

Evaluation of Automatic Ontology Matching for Materials Sciences and Engineering

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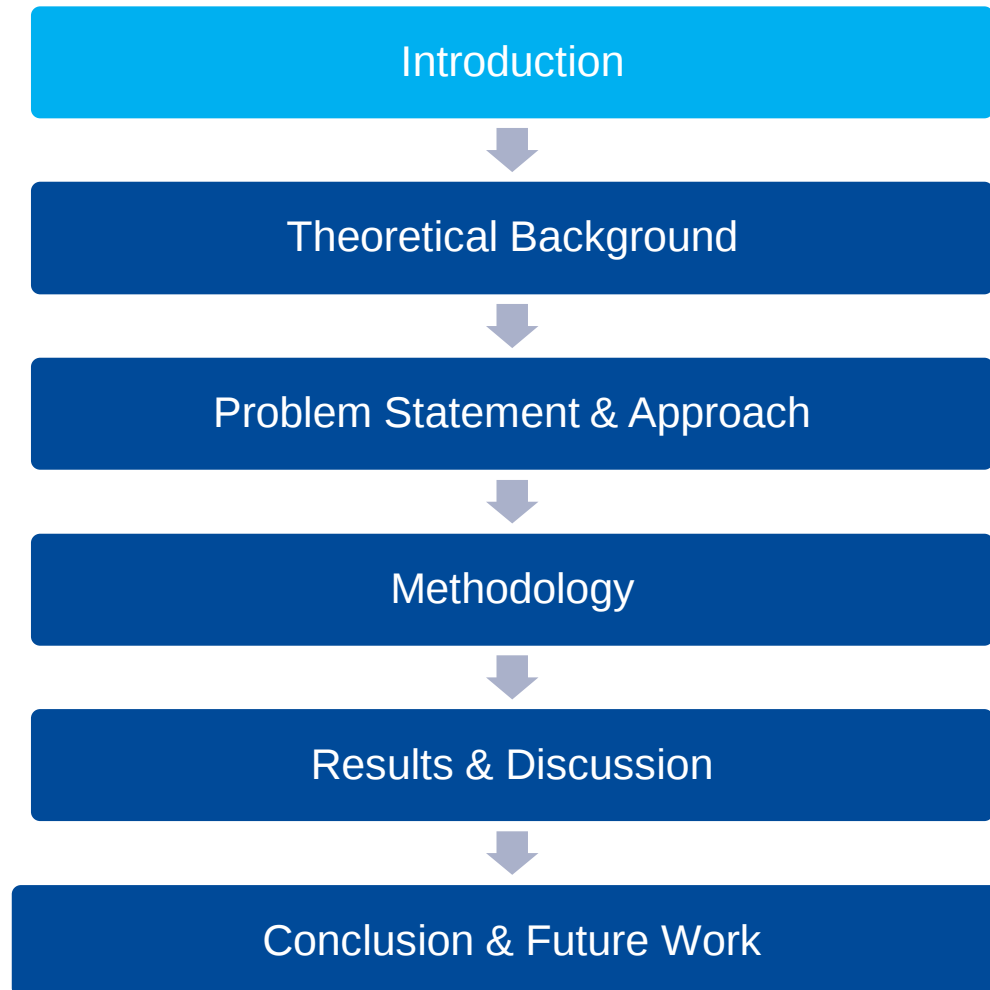


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Engy Nasr

Department of Computer Science
Chair for Algorithms and Data Structure

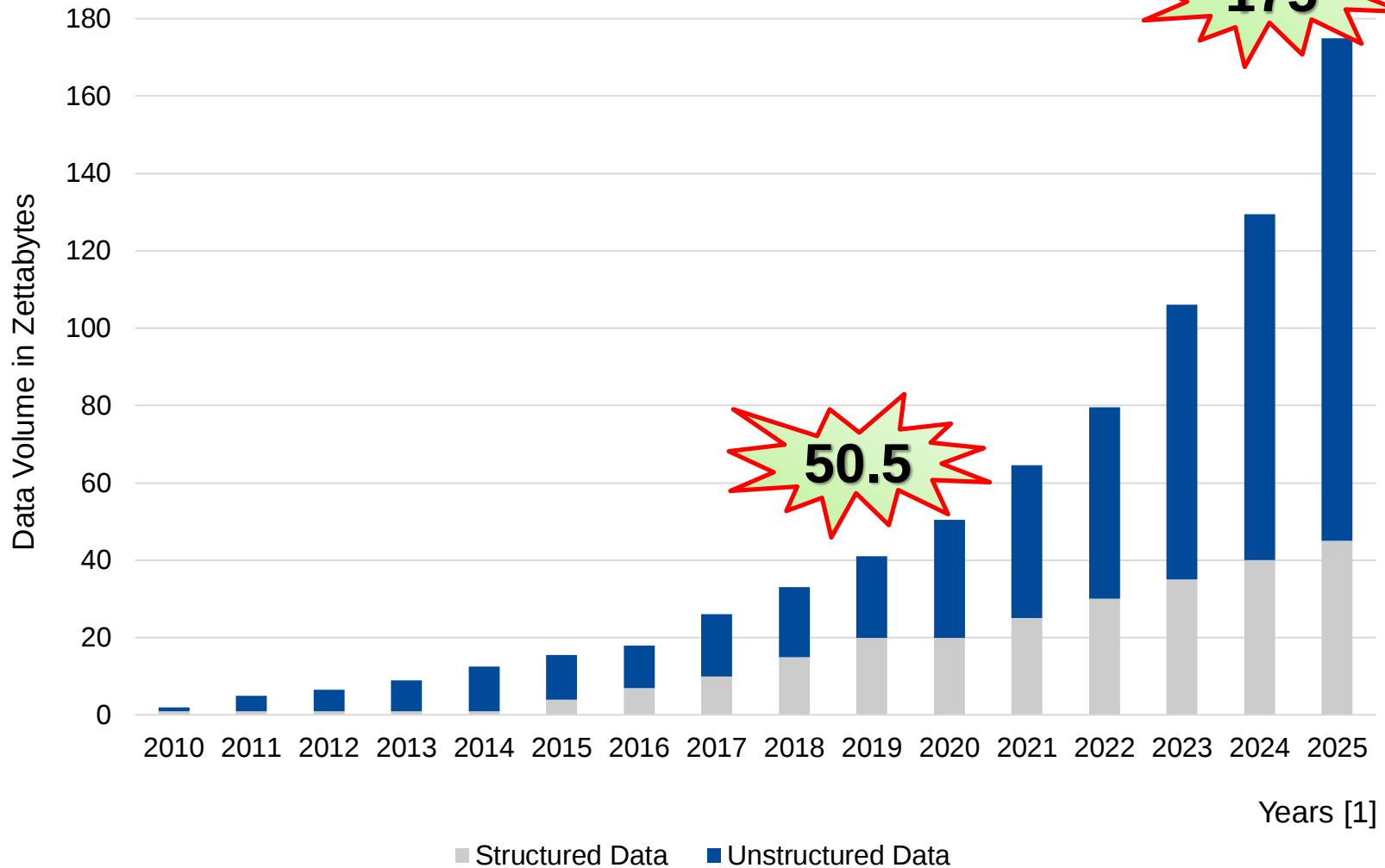




Data .. Data .. Everywhere



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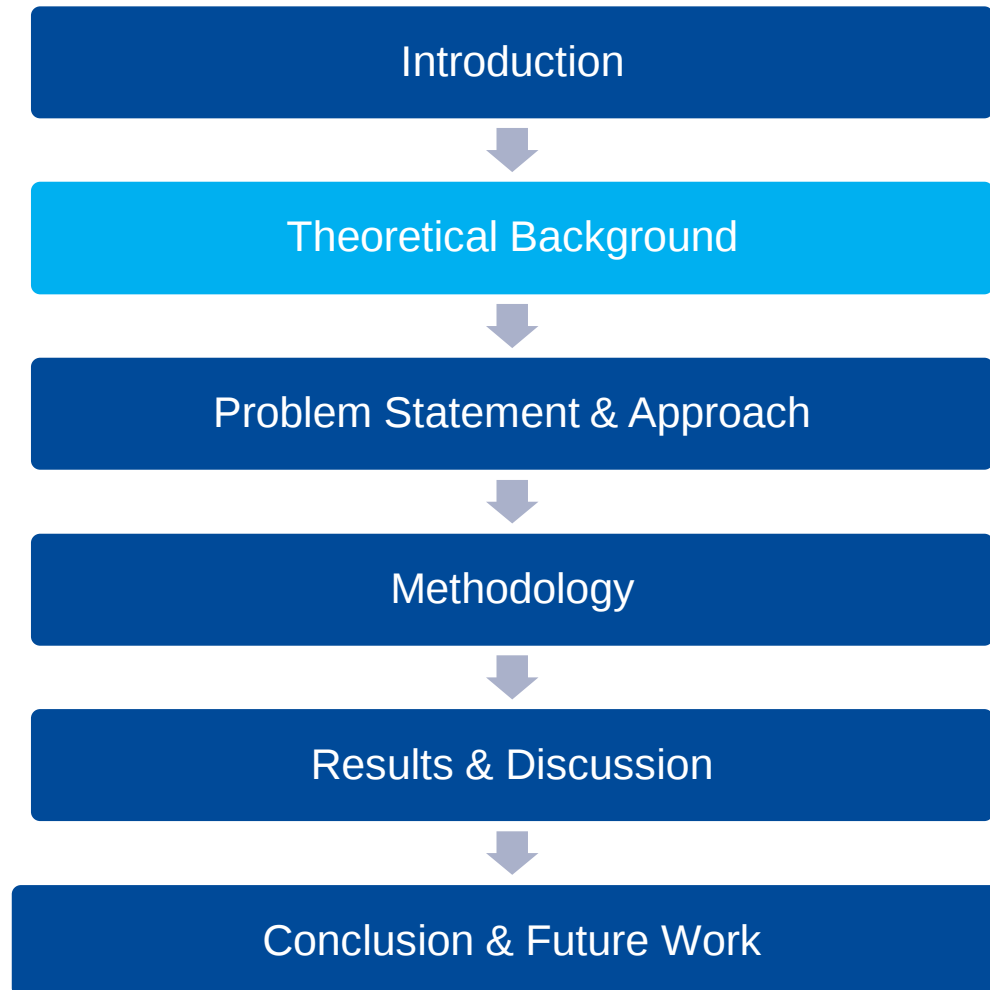


- **Materials Modelling:** is the mathematical representation of a material's behavior under certain applied actions and conditions.



- **Interoperability:** is when systems, actors or applications provide/accept services to/from other systems, actors or applications and collaboratively use the exchanged services.

