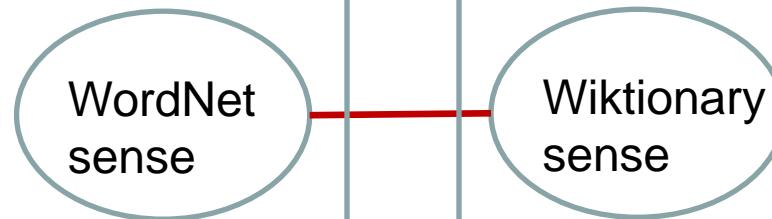
Enriched Senses Based on Sense Alignments

Lexicon pair	Languages	SenseAxis
WN–WP-en	EN–EN	50,351
WN–WKT-en	EN–EN	99,662
WN–VN	EN–EN	40,716
FN–VN	EN–EN	17,529
WP-en–OW-en	EN–EN	3,960
WP-de–OW-de	DE–DE	1,097
WN–OW-de	EN–DE	23,024
WP-en–WP-de	EN–DE	463,311
OW-en–OW-de	EN–DE	58,785
UBY	**All**	**758,435**

- Access to **partly complementary information types** attached to the linked senses
  - e.g., semantic relations, subcategorization frames, sense examples or translations.

- For English, more than **30,000** senses simultaneously take part in **at least two pairwise sense alignments**.

UBY as Sense Inventory

UBY provides sense inventories at different levels of granularity.

- Example: VerbNet – WordNet alignment
- coarse-grained vs. fine-grained sense inventory

VerbNet:

> **sing**
> performance-26.7-1-1

WordNet:

> **sing**
> sing%2:36:01
> *deliver by singing*

> **sing**
> sing%2:36:00
> *produce tones with the voice*

Information Types in UBY – Selection

TECHNISCHE
UNIVERSITÄT
DARMSTADT

Main organizational LMF classes

UKP
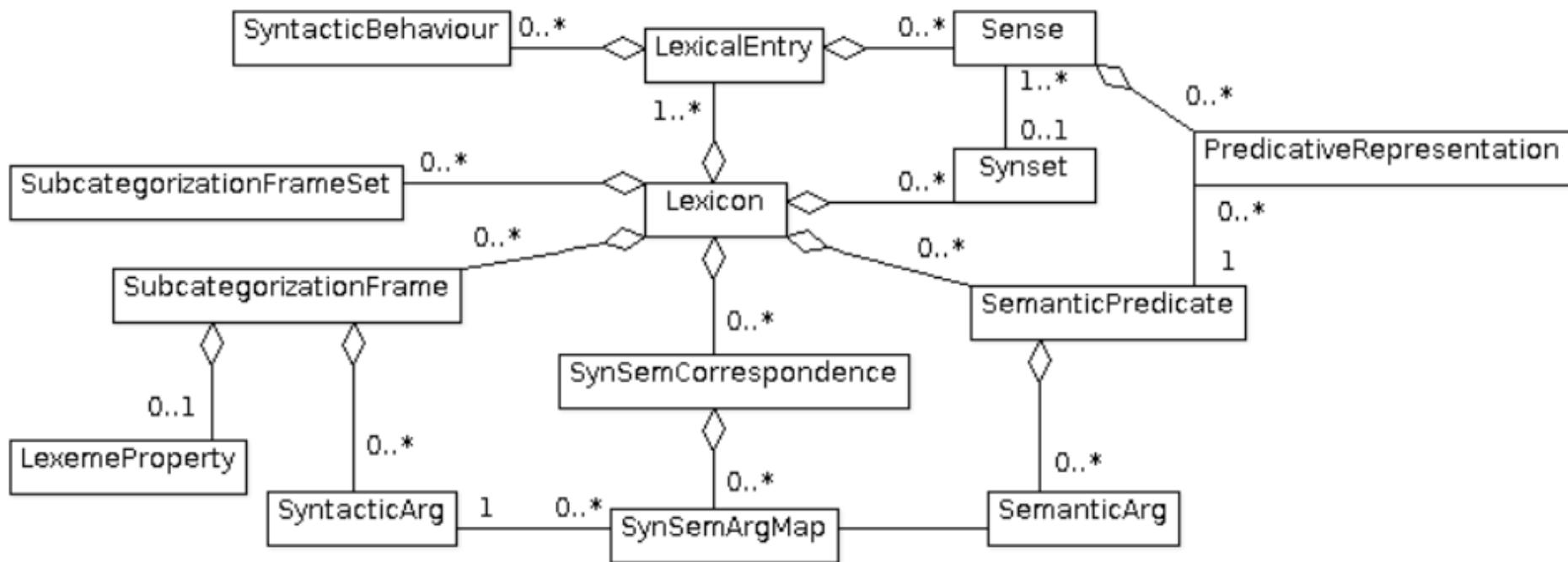
Information Types in UBY – Sense Related

