OntoMeter: Metrics for Ontologies

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The Problem

Formal correctness is just a precondition for a useful ontology. Equally important is the ontology content, i.e. how well the available collection of concepts satisfies the linguistic requirements of a specific domain. Recent research has shown that a major problem in the development and maintenance of ontologies for products and services is the terminological dynamics in markets: New products or business concepts evolve quickly and require new product classes, and existing products change and demand for new properties. It can be assumed that the problem of dynamics with regard to concepts in a domain is of general importance. This indicates the need for additional research in the field of ontology maintenance in order to support a timelier and more comprehensive capture of the active vocabulary in a given domain. In this context, metrics can help monitor the progress in the development and maintenance of ontologies.

Ontology Metrics

Except for the raw number of classes and properties, there are no general, easily ascertainable indicators that help assess the content quality of an ontology. The mere number of those two constructs alone, however, is a poor indicator of the actual quality. Both reflect only the size of an ontology, but ignore
- the actual coverage of relevant meaning,
- the degree of order and structure,
- and the amount of constraints and assertions that make concepts more specific.

The following is a tentative list of metrics categories that are being evaluated:
1. Metrics for size (e.g. number of classes, number of properties, and lines of OWL code)
2. Metrics for structure (e.g. distribution of subclasses along the top-level classes)
3. Metrics for terminology precision (e.g. number of subclasses per top-level class, weighted by the depth of branching; distribution properties of this parameter)
4. Metrics for property usage and restrictions
5. Metrics for comprehensiveness and coverage

With regard to product classification schemes like eCl@ss and UNSPSC, such metrics have already been identified. The current challenge is to adapt those approaches to the greater degree of structural freedom in a full ontology.

Areas of Application

The proposed metrics can be employed to assess the quality of existing ontologies and to point to specific shortcomings. In addition to that, bodies involved in the development of ontologies could use those new metrics to
1. monitor the development of content quality,
2. assess the amount of resources necessary to eliminate the shortcomings,
3. rank content maintenance alternatives, and possibly
4. motivate interest groups to help improve currently weak segments of the ontology.

The OntoMeter Tool

The goal of the OntoMeter project is to develop and evaluate metrics for the content quality of ontologies and simple descriptive languages for products and services. The work includes the OntoMeter tool that automatically determines the relevant values for a given OWL ontology file.

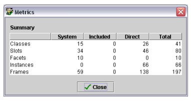

Fig. 1: Metrics in Protegé

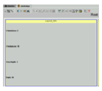

Fig. 2: Metrics in Jambalaya

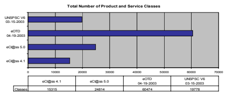

Fig. 3: Size of Product Content Standards

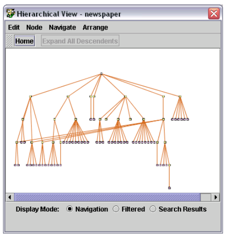

Fig. 4: Displaying the Hierarchy with Jambalaya

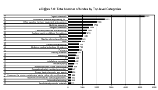

Fig. 5: Distribution of Entries in eCl@ss 5.0

Ontology Size

It is comparatively easy to measure the mere size of an ontology, and popular tools like Protegé (Fig. 1) or Jambalaya (Fig. 2) already provide such basic information. There are, however, two reasons why those metrics are of limited value: (1) Ontologies might not be a well-balanced vocabulary, but can be huge due to many very specific (but probably irrelevant) classes. (2) Ontologies will be merged and thus the size of one single ontology is not very important. For comparison, Fig. 3 shows the pure number of entries in three content standards for products and services.

Ontology Structure

The structure of an ontology, i.e. the network of relationships between classes, seems to be a promising approach to measure the content quality of an ontology. It is either possible to visualize hierarchical relationships (see Fig. 4, created with Jambalaya), or to count all descendents of the top-level classes and sort them by the number of subclasses. This reveals well-populated branches and may point to lack of coverage or semantic precision. Fig. 5 shows the distribution of entries along the top-level hierarchy of the content standard eCl@ss 5.0.

Semantic Weight and Value

A property that is asserted to many classes is generally less specific than one assigned to only a few. This can be used to measure the semantic specificity of classes in an ontology in two steps: First, the *Semantic Weight* for each property in the ontology is determined. In a second step, the *Semantic Value* for each single class is computed by adding the semantic weights of all attributes asserted and inherited.

Semantic Weight of Properties: For each property P_i with $i = 1, \ldots,$ *Number of Properties* in the ontology, count the number of classes that have this property, either by a direct assertion, or by inheritance. This yields the number of occurrences of property P_i. Thus, each property P_i receives a semantic weight SW_i that is equal to the reciprocal value of its usage frequency (this idea resembles basic concepts in information and communication theory).

$$SW_i = \frac{1}{Number\ of\ Classes\ Having\ P_i}$$

Semantic Value: Now, for each class C_j in the ontology, we sum up the semantic weights of all properties. This yields the semantic value SV_j for the Class C_j with $j=1, \ldots,$ *Number of Classes*

The fundamental rationale is that more property assertions mean a higher semantic specificity of the class, but very frequently used properties add less semantic than specific ones.

Work in Progress

The current work focuses on the development and testing of metrics for all listed categories. As a next step, the promising metrics will be implemented in the OntoMeter tool, which will read in OWL ontologies and automatically determine the respective values. This tool will then provide the data for further analysis (e.g. scatter diagrams or correlation coefficients between selected metrics and human quality rating for available ontologies).

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