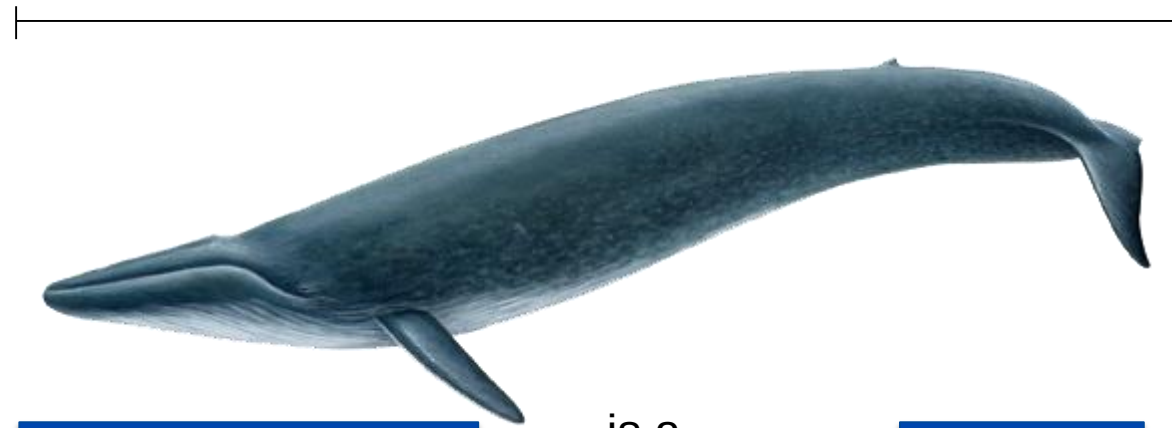




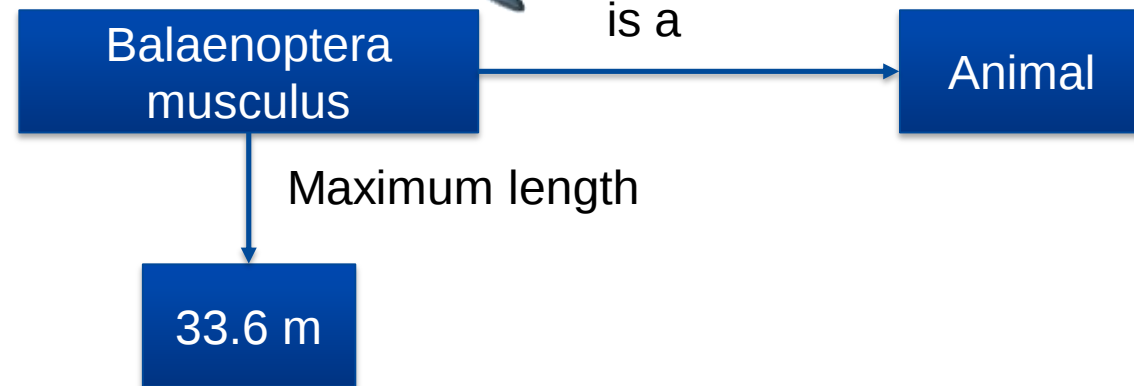
Data

33.6 m

Information



Knowledge



$$Balaenoptera\ musculus \sqsubseteq Animal \sqcap maximum\ length \leq 33.6\ m$$

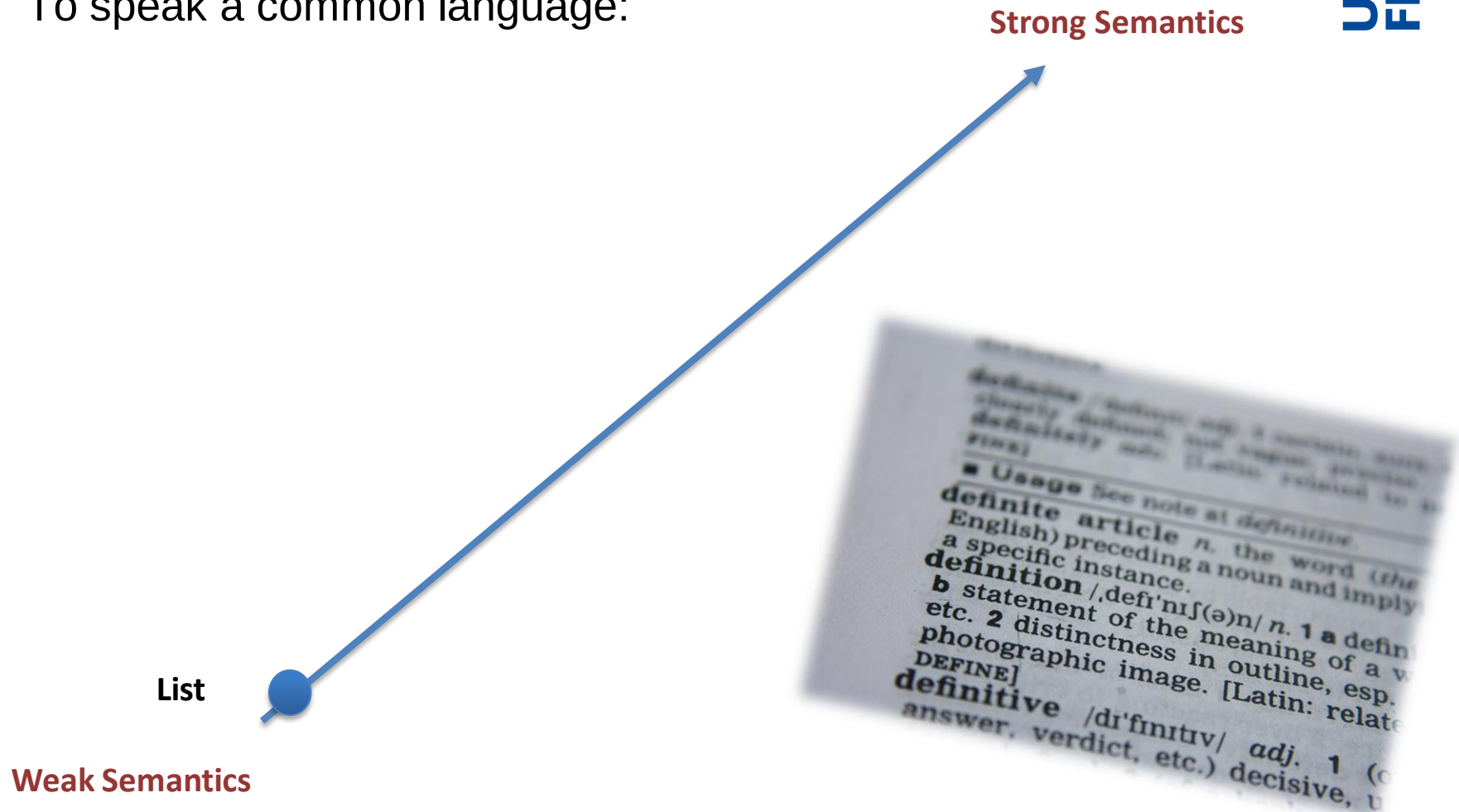
**„People can't share knowledge if they don't
speak a common language“**

Thomas Davenport (1997)

Knowledge Representation Systems



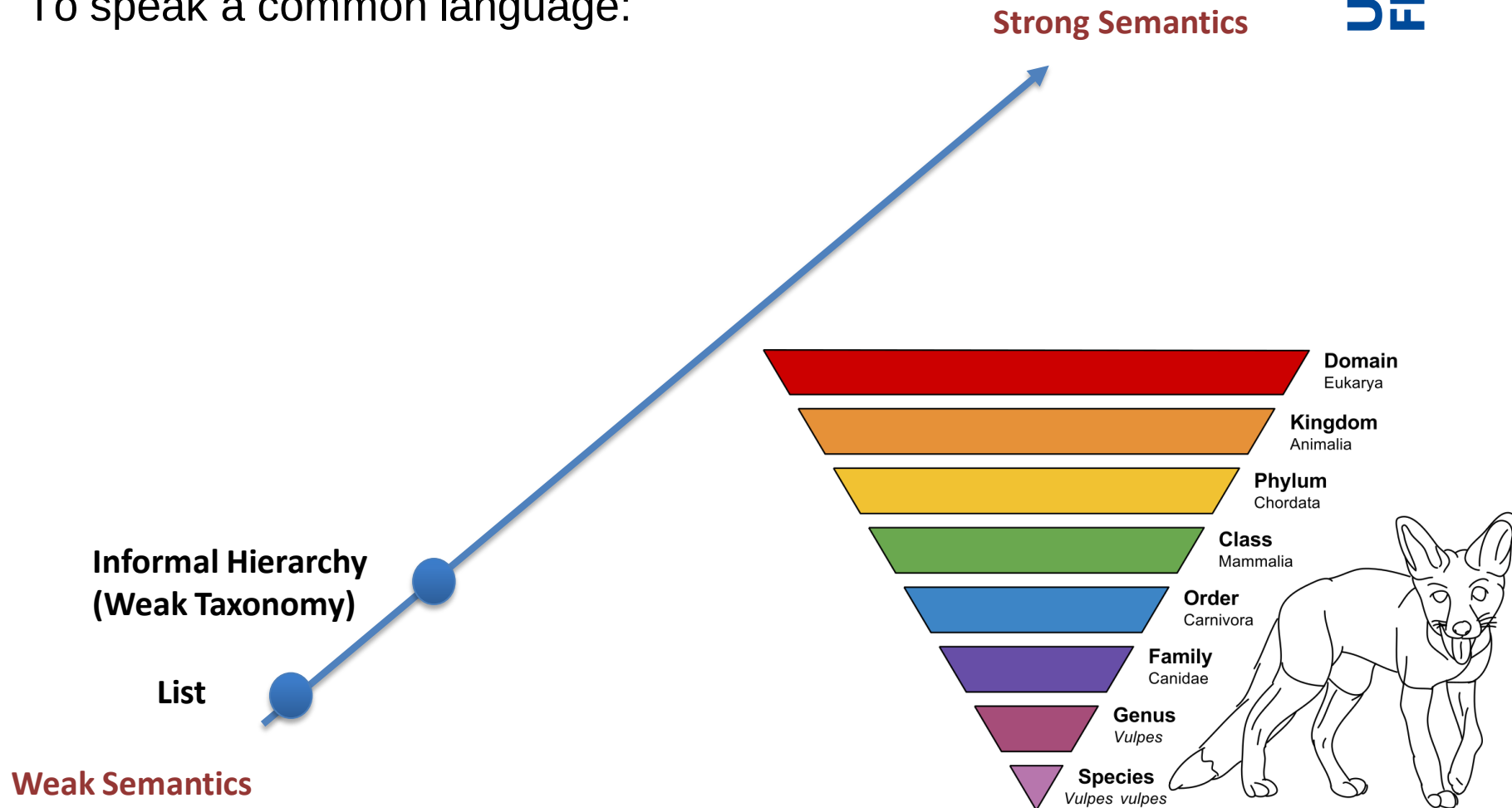
To speak a common language:



Knowledge Representation Systems



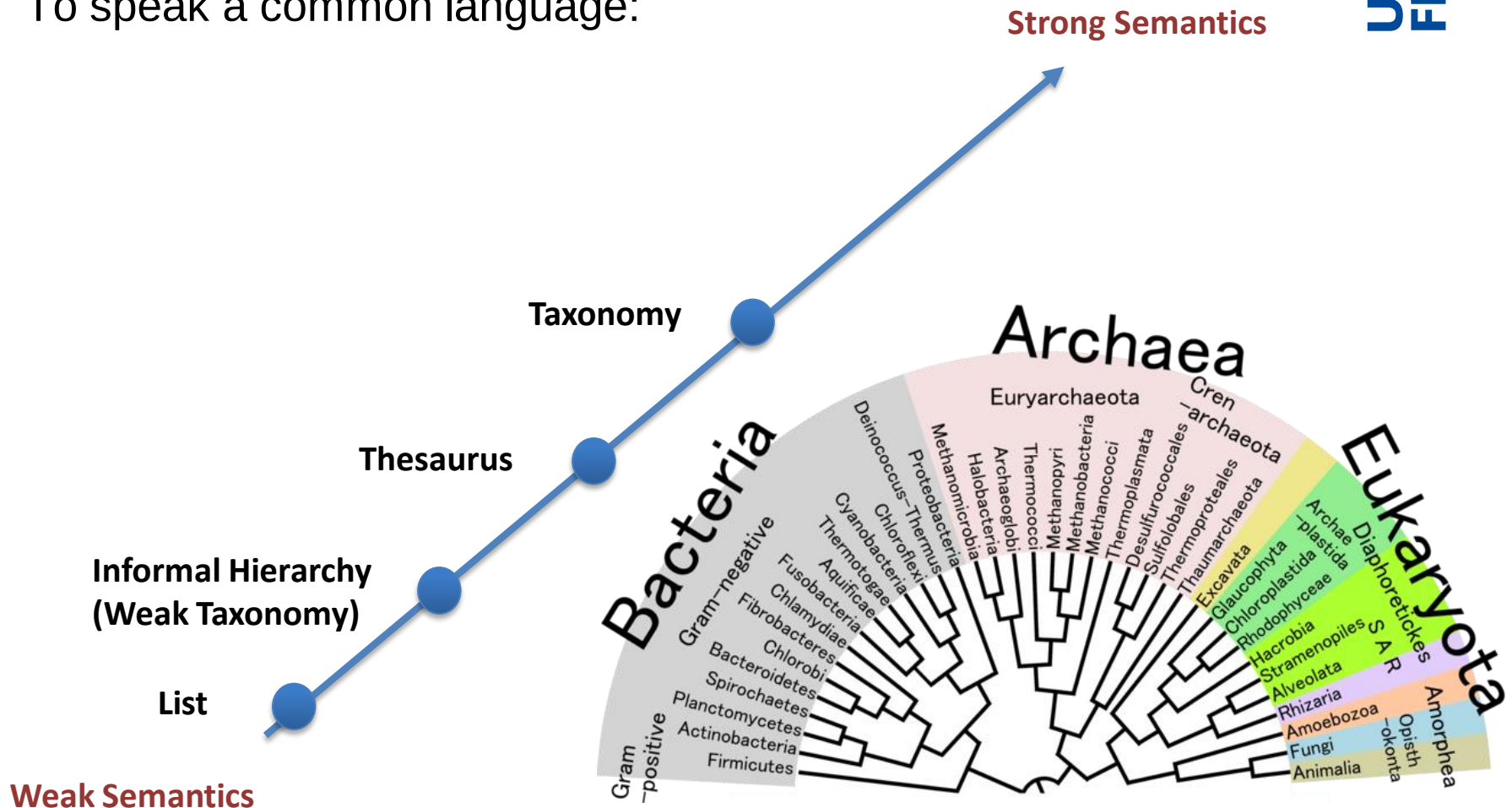
To speak a common language:



Knowledge Representation Systems



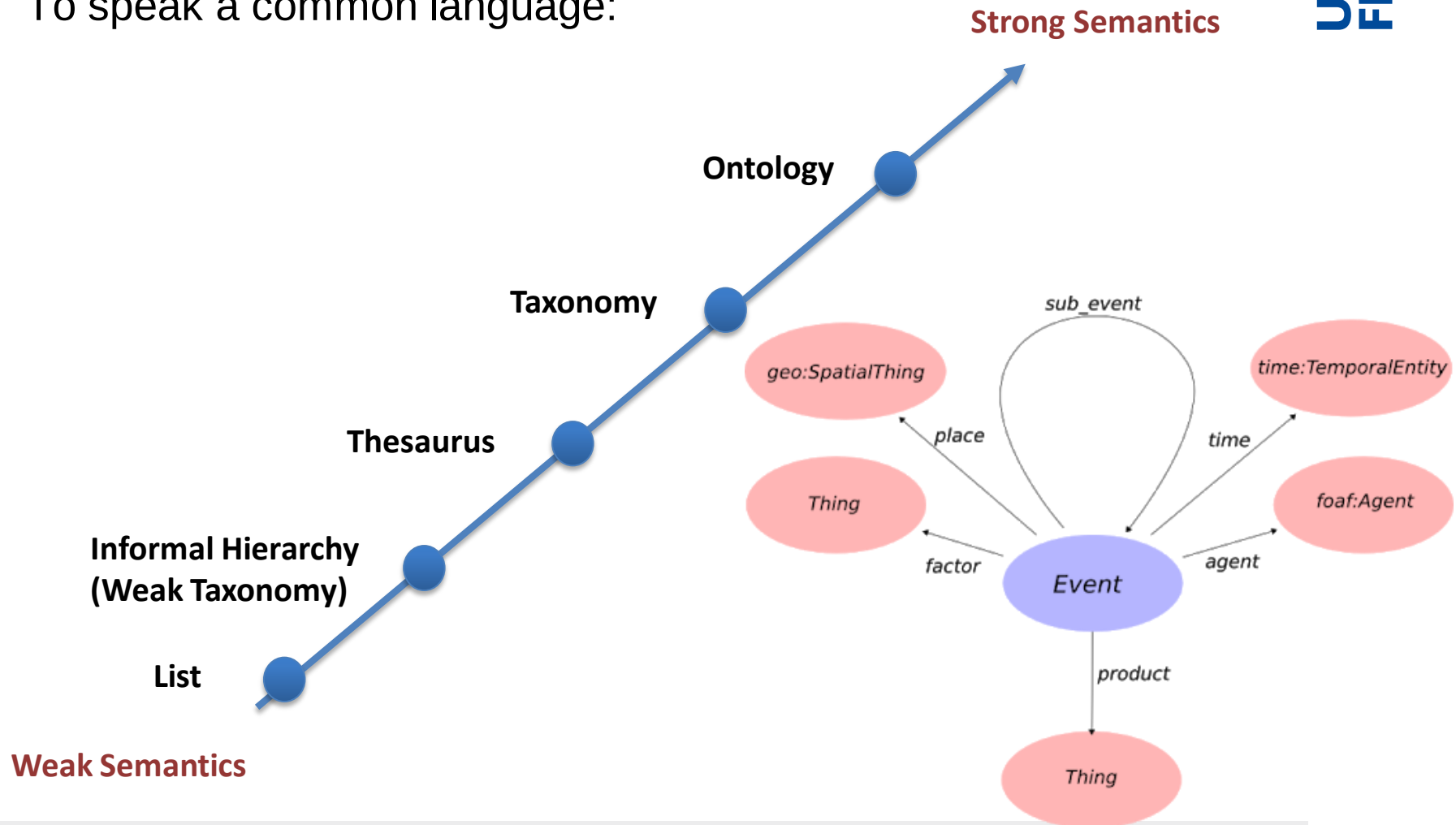
To speak a common language:



Knowledge Representation Systems



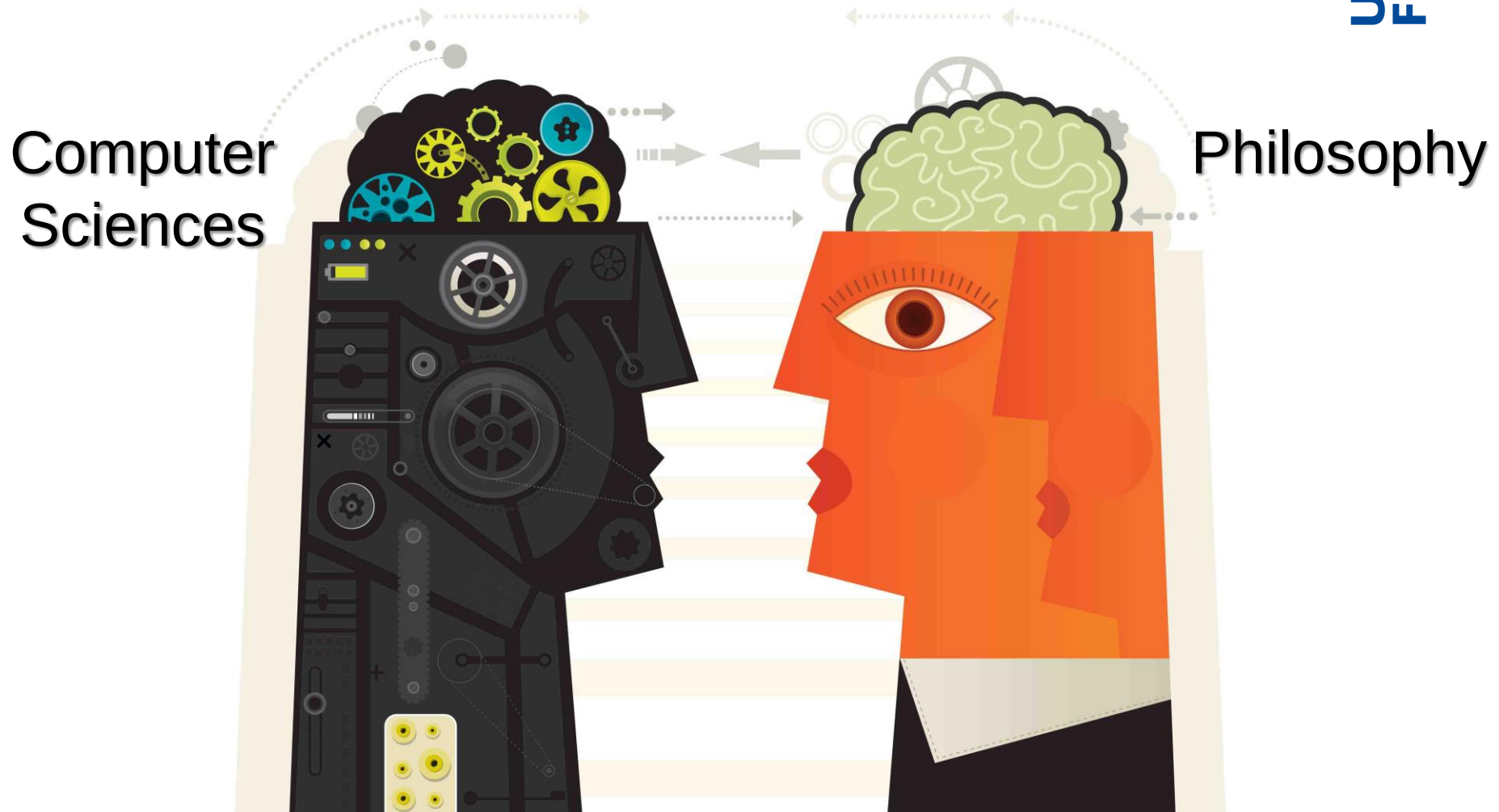
To speak a common language:



Ontology



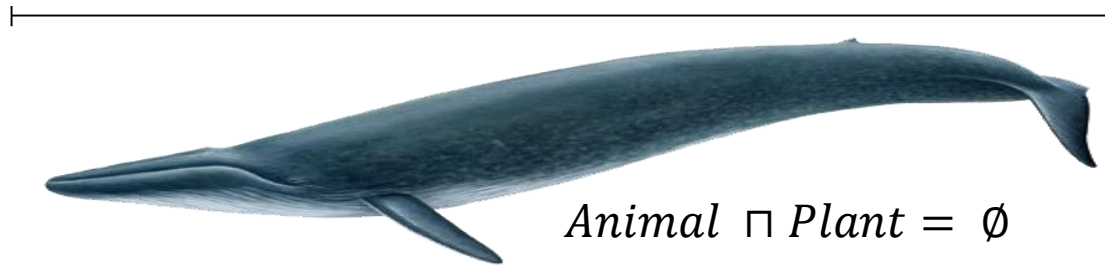
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Ontology Small Example ^[2]



