Data and Metadata of Language Resources as Linked Data on the Web: Examples

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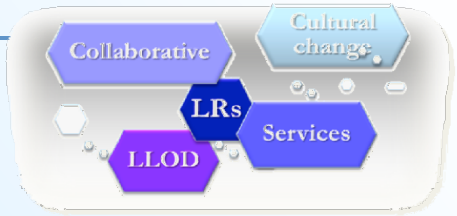
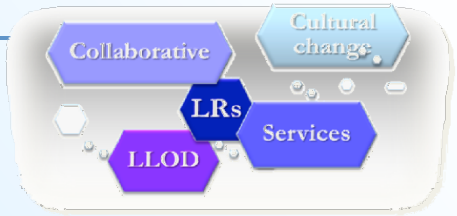
Linked Data **for** Linguistics



- Representation and modelling
- Structural interoperability
- Integrating distributed resources
- Conceptual interoperability
- Dynamic Import
- Ecosystem, infrastructure and community

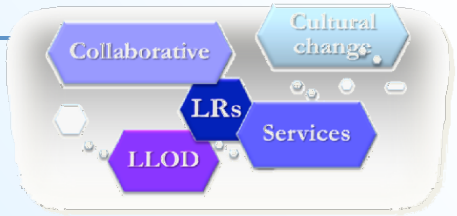
Chiarcos et al. (2013)

Representation and modelling



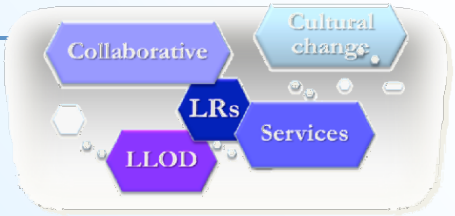
- Different linguistic subcommunities have developed representation standards, e.g.,
  - LMF: Lexical Markup Framework (Francopoulo et al. 2009)
    - lexical-semantic resources
  - GrAF: Graph Annotation Framework (Ide and Suderman 2007)
    - annotated corpora
  - based on labeled directed acyclic graphs (feature structures)
- RDF data model: labeled directed graphs
  - Uniform formalism for *different* resource types
  - Sublanguages (e.g., OWL) to define specific vocabularies

Structural interoperability



- With different language resources represented in RDF, we can combine both sources of information freely
  - cross-resource queries with SPARQL
  - Given a corpus with WordNet sense annotations
    - "Retrieve all sentences that describe locations"
    - i.e., sentences containing a token annotated with a WordNet sense that is a hyponym of "location"
- Difficult to realize with GrAF or LMF

Integrating distributed resources

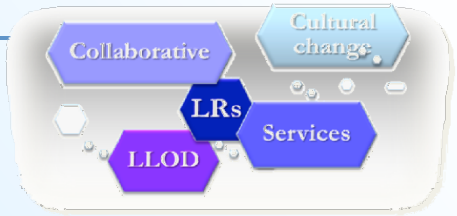


- SPARQL supports nested subqueries to run on different repositories

```
SELECT ?token {
  service <http://wordnet.rkbexplorer.com/sparql> {
    rkbWN:synset-land-noun-2
       wn20:containsWordSense ?sense .
    ?sense rdfs:label ?synonym .
  }
  ?token powla:hasString ?synonym .
}
```

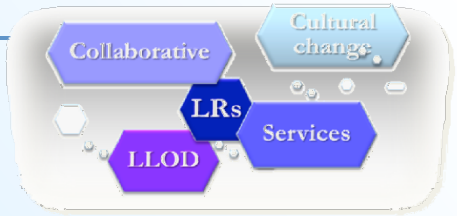
- No physical integration of resources in a single data base required
  - Easy to link to centralized repositories of reference terminology, etc.

