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Creating Executable Agent-Based Models Using SysML

Presented by

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Outline

- Research Objective
- Translation Framework
- SysML vs. ABM: Similarities & Differences
- Translation Mechanism
- Case Study
- Lessons learned

Research Objective

*"To **develop** and **demonstrate** a generic framework to translate a Systems Modeling Language (SysML) conceptual model to an executable agent-based simulation model (ABM)"*

Literature Survey

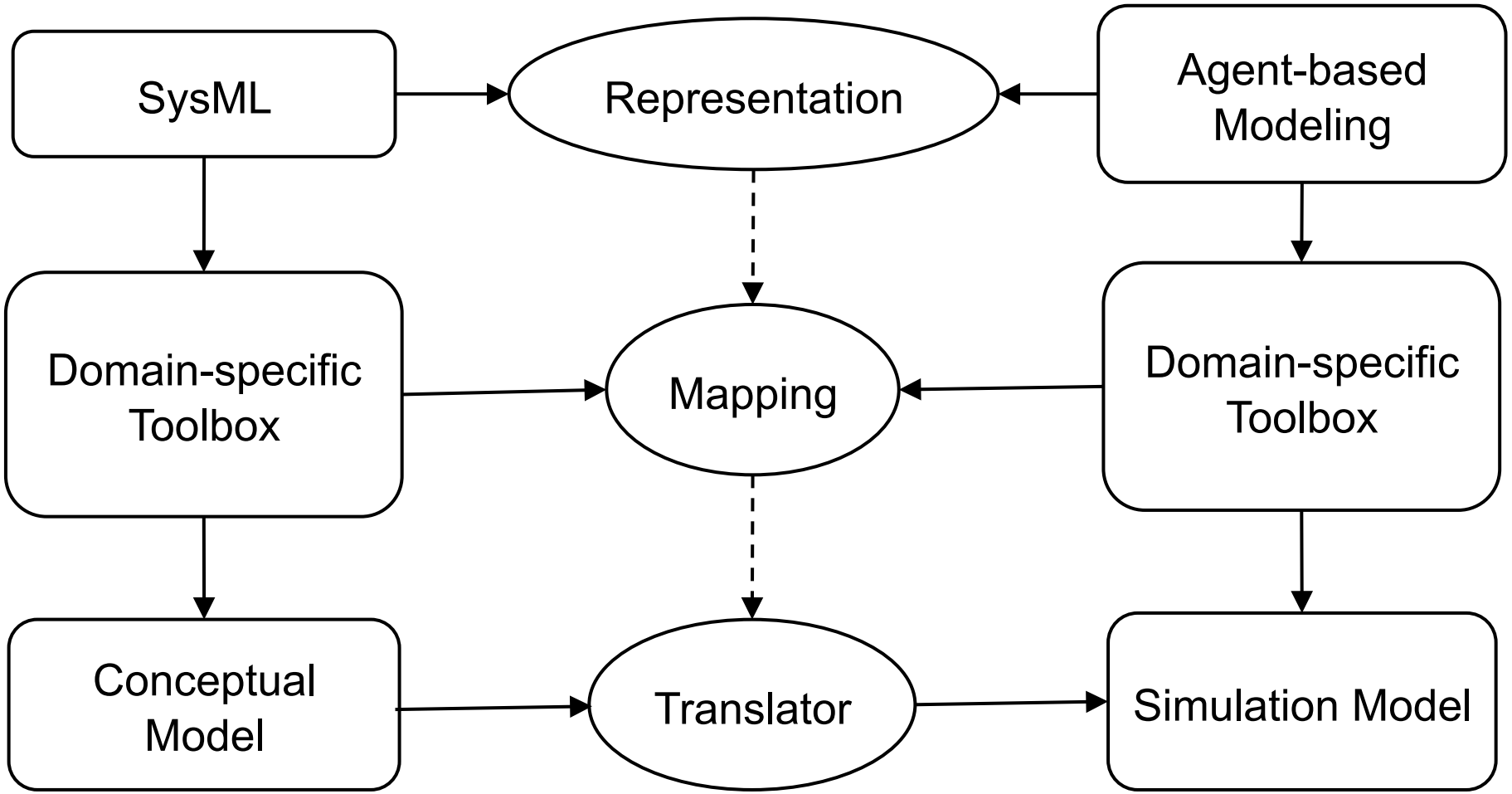
- McGinnis et al. (2009)
  - Identifies need to translate a conceptual model directly to a simulation program to automate (a part of) the implementation side
  - Model-driven architecture approach to develop a discrete event simulation
- Schönherr et al. (2011)
  - Built SysML models after identifying and structuring the significant properties of discrete processes for production systems