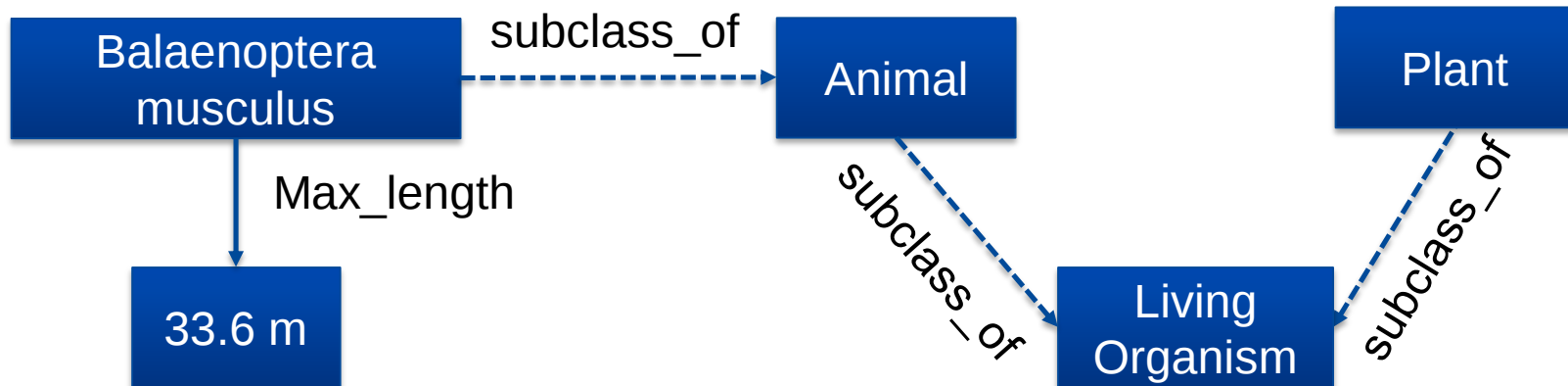
33.6 m



$Animal \sqcap Plant = \emptyset$

$Animal \subseteq Living\ Organism$

$Plant \subseteq Living\ Organism$

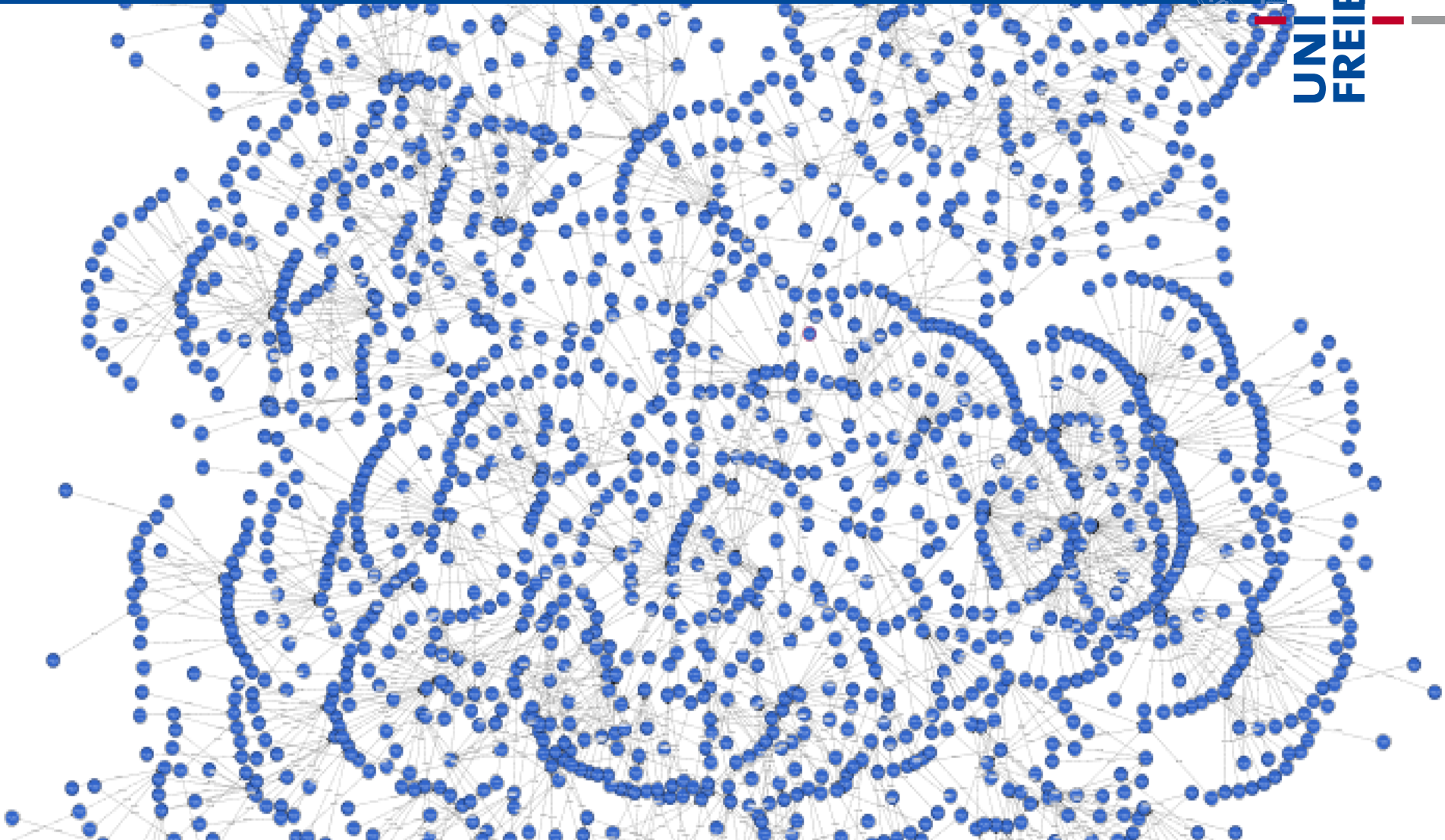


$Balaenoptera\ musculus \subseteq Animal \sqcap maximum\ length \leq 33.6\ m$

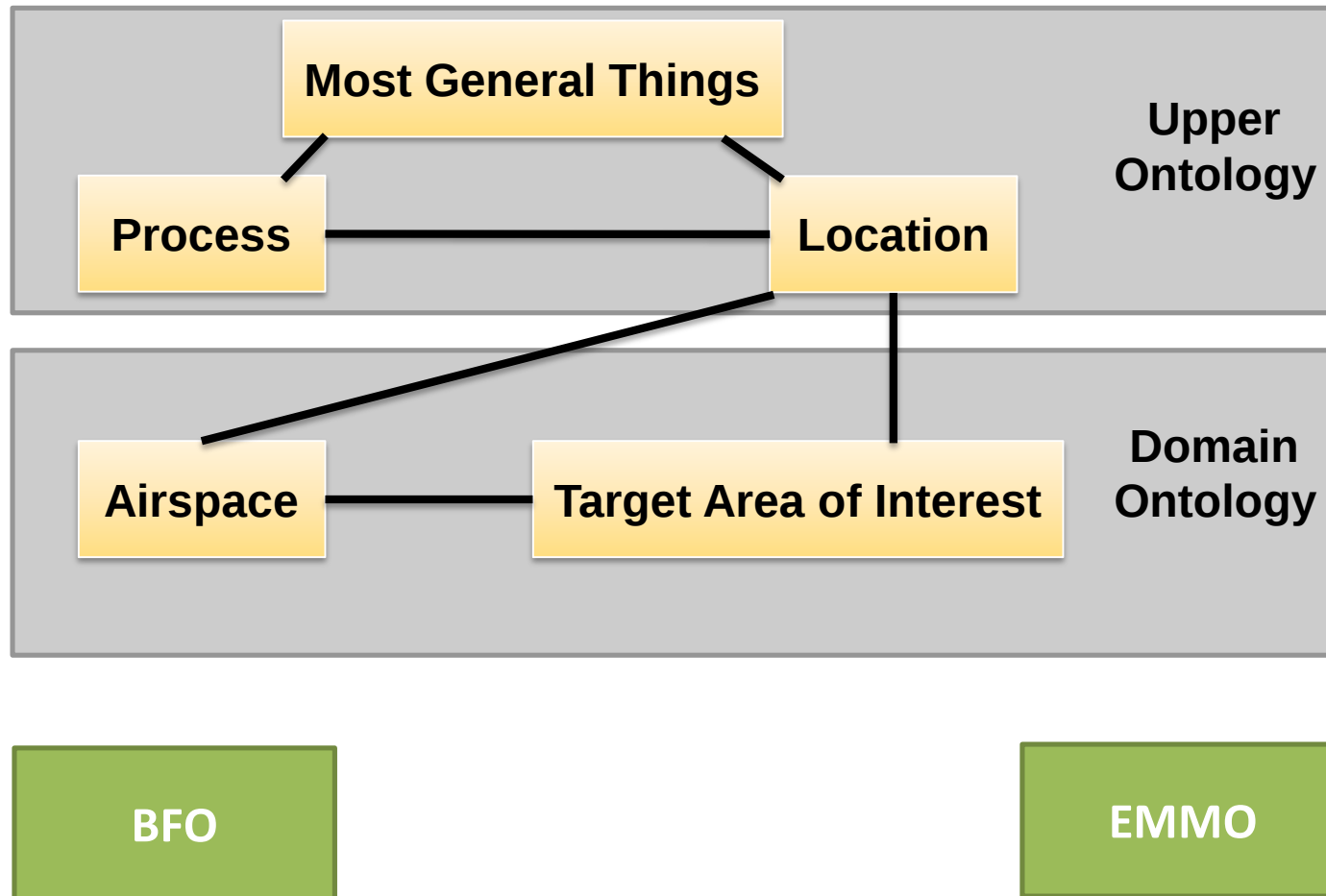
Ontologies can be Huge



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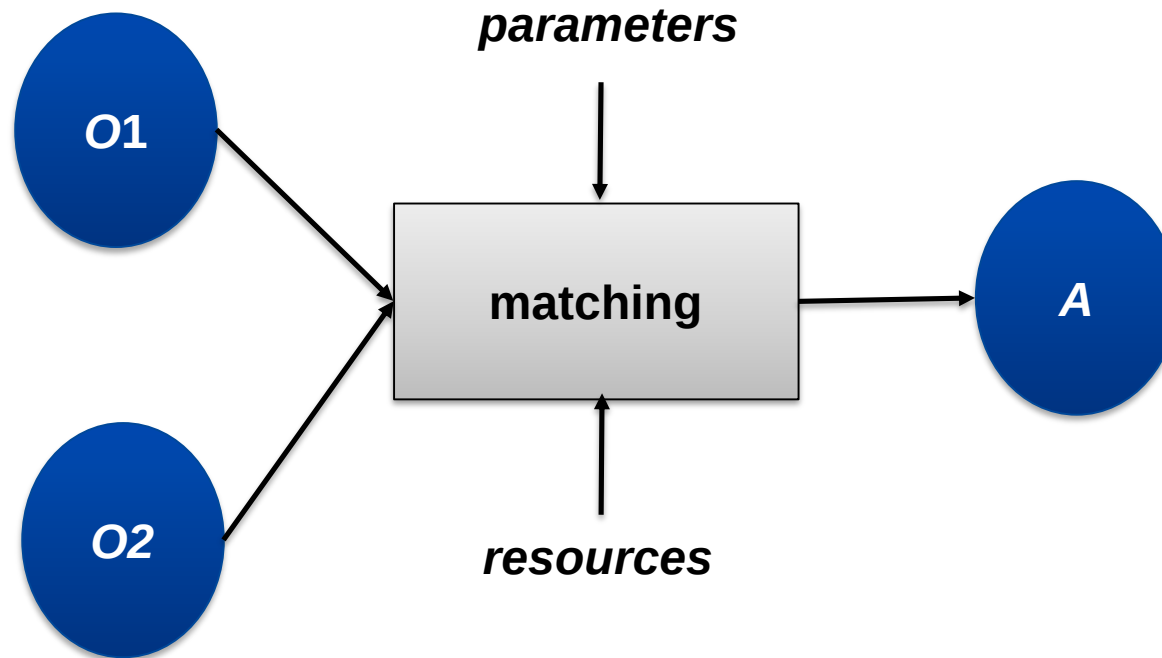
Upper Level Ontologies



Ontology Matching



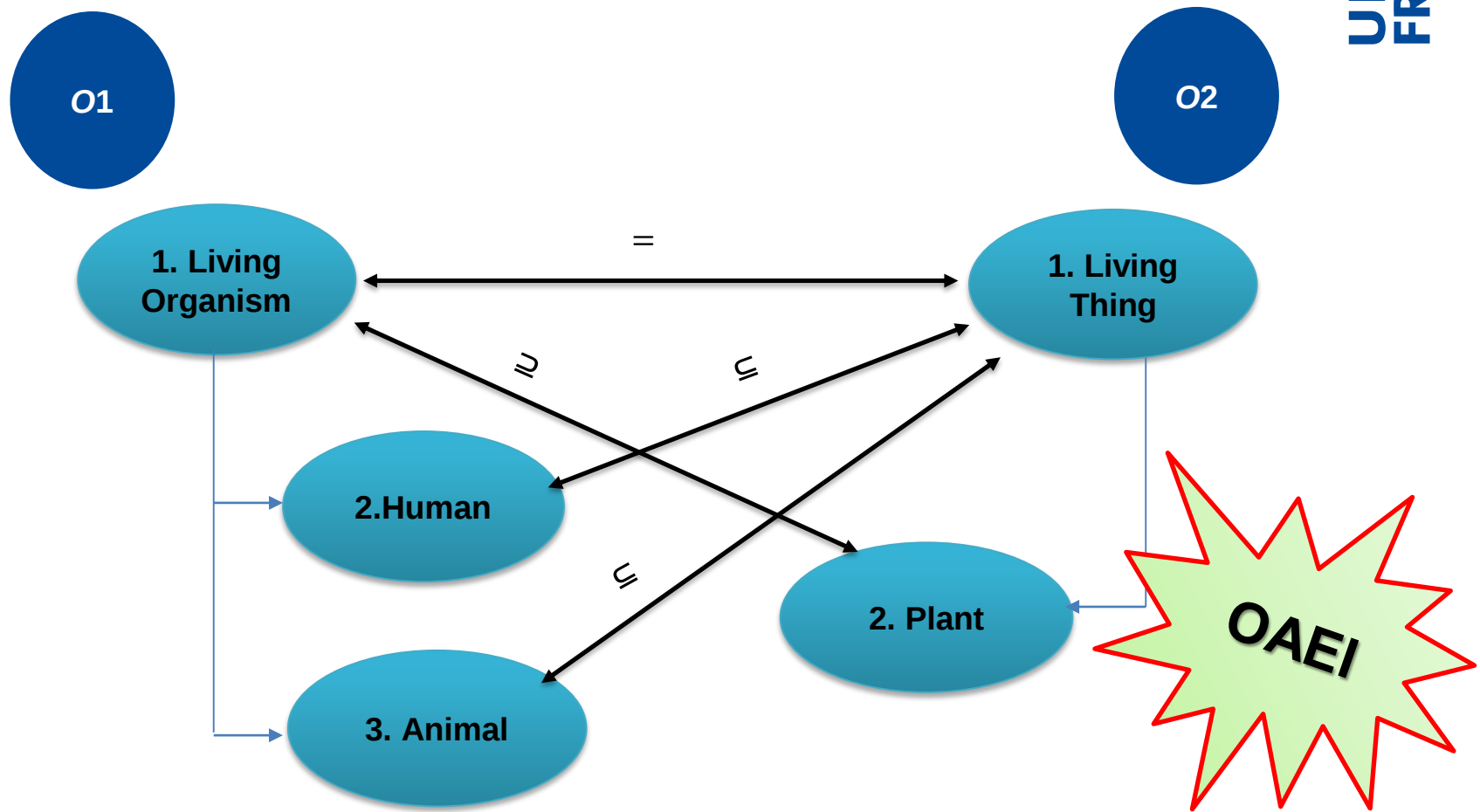
- **Ontology Matching** : is where actual relations & alignments between entities of different ontologies are found.