Conceptual interoperability



- Resources should specify which vocabulary (e.g., for annotation) they use and how it is defined
  - By reference to community-maintained terminology repositories, e.g.,
    - GOLD (Farrar and Langendoen 2010)
    - ISOcat (Windhouwer and Wright @ LDL-2012)
    - OLiA (Chiarcos 2008)
  - Can be used, e.g., for disambiguation
    - e.g., *land* as a noun, but not as a verb

Dynamic import



- Linking resources with URIs

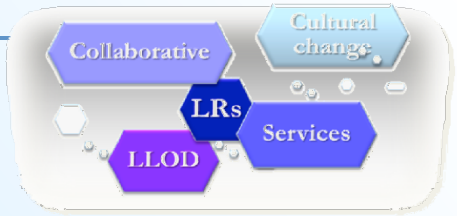
  => resolved on-the-fly to enrich with up-to-date background knowledge

    e.g., every update in a lexical resource is available to every resource linked with it

  => updates are available at query time

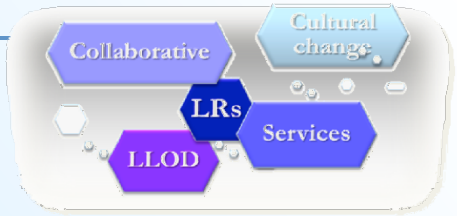
- Inconsistencies can be avoided through versioning

Ecosystem, infrastructure and community



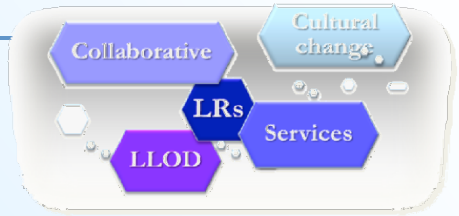
- RDF and related standards are maintained by an active and relatively large community
  - Different fields of application
    - Libraries, GeoData, BioMed, ...
  - Established W3C standard and technological infrastructure
  - Linguistically relevant resources already provided
- RDF facilitates distributed development, re-using data, and, indirectly, interdisciplinary cooperation

Towards LLOD



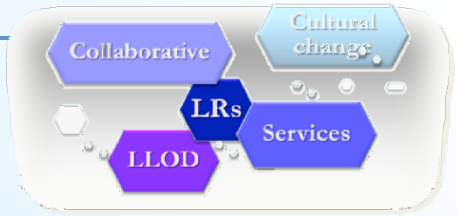
- There are independent motivations to provide data in RDF
  - generic data model
  - generalization over heterogeneous DB schemes
  - generalization over heterogeneous terminologies
  - connect existing resource portals
  - a conceptual view on annotations

Towards LLOD



- There are independent motivations to provide data in RDF
- Side-effects: Data can be
  - linked with other RDF resources
    - e.g., lexicon – linguistic terminology
  - queried (federation)
    - even if stored in physically separated repositories

Towards LLOD



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- Side-effects: Data can be
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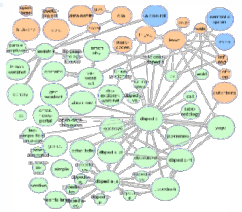
⇒ Linguistic Linked Open Data (LLOD)

An on-going effort orchestrated by the Open Linguistics Working Group of the Open Knowledge Foundation

