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Pushing the Boundary of Parallel Tractability for Ontology Materialization via Boolean Circuits

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Abstract : Materialization is an important reasoning service for applications built on the Web Ontology Language (OWL). To make materialization efficient in practice, current research focuses on deciding tractability of an ontology language and designing parallel reasoning algorithms. However, some well-known large-scale ontologies, such as YAGO, have been shown to have good performance for parallel reasoning, but they are expressed in ontology languages that are not parallelly tractable, i.e., the reasoning is inherently sequential in the worst case. This motivates us to study the problem of parallel tractability of ontology materialization from a theoretical perspective. That is we aim to identify the ontologies for which materialization is parallelly tractable, i.e., in the NC complexity. Since the NC complexity is defined based on Boolean circuit that is widely used to investigate parallel computing problems, we first transform the problem of materialization to evaluation of Boolean circuits, and then study the problem of parallel tractability based on circuits. In this work, we focus on datalog rewritable ontology languages. We use Boolean circuits to identify two classes of datalog rewritable ontologies (called parallelly tractable classes) such that materialization over them is parallelly tractable. We further investigate the parallel tractability of materialization of a datalog rewritable OWL fragment DHL (Description Horn Logic). Based on the above results, we analyze real-world datasets and show that many ontologies expressed in DHL belong to the parallelly tractable classes.

Keywords : ontology materialization, parallel reasoning, datalog, Boolean circuit
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