

Changing the Rules of the Game

REASONING ABOUT DYNAMIC PHENOMENA IN MULTI-AGENT SYSTEMS

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INTRODUCTION

Realistic models of Multi-Agent Systems (MAS) should accommodate change

We propose **LAMB**, an extension of Alternating-Time Temporal Logic (ATL) to reason about **dynamic models**

We focus on the problem of **verifying and synthesizing modifications** of MAS

LAMB - LOGIC FOR ATL MODEL BUILDING

$\varphi ::= p \mid \neg\varphi \mid \varphi \wedge \varphi \mid \langle\langle C \rangle\rangle \mathbf{X}\varphi \mid \langle\langle C \rangle\rangle \varphi \mathbf{U}\varphi \mid \langle\langle C \rangle\rangle \varphi \mathbf{R}\varphi \mid \alpha \mid @_{\alpha}\varphi \mid [\pi]\varphi$

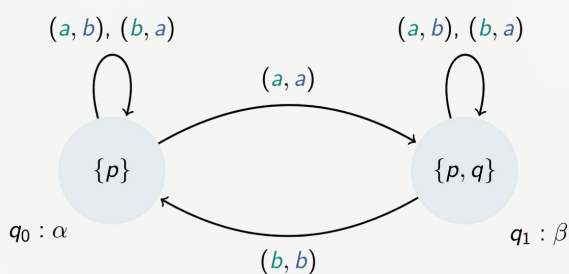
$\pi ::= (p_{\alpha} := \psi) \mid \alpha \xrightarrow{A} \alpha \mid @$

where p is a proposition, C is a coalition, α is a **nominal** (state name), A is an action profile

Hybrid ATL (HATL) is the fragment without $[\pi]\varphi$

- $[\pi]\varphi$ “after the update π , φ holds”
- $p_{\alpha} := \psi$ “ p in α gets the truth value of ψ ”
- $\alpha \xrightarrow{A} \beta$ “the A -labeled arrow that starts in α is redirected to β ”
- $@$ “add a new state and name it α ”
- α “the current state is α ”
- $@_{\alpha}\varphi$ “at the state α , φ holds”

EXAMPLE



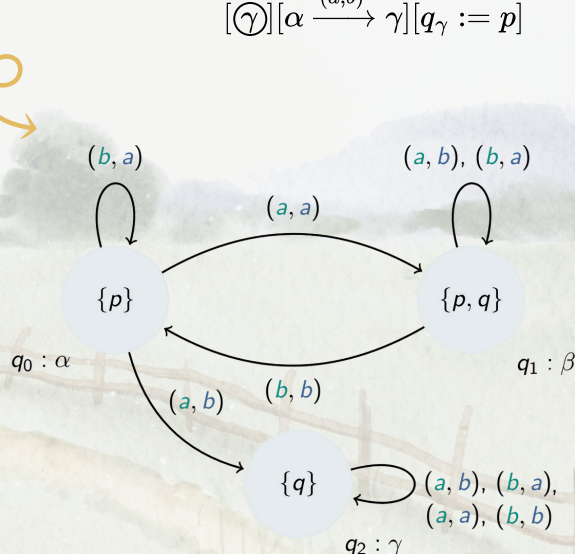
The original model is M

Let $[\text{upd}]$ be the update

$[\gamma][\alpha \xrightarrow{(a,b)} \gamma][q_{\gamma} := p]$

Properties after applying the update:

$M, q_0 \models [\text{upd}]\langle\langle \text{green} \rangle\rangle \mathbf{X}q$
 $M, q_0 \not\models [\text{upd}]@_{\gamma}\langle\langle Ag \rangle\rangle \top \mathbf{U}p$



MAIN RESULTS

- **Expressivity:**
 - $\text{ATL} < \text{HATL} < \text{LAMB}$
 - Allowing for only updates in the form $p_{\alpha} := \psi$ leads to the same expressivity as HATL
- **Model checking complexity for LAMB:**
 - PTime-complete
- Complexity of deciding the existence of a **bounded sequence of updates** that *repairs* a model w.r.t a LAMB specification:
 - NP-complete



CONCLUSION

LAMB is a logic for reasoning about dynamic phenomena that combines ATL with hybrid and model-update operators, which were inspired by Dynamic Epistemic Logic

Future work: satisfiability of LAMB, synthesis of updates, ...