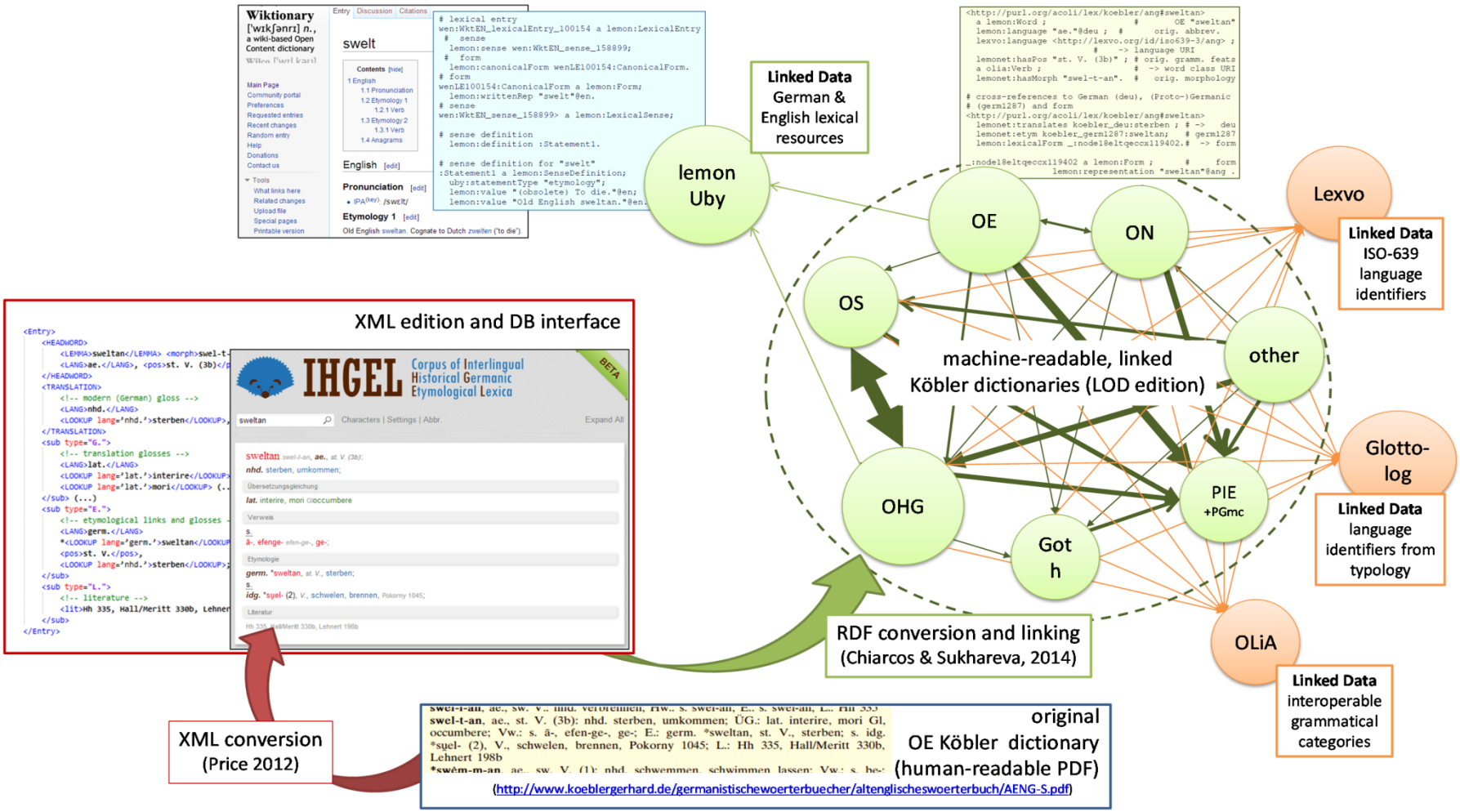
Building the Cloud: Examples



- Each data provider has different incentives to use Linked Data and/or RDF
- Concepts of RDF and Linked Data have been brought up to solve open problems in different subcommunities of linguistics and neighboring fields
- Examples
  - Corpora — Cassidy (2010), Chiarcos (2012)
  - Machine-readable dictionaries
  - Term and data bases — Chiarcos (2010)
  - Etymological dictionaries — Chiarcos & Sukhareva (2014)

  → combined queries — Burchardt et al. (2008), Rehm et al. (2008), Chiarcos & Götze (2007)