Information types attached to senses

SenseExample

SemanticLabel

Synset

Subcategorization-Frame

Semantic-Predicate

Sense

Definition

SenseRelation

Equivalent

Context

UKP

Information Types in UBY – Sense Links

Sense alignments between resource pairs

Sense A

Lexicon X

SenseAxis
id

senseOne: A
senseTwo: B

synsetOne
synsetTwo

senseAxisType

Sense B

Lexicon Y
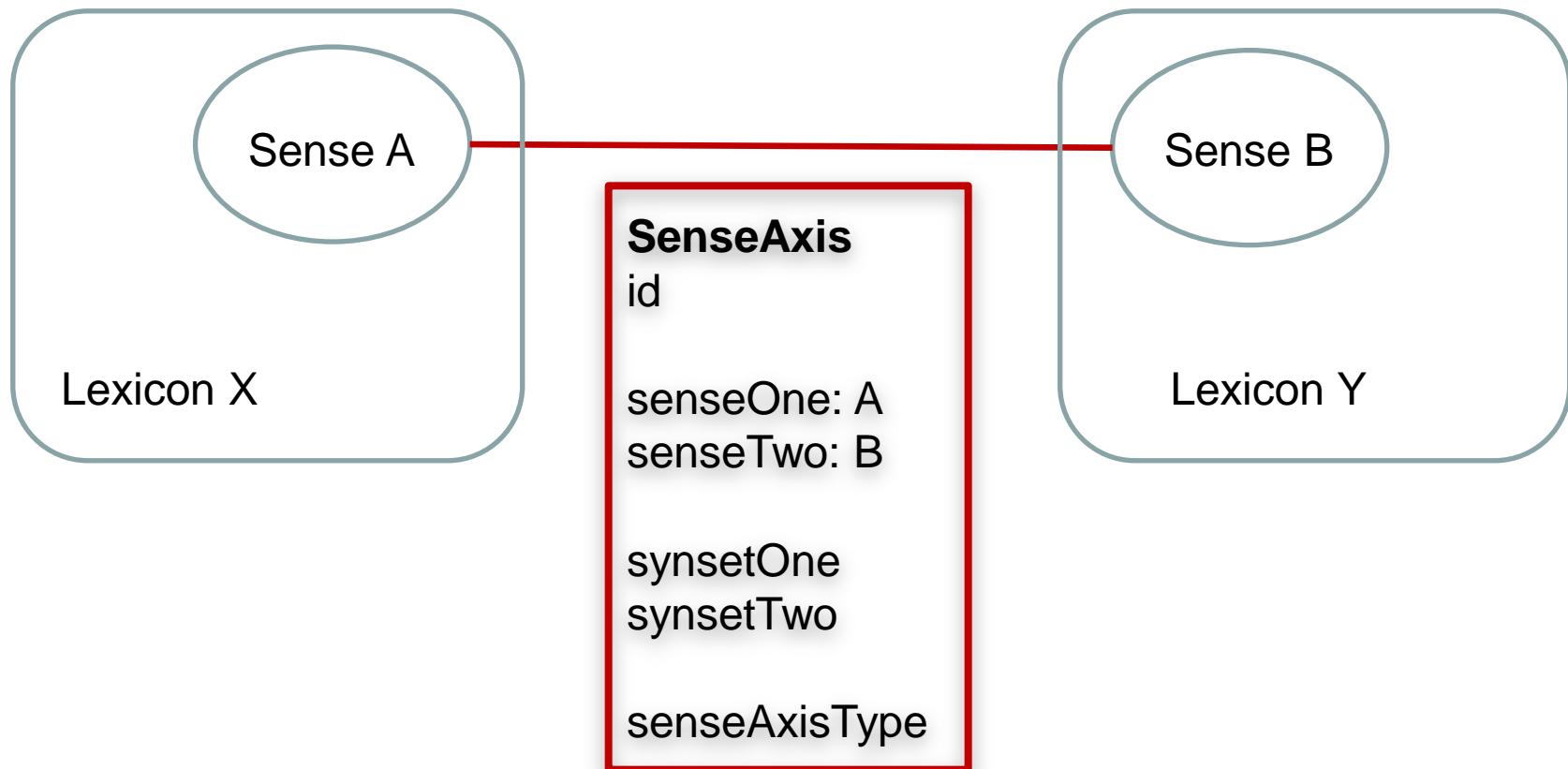
Wordnets in UBY (Main Information Types)
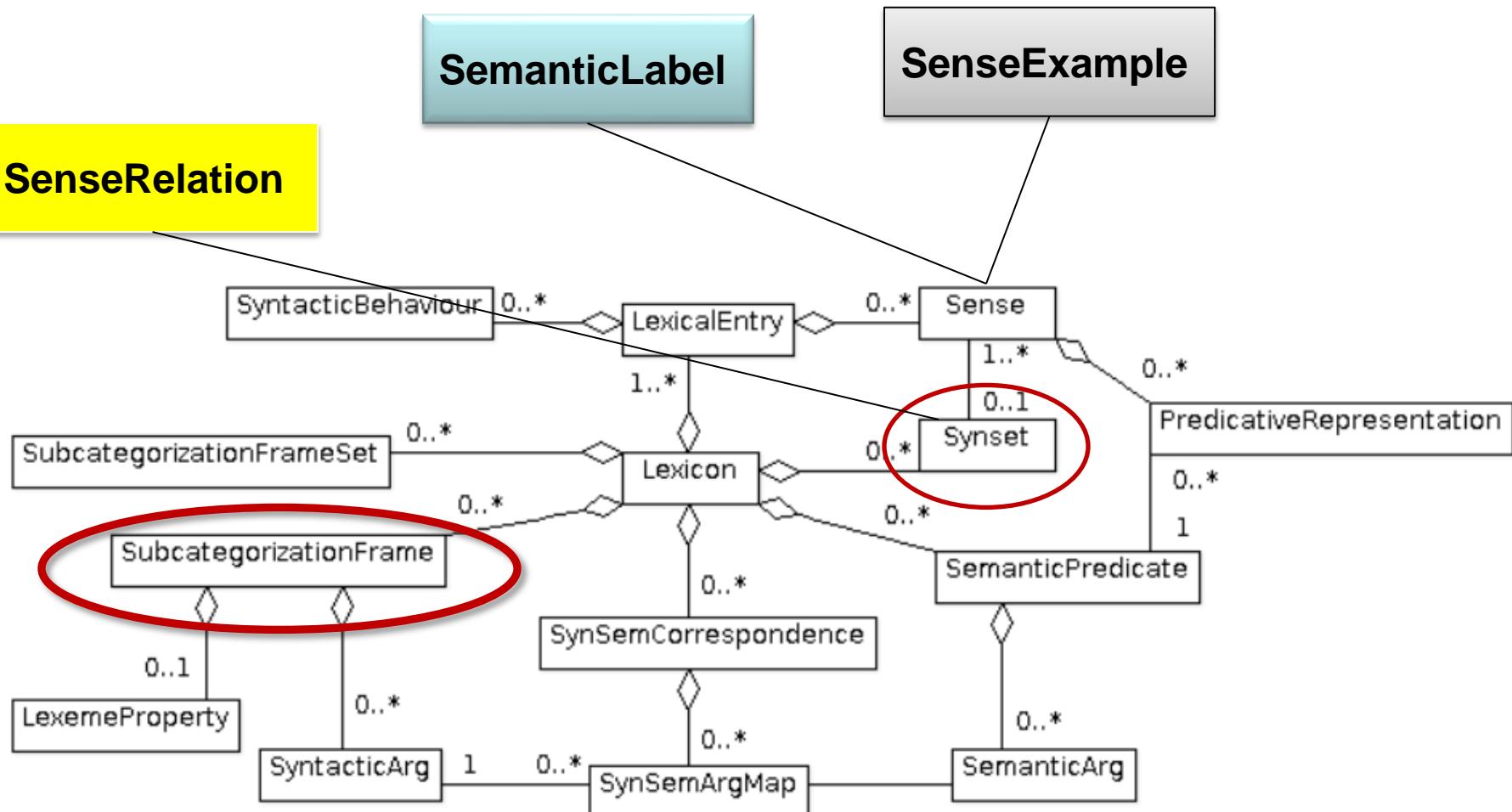
FrameNet in UBY (Main Information Types)
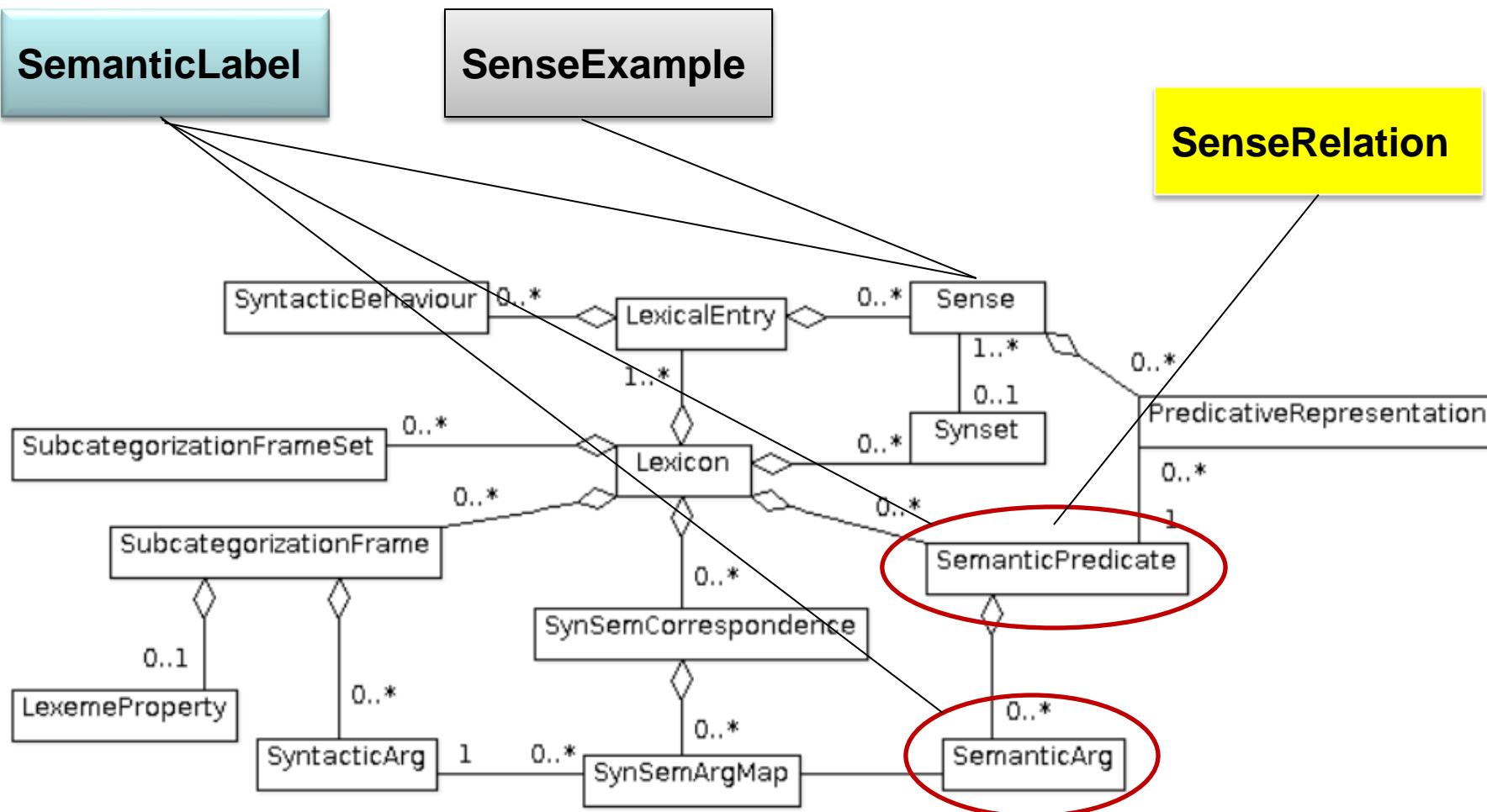
VerbNet in UBY (Main Information Types)

SemanticLabel

UBY VerbNet sense != VerbNet sense
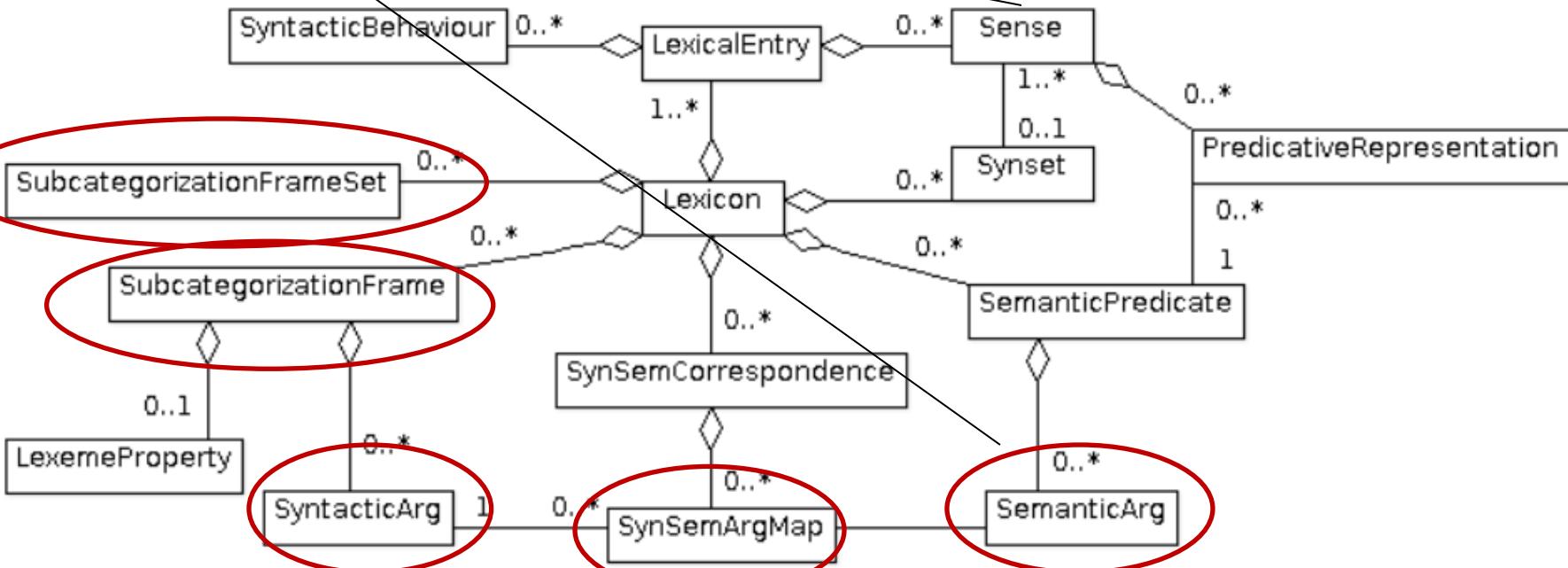
Wiktionary and Wikipedia in UBY (Main Information Types)

