Chapter 11
tOWL: Integrating Time in OWL

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Abstract  The Web Ontology Language (OWL) is the most expressive standard language for modeling ontologies on the Semantic Web. In this chapter, we present the temporal OWL (tOWL) language: a temporal extension of the OWL DL language. tOWL is based on three layers added on top of OWL DL. The first layer is the Concrete Domains layer, which allows the representation of restrictions using concrete domain binary predicates. The second layer is the Time Representation layer, which adds time points, intervals, and Allen’s 13 interval relations. The third layer is the Change Representation layer which supports a perdurantist view on the world, and allows the representation of complex temporal axioms, such as state transitions. A Leveraged Buyout process is used to exemplify the different tOWL constructs and show the tOWL applicability in a business context.

11.1 Introduction

In its role as reference system, time is, beyond any doubt, one of the most encountered dimensions in a variety of domains. Naturally, dealing with time has been, and continues to be, one of the major concerns in different fields, including knowledge representation.

When including time in a knowledge representation language, one can choose to model linear time or branching time. Linear time uses a single line of time (one future), while branching time employs many time lines (possible futures). Based on the inclusion of time representations in the language, we distinguish between explicit and implicit approaches. In an explicit approach, time is part of the language, and in an implicit approach, time is inherent in the ordering of states. For an explicit temporal representation, we differentiate between time points and time intervals. Also, the explicit representations can further be defined using an internal

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or an external view on time. In an external view, an individual has different states at different moments in time, and in the internal view, an individual is seen as collection of different parts, each one holding at a certain moment in time. In other words, the external view uses an endurantist view on the world, and the internal view uses a perdurantist view on the world.

For modeling time one has at least two options to consider: valid time and transaction time. Valid time denotes the time during which the data is true in the modeled world. Transaction time represents the time at which the data was stored. Another differentiation pertains to whether we model relative time as “next week” or absolute time as “24 May 2009 15:00 CEST”.

The considerable and ever-increasing volume of data present on the Web today motivates a need to move from free-text representations of data to semantically rich representations of information. Endeavors in this direction are being undertaken under a common denominator: the Semantic Web [4]. The state-of-the-art tools and languages provided under this umbrella, such as RDF(S) [5, 11] and OWL [3], go beyond the Web and provide the means for data sharing and reuse outside this platform, i.e., in the form of semantic applications. Despite the omnipresence of time in any Web knowledge representation, the current RDF(S) and OWL standards do not support at language level temporal representations, failing thus to provide a uniform way of specifying and accessing temporal information.

Previous attempts [6] to represent time and change relate to RDF extensions that are able to cope only to a limited extent with the semantics of temporal representations. Also, these languages are difficult to use in practice as they do not have an RDF/XML serialization. Other solutions are based on proposing ontologies [9, 17] for modeling time and/or change. These approaches also present shortcomings when modeling temporal semantics as they are bound to the OWL expressivity power.

In this chapter, we present a temporal ontology language, i.e., tOWL, addressing the current limitations on representing temporality on the Semantic Web. We model valid time using an absolute time representation. By employing a similar approach, one can model also transaction time, and by determining the context of temporal expressions it is also possible to use relative time by converting it internally to an absolute representation. Our language is able to represent linear time using an explicit time specification. It supports both time points and time intervals, and adopts an internal (predurantist) view on the world. The proposed language builds upon OWL, the most expressive Semantic Web standard in knowledge representation. The current contribution is focused around employing the tOWL language for the representation of business processes, the Leveraged Buyout process.

Section 11.2 presents the concrete domains and fluents notions needed in order to understand the tOWL language. In Sect. 11.3 we describe the tOWL language by providing its layered architecture, and the OWL schema representation in RDF/XML of its vocabulary. After that, in Sect. 11.4, we present the TBox and ABox of the tOWL ontology for a Leveraged Buyout example. Section 11.5 compares the related work with the tOWL approach. Last, in Sect. 11.6, we present our concluding remarks and identify possible future work.