COMP318

Ontologies and Semantic Web

Ontology Alignment - Part 3

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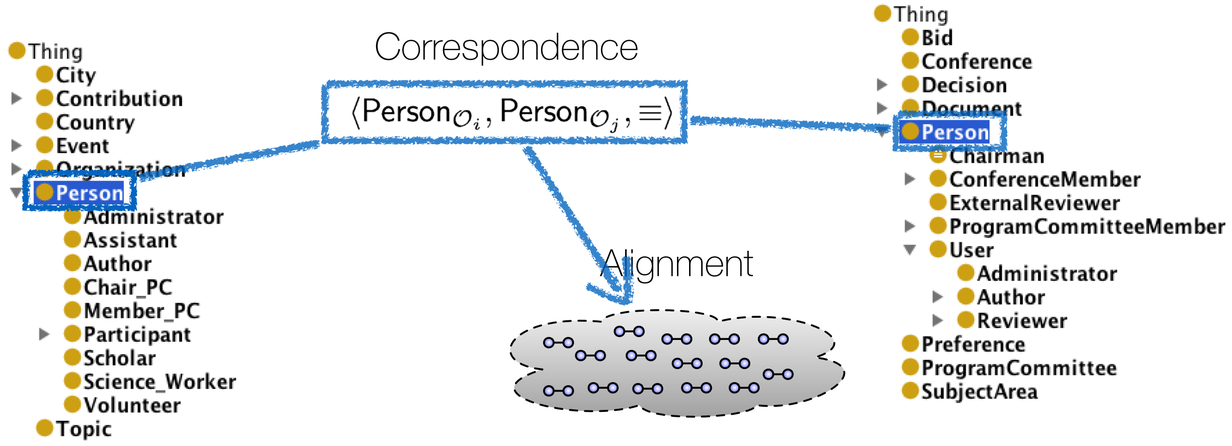
Alignment approaches



