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AN INTEROPERABILITY MODEL FOR COLLABORATIVE DEVELOPMENT OF DISTRIBUTED SUPPLY CHAIN SIMULATIONS

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ABSTRACT

Development of a collaborative distributed supply chain simulation implies interoperation of heterogeneous systems. Interoperability among several independent systems requires mutual understanding and meaning of shared data represented in a common structure. These two requirements are always a real challenge. In a High Level Architecture (HLA) based supply chain simulation, the federation object model (FOM) performs as a contract where mutual understanding and shared information are described. However, this contract is usually established manually and then the consistency and completeness cannot be guaranteed. Developing FOM and modifying existing systems to comply with the FOM implies a significant amount of time and effort which reduce the benefits of system reuse. This paper presents a heavy-weighted ontology-based method to construct interoperation models of HLA based supply chain simulation in a human-friendly, efficient, consistent and complete way. Besides, this method provides support to collaboration among several organizations of a supply chain.

1 ONTOLOGY-BASED CONSTRUCTION METHOD

The High Level Architecture (HLA) standard is a general framework widely used to develop and execute collaborative distributed supply chain simulations applying the concepts of federates and federations. The development of a federation object model (FOM) is an essential part in the execution of such simulation, because this model is used to guarantee interoperability among systems and describes all shared information (interactions, associations, objects and attributes) of macrostructure and behavior of a particular supply chain (SC). The information of FOM is usually established manually by the central organization of the SC, but in the context of collaborative development of distributed SC simulations this approach is prone to errors and cannot guarantee the consistency and completeness of the document. In order to solve these problems, ontologies arise as a suitable solution. Ontologies provides a formal means to define a shared and common understanding of a domain that is the semantic basis of communication between computer systems and users (Mezgár and Rauschecker 2014). An ontology can be used to make inferences or reasoning based on knowledge through the use of axioms and rules that define an automatic way to process information. This paper presents a heavy-weighted ontology-based method to collaborative development of the FOM in a HLA based distributed SC simulation.

Through the use of the method, the information related to macrostructure and behavior of the SC can be collaborative defined by the modelers of each organization in terms of the supply chain operations reference (SCOR) model (Supply Chain Council 2012). The information defined by the modelers is used to instantiate an ontology of SC, then through a set of transformation rules defined in Semantic Web Rule Language (https://www.w3.org/Submission/SWRL), this information is mapped in instances of another ontology that defines HLA object model template (IEEE 2010) components and relations. A more through description of the two ontologies is presented in (Sarli et al. 2016). Finally, an automatic transforming

algorithm from instances of the HLA ontology into FOM is used to construct the interoperability model in eXtensible Markup Language format. The algorithm is implemented in JDOM library (http://www.jdom.org/index.html). Figure 1 describes the workflow for developing a FOM in a HLA based distributed SC simulation.

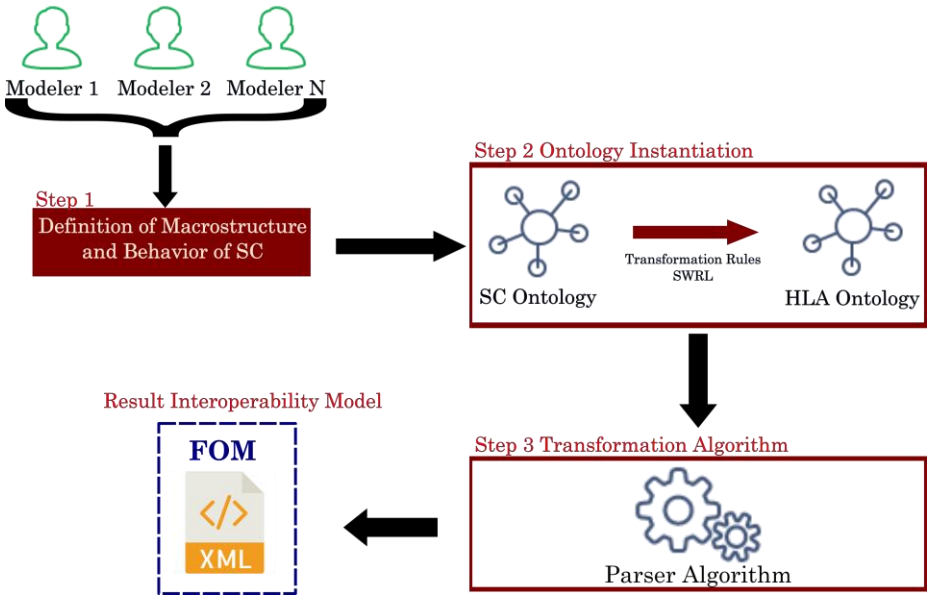

Figure 1: Steps of the ontology-based method.

With the proposed method the structure and behavior of a SC can be described collaboratively in common terms like the SCOR model concepts. The use of ontologies allows to define a formal semantics of the common terms, checks the completeness and consistency of the vocabulary that is part of the FOM and, finally but not less important, reduces the knowledge of HLA needed to construct a FOM. The transformation algorithm generates the FOM in the appropriate format ready to use in the distributed SC simulation run. The approach automates parts of the tasks needed to collaboratively develop a FOM. The steps related to ontologies instantiation and the transformation algorithm are automatic and the first step is the only one that requires manual labor.

The method reduces the human intervention to the minimum necessary, reduces the error prone of establish manually the information of the FOM and presents a verification method to guarantee consistency and completeness through the use of axioms and rules in the ontologies

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