TECHNISCHE UNIVERSITÄT DARMSTADT

SemanticLabel

Equivalent

SenseExample

Wiktionary

SenseRelation

Definition

UKP
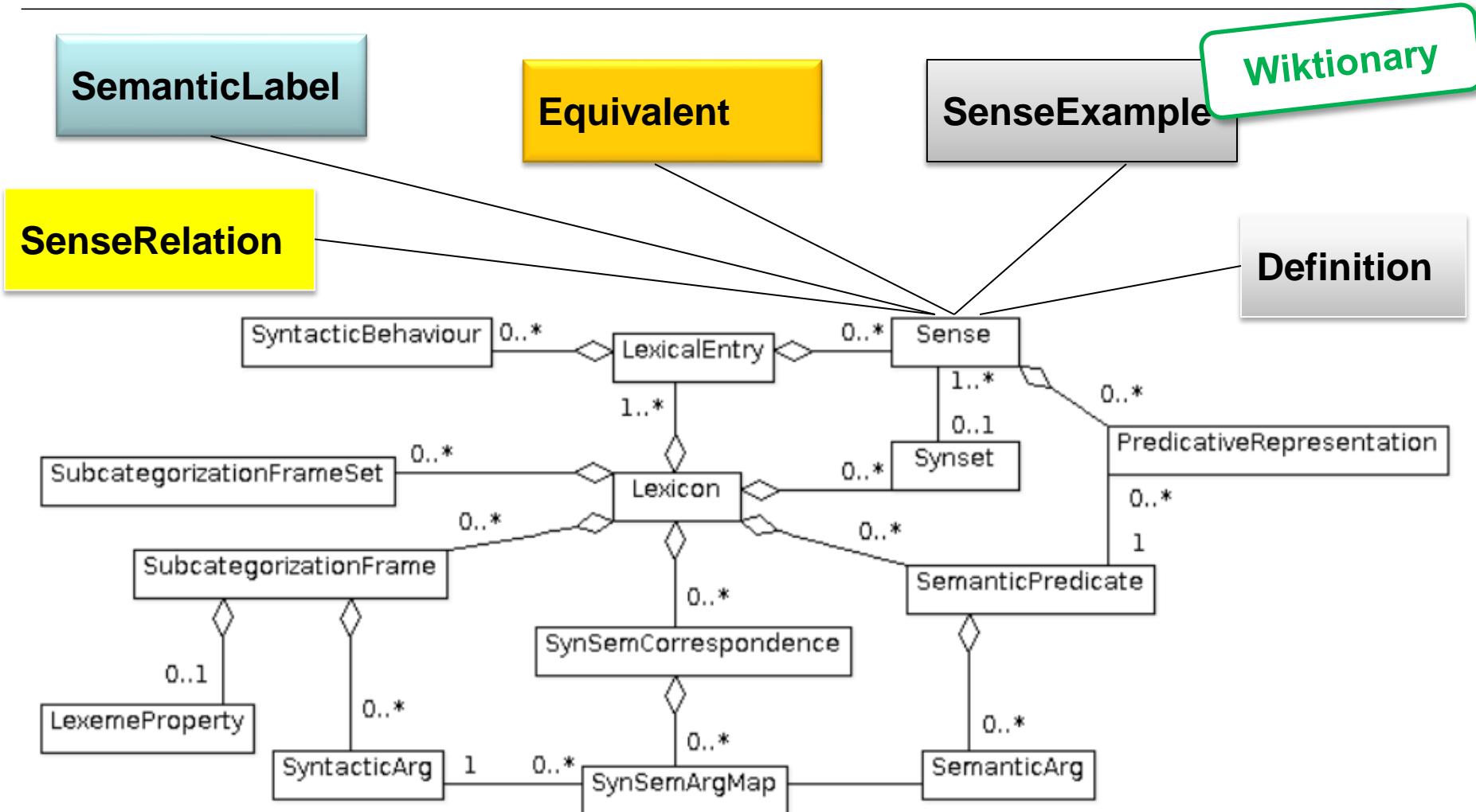
OmegaWiki in UBY (Main Information Types)
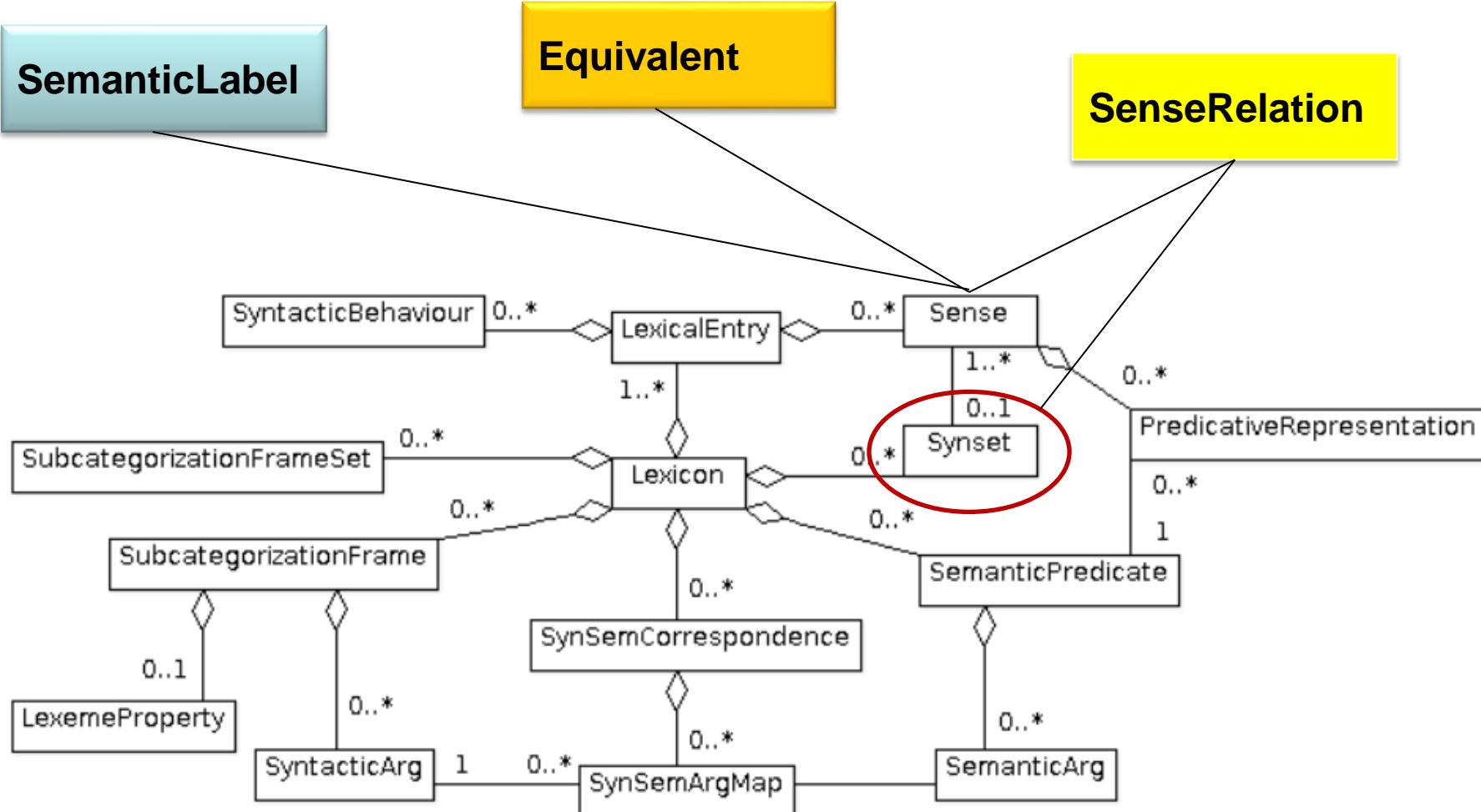
Mapping of POS for Main Word Classes

Resource	Original POS – UBY POS (`EPartOfSpeech`)
WordNet	noun – `noun`, verb – `verb`, adjective – `adjective`
GermaNet	common noun – `nounCommon`, proper noun – `nounProper`, verb – `verb`, adjective – `adjective`
FrameNet	noun – `noun`, verb – `verb`, adjective – `adjective`
VerbNet	verb – `verb`
IMSLex	verb – `verbMain`, noun – `nounCommon`, adjective - `adjective`
WikipediaEN / DE	common noun – `noun`, proper noun – `noun`
Wiktionary EN / DE	noun – `noun`, proper noun – `nounProper`, verb – `verb`, adjective – `adjective`
OmegaWiki	noun – `noun`, verb – `verb`, adjective – `adjective`

Outline

Part 1: Ingredients and Techniques

Part 2: Recipes

Example Code is Open Source:

http://code.google.com/p/dkpro-tutorials/

dkpro-tutorials-discuss@googlegroups.com

Part 2: Recipes

Tools and Planning Guide: What UBY has to offer

Mixed Starters: How to query UBY (for WSD)

Appetizer: UBY as UIMA resource

Main Dish: UBY for UIMA-based Semantic Tagging

Dessert: Cross-lingual verb sense linking

UBY for Knowledge-Based WSD

Motivation

- The WordNet sense inventory, though standard, has issues, e.g. the **overly fine granularity** of the senses.
- UBY as a source for new sense inventories
- **richer (coarse-grained) sense inventories**
  - sense inventories may depend on domains, tasks, etc.

Goal

- Perform sense tagging using UBY
  - to determine which UBY sense occurs in a given text is a **WSD task**

Joint work with Kostadin Cholakov

UBY for Knowledge-Based WSD – Recipe

Ingredients

- All UBY resources that are aligned
  - The sense alignments in UBY help to solve the WSD task, because they enlarge the context (or feature space) for a given UBY word sense.
  - e.g., more input for the various types of the Lesk algorithm

Techniques

- Based on sense linking

http://code.google.com/p/dkpro-tutorials/

Three Ways to Query UBY

UBY-LMF has been implemented in Java. An object-relational mapping (using Hibernate) allows mapping any instance of UBY-LMF to a SQL database.