Literature Survey

- Sha et al. (2011)
  - SysML as a diagramming tool to represent agent-based models
- Broodney et al. (2012)
  - IBM Haifa Research Lab uses a generic SysML-based methodology for improving architectural design phase
- DANSE project (ongoing)
  - SysML models are combined with tabular data to automatically generate architecture variants for system analysis

Sha, Z., Le, Q., Panchal, J. H., 2011, "Using SysML for Conceptual Representation of Agent-based Models," 2011 ASME Computers and Information in Engineering (CIE) Conference, Washington, DC. Paper Number: DETC2011/ 47476

Translation Framework



Features of SysML & ABM

SysML

- Viewpoints
  - Structural
  - Behavioral
  - Requirements
  - Parametric
- Networks
  - Logical
  - Physical

Agent-Based Model

- Agents/Objects
- Space
- Time
- Dynamics

Similarities

Viewpoints	SysML	Agent-Based Modeling
Structural	Element definition	Agent definition
Behavioral	Interaction and architecture of the system	Information flow between the agents
Requirements	Requirement management tool	Verification of agent-based model (indirect)
Parametric	Logical/mathematical constraints on the design	Parameters of intra-agent dynamics

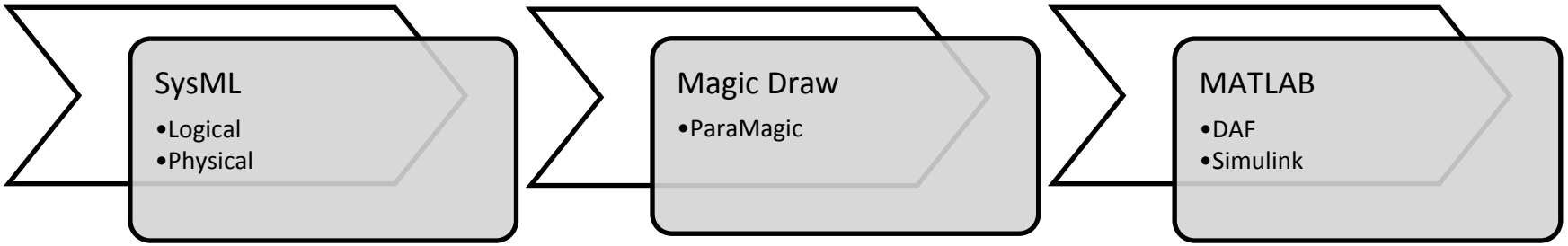
Possible Mismatches

- Triggering an event at particular time
- Static representations to dynamic triggers
- Logical & Physical Networks to ABM dynamics
- Difficult to manage a large number of instances of an elements

