Intelligent Agent for Modeling and Processing Decisional Workflows in Logistics

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ABSTRACT

The authors present the design and some implementation trials of Atlas, a new reasoning and decision making assistant used for processing complex and heterogeneous procedural workflows. Benefiting from a multicore implementation, Atlas includes different solving engines that are selected according to the intrinsic complexity of the problem being processed. The operational knowledge of Atlas is accessed through 2 different views. In an analytical view, the knowledge is modeled on elementary if-then rules, which are processed by a resolution engine written in the Soar architecture. A synthetic view offers a pictorial representation of all the knowledge, and in particular, shows the inter-dependence of the rules and their procedural references. In addition to allowing an efficient processing, the system checks the coherence of the knowledge and produces a justification of the decision with respect to relevant operational procedures.

Keywords: Decision-Support, Information Retrieval, Knowledge Management, Logistics, Supply-Chain Optimization

INTRODUCTION

Owing to their ability to easily organize and update heterogeneous knowledge, Decision-Support Systems form a promising approach for the optimization of logistics businesses (Gordon, 1994; Fehling, 1993). The management and visualization of the knowledge base of these systems are in this regard crucial to ensure a proper functioning and to keep an intuitive view of their expected behavior (Asproth, 2007). They have in fact taken a significant importance for a large set of daily life and business problems that can be formalized through inference rules and combinational cases (Marakas, 1998; Groothuis & Svensson, 2000). In particular, decision support tools are gaining ground both in large companies and public administrations, especially for the efficient handling of dynamic operational requests, such as the (re-) ascribing of tasks (Allen & Greenleaf, 2001) and in logistics control (Almejalli et al., 2004) or planning (Grosche & Rothlauf, 2004).

A historical crossroad in Eastern Europe, the Grand-Duchy of Luxembourg is nowadays characterized by the interconnection between
rail, air and route transportation and an increasingly huge traffic. The project Atlas (Assistance to Transportational Logistics by Automated System) is concerned with the use of Decision-Support Systems to sustain the growth of the country as a prominent logistics place. Atlas seeks to offer tailored solutions for transport management, and dedicated to all economic actors of the supply chain, whether seeking the best way to comply with administrative, legal, and business constraints, or willing to improve on important features such as secure collaboration, traceability, or multimodality. In particular, the decision system will help dealing with the EU-shaped freight framework, notably characterized by the development of multimodality, aids to take off road transport, and new working rules for truck drivers.

As a main result, we develop a collaborative expert system aimed at processing regulation and operational rules related to multimodal freight transportation and involving the European and national contexts. To ease the integration in the working infrastructure of the larger number of related business and administration services, Atlas is deployed as an aggregation of web services supporting collaborating work inside and between organizations. The operators access them, according to specific rights depending on their pre-recorded user profiles, to share and manage their tasks, and to edit or update the knowledge base without the help of a computer specialist. Owing to the flexibility of its reasoning scheme, of its deployment, and of its usability Atlas can therefore be viewed as multi-purpose professional reasoning architecture.

Guidelines

The starting point for building Atlas are on the one hand the operational constraints and on the other hand the legislation regarding transportation. This knowledge consists however not in a monolithic structure, but forms a constellation of commercial offers, national laws, supra-national decisions, and international regulations.

Several approaches have been proposed for modeling operational knowledge in order to apply inference mechanisms in business contexts (O’Callaghan & Popple, 2003). They are based on different data structures, such as decisional graphs (Peebles & Cheng, 2001), or ontologies (Jimbing et al., 2008). However, in Atlas, the heterogeneous nature of the knowledge and the numerous implicit definitions that are used make the translation into a formal and univocal computer language a very long and minute challenge. Consequently, instead of a whole mathematical modeling of references, we decided to concentrate on the explicit drawing of the mental procedures that governs the daily business, and the relations between these procedures to operational constraints, or legislation. The operating knowledge of Atlas is therefore a procedural modeling of the heterogeneous textual references.

An example of a procedure can be: “If goods are perishables, and the expiry date is after 30 days, goods can transit by rail”. Such a procedure is modeled in the shape of a multi-valued acyclic n-ary graph, with nodes representing a factual state (e.g., railroad inter-connection available) used as a condition, and the edges denoting the necessary steps (e.g., testing the expiry date) to enter the state. Moreover, we ensure that a state is always unique in the graph (there are not 2 nodes with the same label), though it is fully possible to go to the same state by different ways. Figure 1 illustrates the graph-based modeling of procedures. The root node is associated with goods to be sent. The concluding leaves decide on accepting or rejecting the possibility to transit by rail.

Implementation

Our graph-procedural modeling has guided our choice relative to the technology used to model the procedures and infer with them. The reasoning on a concrete case consists, indeed, in proceeding from one state to another according to the procedures and the conditions (labeling the edges) that are satisfied. All the paths and all the states must be effectively checked, in order to ensure that no case for a given application is left. This consideration orientates our choice
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