The UBY-API `Uby.java` provides methods …

1. to retrieve UBY-LMF objects based on readily available queries
2. that allow you to specify queries yourself
3. Once an UBY-LMF object has been retrieved from the SQL database, the object-relational mapping allows to access all associated objects in the UBY-LMF graph structure.

Retrieving UBY-LMF Objects Based on Readily Available Queries

- Example: `getSenseAxisBySense`

```
for (Sense sense : lexEntry.getSenses())

  List<SenseAxis> sas = uby.getSenseAxisBySense(sense);
  for (SenseAxis sa : sas) {

      // DO SOMETHING, SEE CODE EXAMPLES
  }
}
```
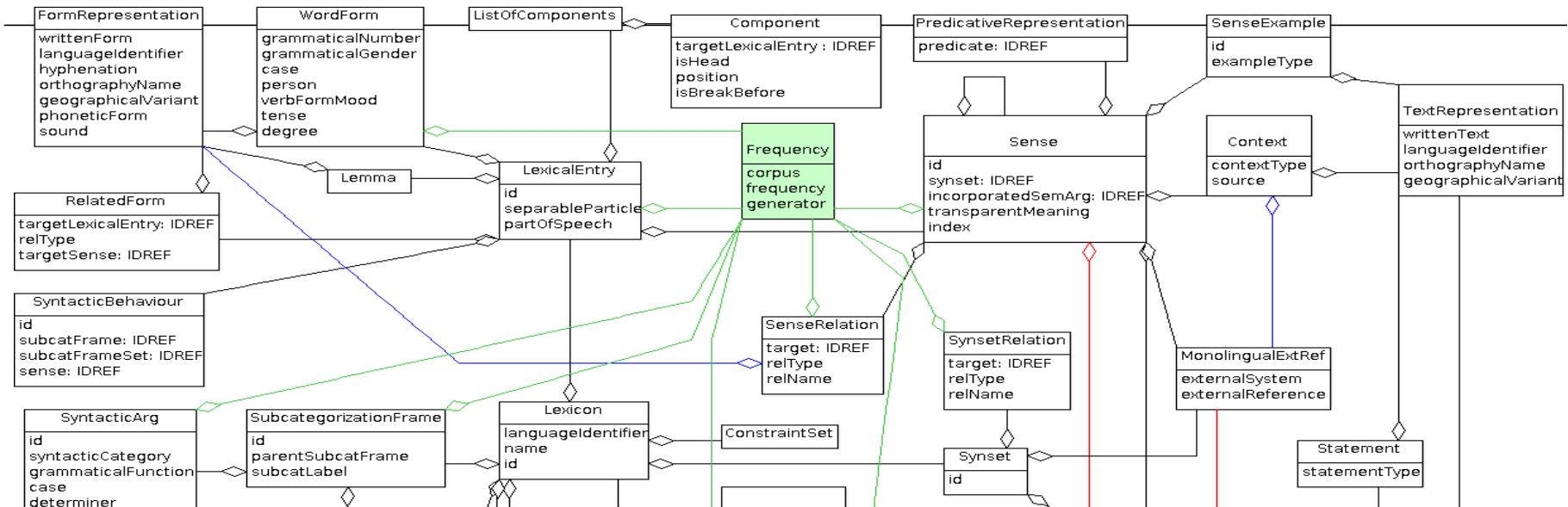
# UBY API with Hibernate – Based on UBY-LMF



Once an UBY-LMF object has been retrieved from the SQL database, the object-relational mapping allows to access all associated objects in the UBY-LMF graph structure.
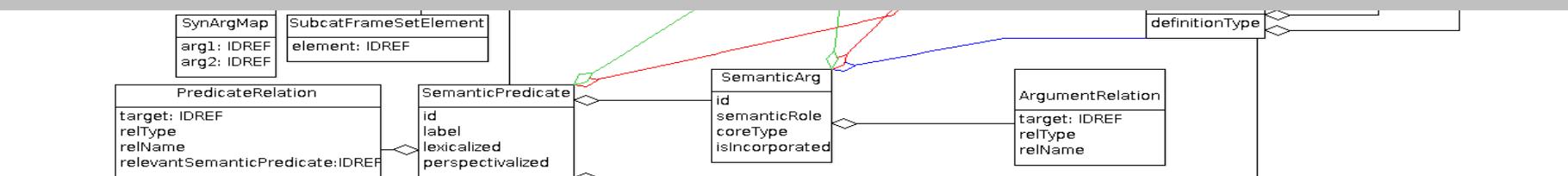
# Accessing Associated Objects in the UBY-LMF Graph Structure

- Example: sense alignments (SenseAxis class)

**backlink – not in UBY-LMF**

```java
for (SenseAxis sa : sas) {

  if (sa.getSenseOne().getId().matches("WktEN.*")) {
    Sense wktSense = sa.getSenseOne();
    String wktVerb =
        wktSense.getLexicalEntry().getLemmaForm();

  } else if (sa.getSenseTwo().getId().matches("WktEN.*")) {
    Sense wktSense = sa.getSenseTwo();
    String wktVerb =
        wktSense.getLexicalEntry().getLemmaForm();

  }
}
```

Using the UBY API to Specify Queries Yourself

- Criteria API provided by Hibernate

- Example: retrieving the mapping of syntactic and semantic arguments from VerbNet

```
Uby uby = new Uby(dbConfig);
session = uby.getSession();


Criteria criteriaSynSem =
        session.createCriteria(SynSemArgMap.class);
List<SynSemArgMap> SynSemArgMaps =
        criteriaSynSem.list();
for (SynSemArgMap synSem : SynSemArgMaps) {
        SynargSemargMap.put(
                synSem.getSyntacticArgument(),
                synSem.getSemanticArgument());
}
```

Part 2: Recipes

Tools and Planning Guide: What UBY has to offer

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Main Dish: UBY for UIMA-based Semantic Tagging

Dessert: Cross-lingual verb sense linking

UBY as UIMA Resource

Motivation

- The component-based architecture UIMA allows to develop **interoperable components** for the analysis of unstructured content.
- Since UBY is based on the standard-compliant model UBY-LMF, it is an **interoperable resource** and consists of **interoperable lexicons**.

Goal

- UBY (or a UBY lexicon) as interchangeable resource in UIMA-based language processing
  - Uniformly accessing information from UBY in UIMA annotators
  - Can be used, e.g., to perform a task-based evaluation of UBY lexicons

Joint work with Richard Eckart de Castilho

UBY as UIMA Resource – Recipe

Ingredients

- UBY

- uimaFIT

  - Specifying UBY as UIMA resource based on uimaFIT

- UIMA-based framework for language processing

  - e.g., DKPro Core for linguistic annotation of text

Techniques

- Based on standardization

  - Exploiting the interoperability of UBY and its integrated lexicons

# UIMA – Unstructured Information Management Architecture

Major goal: transform **unstructured** information to **structured** information

… in order to discover knowledge that is relevant to an end user

- **Component-based** architecture for analysis of unstructured content like text, video, audio
- Originally developed at IBM – today an Apache project
- Used in commercial as well as educational contexts
  - LanguageWare, Watson (IBM)
  - **uimaFIT** (University of Colorado, now: Apache UIMA uimaFIT™)
 - **DKPro Core** (TU Darmstadt)
  - many more...

How it works: think of UIMA components as machines in an assembly line

Analysis Levels in Text Processing

unstructured
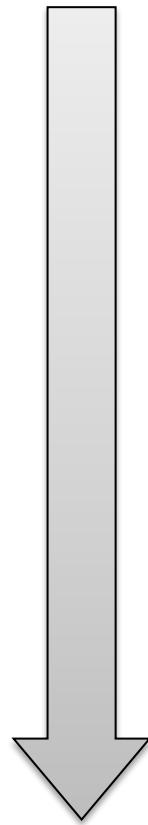
Segmentation

Morphology
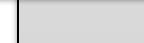
Syntax

Semantics

structured

DKPro Core – Linguistic Annotation of Text
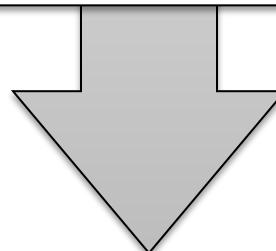
DKPro Core is a collection of software **components for preprocessing and linguistic annotation** of text based on the Apache **UIMA** framework.

http://code.google.com/p/dkpro-core-asl/

DKPro Core builds on uimaFIT.

Integrated Tools

- TreeTagger
- OpenNLP
- Stanford NLP
- JWordSplitter
- Language Tool
- MaltParser
- …

