Model Checking of Strategic Timed Temporal Logics (Extended Abstract)

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1. Multi-agent Systems and ATL

Autonomous agents provide a powerful paradigm for modelling and analysing socio-technical systems. They encompass networks of communicating agents that make autonomous decisions based on AI methods. Modeling strategic behaviors in a real-time context is crucial for ensuring the safety and security of agent systems. Alternating-time temporal logic (ATL) and its fragment ATL[1,2] are logics that enable reasoning about strategic interactions in such systems by extending the framework of temporal logic with the game-theoretic concept of strategic ability. Therefore, ATL allows us to express statements about what groups of agents can achieve. These properties are useful for specifying, verifying, and reasoning about interactions in agent systems [11, 12, 7], as well as security and usability in e-voting protocols [5, 9]. They have become particularly relevant due to very active development of algorithms and tools for verification [15, 6, 8, 10], where the “correctness” is defined in terms of strategic ability.

2. Timed extensions of ATL and SCTL

In this lecture we investigate timed extensions of strategic logics including ATL and ATL’. We begin with discussing the syntax and semantics of ATL and its discrete time extension TATL [14, 13]. Then, we introduce two new strategy logics: Strategic CTL (SCTL) and its timed extension Strategic Timed CTL (STCTL) [4]. Each (timed) strategy logic is interpreted over two types of structures: models of synchronous (Time) Multi-Agent Systems MAS and of asynchronous (Time) Multi-Agent Systems AMAS. We consider two semantics related to information: imperfect (i) and perfect (I), and two semantics related to recall: imperfect (r) and perfect (R). Additionally, Time MAS and Time AMAS can be either discrete (D) or continuous (C). The lecture focuses on the model checking problem for SCTL and STCTL, considering all the semantics mentioned above, and comparing their complexity with other strategy logics. Notably, we demonstrate that SCTL is more expressive than ATL for all semantics, including
the timed versions as well. Furthermore, we analyze the model checking problem for different combinations of semantics. For instance, the model checking problem for $SCTL_{ir}$ has the same complexity as for $ATL_{ir}$, and the model checking problem for $STCTL_{ir}$ has the same complexity as for $TCTL$. Additionally, we provide a practical demonstration of the feasibility of $STCTL_{ir}$ model checking using IMITATOR [3].

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References


