Toward Ontology-based Production - Relations building Airplanes

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1 Ontologies

Ontologies are widely used in computer science for knowledge representation and form a basis for applications in artificial intelligence. Intuitively, they enriche simple taxonomies as known for example from biology by relations between the objects. Similar to object oriented programming, the concepts support inheritance and derivation, and there is the possibility to pose restrictions on the relations between the concepts. As in databases, these concepts and relations can be instanciated whereby the instances have to obey the structure imposed by the concepts and their relations.

There are different tools for creating and editing ontologies; one of the best-known is *Protégé* from Standford University. It offers a intuitive graphical interface for the tree structure of the hierarchy of the concepts, together with a graph visualization for displaying the relations between the concepts. Figure 1 show a screenshot from this tool.

2 Capabilities in Ontologies

During a production process, the involved machines and actuators have to perform various tasks which can be executed using skills and capabilities. For example, the of driving a screw requires the capability of screw driving. However, there may be more sophisticated tasks requiring collaboration of robots as handling of large matrices. Moreover, next to capabilities of plants also materials and their properties can be stored in ontologies. The power of ontologies compared to classical databases or knowledge systems can now be seen by the possibility of defining capabilities as relations betweens machines and materials. Those relations can also be enhanced (similar to labels in edge labeled graphs) by data like maximum weight of a piece of material which can be handled by the respective tool. All those involved concepts like tools, materials and capabilities can be described in a hierarchical manner. For example, assembly capabilities include (among others) gluing, riveting and screwing. Gluing can be divided according to the used glue and the material to be glued, screwing by hole size and material etc.

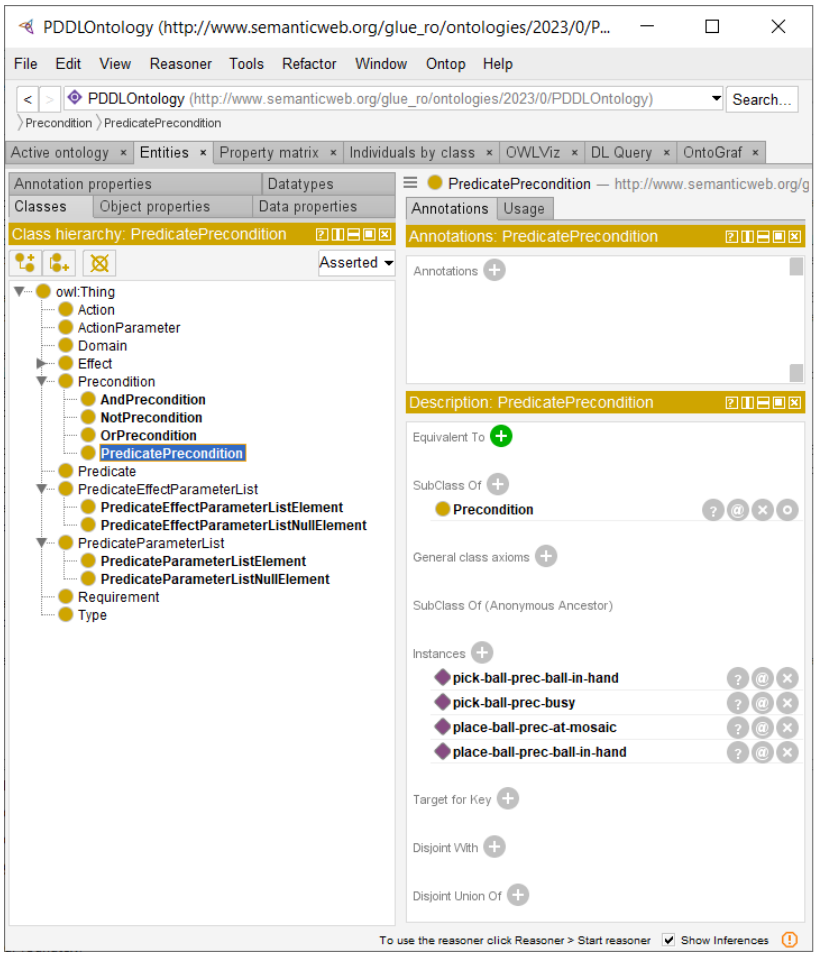

Fig. 1. A PDDL Ontology in Protégé

3 From Ontologies to Processes

Ontologies alone are not enough to model and plan production processes. A common framework for scheduling and planning is built around PDDL (Problem Domain Definition Language). There, actions are modelled by preconditions, involved entities and postconditions; additionally, a set of predicates describing the start and the goal state, resp., has to be specified to formulate a problem instance. On this input, a PDDL planner can search for a suitable sequence of actions transforming the start state into the goal state.

Our work is currently concernced with building an ontology for PDDL which can be derived from ontologies containing available capabilities and an input specifying the goal state (the initial state is in most application some kind of default space which does not need an exact specification). A recent version is shown in Figure 1, where the left side (in yellow) show the actual ontology whereas the right part displays four instances of the concept *Precondition* (this example models a simple pick-and-place sample process of red and white balls forming a mosaic). In turn, from an instance of such an ontology a PDDL instance can be generated and used for further process planning.

4 Outlook

We tried to give a short overview how ontologies can be used in practice and hope that we draw interest of the RAMiCS community to this topic. It seems to us that ontologies are worth to be studied from a formal (relation-)algebraic point of view. Future directions of work could include both verification and generation of ontologies under consideration. A possible starting point of research is the already well-established treatment of relational databases in the (relation)-algebraic setting.