Translation Mechanism

Block definition & internal block diagrams Requirements & Constraints

Execute the simulation using the generated files



Generate DAF files by connecting MagicDraw to MATLAB via plugin

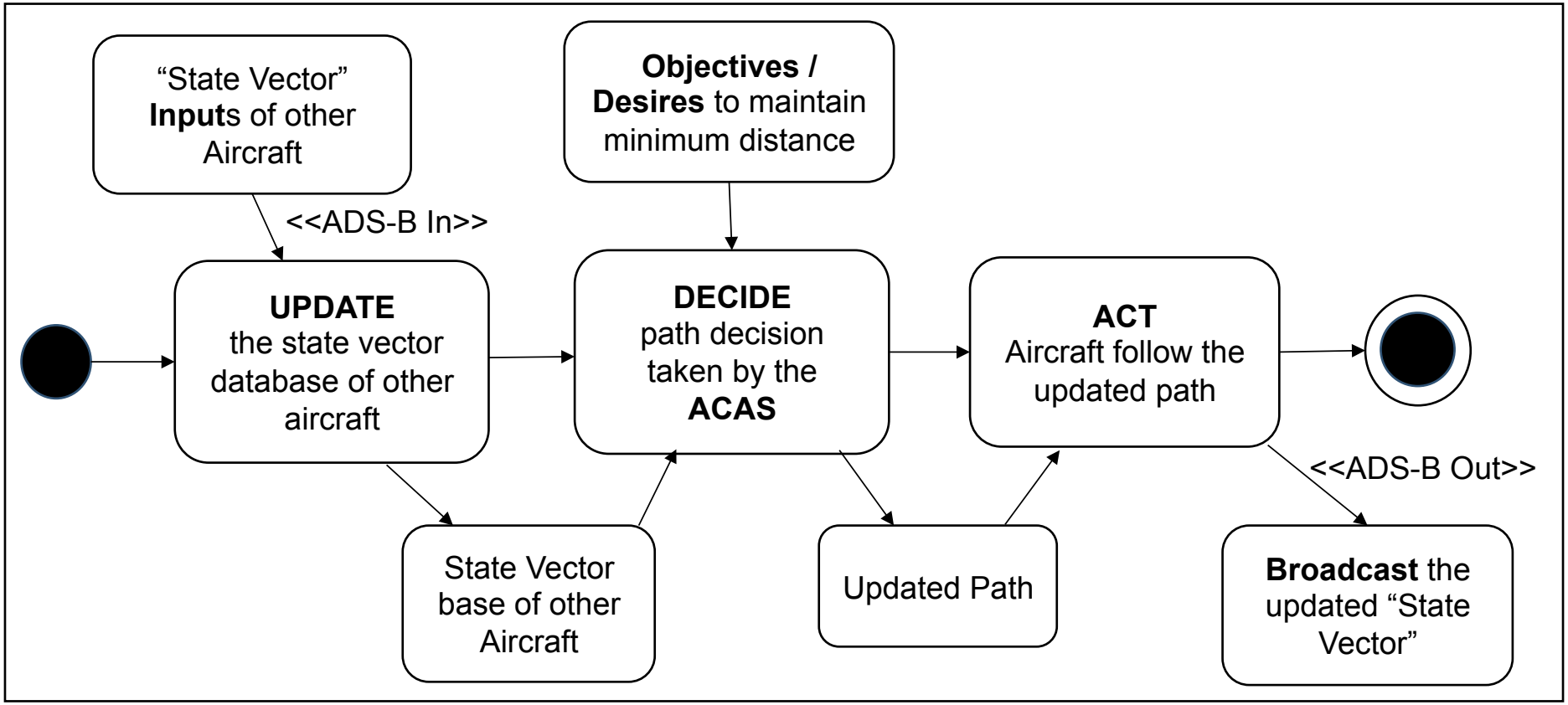
Challenges

- Mapping between DSTs
  - No publically available formal specification for all the toolboxes
- Development of the model translator
  - Different translator for each set of DSTs