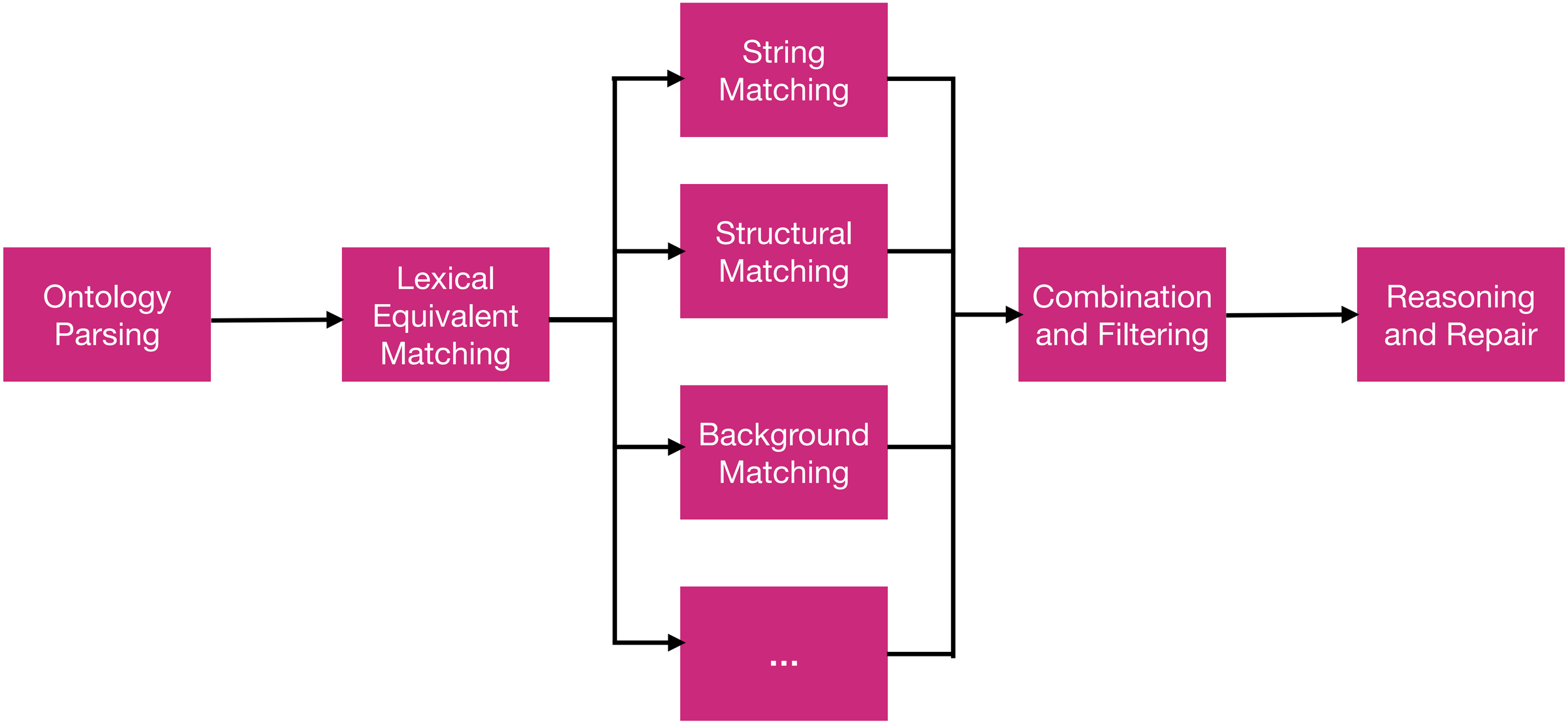
Types of alignment approaches

- **Element-level vs Structure-level:**
  - analyse entities in isolation, or how they appear together in the ontology structure.
- **Syntactic vs semantic**
  - analyse lexical and/or structural characteristics of the entities and/or employ formal semantics
- **Internal vs External**
  - rely solely on the information contained in the ontologies to match, or use external (background) knowledge sources to assist in the matching.
    - Use external thesauri or multi-lingual resources (e.g WordNet)
- **Schema vs Instance**
  - relate schema-level entities and/or instance-level entities.

Types of alignment approaches

- **Similarity vs Logical relationship:**
  - assert similarity between ontology
    entities and/or formally assert a logic relation (e.g., OWL axiom)
- **Atomic vs Complex**
  - relate individual entities and/or combinations of entities (possibly in complex expressions).
- **Homogeneous vs Heterogeneous**
  - relate only entities of the same kind or allow relations between an individual with a class, for example

