ADT2AMAS: Managing Agents in Attack-Defence Scenarios

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Attack-Defence Scenarios in a Multi-agent Setting

- **Idea**: translation from attack-defence trees (ADTrees) into asynchronous multi-agent systems (AMAS)
- New aspect of security scenarios: agent coalitions of various size and action assignment can be considered
- Qualitative and quantitative analysis using existing methods and tools developed for multi-agent systems

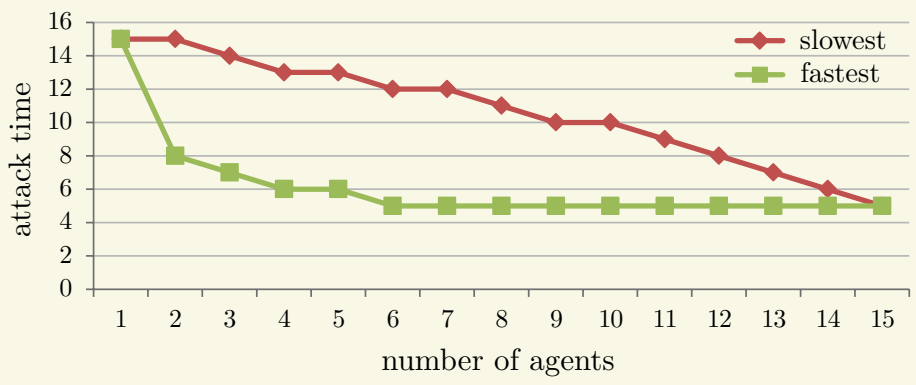
ADTree to AMAS Translation

- EAMAS: AMAS semantics extended with attributes and functions to model ADTrees
- Each ADTree node corresponds to an automaton in the resulting multi-agent system
- Specific patterns for each ADTree construct, embedding reductions to prevent state explosion
- Further reduction on the level of entire EAMAS: exploiting the topology to avoid some interleavings

The Scheduling Algorithm

- Optimal scheduling of agents' actions is crucial to the performance (e.g. attack time) in ADTree scenarios
- A relevant and non-trivial scheduling problem: optimizing both attack time and the number of agents
- Time normalisation and preprocessing: input ADTree becomes a DAG, sequences replace `SAND` gates
- Handling choices: `OR` and defence nodes induce multiple variants for which to compute the schedule
- Schedule length kept at minimum, extra agents added only if execution impossible without increasing time
- Quadratic complexity in the number of nodes, but an exponential number of `OR`/defence variants

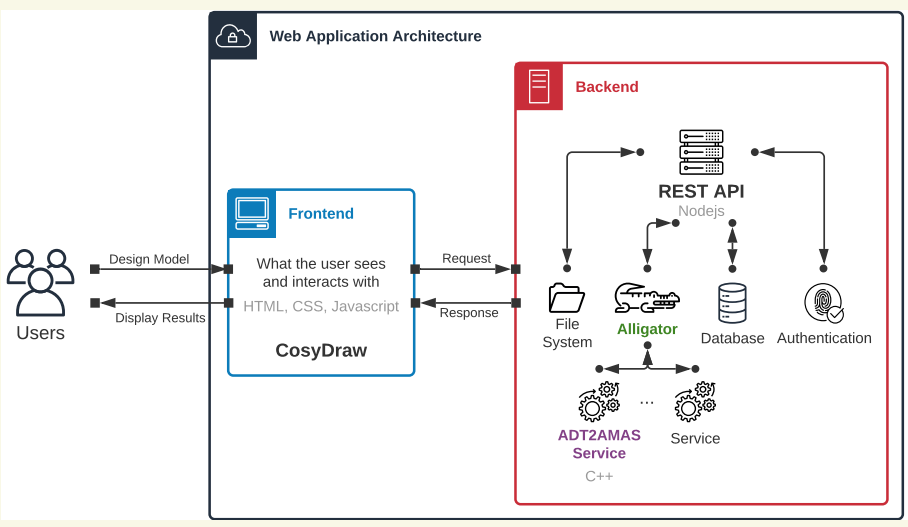
Assignment is Equally Important to Coalition Size!



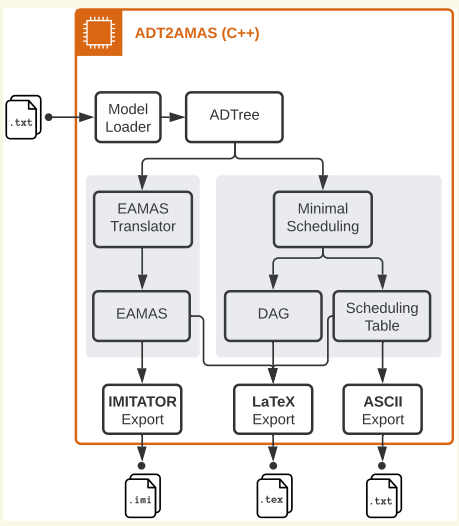
Our Tool: `ADT2AMAS`

- Open-source tool written in `C++`
- Input ADTree: simple-syntax text or a user-generated model in the intuitive web interface `CosyVerif`
- Intermediary steps of the scheduling algorithm visualized with generated LaTeX files
- Output: minimal schedule using the fewest agents
- Also generates models for verification with IMITATOR

Web App Architecture



ADT2AMAS Architecture



Summary: Our Contribution

- Unified/extended scheme for ADTree representation
- Formal semantics of EAMAS to model ADTrees
- ADTree to EAMAS pattern transformation rules
- Translation and optimal scheduling with `ADT2AMAS`
- Agent coalitions: study of peformance metrics impact
- Parametric synthesis of ADTree attributes in IMITATOR

References

ADT2AMAS. `https://lipn.univ-paris13.fr/adt2amas/`.

CosyVerif. `https://cosyverif.lipn.univ-paris13.fr`.

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J. Arias, L. Petrucci, W. Penczek, and T. Sidoruk. Minimal Schedule with Minimal Number of Agents in Attack-Defence Trees. *CoRR*, abs/2101.06838.

L. Petrucci, M. Knapik, W. Penczek, and T. Sidoruk. Squeezing State Spaces of (Attack-Defence) Trees. In *Proceedings of ICECCS 2019*. IEEE, 2019.