The tOWL Temporal Web Ontology Language

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Abstract

The emergence of Web 2.0 and the Semantic Web as established technologies is fostering a whole new breed of intelligent Web applications and systems. These are often centered on knowledge engineering and context awareness. However, adequate temporal formalisms underlying context awareness are currently scarce. Our focus in this paper is two-fold. We first introduce a new OWL-based temporal formalism - tOWL - for the representation of time, change, and state transitions. Based hereon we present a financial Web-based application centered on the aggregation of stock recommendations and financial data.

1 Introduction

Information on the Web is mostly textual in nature. Its character is descriptive and meaningless without its most skilled interpreter: the human brain. If the goal of automating the aggregation of vast amounts of information is to be achieved, then this information should be described in a machine-readable way enabling applications to at least simulate some understanding of the data being processed. The emergence of Web 2.0 and the Semantic Web as established technologies is fuelling a transition from a Web of data to a Web of knowledge. In turn, this knowledge rich environment is fostering a whole new breed of intelligent Web applications and systems, centered on knowledge aggregation and context awareness. Focusing on the latter, it can rightfully be stated that enabling context awareness involves the existence of adequate temporal formalisms - currently very scarce in a Semantic Web context. This results in ad hoc (and often not reusable) solutions for dealing with temporal aspects on the Web.

One of the domains with a prominent temporal aspect, which forms the focus of our current research, is the financial one. More specifically, we seek to explore the area of engineering Web applications for automated trading, an area far too little investigated in such a context. Although seemingly not directly related to automated trading, the Semantic Web may come to meet the increased technological demands emerging in the world of trading. In achieving this purpose, it is necessary to provide extensions to current Semantic Web languages, thus making the latter more suitable for the knowledge we seek to represent. One such extension is presented in this paper and concerns a temporal ontology language based on OWL-DL - the TOWL language. This language stands at the basis of the financial application we present in this paper, and forms one of the key ingredients allowing the aggregation of historical stock recommendations and financial data.

2 The Approach

The temporal language we propose is designed as a set of extensions built on top of OWL-DL. The complete tOWL layer cake is presented in Figure 1. As can be observed from this figure, the foundation for our current approach consists of the DL species of OWL, upon which time-related functionality is added. The first extension introduced by tOWL concerns the expressiveness of the language in a broader sense, rather than being restricted to a temporal domain. Based on current results on concrete domains [1], tOWL has a *Concrete Domains Layer* (CDL) that enables the representation of restrictions over pairs of

compositions of functional roles (feature chains) as well as restrictions over pairs of compositions of a functional and a non-functional role.

Partly enabled by the CDL, the *Time Representation Layer* (TRL) adds a temporal reference system to the language, in the form of concrete time (instants and intervals) and 13 concrete temporal relations – Allen relations (e.g., 'equal', 'before', 'after', 'meets', 'met-by', etc.). The TRL employs the CDC layer for the representation of temporal restrictions between time-bounded entities, as for example the interval concept is defined as having the start time instant before or equal to the end time instant.

Upon enabling temporal reference in the language, the representation of change and state transitions is provided through the *TimeSlices/Fluents Layer* (TFL). This extension enables the representation of temporal parts of individuals, through timeslices and fluents [2]. Timeslices represent the temporal parts of concept instances. Fluents are properties associated to concepts that may have differerent values at various moments in time.

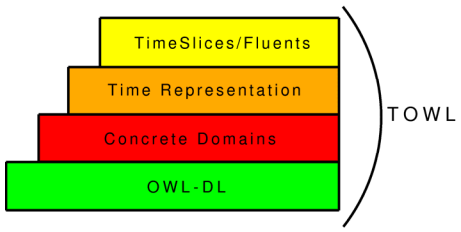

Figure 1. The tOWL Layer Cake

3 Stock Recommendations Aggregation System

Stock recommendations, although taking on different denominations, can always be reduced to advices of the form buy/hold/sell. They are issued by large brokerage firms, and mirror the expectations regarding the development of the stock price of the envisioned company. The collection of such recommendations that are true at a given point in time is denoted as market consensus, and can often be a good indicator of the average expectation regarding the future (within 1 year) value of a company. Roughly, a stock recommendation thus consists of the issuer (the brokerage firm), the targeted company, and the type of the advice (buy/hold/sell).

As a proof-of-concept we have implemented a Stock Recommendations Aggregation System (SRAS), which uses tOWL to represent and reason with the temporal dimension of emerging stock recommentions. The preliminary results present a number of interesting aspects. Perhaps the most striking one relates to the fact that the aggregated recommendation generated by SRAS does not always follow the market consensus. In other words, a recommendation's distribution (across buy, hold and sell) that has a unique maximum (say buy), does not always agree with the advice generated by the application. This could be an indicator that taking into account historical performance of brokerage firms leads to the creation of new knowledge regarding the most likely development of a company's share price.

4 Acknowledgement

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