Alignment pipeline

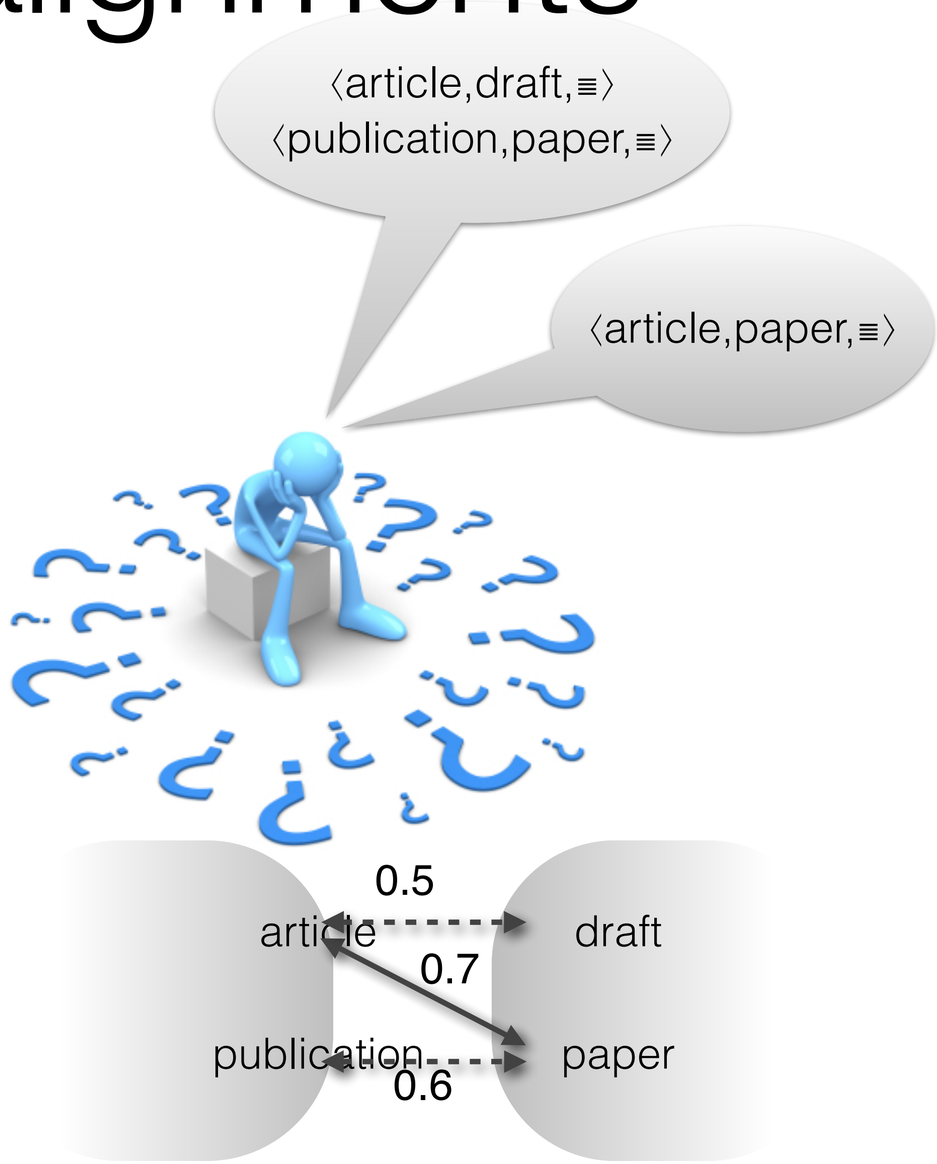


Challenges in using alignments

- Large ontology size
- Rich and complex vocabularies
- Different modelling views
- Use of background knowledge

- Combination with ML techniques
- Quality vs Quantity: coverage vs best
- User involvement

- Need for complex mappings beyond atomic equivalence/subsumption



Aligning large ontologies

- Ontologies may be large (i.e., tens of thousands of classes or even **hundreds of thousands**) like SNOMED Clinical Terms.
  - The matching problem has quadratic complexity: Size($\mathcal{O}_1$) Size($\mathcal{O}_2$) potential candidates.
- Strategies:
  - Pruning: avoid comparing all entities - e.g. hash-based searching
    - Dividing the matching tasks into independent subtasks - parallelise
      - Partitioning: split into vertical blocks.
      - Modularization: identify overlapping self-contained sub-ontologies.

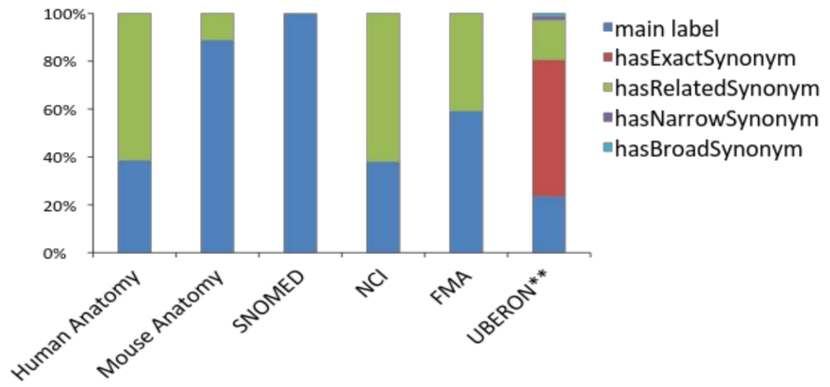
Aligning large ontologies

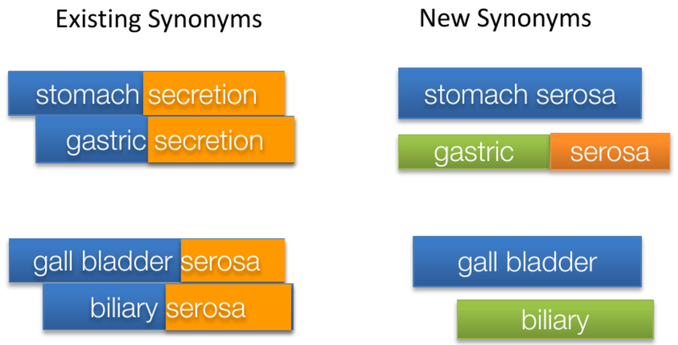
- Division (facilitate parallelization):
  - Partitioning: divides ontologies into (vertical) partitions.
  - Modularisation: extracts self-contained sub-ontologies preserving logical properties.

