Strategic Reasoning Under Imperfect Information with Synchronous Semantics

Sophie Pinchinat
IRISA Laboratory/University of Rennes, France

Abstract

Dynamic Epistemic Logic is a modal logic dedicated to specifying epistemic property changes along the dynamic behavior of a multi-agent system. The models that underlie this logic are (epistemic) states together with transitions caused by events, the occurrence of which may modify the current state. We first develop a setting where the entire dynamics of the system starting from an initial state is captured by a single infinite tree, in a way similar to what has been considered for Epistemic Temporal Logic, and second go through the current state-of-the-art regarding strategic reasoning, with a focus on planning problems in this infinite structure.

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Category Invited Talk

1 Extended Abstract

Strategic reasoning is a field of formal methods that focuses on the quest for mathematical settings that allow for specifying and verifying properties in a multiplayer game-like framework where the focus is put on quantifying over strategies of individual players to achieve some goals. The game arena arises from a compositional operational semantics of some multi-agent system, that gives rise to infinite-horizon computations one wants to reason about. Not surprisingly, the kind of goals involved in strategic reasoning resembles the one used in formal verification, and is considered to be specified in temporal logic, the simplest ones being reachability properties. Additionally, and contrary to many approaches for system verification, the need for handling *imperfect information* is central: this is because, in multi-agent systems, the limited information available to each agent/player of the system prevents her from knowing the global state of the system. With this limited player ability of observing the system, strategic reasoning becomes hard to deal with. Indeed, while in a full information setting a strategy can be seen as a subtree of the full computation tree of the system's behavior, in a partial information setting, one has to deal with an extra property of these subtrees that guarantees the consistency of players' decision with their observation, known as *uniformity* [5]: in two different executions of the system that look the same to a player, the player's decision should be the same.

The uniformity property requires to reasoning about infinite trees that involve binary relations between nodes not considered in classical logic for trees [9] and that threatens the decidability of the resulting logics. Typically, extending monadic second-order logic (MSO) on trees with the extra binary "equal level" predicate makes it undecidable [10].

The purpose of this talk is to describe a setting where the uniformity property of players' decision can be handled. This setting is borrowed from the automated planning field where the Dynamic Epistemic Logic (DEL) [11] was introduce to provide one-player games with

imperfect information and compute (uniform) strategies (there named "plans") to achieve reachability epistemic goals. One major feature of the DEL setting is to deal with synchronous semantics of the players' observation.

The talk consists in presenting a restricted version of the DEL setting where one-player uniform strategies for arbitrary omega-regular linear-time temporal goals can be represented by finite-state automata and makes strategic reasoning computable. We resort to fairly recent results from the authors and colleagues [2, 3, 8] that exhibit decidable strategic reasoning decision problems and strategy synthesis. A central tool is the class of *automatic structures* [4, 1], a class of possible infinite-state models with a decidable first-order theory, as well as the subclass of *regular automatic trees* [3] where chain-MSO becomes decidable, as opposed to the former.

Due to time limitation, it is unlikely that we discuss the multi-player extensions as done afterward in [6, 7].

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