Supported Formats

- Text
- PDF
- TEI XML, BNC XML
- SQL Databases
- Google web1t n-grams
- …

UIMA Example Pipeline

Segmentation

Morphology

Syntax

Semantics

Collection Reader

Segmenter

POS Tagger

Lemmatizer

UbyAnnotator

CAS Consumer
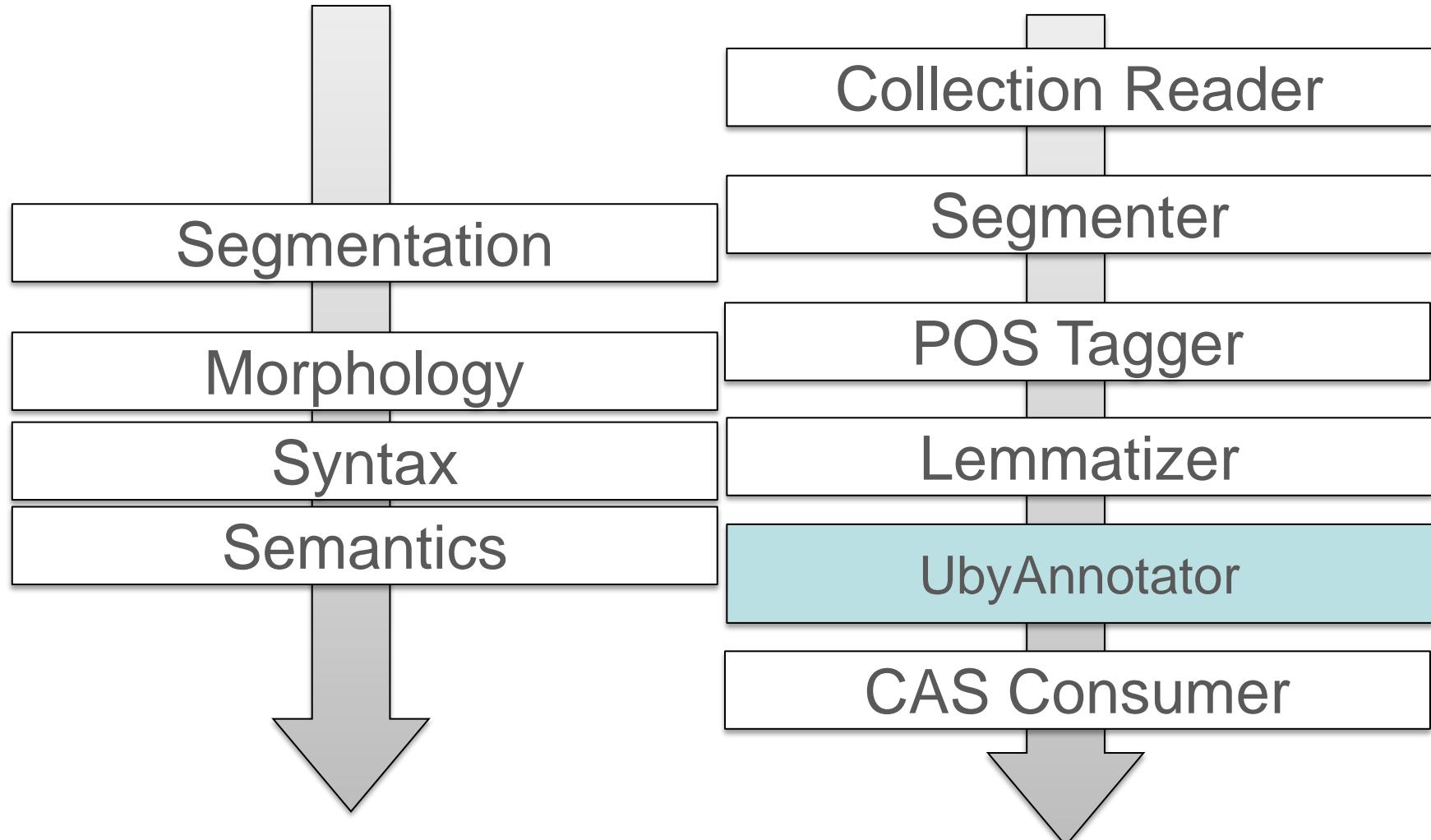
UBY Annotator – Example Use Cases

A UBY annotator can add information from UBY to the CAS in order to **enrich the context of a token or a phrase** listed as lemma in UBY:

- Semantic label information, e.g., semantic field, domain, register
- Lexical information attached to related senses, e.g., synonyms, hypernyms
- Translations

- **Example use cases** include
  - processing of text corpora (document collections) in order to perform knowledge-based sense tagging, e.g., using Lesk-based WSD
  - processing of example sentences from lexical resources in order to acquire more fine-grained lexical information, e.g., subcategorization frames

Interoperable Lexical Resources
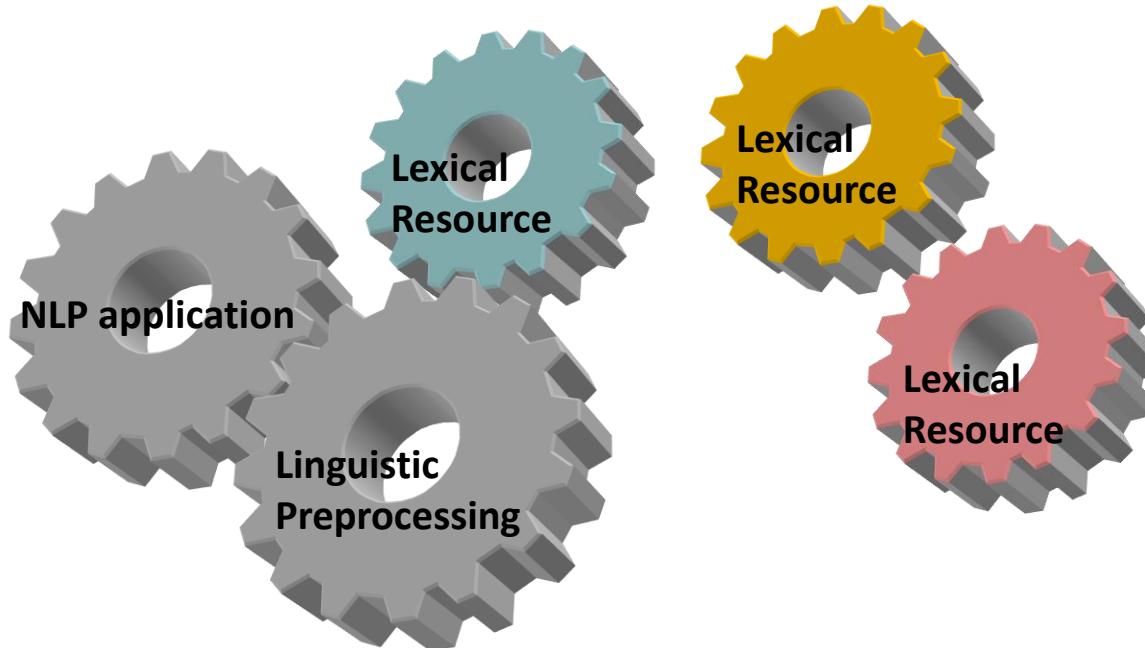
- UIMA resources may be shared between UIMA components.
- A processing component can easily switch between interoperable UIMA resources.

uimaFIT

uimaFIT is an „add-on" for UIMA, **it simplifies typical development tasks** and allows for **rapid and easy development of NLP processing pipelines.**

http://uima.apache.org/d/uimafit-current/tools.uimafit.book.html

For instance, uimaFIT provides annotations for component configuration:
- `@ConfigurationParameter` annotation
- `@ExternalResource` annotation for (shared) resource management

To specify UBY as UIMA resource based on uimaFIT, we use
- the base class for external resources `Resource_ImplBase`
- the interface `ExternalResourceLocator`
- the `@ExternalResource` annotation

@ExternalResource Annotation

uimaFIT provides an annotation-based mechanism for the **configuration of UIMA resources** in annotator components.

Example: `@ExternalResource` annotation used in a UbyAnnotator component

```
public static final String PARAM_UBY_RESOURCE = "uby";
@ExternalResource(key = PARAM_UBY_RESOURCE)
Uby uby;
```

UBY as Resource – Pipeline Configuration

```
AnalysisEngineDescription analysisEngine =
  createEngineDescription(
    UbyAnnotator.class,
    UbyAnnotator.PARAM_UBY_RESOURCE,
    createExternalResourceDescription(
    UbyResourceLocator.class,
    UbyResourceLocator.PARAM_URL, "localhost/uby_open",
    UbyResourceLocator.PARAM_DRIVER, "com.mysql.jdbc.Driver",
    UbyResourceLocator.PARAM_DRIVER_NAME, "mysql",
    UbyResourceLocator.PARAM_USERNAME, "user",
    UbyResourceLocator.PARAM_PASSWORD, "pass"
  )
);
```

Part 2: Recipes

Tools and Planning Guide: What UBY has to offer

Mixed Starters: How to query UBY (for WSD)

Appetizer: UBY as UIMA resource

Main Dish: UBY for UIMA-based Semantic Tagging

Dessert: Cross-lingual verb sense linking

Semantic Tagging with UBY

Motivation

- WordNet provides semantic field information that is often used as coarse-grained semantic feature in NLP

- However, the coverage of WordNet is limited

  - This is especially true for the vocabulary (i.e., lemmas) covered: **WordNet lacks vocabulary** for particular domains, e.g., IT domain

Goal

- Broad-coverage semantic tagging of text with semantic field information

  - Exploiting the **increased lemma coverage** offered by UBY

Joint work with Richard Eckart de Castilho

Semantic Field Information in NLP – Previous Work

WordNet provides coarse-grained **semantic field information** through its **lexicographer file** names.

WordNet semantic field information has widely been used in many NLP tasks and applications, including Information Extraction and text classification.

- Semantic field information from WordNet has also been called *supersenses* and has been applied for *supersense tagging*, e.g.
  - (Ciaramita and Johnson, 2003) and (Qiu et al., 2011) each present a framework for classifying words not in WordNet into the WordNet semantic fields
  - (Ciaramita and Altun, 2006) describe a supersense tagger based on sequence labeling

Semantic Tagging with UBY – Recipe

Ingredients

- UBY version of WordNet / GermaNet
- UBY (to increase the lemma coverage)
- DKPro Core and uimaFIT

Techniques

- Based on standardization

http://code.google.com/p/dkpro-tutorials/

UIMA Example Pipeline for Semantic Tagging

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DARMSTADT

	Collection Reader
Segmentation	Segmenter
Morphology	POS Tagger
Syntax	Lemmatizer
Semantics	UbySemanticFieldAnnotator
	CAS Consumer