O1: 1st Ontology (source) O2: 2nd Ontology (target)

A: output alignment

Ontology Matching



O1: 1st Ontology (source) O2: 2nd Ontology (target)

OAEI: Ontology Alignment Evaluation Initiative

Theoretical Background



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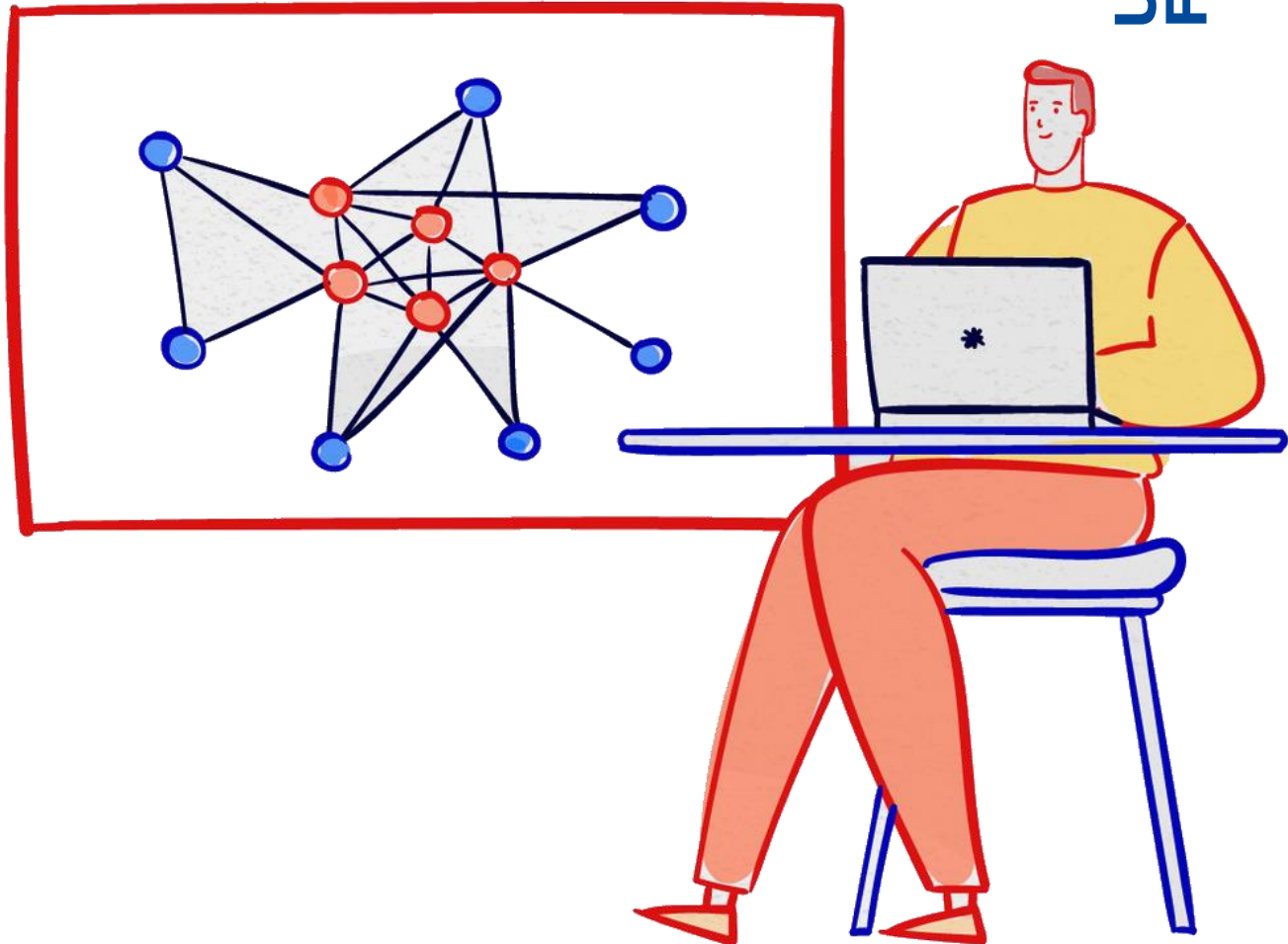
Semantics

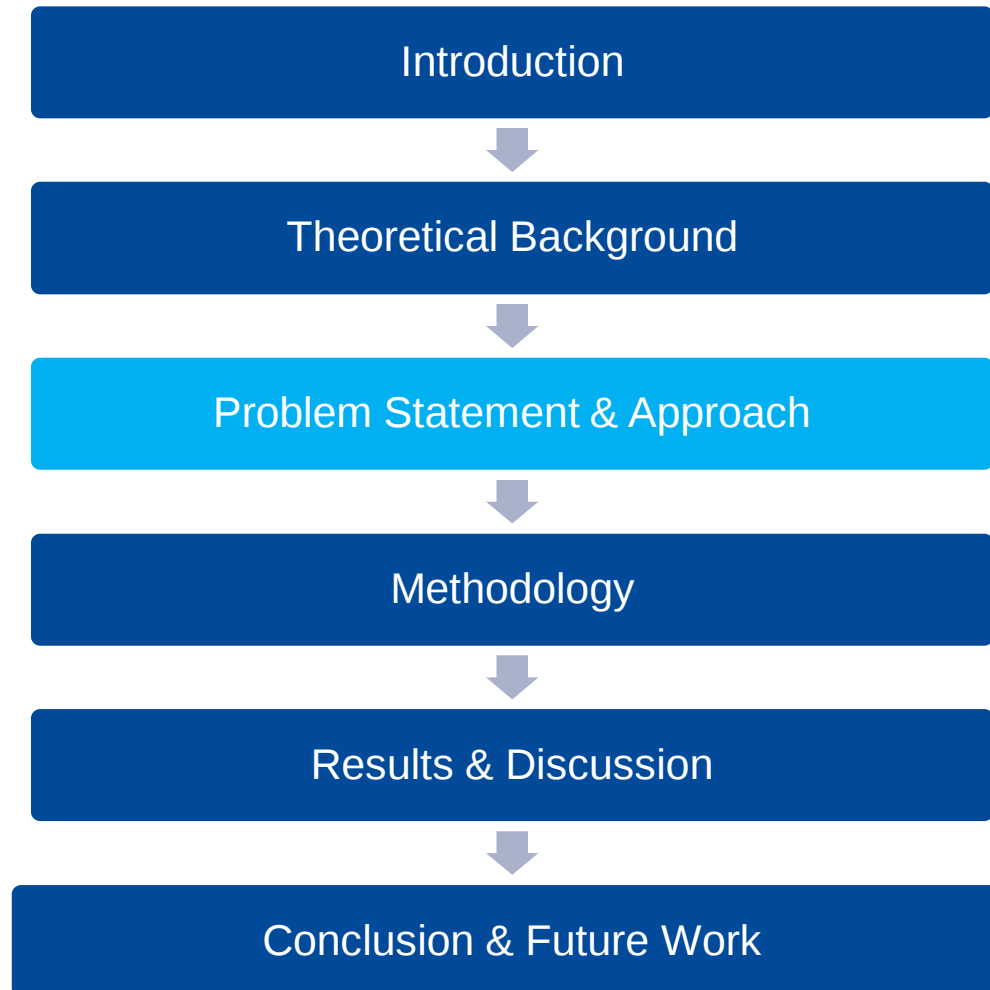
Computers

Logic

Ontologies

Ontology Matching



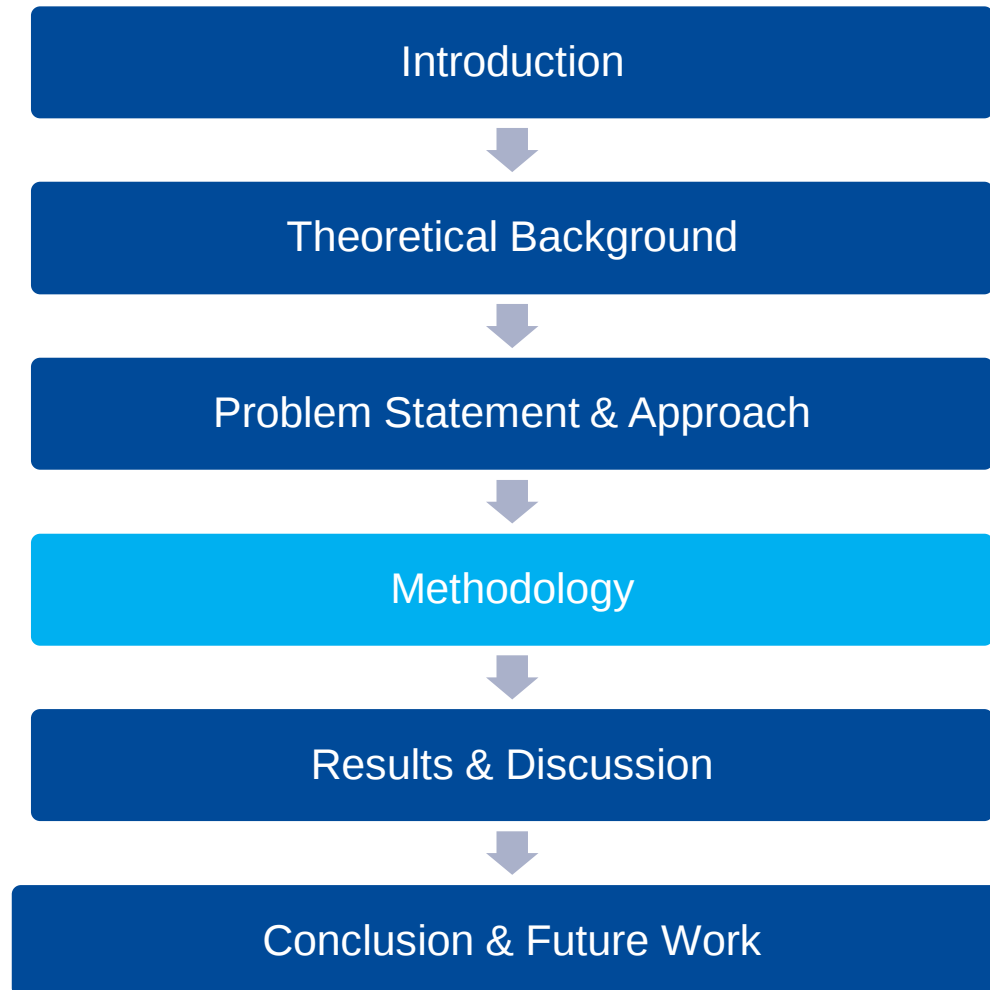


Automatic ontology matching tools are yearly evaluated, updated and adapted to the fields of biomedicine, bioinformatics and medicine

