Probabilistic Information Retrieval Based on Conceptual Overlap in Semantic Web Ontologies

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The Problem

- Ontologies are used in information retrieval to represent background knowledge about a domain in a machine understandable format.
- Ontologies are based on crisp logic and do not provide means for expressing subtleties in relations between concepts. Hinders the usability of ontologies.
- A Crisp partOf meronymy can not express the situation of the adjacent Venn diagram correctly. No way to quantify the concepts and the overlap between them.

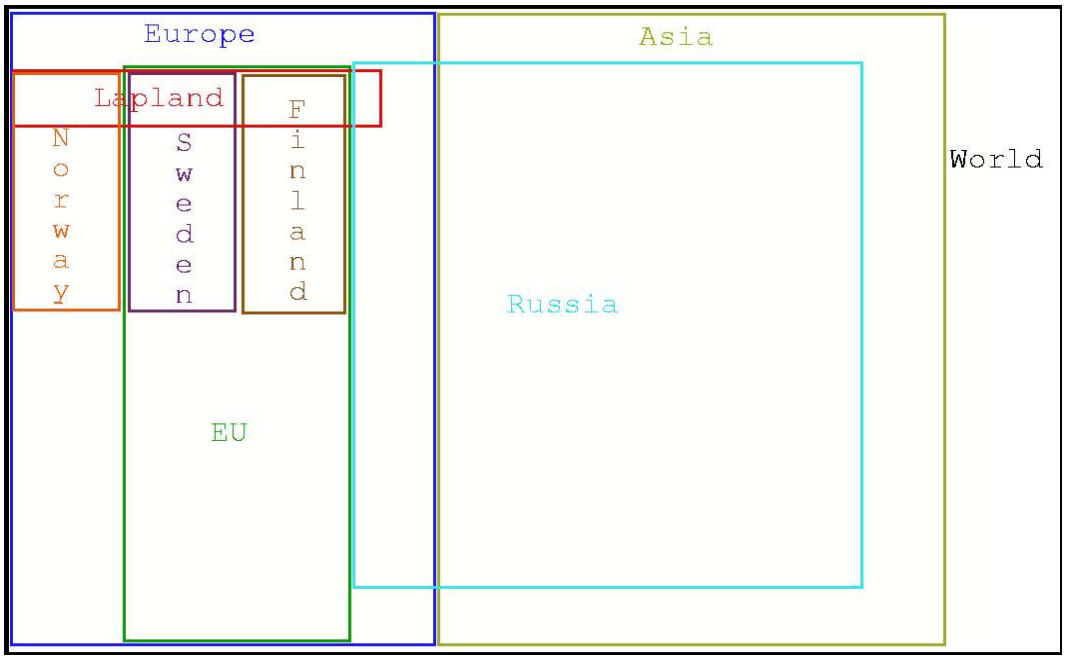

Figure 1: A Venn diagram illustrating countries, areas their overlap and size in the world.

Solution Approach

- The goal is to create a method for computing the overlaps between a selected concept and the other concepts of a taxonomy.
  - o = |Referred ∩ Selected| / |Referred|
  - An overlap table for each concept
- Each value depicts the relevance of the selected concept to the referred one
  - Hits can be sorted accordingly in a search engine
- The goal is reached in two steps:

1. Create a notation to represent concepts and degrees of subsumption in quantified form as an overlap graph
2. Compute the overlap values by transforming the graph into a Bayesian network.

Selected	Referred	Value (o)
Lapland	World	0.0306
	Europe	0.0754
	Asia	0
	EU	0.0953
	Norway	0.2222
	Sweden	0.2222
	Finland	0.2222
	Russia	0.0059

Table 1: An overlap table created for Lapland, based on the Venn diagram of figure 1.

