Application of Semantic Web Technologies to UML based Air Force DoDAF Efforts

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Introduction

The Department of Defense (DoD) Architecture Framework[1] (DoDAF) "defines a common approach for architecture description, development, presentation, and integration for both operational and business processes. It is intended to ensure that architecture descriptions can be compared and related across organizational and mission area boundaries, including Joint multi-national boundaries and DoD warfighting and business domains."[2] As such, it guides the Air Force's architecture development efforts to describe system(s) performance, interoperability, and processes. A typical architecture consists of several views showing such things as node connectivity, information exchanges, and organizational models. Several UML diagrams, particularly Class, Activity, and Sequence diagrams, are used extensively in DoDAF efforts. However, the end products are intended for a human audience and are not easily machine reasonable.

A natural set of questions are: how can the information contained within these UML models be used to support automated reasoning and other processing to achieve better, more integrated architectures? How does context come into play when comparing these diagrams, both within an architecture, and especially, across architectures? What techniques and methods exist to capture and relate the semantics contained in these UML diagrams? Is an ontology (or some other formal knowledge representation) a prerequisite to establish context?

Background

The relationship between UML and ontologies has been of interest to the knowledge engineering community for some time. Many of these efforts have focused on using UML as a means for developing ontologies, with less emphasis on extracting semantic data from existing UML diagrams [3-6]. There are also efforts aimed at transformation [7], and efforts to develop tools to support closer interaction between UML and ontologies [8,9]. One project has developed code to convert Rational Rose petal files into RDF [10].

On the DoDAF side, TopQuadrant is developing a set of ontologies specifically for the DoDAF [11], although they are not (yet?) available for public release. These appear to be built using Protégé; no mention is made of UML.

What may be the most comprehensive effort is being led by the Object Management Group (OMG), which is sponsoring a Model Driven Architecture (MDA) based initiative to represent the semantics of ontologies (including, but not limited to OWL) in a MOF2 compliant metamodel, called the Ontology Definition Metamodel (ODM). Also included in this initiative is a requirement for a UML Profile that extends the UML2 metamodel to support ontology definition. The ODM will therefore act as a bridge between UML models and ontologies. This effort holds forth the prospect that automated conversion between the two may be available in the near future, at least as far as the fundamental differences between the two will allow. The OMG has issued an RFP for the ODM, which industry has responded to [12].

Discussion

If extracting the semantic data from UML diagrams were sufficient to provide all of the information needed for architecture integration, then a purely mechanical conversion process would be all that was needed. However, context plays an important role in determining which semantic interpretations are valid and under what circumstances. For example, in the simple activity diagram below, operational activity 1.1 requires information item 1 in order to be completed, and produces information item 2.

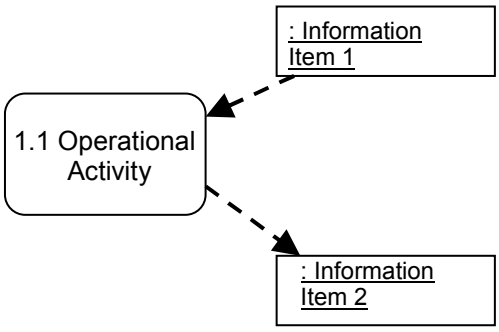

Figure 1 – UML Activity Diagram Fragment

The semantics of this diagram can be extracted, but does it follow that the behavior applies in all situations where operational activity 1.1 occurs? If not, where and how is it defined? Also, at what level of detail does an architect need to represent operational activity 1.1 (and information items 1 and 2) in order to make such analysis feasible? It is

very possible that the same activity may occur in another architecture under a different name.

To support the DoDAF objective of relating architectures across organizational and mission area boundaries it is clear that:

- comparison and integration of architectures must be done in context and with some level of formalism
- ontologies (or some other KR representation) are needed to express context and formalism
- architecture integration will require the merger (and reconciliation) of each architecture's formal representation

Obstacles preventing the integration of architectures include the lack of formalism and context in UML diagrams, effects of different architecting style (subtle variations of style among architects and the existence of legacy diagrams), and organizational barriers that prevent architects from working together. Recently, the DoD has seen the formation of a number of Communities of Interest (COIs) to encourage the development of common vocabularies and shared services. Perhaps these will be convenient vehicles for defining the semantics necessary for architecture integration.

The DoD has made a substantial investment in architecture efforts. In order to achieve its objective it is necessary for these efforts to work together synergistically. This represents a wide open area of research and application for semantic web technologies.

References

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