UKP
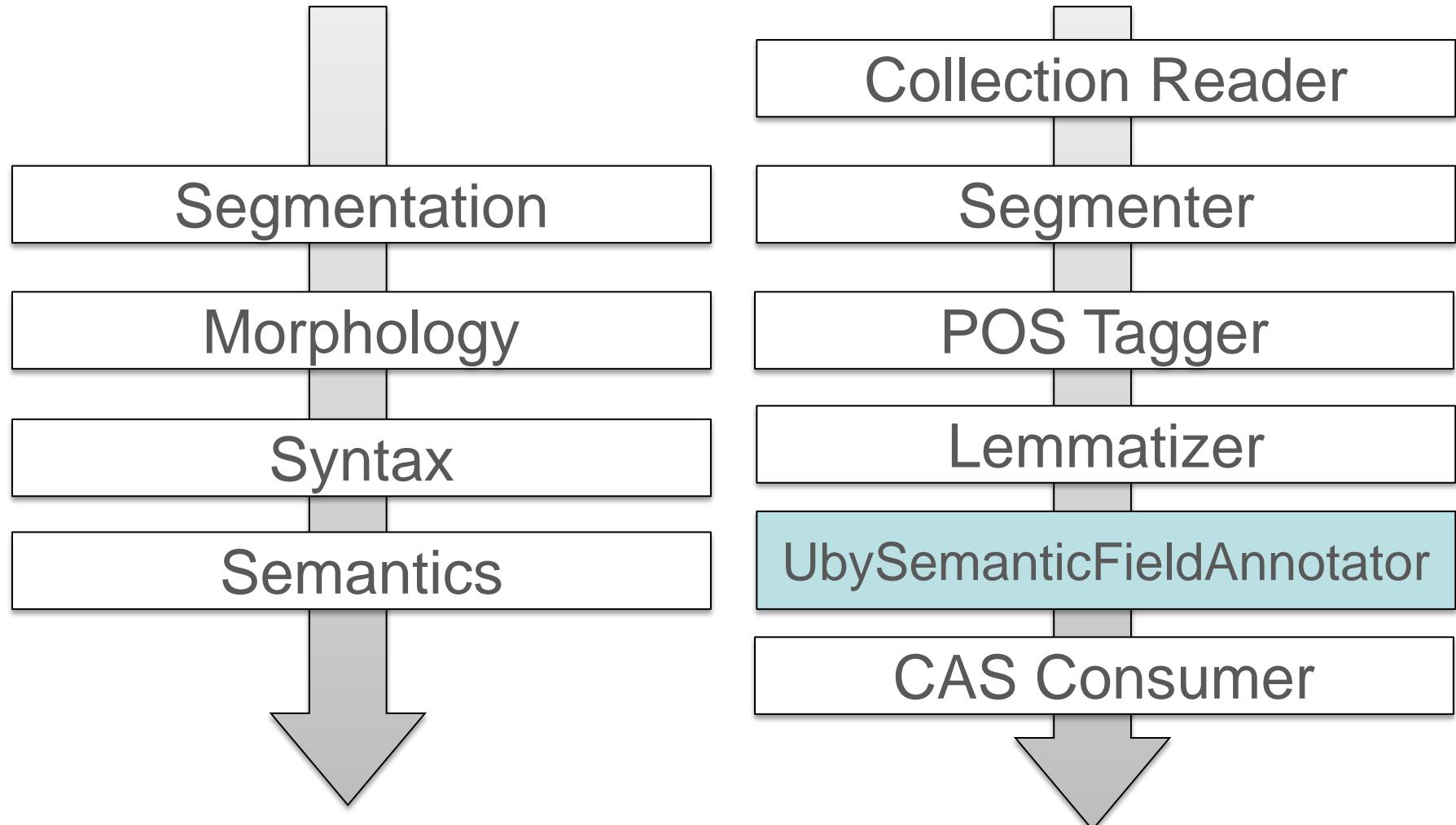
Interface `SemanticTagProvider`

- Interface to create various UIMA resources that provide semantic tags: `SemanticTagProvider`

- The interface `SemanticTagProvider` can be used to retrieve semantic tag information from
  - simple key value files
  - UBY
  - many other (linked) lexical resources, such as BabelNet, UWN, …

`SemanticTagProvider` offers the method `getSemanticTag`:

```
String getSemanticTag(Token token)
```

UIMA Resource `UbySemanticFieldResource`

`UbySemanticFieldResource`

- **extends** `Resource_ImplBase` **and implements** `SemanticTagProvider`

- **follows the first sense (WordNet) / random sense (other UBY resources) heuristic**

How to use `UbySemanticFieldResource` in annotator components:

```
public static final String PARAM_UBY_SEMANTIC_FIELD_RESOURCE =
        "ubySemanticFieldResource";

@ExternalResource(key = PARAM_UBY_SEMANTIC_FIELD_RESOURCE)
private UbySemanticFieldResource ubySemanticFieldResource;
```

UIMA Annotator
`UbySemanticFieldAnnotator`

How to use `UbySemanticFieldAnnotator` in a pipeline:

```
AnalysisEngineDescription processor = createEngineDescription(
 createEngineDescription(
  UbySemanticFieldAnnotator.class,
  UbySemanticFieldAnnotator.PARAM_UBY_SEMANTIC_FIELD_RESOURCE,
  createExternalResourceDescription(
  UbySemanticFieldResource.class,
  UbySemanticFieldResource.PARAM_URL, "localhost/uby_open",
  UbySemanticFieldResource.PARAM_DRIVER, "com.mysql.jdbc.Driver",
  UbySemanticFieldResource.PARAM_DRIVER_NAME, "mysql",
  UbySemanticFieldResource.PARAM_USERNAME, "root",
  UbySemanticFieldResource.PARAM_PASSWORD, "pass"
  )
 )
);
```

Part 2: Recipes

Tools and Planning Guide: What UBY has to offer

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Appetizer: UBY as UIMA resource

Main Dish: UBY for UIMA-based Semantic Tagging

Dessert: Cross-lingual verb sense linking

Cross-lingual Verb Sense Linking

Motivation

- German resources that are publicly available for research **lack semantic role and selectional preference information** for verbs.

Goal

- Enriching verb senses in GermaNet and IMSLex with semantic role and selectional preference information
  - Using this information, e.g., in WSD

Cross-lingual Verb Sense Linking – Recipe

Ingredients

- UBY versions of IMSLex, GermaNet, WordNet, VerbNet
- Interlingual Index (Sense Alignment between GermaNet and WordNet Synsets)

Techniques

- Based on sense linking and standardization
- Exploiting the **standardized format for subcategorization frames** (SCFs) in English (EN) and German (DE) provided by UBY-LMF in order to perform a cross-lingual linking of verb senses and their SCFs

# Standardized Format for SCFs in English (EN) and German (DE)

Requirement: flexible format for SCFs in EN and DE, applicable both across languages and at the language-specific level

- Across languages: in order to automatically detect correpondences
- Language-specific: preserve distinctions between fine-grained EN and DE SCFs in order to automatically identify them as well

UBY-LMF – based on ISO-Standards – meets this requirement

- ISO 24613:2008 Lexical Markup Framework (LMF)
- ISO 12620:2009 Data Category Registry: ISOcat

SCFs in UBY-LMF –
Specification of Syntactic Arguments
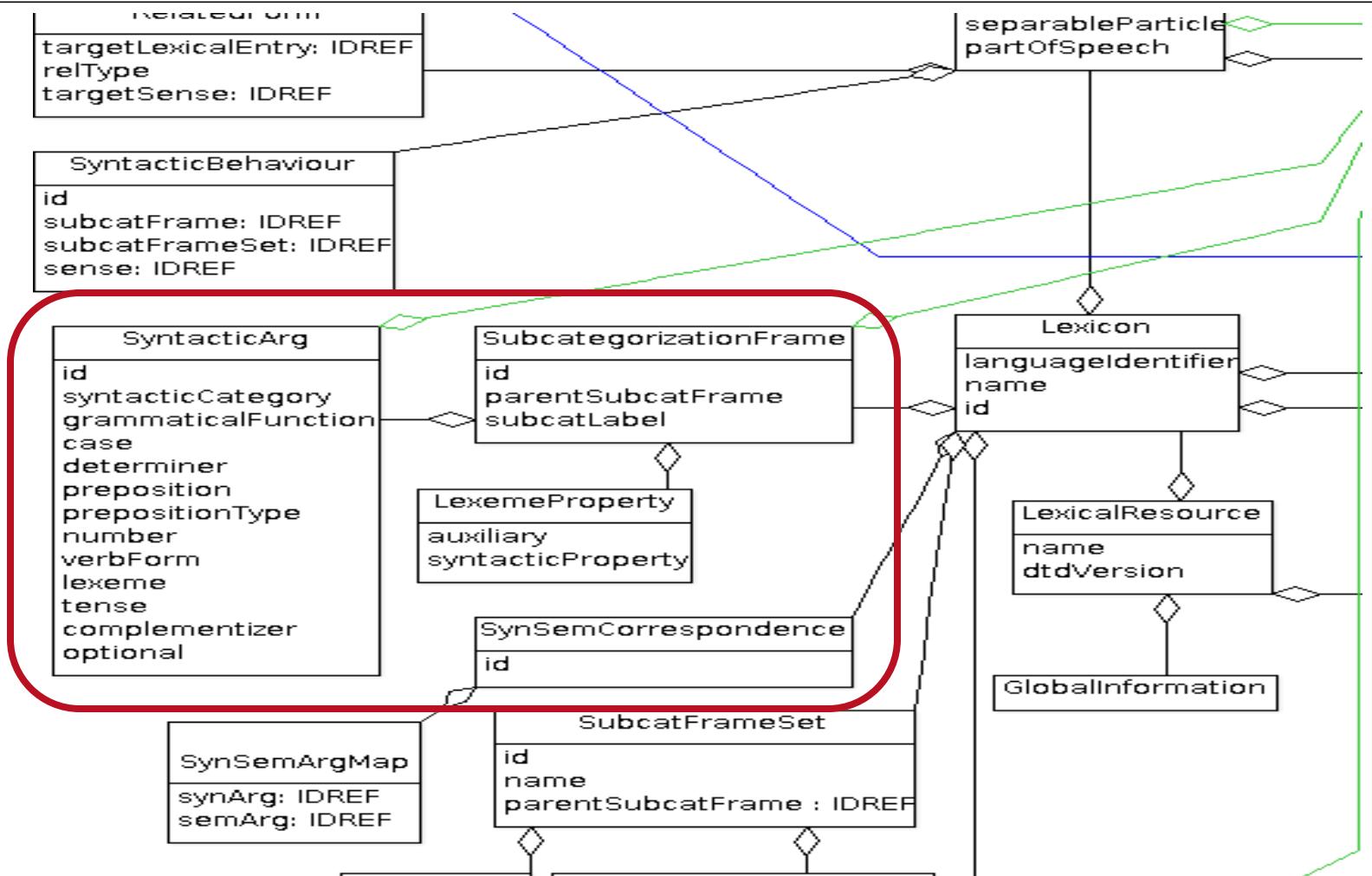
SCFs in UBY-LMF – Example