Case Study

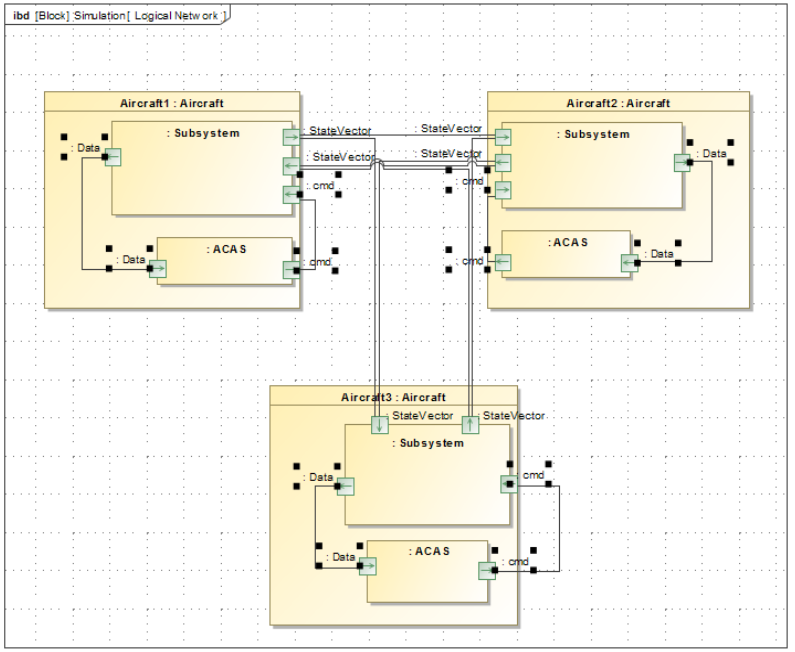
- NextGen Air Traffic Control System of Systems
  - Aircraft - operationally independent systems satisfying the overarching goal of fulfilling the demand of the air transportation network
- Modeling & Simulation plays a crucial role
- Automatic Dependent Surveillance-Broadcast (ADS-B)
  - More accurate information
  - Based on GPS and inter-aircraft communication

