STV+AGR: Towards Verification of Strategic Ability using Assume-Guarantee Reasoning

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Outline

Logical Specification of Strategic Abilities

Tool

Assume-guarantee verification

Evaluation

Conclusions

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ATL: What Agents Can Achieve

- ATL: Alternating-time Temporal Logic [Alur et al. 1997-2002]
- Temporal logic meets game theory
- Main idea: cooperation modalities

$\langle\langle A \rangle\rangle \Phi$: coalition A has a collective strategy to enforce Φ

$\rightsquigarrow$ Φ can include temporal operators: X (next), F (sometime in the future), G (always in the future), U (strong until)

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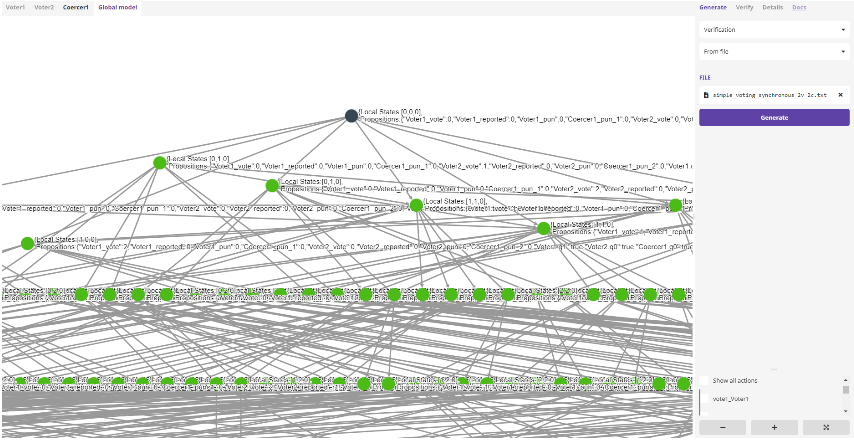
- Model-checking algorithms: fixpoint-approximations and depth-first strategy synthesis.
- Reduction methods: partial-order reductions and assume-guarantee reasoning.
- Asynchronous semantics with: action-oriented synchronization and data-oriented synchronization.
- Properties: reachability and safety.

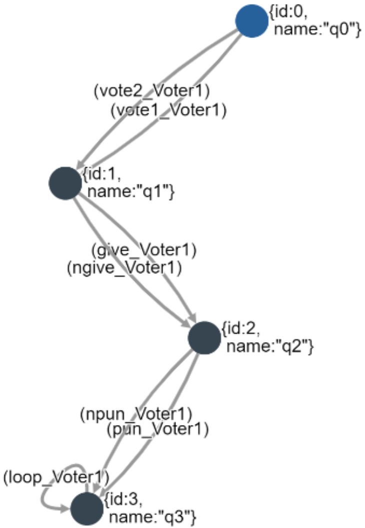
Simple Voting model in STV



Model specification - voter

```
Agent Voter[2]:

init: q0

vote1: q0 -> q1 [aID_vote=1]
vote2: q0 -> q1 [aID_vote=2]

give: q1 -> q2 [aID_reported=?aID_vote]
ngive: q1 -> q2 [aID_reported=-1]

pun: q2 -[Coercer1_pun_ID == 1]> q3 [aID_pun=1]
npun: q2 -[Coercer1_pun_ID == -1]> q3 [aID_pun=0]

loop: q3->q3
```

Voter model in STV



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4. Use STV to automatically generate specification files for each assumption group.
5. Verify each model in the tool.

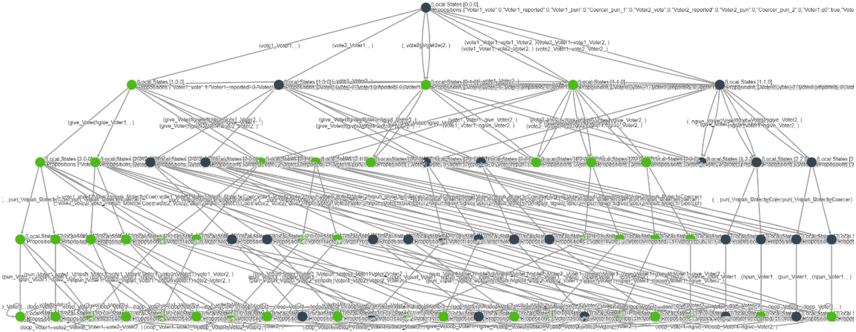
Assumption specification

```
Group 1:

Agent Voter1:
init: q0
LOCAL: [Voter1_vote, Voter1_reported, Voter1_pun]
INTERFACE: [Coercer_pun_1]
vote1: q0 -> q1 [Voter1_vote=1]
vote2: q0 -> q1 [Voter1_vote=2]
give: q1 -> q2 [Voter1_reported=?Voter1_vote]
ngive: q1 -> q2 [Voter1_reported=-1]
pun: q2 -[Coercer_pun_1 == 1]> q3 [Voter1_pun=1]
npun: q2 -[Coercer_pun_1 == -1]> q3 [Voter1_pun=-1]
loop: q3->q3

FORMULA: <<Voter1>>G(Voter1_pun=-1 | Voter1_vote=1)
```

Model generated from the assumption



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Simple Voting Model: Results

Formula

$$\langle\langle \mathit{Voter}_1 \rangle\rangle \mathrm{G}(\neg \mathrm{pstatus}_1 \vee \mathrm{voted}_1 = 1)$$

V	Monolithic model checking				Assume-guarantee verification			
	#st	**#tr**	**DFS**	**Apprx**	**#st**	**#tr**	**DFS**	**Apprx**
2	529	2216	< 0.1	$< 0.1/$*Yes*	161	528	< 0.1	$< 0.1/$*Yes*
3	12167	127558	< 0.1	0.8/*Yes*	1127	7830	< 0.1	$< 0.1/$*Yes*
4	2.79*e*5	6.73*e*6	memout		7889	1.08*e*5	< 0.1	0.8/*Yes*
5	memout				5.52*e*4	1.45*e*6	< 0.1	11/*Yes*

Table: Results of assume-guarantee verification (times given in seconds)

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- Much complexity of model checking for strategic abilities is due to the size of the model of the system.
- STV addresses the challenge by implementing a compositional model checking scheme, called assume-guarantee verification.
- STV supports user-friendly modelling of MAS, and automated generation of abstractions that are used as assumptions in the scheme.

THANK YOU