GermaNet

lachen

`NN.Pp`

laugh

`NP V PP {about}`

VERBNET

UBY

GermaNet Syntactic Arguments	VerbNet Syntactic Arguments
syntacticCategory: nounPhrase grammaticalFunction: subject	syntacticCategory: nounPhrase grammaticalFunction: subject
syntacticCategory: prepositionalPhrase	syntacticCategory: prepositionalPhrase
grammaticalFunction: prepositionalComplement	grammaticalFunction: prepositionalComplement
Preposition: -	Preposition: about

UKP

Syntactic Arguments in UBY-LMF: Attributes

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syntacticCategory

grammaticalFunction

Defined for all syntactic arguments

case

determiner

number

verbForm

tense

complementizer

preposition

lexeme

Language-specific attribute values

UKP

Cross-lingual Linking of Verb Senses
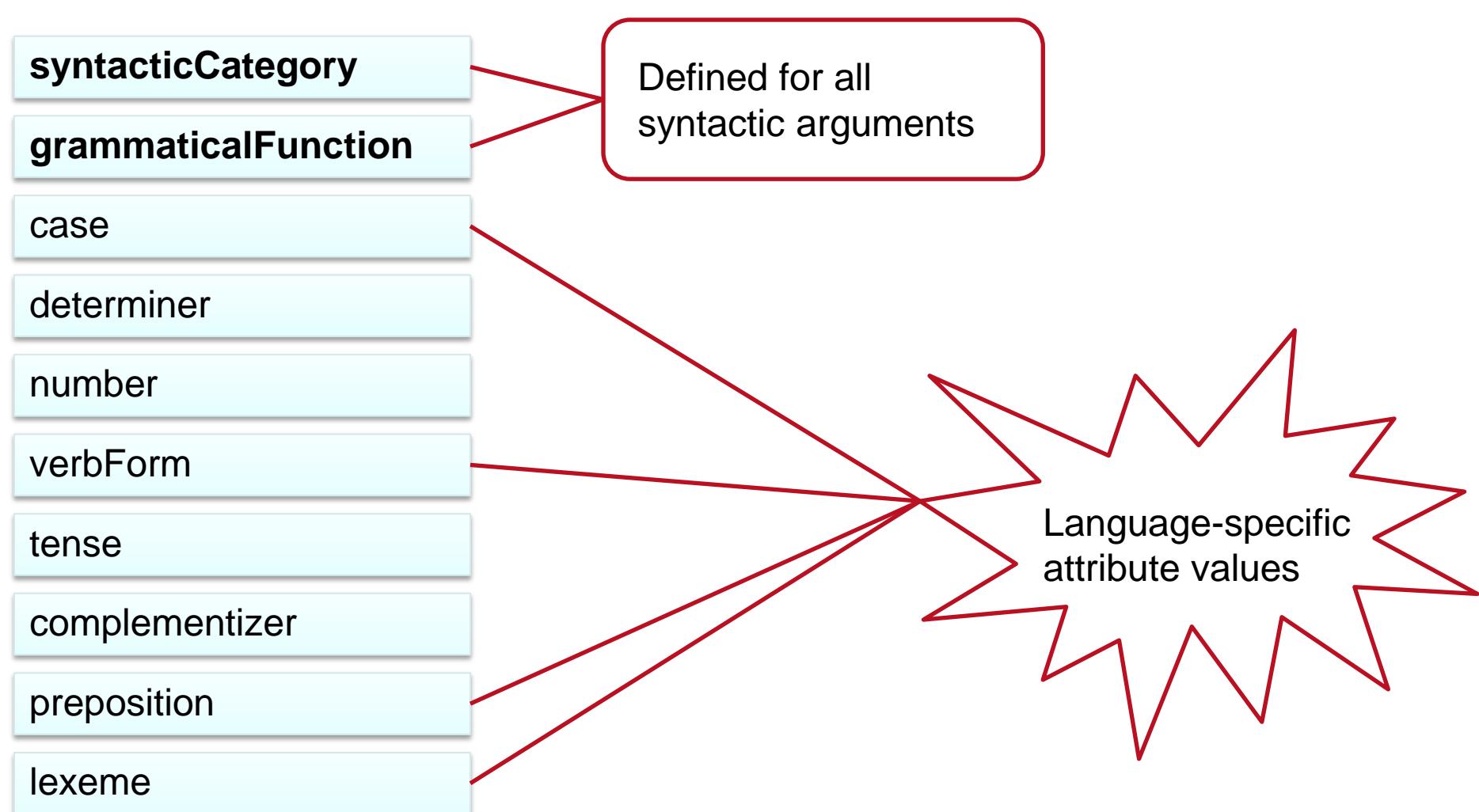
IMSLex-Subcat

(Eckle-Kohler, 1999)

UBY

VERBNET

GermaNet
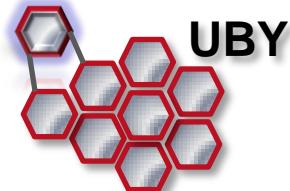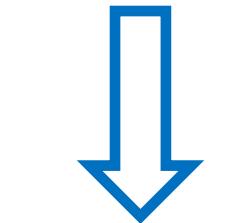
WordNet
Verb lemmas
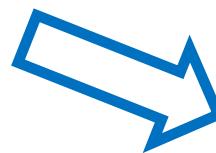
Interlingual Index (ILI)
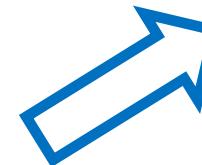
Cross-lingual Linking of Verb Senses – Case Study

IMSLex-Subcat

UBY

VERBNET
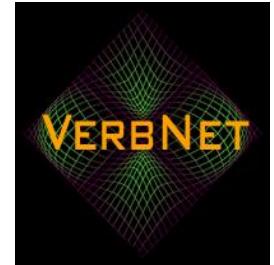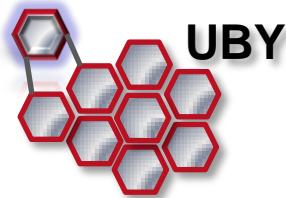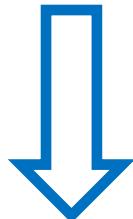
Verbs from IMSLex-Subcat which can be used with zu-infinitive or complement clause: **784 verbs**

GermaNet

WordNet
Verb lemmas

Interlingual Index (ILI)

UKP
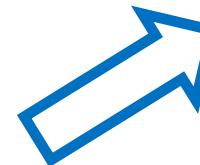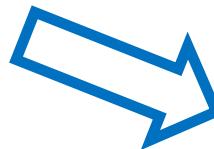
How to Exploit UBY-LMF Compliant SCFs: Linking of IMSLex-Subcat and GermaNet

syntacticCategory

gramm.Function

case

determiner

number

verbForm

tense

complementizer

preposition

lexeme

IMSLex-Subcat

GermaNet

lemma SCF

lemma SCF
sem. field

98,75% Precision

Synset, Gloss, Hypernyms …

- Same number of syntactic arguments
- syntacticCategory , case und complementizer values are compatible

➡ **senses are linked**

44 (out of 784) IMSLex verbs do not occur in GermaNet

How to Exploit UBY-LMF Compliant SCFs: Linking of IMSLex-Subcat und VerbNet

syntacticCategory

gramm.Function

case

determiner

number

verbForm

tense

complementizer

preposition

lexeme

IMSLex-Subcat

VERBNET

lemma
SCF
lemma EN

72,68%
Precision

lemma
SCF
VerbNet class

Semantic roles,
Selectional preferences …

- Same number of syntactic arguments
- syntacticCategory values are compatible

➡ **senses are linked**

- Based on translation via ILI

(140 WordNet verbs do not occur in VerbNet)

Future Work: Cross-lingual Verb Sense Linking on the Semantic Web

lemonUby is the Semantic Web version of UBY

http://lemon-model.net/lexica/uby/

- *lemon*: lexicon model for the Semantic Web
- mapping from UBY-LMF to *lemon*

lemonUby

- comprises a subset of UBY resources
- *lemonUby* is linked with other language resources in the Linguistic Linked Open Data (LLOD) cloud:
  - lexical resources: WordNet 3.0, WordNet 2.0, Wiktionary
  - linguistic terms in *lemonUby* are linked to the Ontologies of Linguistic Annotations (OLiA) (Chiarcos, 2012)

(Eckle-Kohler, McCrae & Chiarcos, to appear)

Take Home Messages

Automatically linking lexical resources at the sense level

- is a difficult NLP task that involves WSD
- benefits from lexical resource standardization

Many linked lexical resources exist and their potential for various NLP tasks and applications is waiting to be tapped.

Unique features of UBY are

- the wide variety of lexical resources it integrates
- its ISO-compliant standardized format

Thank You!

Ubiquitous Knowledge Processing Lab
Department of Computer Science
Technische Universität Darmstadt

Selected References – Classic Lexical Resources

WordNet, GermaNet

- Christiane Fellbaum. 1998. WordNet: An Electronic Lexical Database. MIT Press, Cambridge, MA, USA.
- Claudia Kunze and Lothar Lemnitzer. 2002. GermaNet – representation, visualization, application. In Proceedings of the Third International Conference on Language Resources and Evaluation (LREC), pages 1485–1491, Las Palmas, Canary Islands, Spain.

FrameNet

- Collin F. Baker, Charles J. Fillmore, and John B. Lowe. 1998. The Berkeley FrameNet project. In Proceedings of the 36th Annual Meeting of the Association for Computational Linguistics and 17th International Conference on Computational Linguistics (COLING-ACL'98, pages 86–90, Montreal, Canada.
- Charles J. Fillmore. 1982. Frame Semantics. In The Linguistic Society of Korea, editor, Linguistics in the Morning Calm, pages 111–137. Hanshin Publishing Company, Seoul, Korea.