Linked Germanic Etymologies



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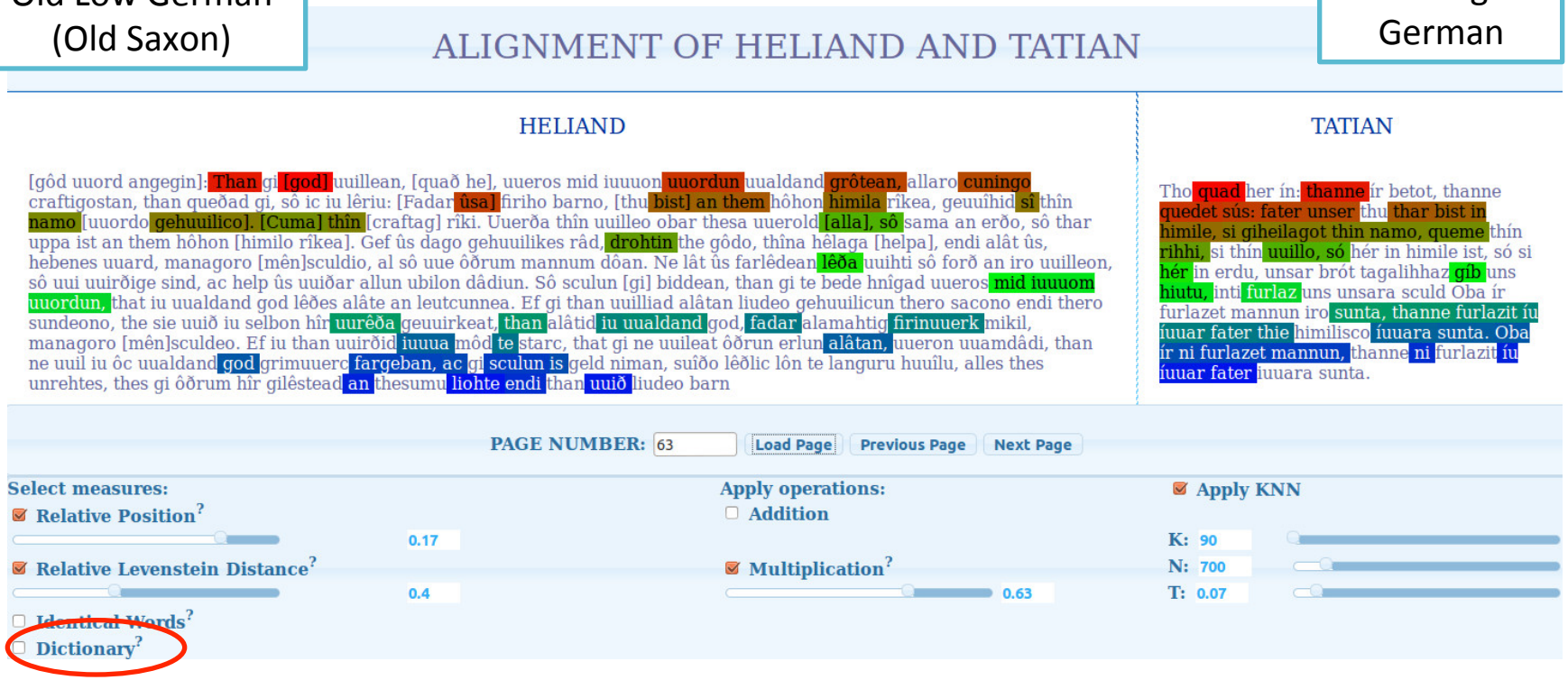
Linked Germanic Etymologies

Application:

Aligning early medieval gospel harmonies

Old Low German (Old Saxon)

Old High German



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Linked Germanic Etymologies

Conversion of etymological dictionaries to RDF

- **Linkability**: representation of relations within and beyond lexicons
- **Interoperability**: (meta)data representation through community-maintained vocabularies (lexvo, Glottolog, OLiA, *lemon*)
- **Inference**: filling the logical gaps of the original XML representation
  - *Symmetric closure of cross-references*