The Process

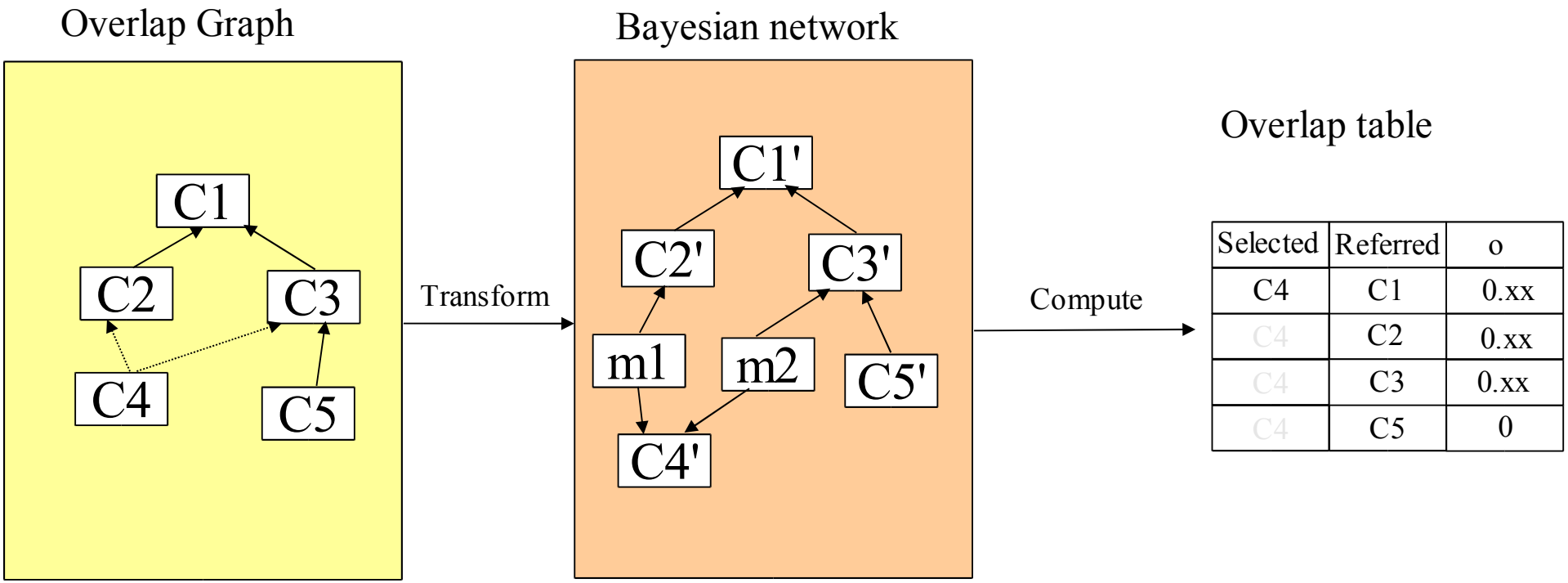

Figure 2: The overlap table computation process.

Representing Overlap

- In RDFS and OWL concept (class) refers to a set of individuals. Subsumption reduces into the subset relationship between the respective sets
  - A taxonomy can be represented as a Venn diagram
- In the graph (DAG), concepts are nodes, black arrows denote crisp subsumption, dashed arrows disjointness, and the dotted arrows quantified partial subsumption.
- Can be easily represented in RDF(S)

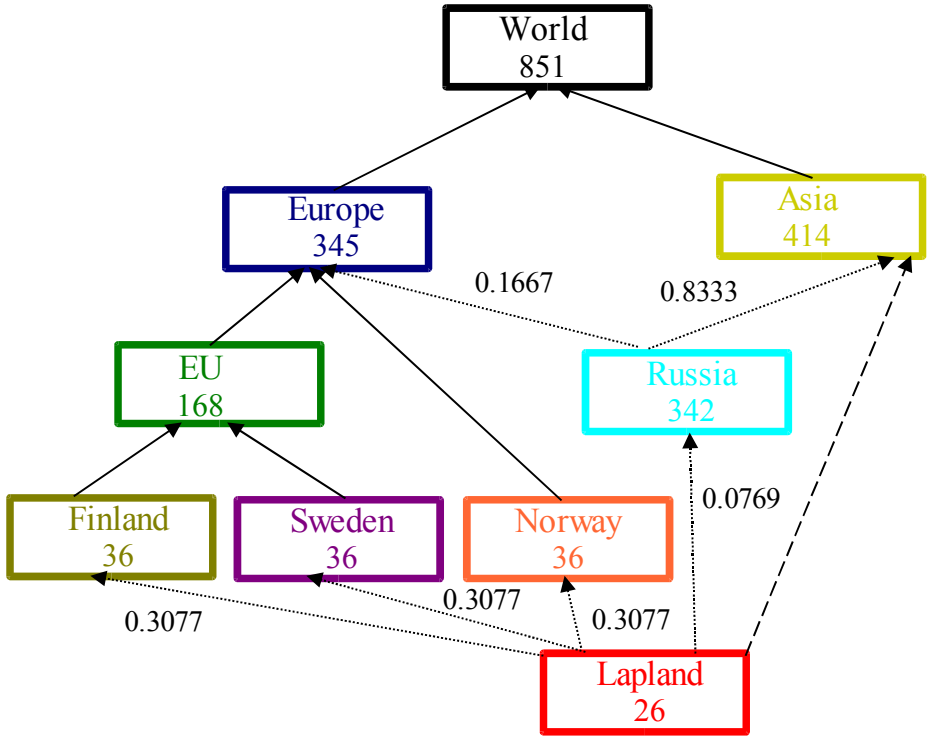

Figure 3: An overlap graph representing the Venn diagram of figure 1.

Computing the Overlaps

- An overlap value between concept A (selected) and B (referred) can be written as the conditional probability P(B'=true |A'=true).

- A' is a binary variable, s.t, A'=true means that the user is interested in concept A. P(B'=true|A'=true) is the probability that the user is interested in documents about concept B when we know that she is interested in concept A.

- For computing the overlaps we transform the overlap graph into a Bayesian network.