P. Doran, V. Tamma, T.R. Payne, I. Palmisano: Dynamic Selection of Ontological Alignments: A Space Reduction Mechanism. IJCAI 2009

Exploiting rich and complex vocabularies

- How can we handle different types of labels?
  - UBERON_0000948
    - `rdfs:label: “heart”`
    - exact synonyms: “vertebrate heart”, “chambered heart”
    - narrow synonym: “branchial heart”
    - related synonym: “cardium”
  - Existing synonymous can derive
    - new synonyms
    - e.g., “stomach” “gastric”





C. Pesquita et al. What’s in a ‘nym’? Synonyms in Biomedical Ontology Matching 2013

Alignment repair

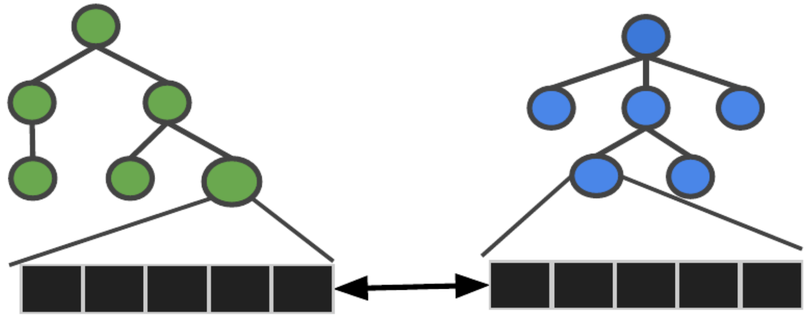
- The integration of different models can cause unsatisfiabilities.

- The integration of different models can lead to unintended logical consequences (others than unsatisfiabilities).
  - Possible solution: repair/remove mappings.

E. Jiménez-Ruiz, T. R. Payne, A. Solimando, and V. Tamma. Limiting logical violations in ontology alignment through negotiation. In Proc. KR'16, 2016.
A. Solimando, E. Jiménez-Ruiz, G. Guerrini: Minimizing conservativity violations in ontology alignments: algorithms and evaluation. Knowl. Inf. Syst. 2017

Machine learning & Alignment

- ML models to learn mappings:
  - Supervised.
  - Distant-supervision.
- Source of embeddings
  - Embeddings: vector representation capturing the context/semantics of a word or entity
  - Use of pre-trained language models to obtain word embeddings for the entity labels.
  - Ontology embedding techniques.

