Product modelling and the Semantic Web

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ABSTRACT
This poster describes the scope and current work of the W3C Product Modelling Incubator Group.

Categories and Subject Descriptors
J.6 Computer applications: Computer-aided engineering – *computer-aided design, product design, Product Lifecycle Management(PLM), Product Data Management (PDM),* Life Cycle Assessment (LCA).

General Terms
Theory, standardization

Keywords
product, model, structure, ontology, property, quantity, unit

SCOPE
The poster will show the latest results of the W3C Product modelling XG [1], which began work in June 2008. The first topics addressed by the XG have been:

- how physical products are put together from parts – this is product structure; and
- the physical properties of products – these are properties which are observable or measurable.

PROBLEM
There has been more than twenty years of development of standards for the representation of the structure of a product and its physical properties. The notable result has been the STEP (ISO 10303) [2] family of standards and the PDM (Product Data Management) [3] schema, which is used within the aerospace and automotive industries and the military.

Although the representation of the PDM schema is formal (it is in the EXPRESS language), the objects within the schema do not have formally defined semantics. As a result the schema is complicated, and is surrounded by implementers' agreements which are necessary for reliable exchange.

The pressure to produce a more formal representation of product data comes from two groups of users:

1) Within the existing community using ISO 10303, there is a need to use formal methods to validate designs. For example, a design rule could be "if there is no heating for the fuel line, then the equipment cannot be used in a low temperature environment." A formal representation of the design enables an automated query to decide "can an item of design X be used in a low temperature environment".

2) Collaborative product development involving multiple companies need to share design information produced within multiple design authoring tools with the ability to reliably integrate information and track design changes.

3) Smaller companies wish to publish product data on the Web for the benefit of their direct customers and end users. A simple solution is required, because smaller companies do not have the budget for PDM software.

The publication of product structure and properties on the Web will allow navigation that is both down the assembly structure of a product and back along the supply chain. A simple use of this capability would be to calculate the total mass of a product from the masses of its components. This is not trivial to do automatically, because the following must be stated explicitly:

- an enumerated set of components contains *all* components, so that each part of the whole that is part of an assembly of one or more of the components;
- each components in the set is disjoint with all the rest, so that there is no part of one component that is also a part of another.

Two examples of the use of product data published on the Web are as follows:

- Navigation back along the supply chain is necessary for LCA (Life Cycle Assessment). The total inputs from resources and outputs to the environment for an assembly can be calculated by looking a the processes required to manufacture the assembly, and to manufacture each part.
- Navigation down the assembly structure is necessary for compliance with the EU REACH (Registration, Evaluation, Authorisation and Restriction of CHemical substances) directive. Under this directive, a supplier is required to know what chemicals are within a product.

OBJECTIVE OF THE PRODUCT MODELLING XG
The Product Modelling XG intends to create a "product core" ontology, so that statements about a product can be made using:

- A generic "product core", which will consist of a few tens of classes and properties.
- Standard extensions to the "product core" specific to particular applications. The scope will be similar to the information models contained within IFC [4], STEP and ISO 15926 [5], and to the ontologies being developed within the

SWOP [6] and S-TEN [7] projects. These will consist of a few hundreds of classes and properties.

- Reference data which may be defined by engineering data standards such as ISO 15926-4 or by product suppliers. This will consist of many hundreds of thousands of classes and properties.

The further objective is to use existing ontology modelling languages, with extensions if necessary to host a “product core” ontology and the specializations that will be constructed for specific product development activities. An ontology modelling language would be used to express the content existing standards work such as ISO 10303.

The existing standards represent an immense amount of valuable domain knowledge. However, these standards do not have a formal semantics. The result of not having a formal semantics is that the meaning of the concepts depends on their interpretation by domain subject matter experts. A formal semantics allows for precision in defining the meaning of product modelling concepts. Reasoning algorithms could then be used to provide logically valid answers questions regarding product models.

INITIAL PROGRAM OF WORK

The XG is working initially on a good reusable semantic modelling pattern for the important issues of "quantities, units and scales". After that the group sees a clear roadmap of other product modelling issues ahead to be resolved. In the short term, the issues that are targeted will include: product decomposition and topological relationships (objects bounding and/or including other objects).

In the longer term, the group will work on explicit shape representation (geometry), handling of features, product knowledge rules in the form of assertions and derivations, variant classes involving fixed values, defaults values/instances, change and version management and the modelling and matching of end-user product requirements.

APPROACH

The XG approach is to integrate existing standards work such as ISO 10303 within a Description Logic framework as exemplified by OWL 2 [8]. OWL 2 is the paradigm of an expressive conceptual modeling language with a formal semantics which is designed to be decidable and so have tractable reasoning algorithms. OWL has much of the expressiveness needed for product modeling, but extensions to OWL 2 may be required [9], however any extensions must be considered carefully to avoid compromising the tractableness of OWL reasoning.

QUANTITIES, UNITS AND SCALES

A basic technology for all scientific and engineering data is a formal approach to physical properties which is based upon standards for quantities, units and scales, such as ISO/IEC 80000 and ISO 1000, and the formal definitions provided by the BIPM.

Previous data modelling standards have specified the use of keywords which are linked to the standards for quantities, units and scales by person readable text. The Semantic Web requires something more formal, so the approach within the Product Modelling XG is:

1. create an ontology which encompasses objects defined within the standards, such as ‘quantity’, ‘unit’ and ‘scale’;
2. work with the organisations with authority in this area, such as ISO TC 12, to assign URIs to quantities such as ‘length’ and ‘thermodynamic temperature”, to units such as ‘metre’ and ‘Kelvin’, and to scales such as ‘Celsius’.

Step (2) is essential because on the Semantic Web the URI for the metre should be assigned by the organization responsible for the metre and within its domain.

It could be argued that, because the metre is unlikely to change and because there is no requirement to dereference the metre, it does not matter who assigns the URI. This may be true of the metre, but it is not true of the International Temperature Scale of 1990 [10]. The scale is certain to change in the future with advances in metrology. The specification of the scale could also have a formal representation as a set of computer interpretable statements.

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