Solid Path Structure

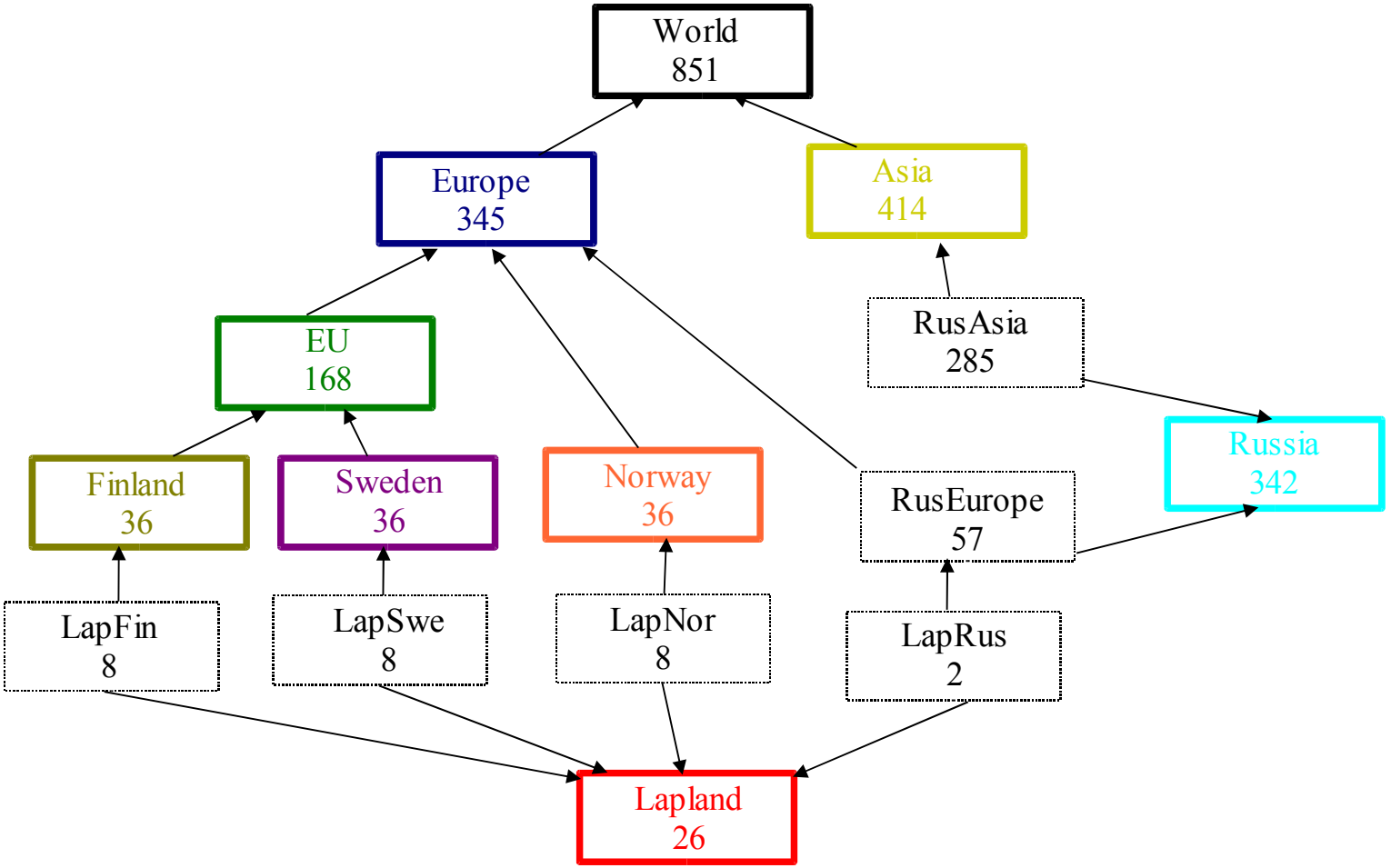

Figure 4: The graph of figure 3 transformed into a solid path structure. The dashed boxes indicate middle concepts.

Discussion

- The problem of representing uncertainty or vagueness in ontologies has been tackled also by using fuzzy logic and rough sets
  - Crisp set theory and Bayesian networks were chosen because of the sound mathematical foundations they offer
  - The calculations are simple but still enable the representation of overlap and degrees of subsumption
  - The Bayesian representation of a taxonomy can be used also in other tasks than in sorting hits in a search engine.
- Open questions and future work
  - How to quantify concept that do not have natural extensions?
  - The method makes ontologies more complicated. What are the consequences of this?
  - Is conceptual overlap a sensible basis for sorting hits in a search engine?
  - The method should be tested in realistic application situations.

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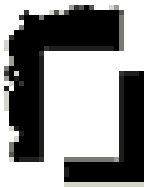

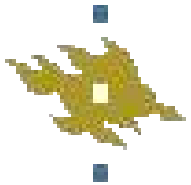

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