BUT NOT

to the Materials Sciences field

- **Adapt:** Existing evaluation workflow for automatic ontology matching
- **Identify:** Existing automatic ontology matchers
- **Develop:** Materials Sciences Benchmark
- **Evaluate:** Performance of selected matchers using the adapted evaluation workflow along with the developed benchmark



Identification of Matchers



- Ontology Alignment Evaluation Initiative (OAEI)
- Active
- Openly Available on the Web

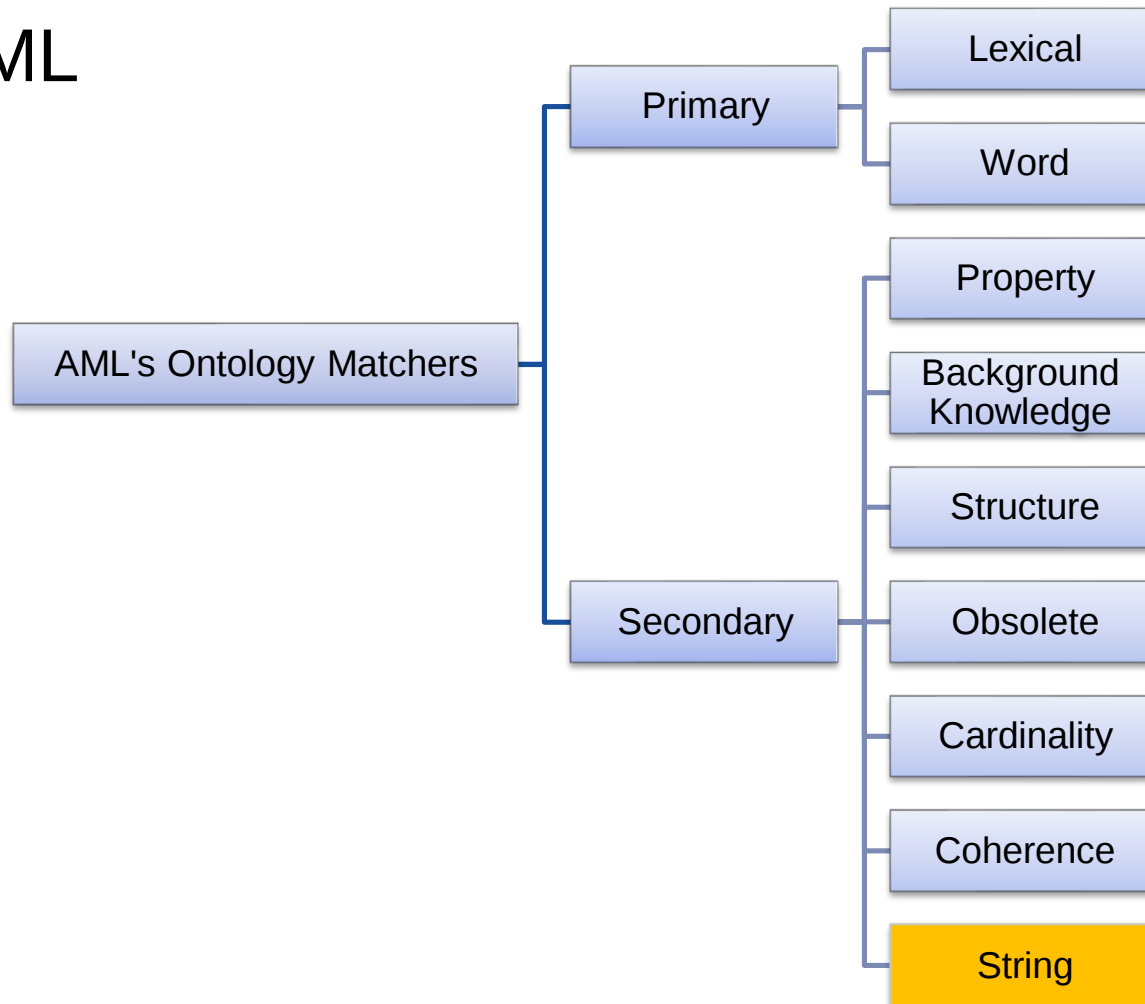


Participating Ontology Matchers

Agreement Maker Light



■ AML



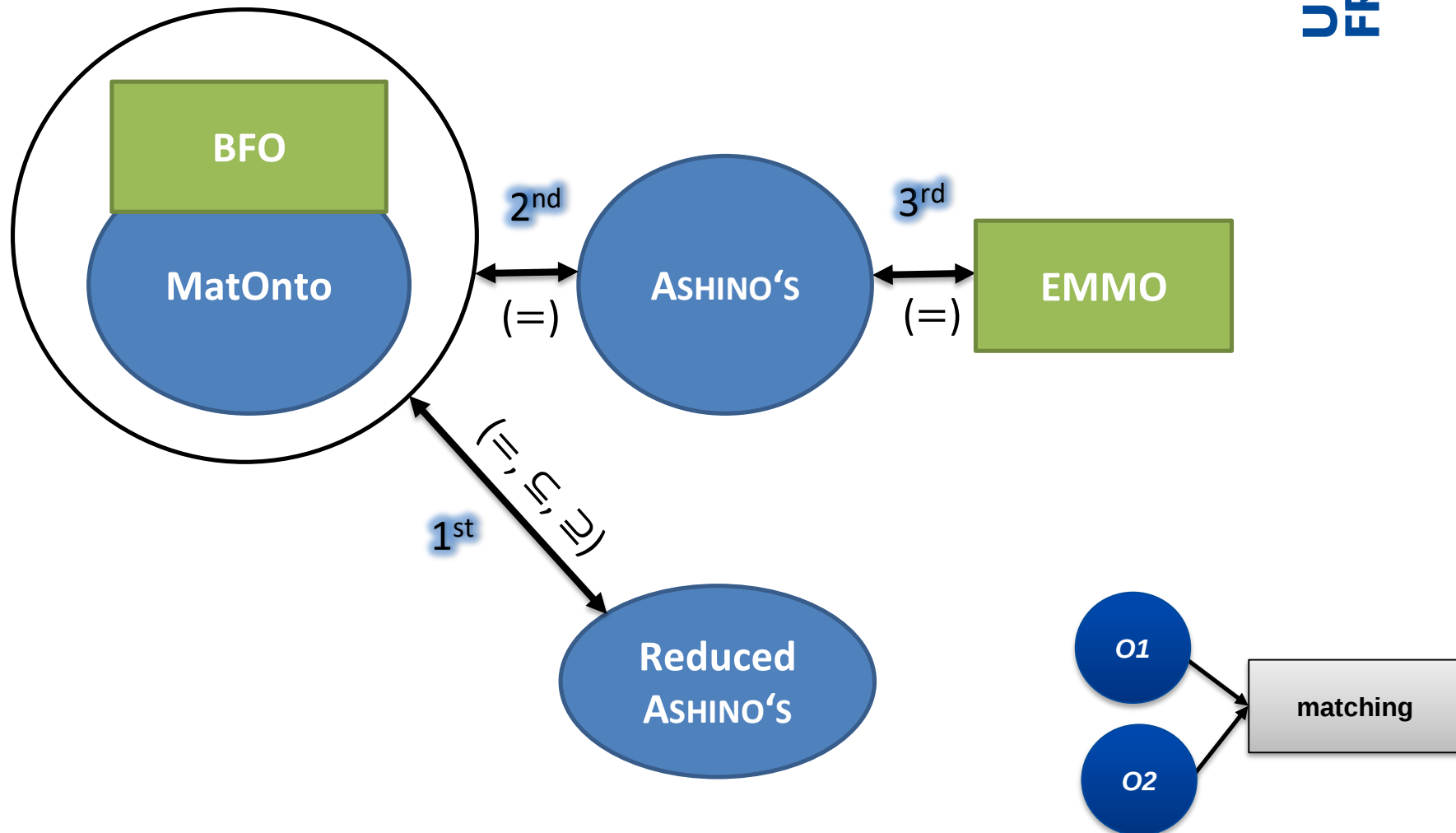
Participating Ontology Matchers

Logic-based Methods for Ontology Mapping (LogMap)



- LogMap
 - It has a high repair algorithm
 - A highly scalable ontology matching system, which can handle large sized ontologies.

Materials Sciences Benchmark Test Cases



Materials Sciences Benchmark Manual Reference Alignments



	1 st Test Case	2 nd Test Case	3 rd Test Case
<i>No of Alignments R </i>	23	302	11

For 1st Test Case: subclass ($\subseteq$) , superclass ($\supseteq$) and equivalence ($=$), no property and no instances.

For 2nd Test Case: equivalence ($=$), no property and no instances.

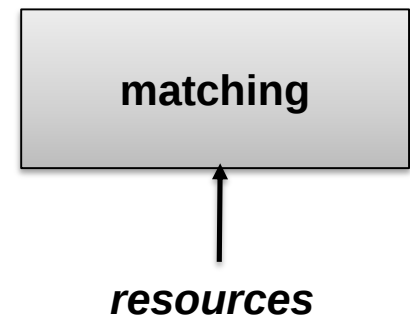
For 3rd Test Case: equivalence ($=$), no property and no instances.

Materials Sciences Benchmark Background Knowledge Ontologies

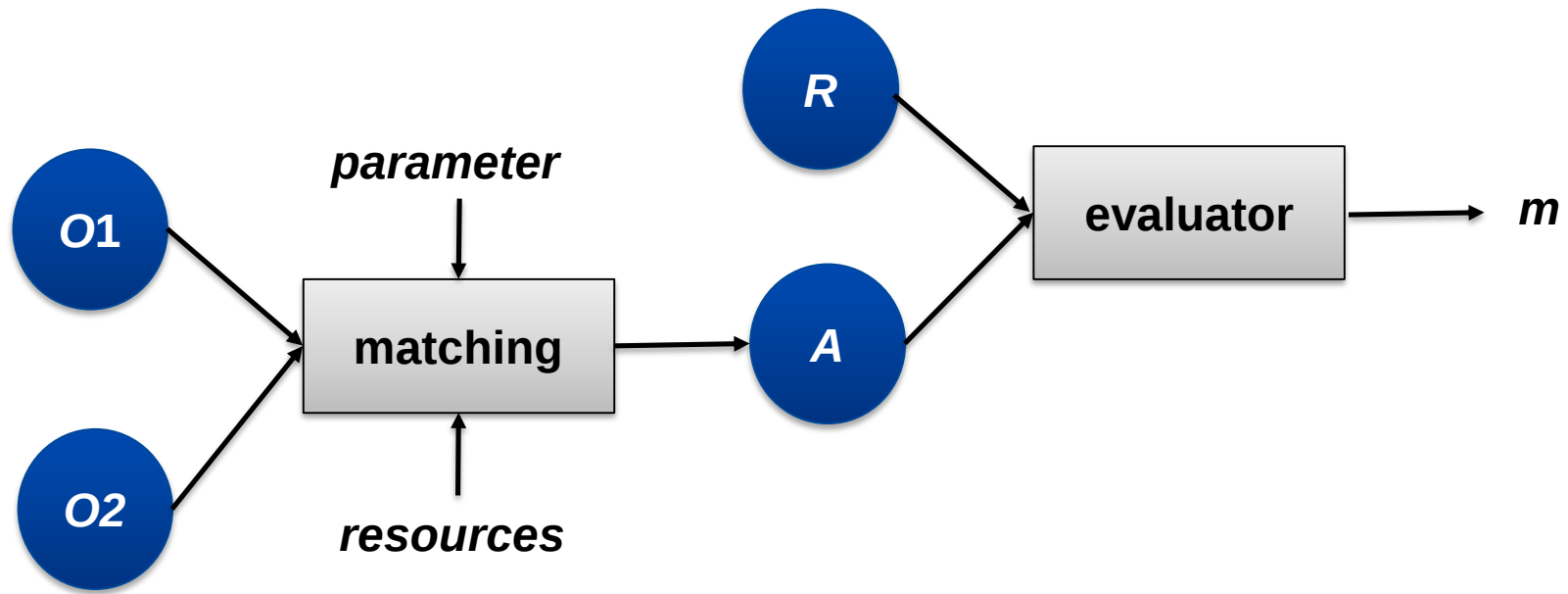


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- Periodic Table
- European Materials Modelling Ontology (EMMO)



Evaluation Workflow



O1: 1st Ontology (source)
O2: 2nd Ontology (target)