VerbNet

- Karin Kipper, Anna Korhonen, Neville Ryant, and Martha Palmer. 2008. A Large-scale Classification of English Verbs. Language Resources and Evaluation, 42:21–40.

IMSLex-Subcat

- Judith Eckle-Kohler. 1999. Linguistisches Wissen zur automatischen Lexikon-Akquisition aus deutschen Textcorpora, Logos, Berlin.

Selected References –
Collaborative Resources

Wikipedia, Wiktionary, OmegaWiki

- Christian Bizer, Jens Lehmann, Georgi Kobilarov, Sören Auer, Christian Becker, Richard Cyganiak, and Sebastian Hellmann. 2009. DBpedia A Crystallization Point for the Web of Data. Journal of Web Semantics: Science, Services and Agents on the World Wide Web, (7):154–165.

- Christian M. Meyer and Iryna Gurevych. To Exhibit is not to Loiter: A Multilingual, Sense-Disambiguated Wiktionary for Measuring Verb Similarity, in: Proceedings of the 24th International Conference on Computational Linguistics (COLING), Vol. 4, p. 1763–1780, December 2012. Mumbai, India.

- Michael Matuschek , Christian M. Meyer and Iryna Gurevych. Multilingual Knowledge in Aligned Wiktionary and OmegaWiki for Translation Applications. In: Translation: Corpora, Computation, Cognition (TC3), vol. 3, no. 1, p. 87-118, July 2013. ISSN 2193-6986.

- Torsten Zesch, Christof Müller, and Iryna Gurevych. 2008. Extracting Lexical Semantic Knowledge from Wikipedia and Wiktionary. In Proceedings of the 6th International Conference on Language Resources and Evaluation (LREC), pages 1646–1652, Marrakech, Morocco.

Selected References – Linked Lexical Resources I

- Jordi Atserias, Luıs Villarejo, German Rigau, Eneko Agirre, John Carroll, Bernardo Magnini, and Piek Vossen. 2004. The Meaning Multilingual Central Repository. In Proceedings of the second international WordNet Conference (GWC 2004), pages 23–30, Brno, Czech Republic.

- Gerard de Melo and Gerhard Weikum. 2009. Towards a universal wordnet by learning from combined evidence. In Proceedings of the 18th ACM Conference on Information and Knowledge Management (CIKM 2009), pages 513–522, New York, NY, USA.

- Iryna Gurevych, Judith Eckle-Kohler, Silvana Hartmann, Michael Matuschek, Christian M. Meyer and Christian Wirth. UBY - A Large-Scale Unified Lexical-Semantic Resource Based on LMF. In: Proceedings of the 13th Conference of the European Chapter of the Association for Computational Linguistics (EACL 2012), p. 580--590, April 2012.

- Egoitz Laparra and German Rigau. 2010. eXtended WordFrameNet. In Proceedings of the Seventh International Conference on Language Resources and Evaluation (LREC'10), pages 1214–1419, Valletta, Malta.

- Clifton J. McFate and Kenneth D. Forbus. 2011. NULEX: an open-license broad coverage lexicon. In Proceedings of the 49th Annual Meeting of the Association for Computational Linguistics: Human Language Technologies: short papers - Volume 2, HLT '11, pages 363–367, Portland, OR, USA.

- Roberto Navigli and Simone Paolo Ponzetto. 2010. Babelnet: Building a very large multilingual semantic network. In Proceedings of the 48th Annual Meeting of the Association for Computational Linguistics, pages 216–225, Uppsala, Sweden.

Selected References –
Linked Lexical Resources II

- Roberto Navigli and Simone Paolo Ponzetto. 2010. Knowledge-rich Word Sense Disambiguation Rivaling Supervised Systems. In Proceedings of the 48th Annual Meeting of the Association for Computational Linguistics, pages 1522–1531, Uppsala, Sweden.

- Martha Palmer. 2009. Semlink: Linking PropBank, VerbNet and FrameNet. In Proceedings of the Generative Lexicon Conference (GenLex-09), pages 9–15, Pisa, Italy.

- Fabian M. Suchanek, Gjergji Kasneci, and Gerhard Weikum. 2007. Yago: A Core of Semantic Knowledge. In Proceedings of the 16th International Conference on World Wide Web, pages 697–706, Banff, Canada.

Selected References –
Linking Lexical Resources I

- Christian M. Meyer and Iryna Gurevych. What Psycholinguists Know About Chemistry: Aligning Wiktionary and WordNet for Increased Domain Coverage, in: Proceedings of the 5th International Joint Conference on Natural Language Processing (IJCNLP), p. 883–892, November 2011. Chiang Mai, Thailand.

- Oscar Ferrandez, Michael Ellsworth, Rafael Munoz, and Collin F. Baker. 2010. Aligning FrameNet and WordNet based on Semantic Neighborhoods. In Proceedings of the Seventh International Conference on Language Resources and Evaluation (LREC'10), pages 310–314, Valletta, Malta.

- Judith Eckle-Kohler, John P. McCrae and Christian Chiarcos. lemonUBY- a large, interlinked, syntactically-rich resource for ontologies, in: Semantic Web Journal (to appear).

- Silvana Hartmann and Iryna Gurevych. FrameNet on the Way to Babel: Creating a Bilingual FrameNet Using Wiktionary as Interlingual Connection. In: Proceedings of the 51st Annual Meeting of the Association for Computational Linguistics (ACL 2013), vol. 1, p. 1363-1373, Association for Computational Linguistics, August 2013.

- Egoitz Laparra and German Rigau. 2009. Integrating WordNet and FrameNet using a Knowledge-based Word Sense Disambiguation Algorithm. In Proceedings of the International Conference RANLP-2009, pages 208–213, Borovets, Bulgaria.

- Michael Matuschek and Iryna Gurevych. Dijkstra-WSA: A Graph-Based Approach to Word Sense Alignment. In: Transactions of the Association for Computational Linguistics (TACL), vol. 1, p. 151-164, May 2013.

Selected References – Linking Lexical Resources II

- Elisabeth (geb. Wolf) Niemann and Iryna Gurevych. 2011. The People's Web meets Linguistic Knowledge: Automatic Sense Alignment of Wikipedia and WordNet. In Proceedings of the International Conference on Computational Semantics (IWCS), pages 205–214, Singapore.

- Lei Shi and Rada Mihalcea. 2005. Putting pieces together: Combining FrameNet, VerbNet and WordNet for robust semantic parsing. In Computational Linguistics and Intelligent Text Processing, pages 100–111. Springer, Berlin Heidelberg.

- Sara Tonelli and Daniele Pighin. 2009. New Features for FrameNet - WordNet Mapping. In Proceedings of the Thirteenth Conference on Computational Natural Language Learning (CoNLL-2009), pages 219 - 227, Boulder, CO, USA.

Selected References – Standardizing Lexical Resources I

- Daan Broeder, Marc Kemps-Snijders, Dieter Van Uytvanck, Menzo Windhouwer, Peter Withers, Peter Wittenburg, and Claus Zinn. 2010. A Data Category Registry- and Component-based Metadata Framework. In Proceedings of the 7th International Conference on Language Resources and Evaluation (LREC), pages 43–47, Valletta, Malta.

- Christian Chiarcos. 2012. Ontologies of Linguistic Annotation: Survey and Perspectives, in: Proceedings of the 8th International Conference on Language Resources and Evaluation (LREC), pp 303-310, May 2012. Istanbul, Turkey.

- Judith Eckle-Kohler, Iryna Gurevych, Silvana Hartmann, Michael Matuschek and Christian M. Meyer. UBY-LMF - Exploring the Boundaries of Language-Independent Lexicon Models. In: Gil Francopoulo: LMF Lexical Markup Framework, chap. 10, p. 145-156, ISTE - HERMES - Wiley, 2013. ISBN 978 184 821 4309.

- Judith Eckle-Kohler, Iryna Gurevych, Silvana Hartmann, Michael Matuschek and Christian M. Meyer. UBY-LMF - A Uniform Model for Standardizing Heterogeneous Lexical-Semantic Resources in ISO-LMF. In: Nicoletta Calzolari and Khalid Choukri and Thierry Declerck and Mehmet Uğur Doğan and Bente Maegaard and Joseph Mariani and Jan Odijk and Stelios Piperidis: Proceedings of the 8th International Conference on Language Resources and Evaluation (LREC), p. 275--282, May 2012.

- Gil Francopoulo, Nuria Bel, Monte George, Nicoletta Calzolari, Monica Monachini, Mandy Pet, and Claudia Soria. 2006. Lexical Markup Framework (LMF). In Proceedings of the 5th International Conference on Language Resources and Evaluation (LREC), pages 233–236, Genoa, Italy.

- Gil Francopoulo (editor) LMF Lexical Markup Framework, ISTE / Wiley 2013 (ISBN 978-1-84821-430-9).

Selected References – Standardizing Lexical Resources II

- John McCrae, Guadalupe Aguado-de-Cea, Paul Buitelaar, Philipp Cimiano, Thierry Declerck, Asunción Gómez-Pérez, Jorge Gracia, Laura Hollink, Elena Montiel-Ponsoda, Dennis Spohr, Tobias Wunner. (2012) Interchanging lexical resources on the Semantic Web. Language Resources and Evaluation 46:701–719.

Selected References – Semantic Tagging

- Massimiliano Ciaramita and Mark Johnson. 2003. Supersense tagging of unknown nouns in WordNet. In Proceedings of the 2003 conference on Empirical methods in natural language processing (EMNLP '03).

- Massimiliano Ciaramita and Yasemin Altun (2006). Broad-coverage sense disambiguation and information extraction with a supersense sequence tagger. In Proceedings of the 2006 Conference on Empirical Methodsin Natural Language Processing, pages 594{602, Sydney, Australia.

- Likun Qiu, Yunfang Wu, and Yanqiu Shao. 2011. Combining contextual and structural information for supersense tagging of chinese unknown words. In Proceedings of the 12th international conference on Computational linguistics and intelligent text processing - Volume Part I (CICLing'11), Alexander Gelbukh (Ed.), Vol. Part I. Springer-Verlag, Berlin, Heidelberg, 15-28.