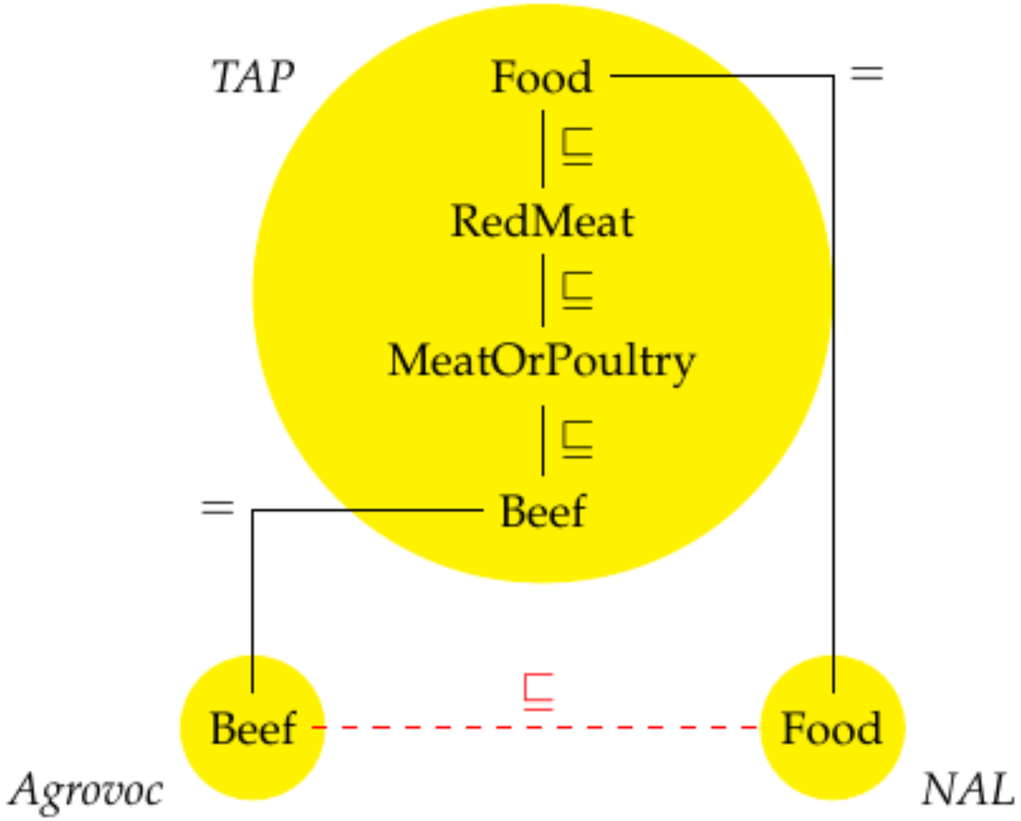


P. Kolyvakis et al. Biomedical ontology alignment: an approach based on representation learning. J. of Biomed. Semantics 2018

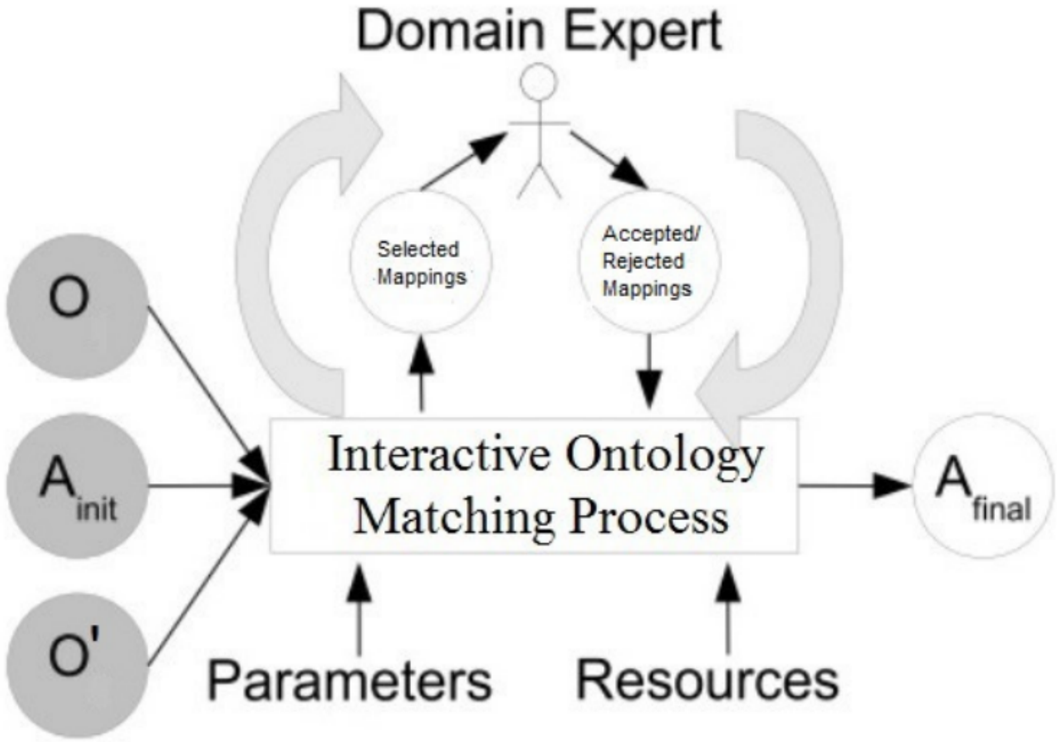
J. Chen et al. Augmenting Ontology Alignment by Semantic Embedding and Distant Supervision. ESWC 2021

External resources & background knowledge

- Third ontology as mediator
  - WordNet thesaurus
  - UMLS metathesaurus (life sciences)
  - Repository of ontologies (e.g., BioPortal)
  - Pre-trained embeddings.
  - Online multilingual translators
  - BabelNet multilingual semantic network.