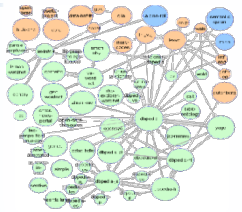
Linked Germanic Etymologies

	West Germanic					other		reconstr.	
lexicon	OE	OHG	OS	OLF	OFr	ON	Got	PGmc	PIE
entries (XML, in K)									
	25	24	9	2	13	12	5	9	7
triples (RDF, in M)									
	1.2	1.6	.6	.2	.6	.7	.4	.2	.2
lemon:Words & links (in K)									
OE	25					1			
OHG	2	26	7	2	3	1			
OS	1	4	9	1	2	1			
ON	1				1	14			
Got	1	1			1	1	6		
PGmc	5	3	3	1	2	4	2	8	
PIE	2	1	1	1	1	1	1		8
German	16	23	8	4	10	12	7	6	3
English		10	4	2	5		9		2
symmetric closure of etym. links (triples *per lang.* in K)									
	+11	+14	+11	+5	+9	+8	+5	+21	+9
links to (L)LOD data sets (triples *per data set* in K)									
OLiA	24	22	8	2	12	11	5	8	7
lexvo	132	186	82	21	68	82	49	14	15
Glottolog	15	11	8	3	7	11	6	9	13

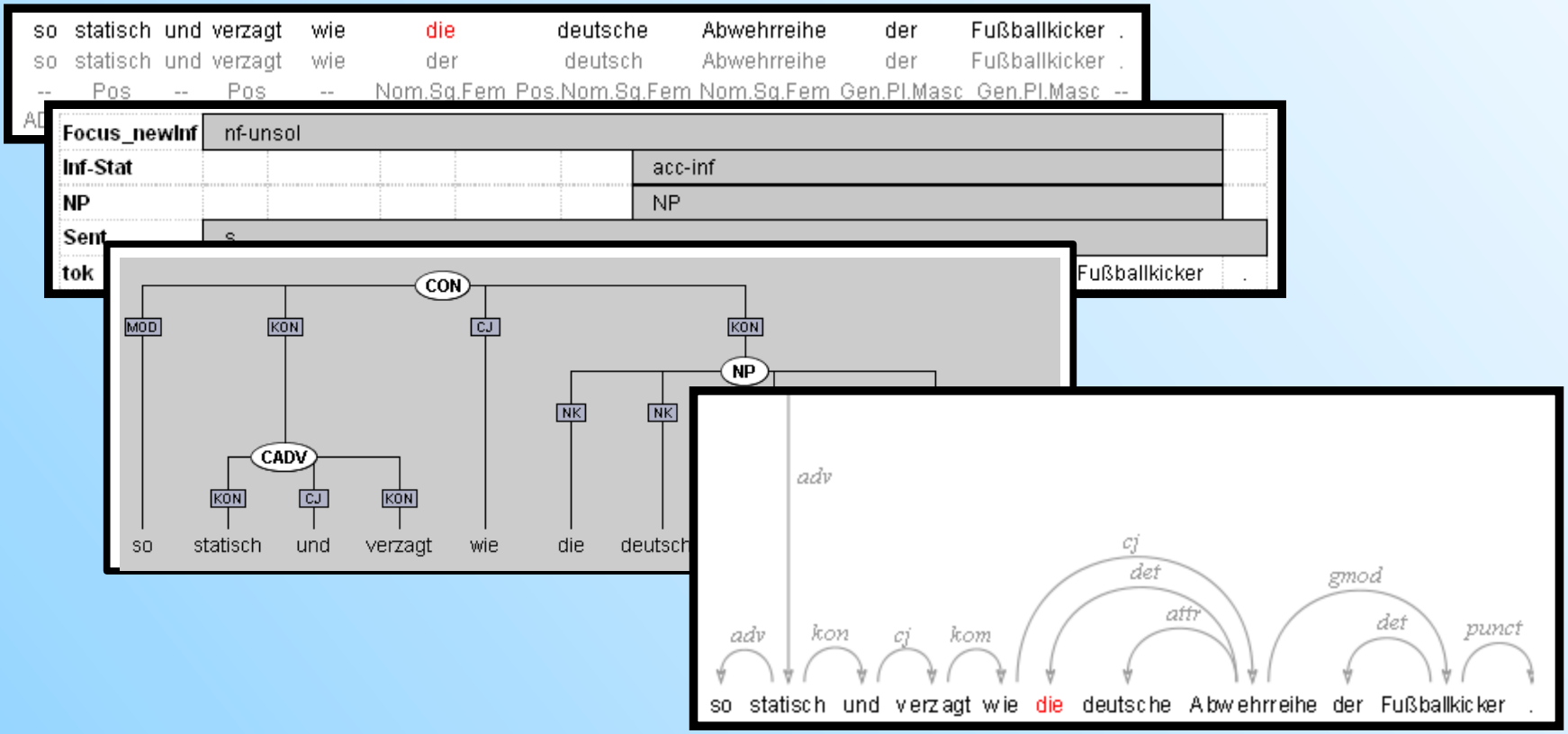
A few critical remarks

- existing vocabularies insufficient
  - lemon: etymological relations between lexical entries ?
  - glottolog/lexvo/ ISO-693: reconstructed languages ?
  - OLiA: Old Germanic inflection paradigms ?

