Chapter 16
Formal Representation and Verification of Ontology Using State Controlled Coloured Petri Nets

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Abstract Ontologies are widely used in many areas. Different automatic or semi-automatic extraction techniques have been proposed for building domain ontology in recent years. The correctness of the extracted ontology, however, has often been ignored or not verified formally. With increasingly complex and sophisticated real-world domains, the issue of correctness and verification of ontology is becoming more important. This chapter proposes a formal technique for ontology representation and its verification, based on State Controlled Coloured Petri Net (SCCPN), which is a high level net combining Coloured Petri Net and State Controlled Petri Net. It provides the capability of detection and identification of potential anomalies in ontology. We first describe the formal representation of ontology by SCCPN. The definition of SCCPN for modeling ontologies and the mapping between them are presented in detail. Moreover, the ontology inference in SCCPN is also formulated with specified inference mechanisms. After modeling ontology by SCCPN, the formal verification of potential anomalies (including redundancy, circularity and contradiction) is discussed. It is based on the reachable markings generated by transition firings in the Petri nets.
16.1 Introduction

An ontology is a means of representing semantic knowledge [9], which can facilitate capture and construction of domain knowledge and enable representation of skeletal knowledge to facilitate integration of knowledge bases irrespective of the heterogeneity of knowledge source [25]. It further enables advanced functionality in knowledge systems and forms the knowledge base for future innovations. In general, ontology can be a formal representation of concepts and their interrelationships [8]. It can take the simple form of a taxonomy (i.e. knowledge encoded in some hierarchical structure) or a vocabulary with standardized machine interpretable terminology supplemented with natural language definitions, and also can be used to describe a logical domain theory with very expressive, complex, and meaningful information [20]. As such, ontologies are useful in many areas, such as knowledge management, natural language processing, information retrieval, and especially the semantic web which is increasingly popular, but then the engineering of knowledge construct using relation tagging of concepts is very time consuming and expensive involving a large amount of human resources. This is despite the fact that several tools including Ontolingua [3], OilEd [1], Prog [21], and OntoEdit [27] are developed for the construction and management of ontologies. Recently, different automatic or semi-automatic extraction techniques have been proposed and implemented in several contexts for building domain ontology (e.g. [17, 2, 13]).

Along with the considerable progress has been made in developing extraction techniques, an essential and vital problem that how to evaluate, or verify and validate, the extracted ontologies emerges. It is becoming even more important, with increasingly complex and sophisticated real-world domains. However, no comprehensive and global approach to this problem has been proposed to date [4]. A deep core of preliminary ideas and guidelines for this issue is still missing [6], despite the fact that growing interest has been paid on it (e.g. [26, 29] ) and some important developments have been obtained in recent years.

In literature, the term ontology evaluation has been used in a much broader way, and usually subsumes ontology verification and ontology validation. In general, it refers to a judgment of the ontology with respect to a set of predefined criteria, standards, requirements, etc. To evaluate a given ontology, the criteria may include consistency, completeness, conciseness, expandability, sensitiveness, etc [6]. In the area of expert system, there is a general consensus that validation refers to the process of building the right system, while verification refers to the process of building the system right [18]. From this perspective, it is relatively easy and reasonable to get that ontology verification referring to the process of building the ontology right (in other words, substantiating that the ontology correctly implements its specifications). The goal of ontology verification is to ensure the consistency and completeness of the ontology and to guarantee that the building of the ontology proceeds in a way that meets the requirements. In this chapter, the process of verification focuses on the checking of potential anomalies in ontology that may cause inconsistency and incompleteness.