User involvement in ontology alignment



H Li et al. User validation in ontology alignment: functional assessment and impact. KER 2019
J. da Silva et al. Alin: improving interactive ontology matching by interactively revising mapping suggestions. KER 2020

Complex ontology alignment

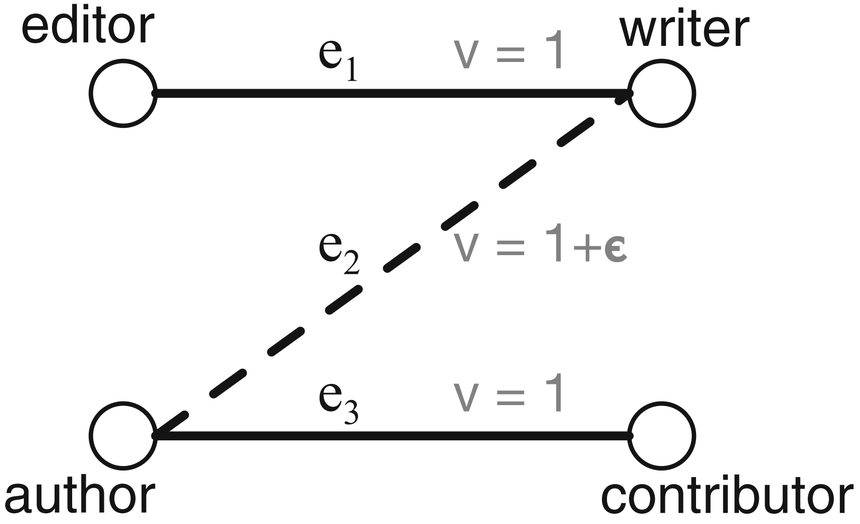
- Links across ontologies involving complex constructors, potentially complex transformations (extends the mapping definition)

Source entity	rel.	Target construction	type
cmt:ExternalReviewer	$\equiv$	$\exists$ *conference:invited_by.*$\top$	CAE
conference:Submitted_contribution	$\equiv$	$\exists$*cmt:submitPaper*$^-$.$\top$	CIAE
cmt:ProgramCommitteeMember	$\equiv$	$\exists$*conference:was_a_member_of.* *conference:Program_committee*	CAT
conference:Conference_part	$\equiv$	$\exists$*ekaw:hasPart*$^-$. *ekaw:Conference*	CIAT
ekaw:ScientificEvent	$\equiv$	*conference:Conference_part* $\sqcup$ *conference:Conference*	union(c)
ekaw:SubmittedPaper	$\sqsupseteq$	*conference:Submitted_contribution* $\sqcap$ *conference:Paper*	inters(c)
cmt:hasProgramCommitteeMember	$\equiv$	*conference:has_members.* *conference:Program_committee.*$\top$	dom(rel)
ekaw:reviewerOfPaper	$\equiv$	*conference:contributes* $\circ$ *conference:reviews*	chain(rel)
cmt:writeReview	$\equiv$	*ekaw:reviewWrittenBy*$^-$	inv(rel)

E. Thiéblin et al. Survey on complex ontology matching. Semantic Web 2020

Quality or Quantity

- Use game theoretic mechanisms to decide whether to go for a maximal alignment:
  - global solutions vs stable solutions



Zhi, N., Payne, T.R., Krysta. P., Li, M. Truthful Mechanisms for Multi Agent Self-Interested Correspondence Selection. In ISWC 2019

Payne T.R., and Tamma, V. A Dialectical Approach to Selectively Reusing Ontological Correspondences. In EKAW2014

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End Ontology Alignment - Part 3

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