Use Case I: Corpora

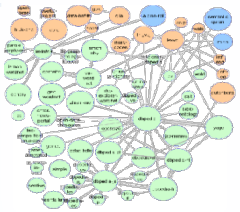


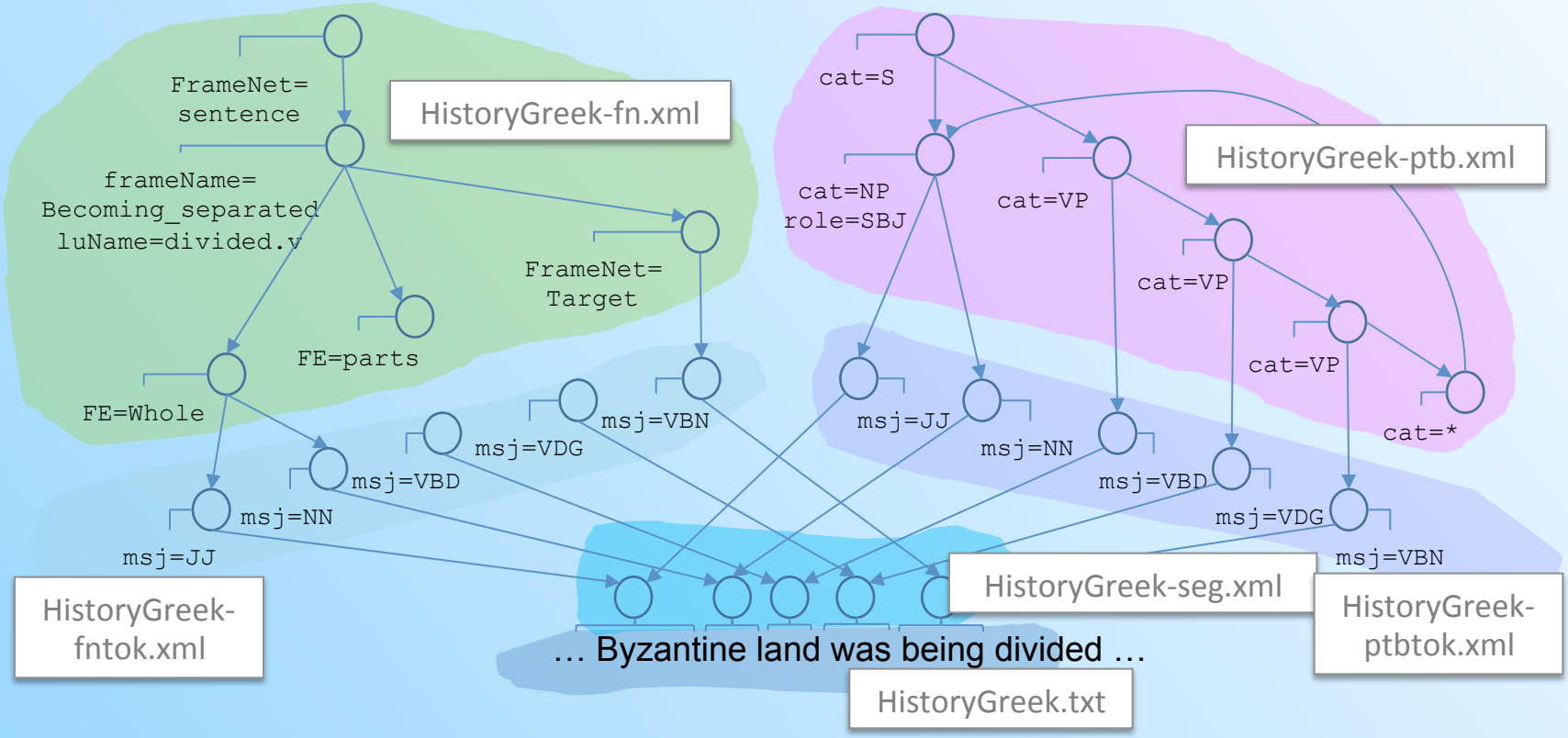
Analyses produced by different researchers / NLP tools use different representation formalisms



