Abstract

Multi-Context Reasoning in Continuous Data-Flow Environments

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The field of artificial intelligence, research on knowledge representation and reasoning has originated a large variety of formats, languages, and formalisms. Over the decades many different tools emerged to use these underlying concepts. Each one has been designed with some specific application in mind and are even used nowadays, where the internet is seen as a service to be sufficient for the age of Industry 4.0 and the Internet of Things. In that vision of a connected world, with these many different formalisms and systems, a formal way to uniformly exchange information, such as knowledge and belief is imperative. That alone is not enough, because even more systems get integrated into the online world and nowadays we are confronted with a huge amount of continuously flowing data. Therefore a solution is needed to both, allowing the integration of information and dynamic reaction to the data which is provided in such continuous data-flow environments.

This work aims to present a unique and novel pair of formalisms to tackle these two important needs by proposing an abstract and general solution. We introduce and discuss reactive Multi-Context Systems (rMCS), which allow one to utilise different knowledge representation formalisms, so-called contexts which are represented as an abstract logic framework, and exchange their beliefs through bridge rules with other contexts. These multiple contexts need to mutually agree on a common set of beliefs, an equilibrium of belief sets. While different Multi-Context Systems already exist, they are only solving this agreement problem once and are neither considering external data streams, nor are they reasoning continuously over time. rMCS will do this by adding means of reacting to input streams and allowing the bridge rules to reason with this new information. In addition we propose two different kind of bridge rules, declarative ones to find a mutual agreement and operational ones for adapting the current knowledge for future computations.

The second framework is more abstract and allows computations to happen in an asynchronous way. These asynchronous Multi-Context Systems are aimed at modelling and describing communication between contexts, with different levels of self-management and centralised management of communication and computation.

In this thesis rMCS will be analysed with respect to usability, consistency management, and computational complexity, while we will show how asynchronous Multi-Context Systems can be used to capture the asynchronous ideas and how to model an rMCS with it. Finally we will show how rMCSs are positioned in the current world of stream reasoning and that it can capture currently used technologies and therefore allows one to seamlessly connect different systems of these kinds with each other. Further on this also shows that rMCSs are expressive enough to simulate the mechanics used by these systems to compute the corresponding results on its own as an alternative to already existing ones. For asynchronous Multi-Context Systems, we will discuss how to use them and that they are a very versatile tool to describe communication and asynchronous computation.