A: output alignment
R: reference alignment

m: performance measurements

$$Recall = \frac{|R \cap A|}{|R|}$$

$$Precision = \frac{|R \cap A|}{|A|}$$

$$F\text{-measure} = \frac{Precision \times Recall}{(1 - \alpha) \times Precision + \alpha \times Recall}$$

Experiments

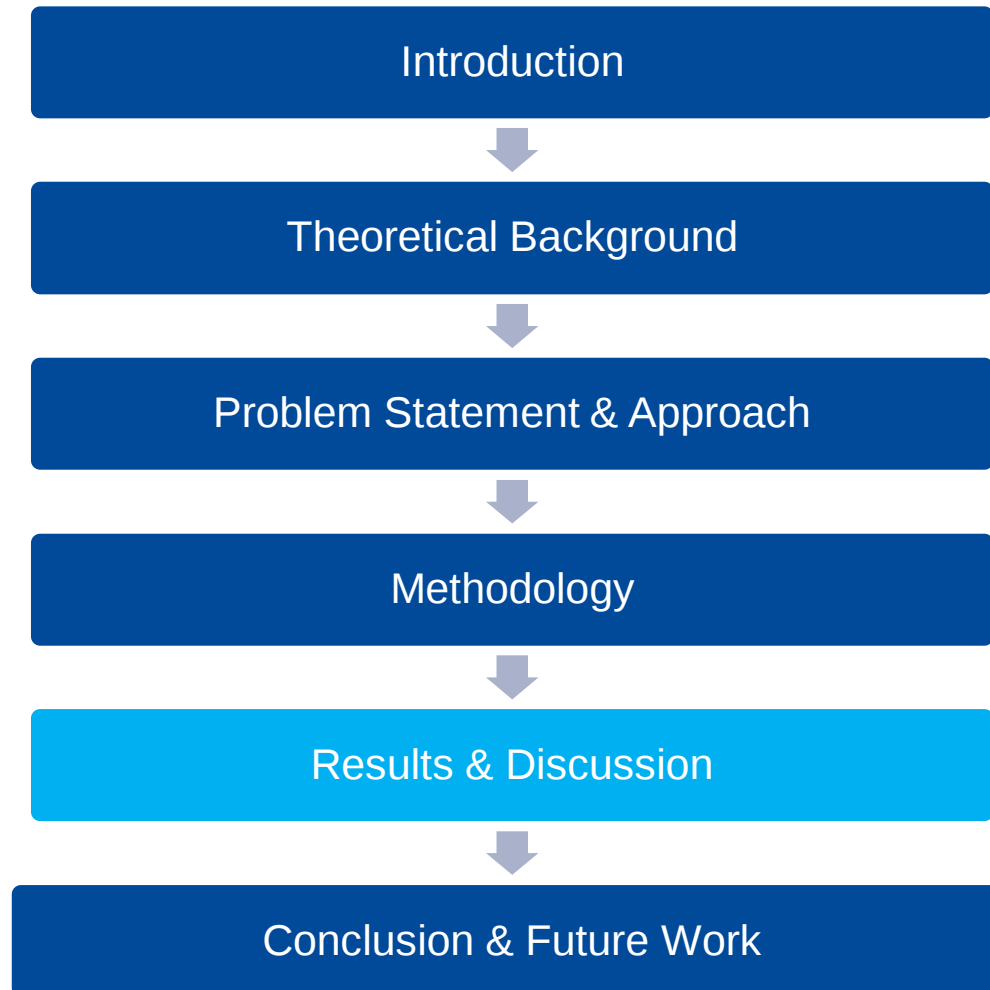


Experiments from 1 to 5 designed using AML matchers:

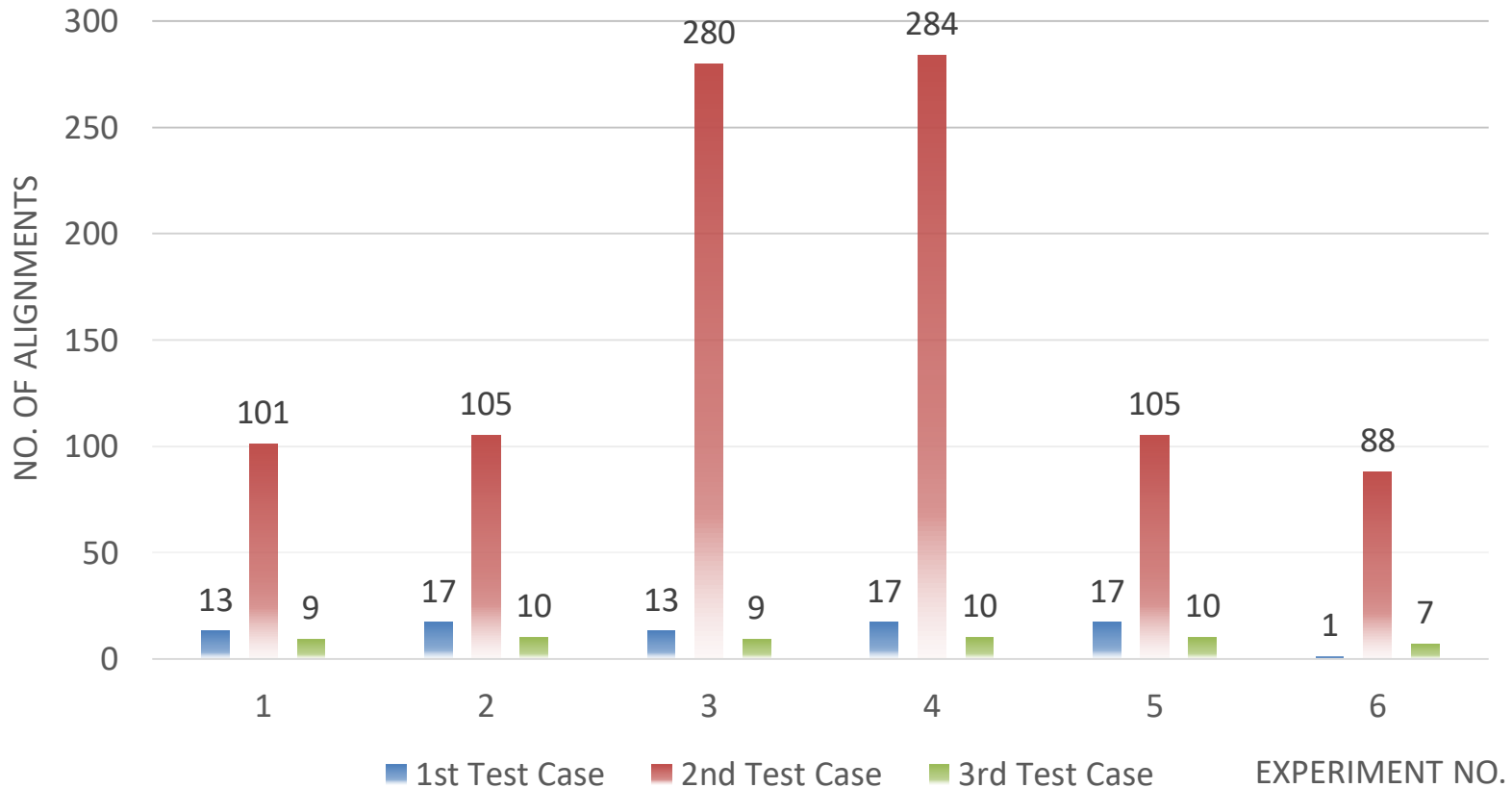
<i>Experiment No.</i>	Experiment ID	AML Property Matcher	AML Background Knowledge Matcher	Background Knowledge Ontology Used
1	AML - L	—	—	—
2	AML - LP	✓	—	—
3	AML - LB _{pt}	—	✓	Periodic Table
4	AML - LPB _{pt}	✓	✓	Periodic Table
5	AML - LPB _{EMMO}	✓	✓	EMMO

The sixth experiment designed using LogMap:

<i>Experiment No.</i>	Experiment ID	LogMap Ontology Matcher
6	LogMap - L	✓

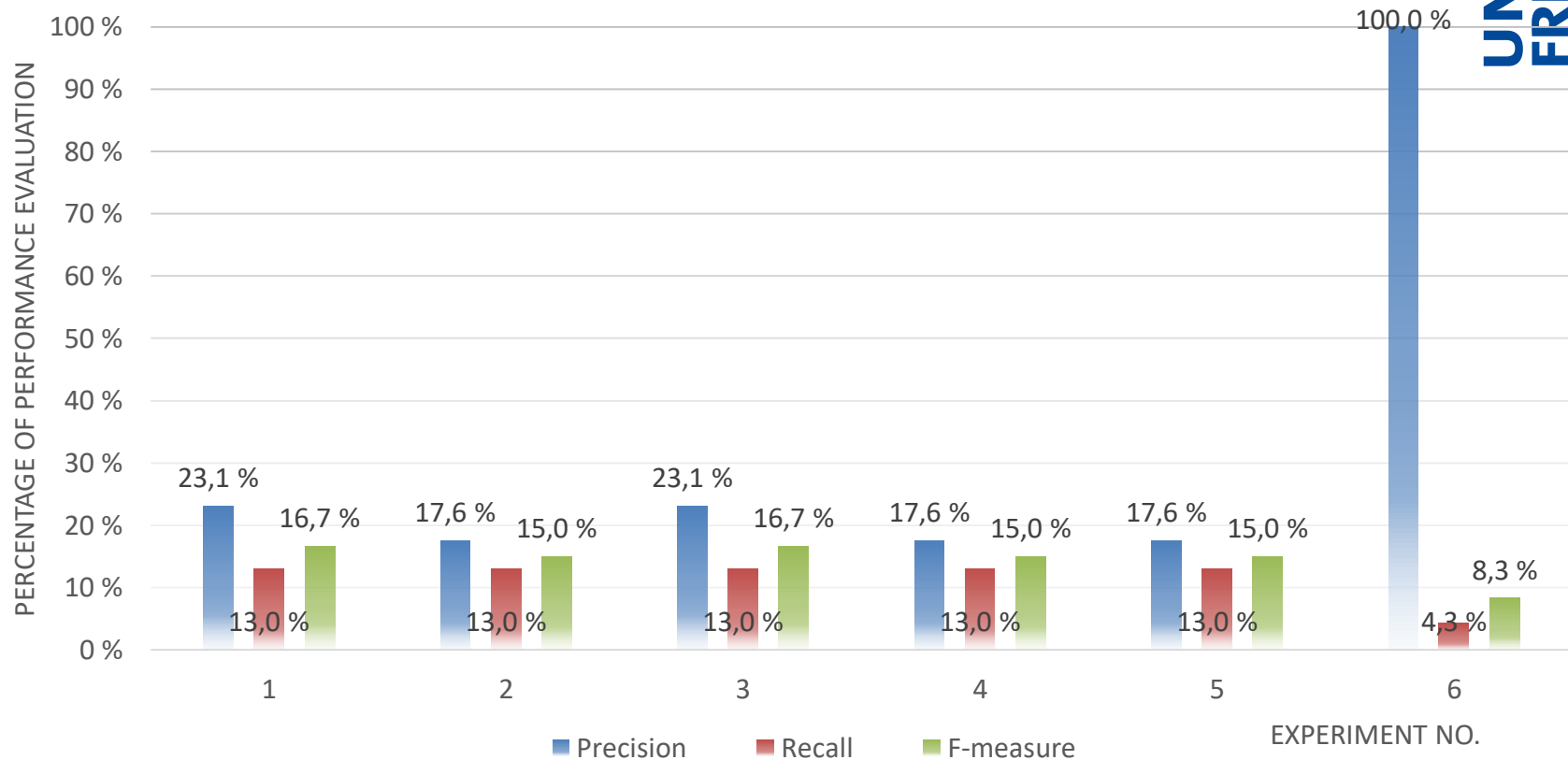


Total No. of Alignments per Experiment



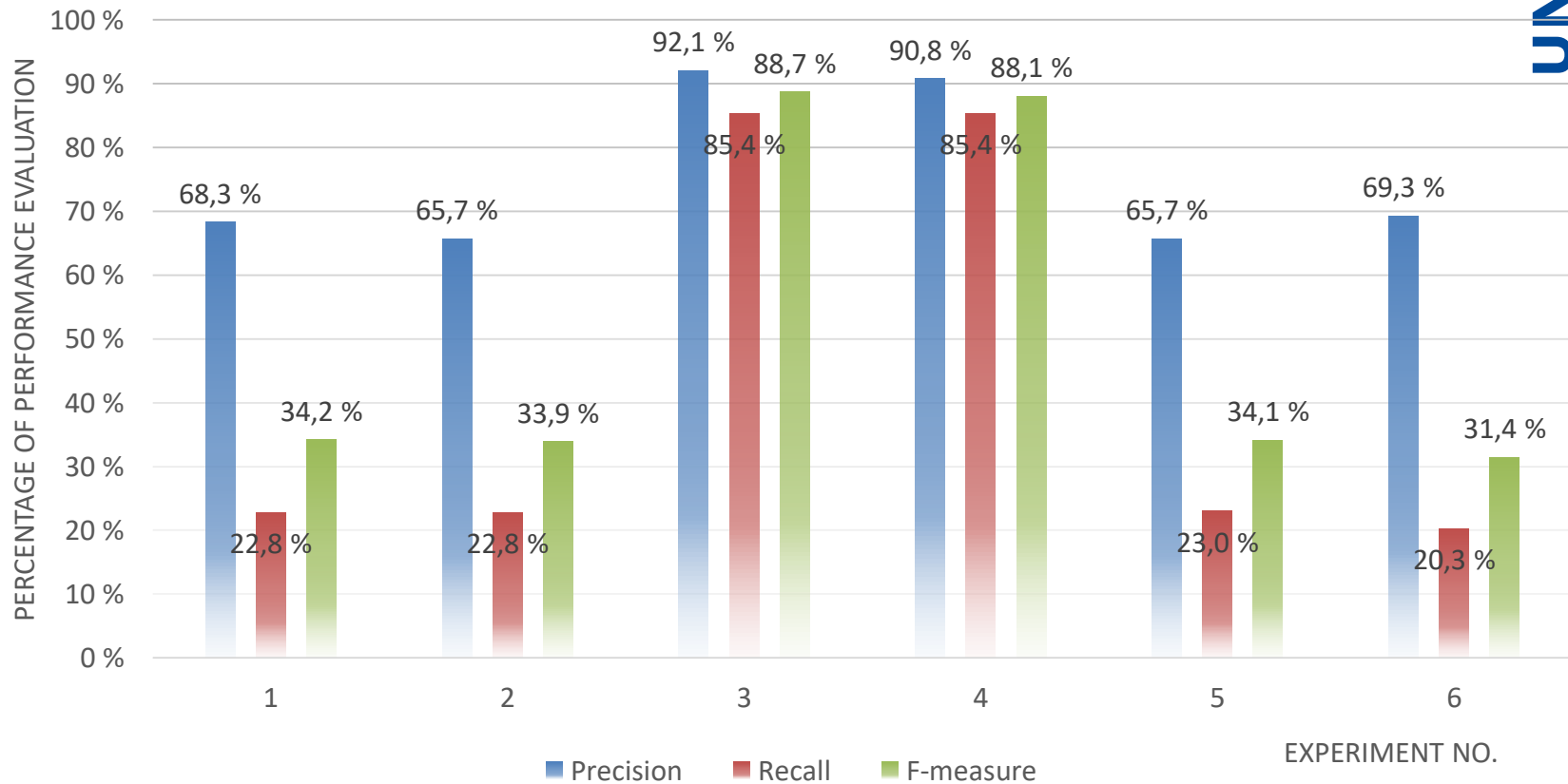
Exp 1	Exp 2	Exp 3	Exp 4	Exp 5	Exp 6
AML - L	AML - LP	AML - LB _{pt}	AML - LPB _{pt}	AML - LPB _{EMMO}	LogMap - L

1st Test Case Results



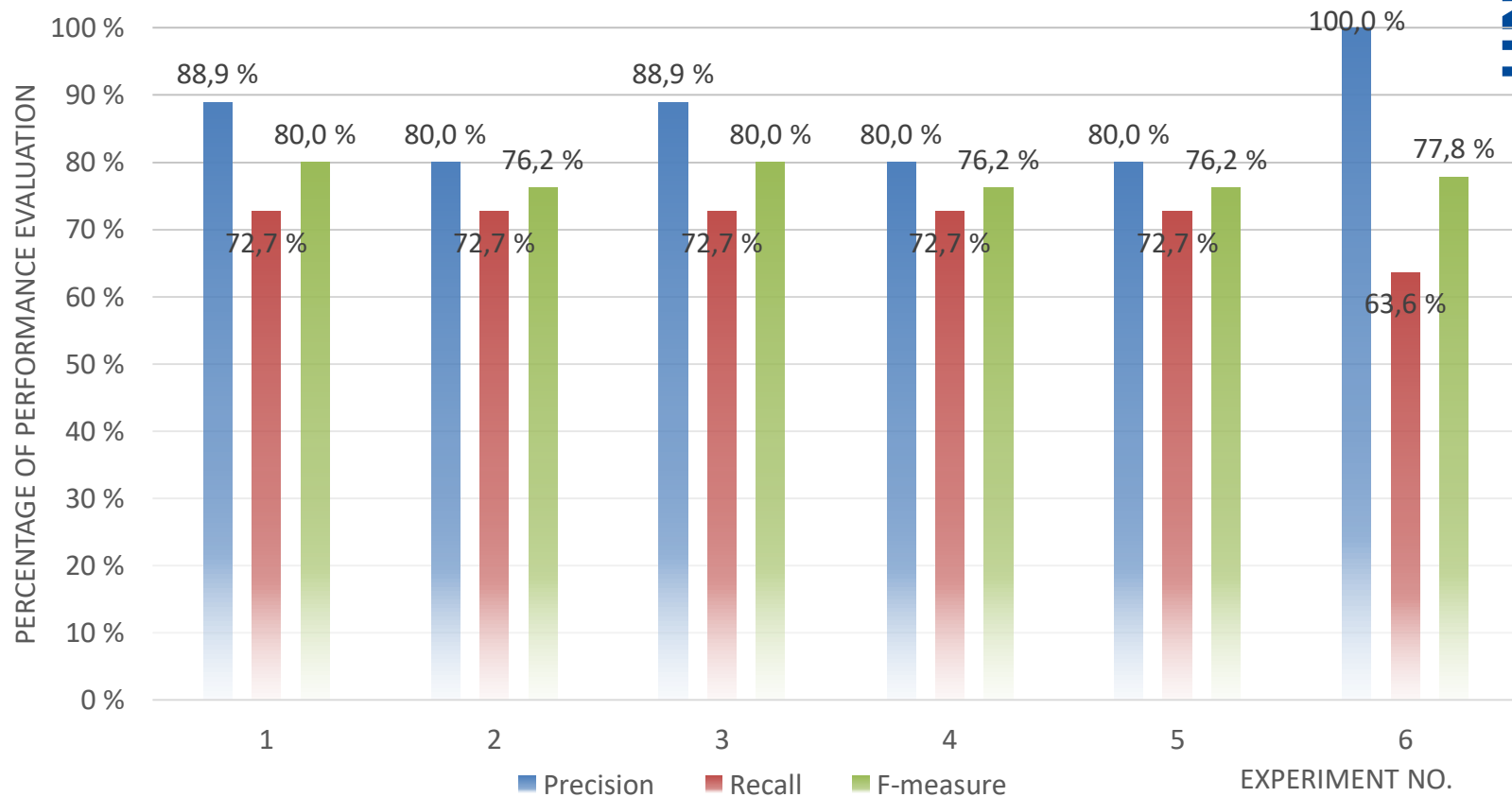
Exp 1	Exp 2	Exp 3	Exp 4	Exp 5	Exp 6
AML - L	AML - LP	AML - LB _{pt}	AML - LPB _{pt}	AML - LPB _{EMMO}	LogMap - L

2nd Test Case Results

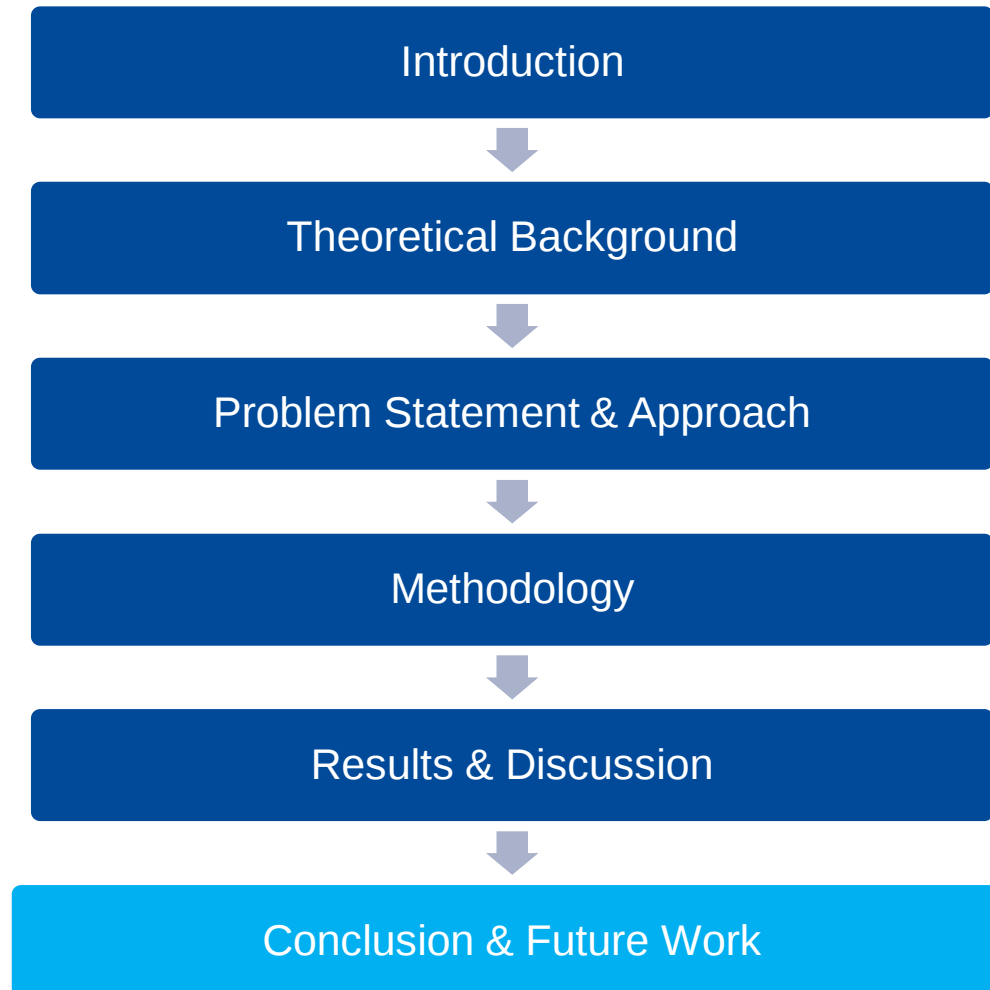


Exp 1	Exp 2	Exp 3	Exp 4	Exp 5	Exp 6
AML - L	AML - LP	AML - LB _{pt}	AML - LPB _{pt}	AML - LPB _{EMMO}	LogMap - L

3rd Test Case Results



Exp 1	Exp 2	Exp 3	Exp 4	Exp 5	Exp 6
AML - L	AML - LP	AML - LB _{pt}	AML - LPB _{pt}	AML - LPB _{EMMO}	LogMap - L



Conclusion



- The more **number of matcher** used the more number of alignments found.
- The **LogMap** achieves high precision value.
- Best evaluation results are observed using the right **Background Knowledge ontology**.
- **Property matcher** lowers the precision value.
- No fully automatic ontology matching presents.

- Improvement of Materials Sciences test cases based on more developed Materials Sciences ontologies.
- Other Materials Sciences background knowledge ontologies have to be created.
- The examined ontology matching tools have to be improved in terms of the property matcher.
- Other logically related alignments from the ontology matchers are essential, and accordingly improved benchmark will include them too.

- [1] A. Holst „Information Created Globally 2010-2025“, Sep 27, 2019.
- [2] H. Sack „What are Ontologies and why is one studying it? “, Oct 21, 2019.

*Thank
you*