Standoff XML: GrAF, MASC corpus

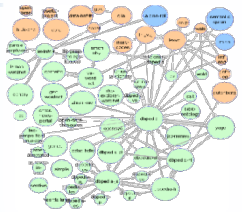
(Ide & Suderman 2007, Ide et al. 2008)





node (segment) — edge (relation, hierarchical) — edge (relation, non-hierarchical) — label attached to a node or an edge (annotation) — filename — GrAF file (layer id)

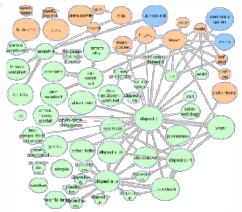
Use Case I: Corpora



Developmental trajectory

- proprietary/ad hoc formats
- XML
- directed acyclic graphs
  - standoff XML
- RDF
  - to store, query and integrate standoff annotations
    - Burchardt et al. (2008), Cassidy (2010), Chiarcos (2012), Rubiera et al. (2012), Hellmann et al. (2012), etc.

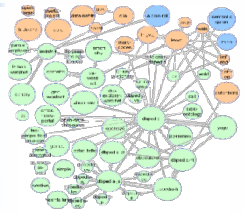
Use Case II: Lexical Resources



Similar trajectory

- proprietary formats
- XML, e.g., TEI dictionary
  - primarily for printed dictionaries
  - application in, e.g., NLP Budin et al. (2012)

Use Case II: Lexical Resources

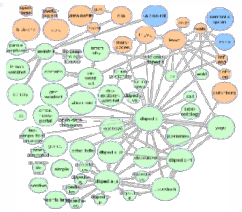


Similar trajectory

- proprietary formats
- XML, e.g., TEI dictionary
- generic data model, LMF
  - feature structures/directed acyclic graphs
  - linearized in XML/UML
  - **but**: semantics of links needs to be externally specified

(Francopoulo et al. 2009)

Use Case II: Lexical Resources

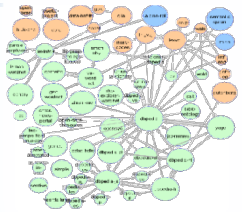


Similar trajectory

- proprietary formats
- XML, e.g., TEI dictionary
- generic data model, LMF
- RDF, e.g., lemon
  - Buitelaar et al. (2013), Fiorelli et al. (2013), Moran & Brümmer (2013)

=> links to language resources other than lexicons

Use Case III: Bring them together



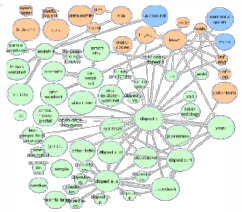
e.g.,

- words in a corpus and lexical concepts
  - at the moment, there exists no other unified formalism capable to express the following query

WordNet	syntax	WordNet
all hyponyms of *land*	modified by	a pertainym of *Byzantium*

- lemmas in a lexicon and grammatical features from a repository of linguistic reference terminology

Use Case IV: Term Bases



- linguistic terminology
  - Ontologies of Linguistic Annotation (http://purl.org/olia)
- language identifiers and descriptions
  - Glottolog (http://glottolog.org)

=>

  - ontology-based querying
    - via query rewriting for corpus information systems

(Rehm et al. 2007, Chiarcos & Götze 2007)

  - ensemble combination architectures
    - merge output of different NLP tools on a conceptual basis

(Chiarcos 2010, Pareja-Lora 2010)