Aircraft Agent

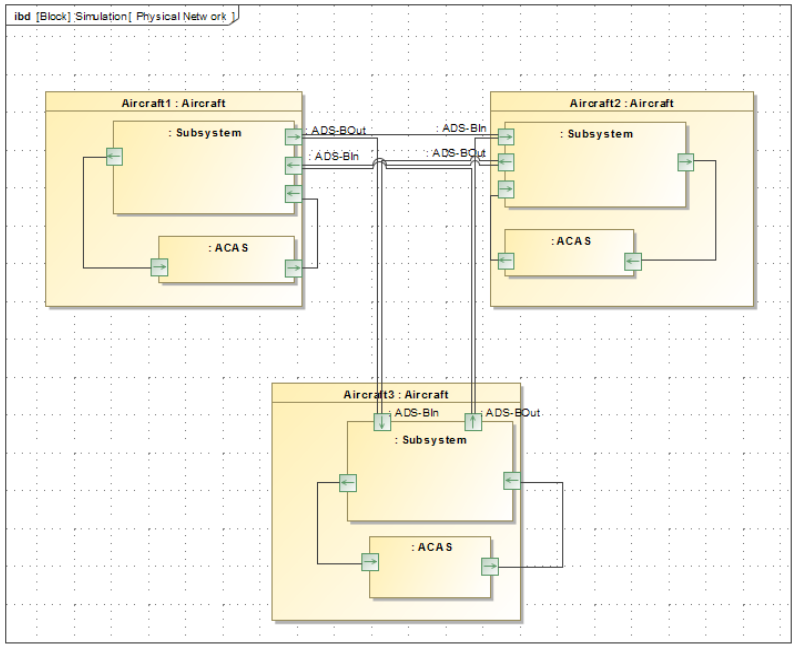


SysML Networks

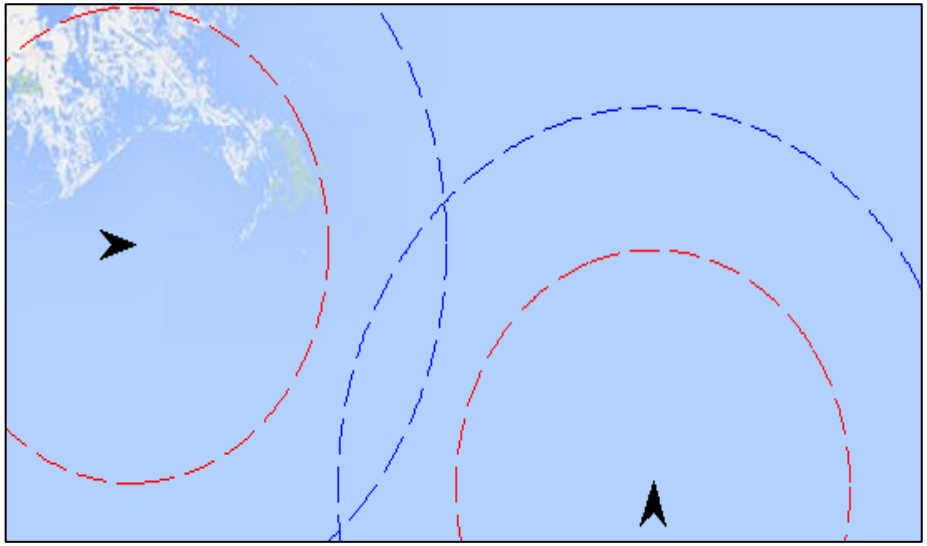
Logical Network



Physical Network



DAF Simulation Results



Symbol	Aircraft Mode
➤	Normal Mode
➤	Receiving ADS-B data
➤	Fault in ADS-B In

ADS-B In Range

Separation Bubble

- Aircraft Agents
  - Equipped with ADS-B (In & Out) with specific range
  - Separation bubble for maintaining separation
  - Broadcast and receive ADS-B data
- Fault introduced in “ADS-B In” of one aircraft

Concerns

- Scalability
  - Example was a very simplified version of a real-world situation; difficult to scale it up
- Coarse-Graining
  - Identify and then extract “relevant” information

Conclusions

- Generic translation framework
- Demonstration
- Major challenges
  - Scalability
  - Efficient Mapping
  - Requires development of formal specifications for the DSTs involved

Future Work

- Focus on automated analysis process for design space exploration based on certain performance metrics

- Focus on making the translation scalable

Thank You!
Questions?

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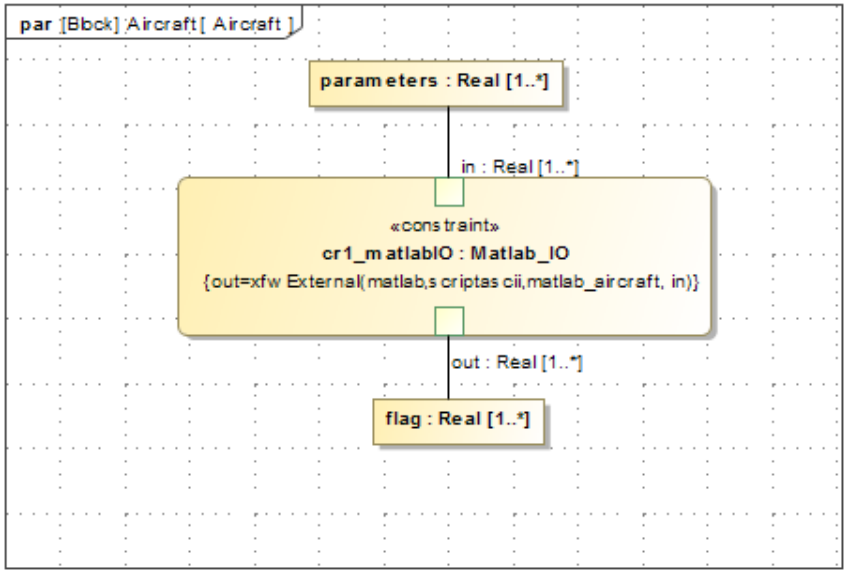
Back-up Slides

Parametric Diagram



- DAF agent file generation using parametric diagram
  - *matlab_aircraft*
  - *parameters*
  - *flag (1, if successful)*

Instance browser for agent file generation