A General Framework for Representing Behavior in Agent Based Modeling

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September 28, 2000

Collaborators on the Archimedes Military Operations Modeling Platform

- David Dixon, Least Squares Software LLC
- Al Sawyers, Computing Technologies.

Project Supported by Project Albert, MCCDC, USMC

Project now in Phase II. Phase I duration: 12 weeks.

Nigel Gilbert: *Thinking Tool* models vs. *Facsimile* models

Proposition:

- Building an interesting and educational *Thinking Tool* System is possible.
- Building a useful *Facsimile* system is very hard.

While *Thinking Tools* are an essential part of complexity science,

Customers Want *Facsimiles*

Problem

- *Communications Gap* between Technical Experts and Domain Experts.
- *No framework* with which to bridge that gap.

Too often, these problems cause the endeavor to CRASH AND BURN.

Our Approach

- Select a methodology: Agent Based Modeling
- Don’t try to build a specific model. Instead provide a toolkit that facilitates the construction of simulations customized to the problem domain.
- Break the project up into two subtasks:
  - *Behavioral Specification:* Domain Experts.
  - *Technical Specification*: Complexity/Software Experts.

Domain Expert

Behaviors

Interested in specifying Agents' *Behavioral State* and dynamics on that state. Examples:

- Tactical Doctrine
- Investment Strategies
- Scheduling Strategies
- Purchasing Patterns

Technical Expert

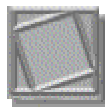
Software/Physical Reality

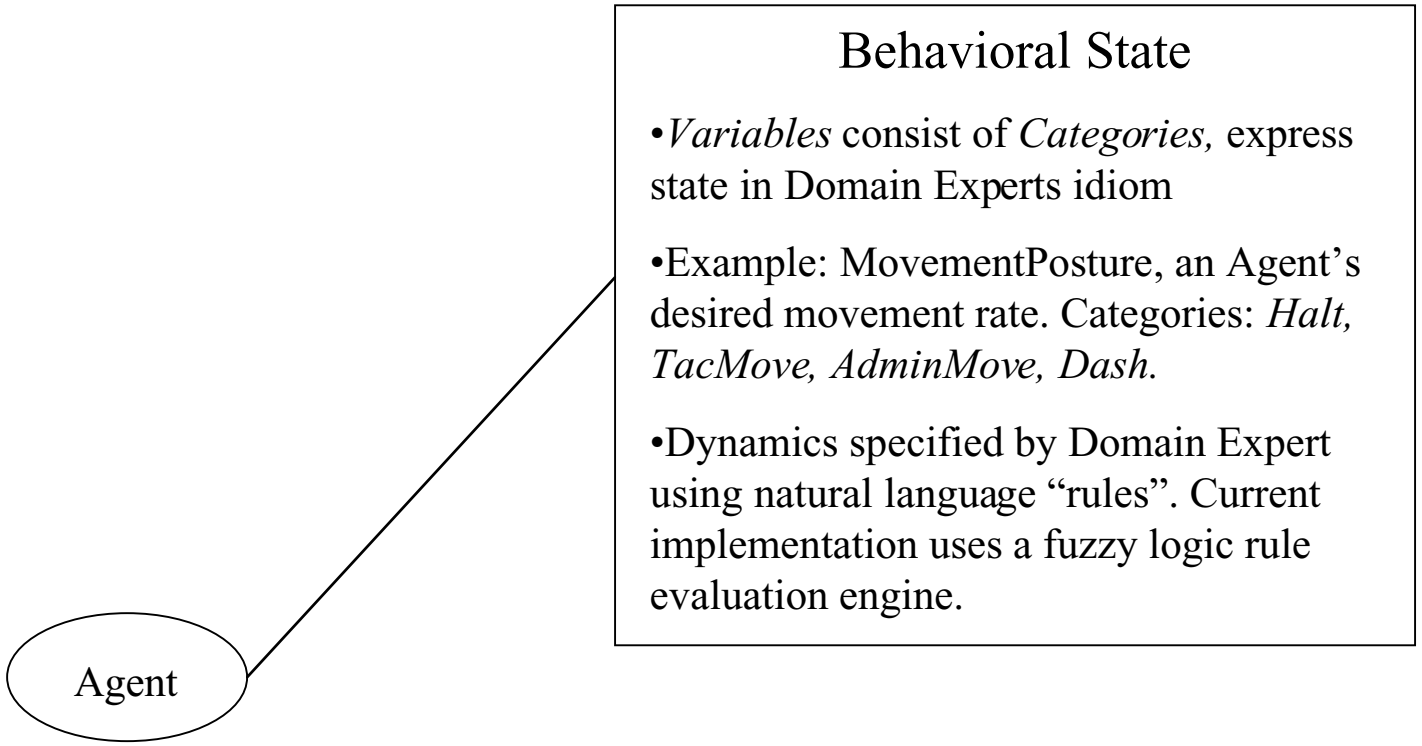
Interested in specifying Agents' *Physical State,* dynamics on that state, and developing supporting software. Examples:

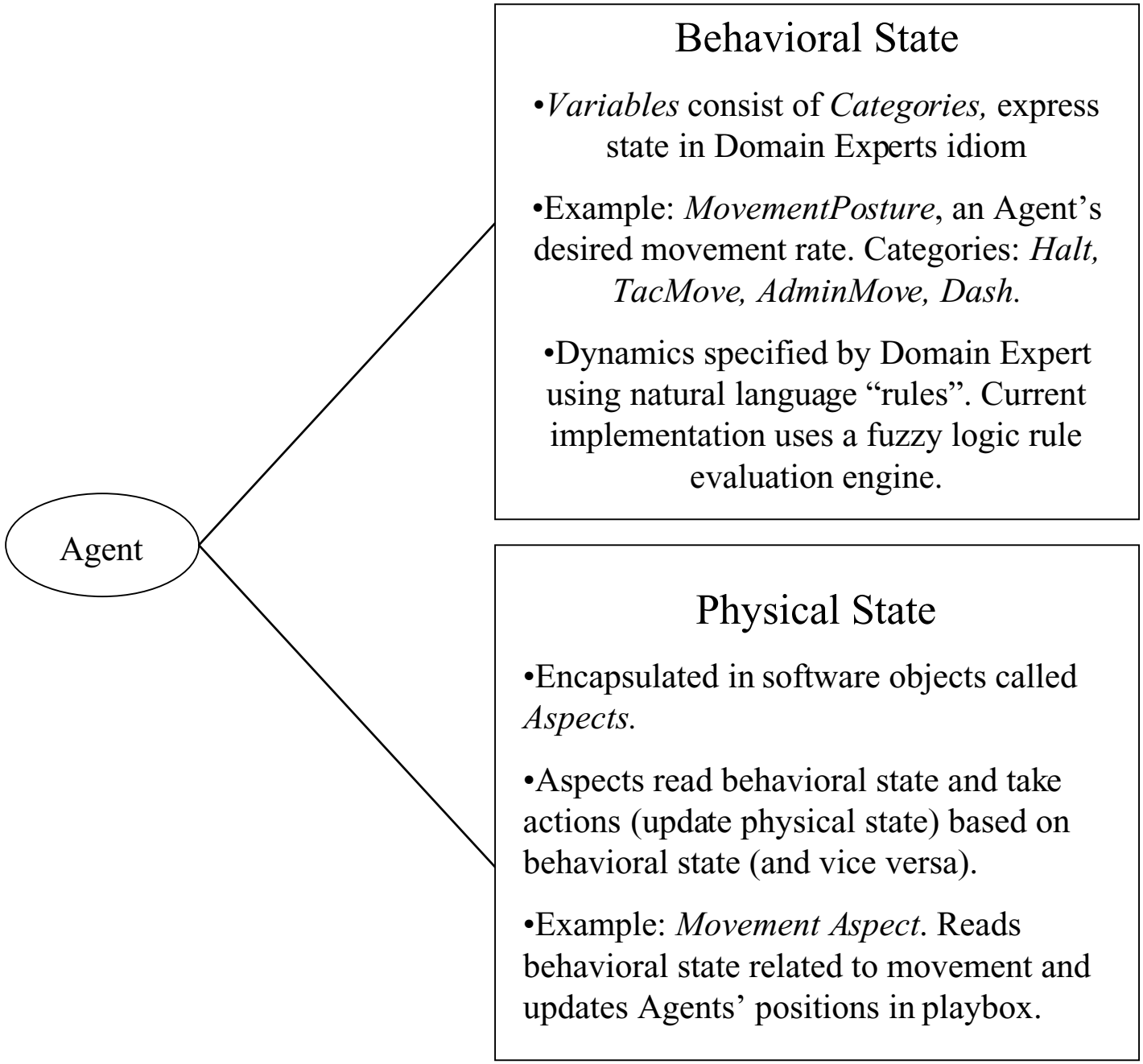
- Combat Adjudication
- Option Pricing
- Data Analysis
- Visualization

Behavioral State affects Physical State and Vice Versa

- Example Problem Domains:
  - Military Simulation (implemented in the Archimedes system)
  - Business Problems (job-shop scheduling, supply chain, organizational optimization)
  - Market Processes
  - Political Dynamics (Election dynamics, Ethnic Conflict, Civil Insurrections)




Behavioral State
•*Variables* consist of *Categories,* express state in Domain Experts idiom
•Example: MovementPosture, an Agent's desired movement rate. Categories: *Halt, TacMove, AdminMove, Dash.*
•Dynamics specified by Domain Expert using natural language "rules". Current implementation uses a fuzzy logic rule evaluation engine.
Agent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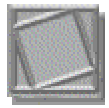
Physical State
•Encapsulated in software objects called *Aspects.*
•Aspects read behavioral state and take actions (update physical state) based on behavioral state (and vice versa).
•Example: *Movement Aspect*. Reads behavioral state related to movement and updates Agents' positions in playbox.

Advantages

- Framework provided for tasks - facilitates definition of target problem (the hard part!).
- Natural Language specification of behaviors allows Domain Expert to learn system quickly and helps provide framework for guiding work of Technical Experts.
- Physics encapsulated in Aspects - leads to “buffet-style” simulation development, component reusability leverages work of Technical Experts.
- Preexisting Software “Plumbing” allows experts to concentrate on problem domain.



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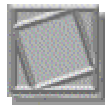
Disadvantages

- Framework limiting, only useful for ABM.
- Programming necessary to extend system. Cannot shrink-wrap general simulation platform and deliver to analysts (although a *simulator instance* which addresses a particular problem domain can be shrink-wrapped).



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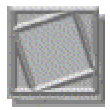
Simulation Structure

- Simulation Consists of:
  - *Agents*
  - *Connections*
  - *Triples*
- All entities endowed with behavioral state and physical state (*Variables* and *Aspects)*
- N-Body interactions possible, although not necessary to date.



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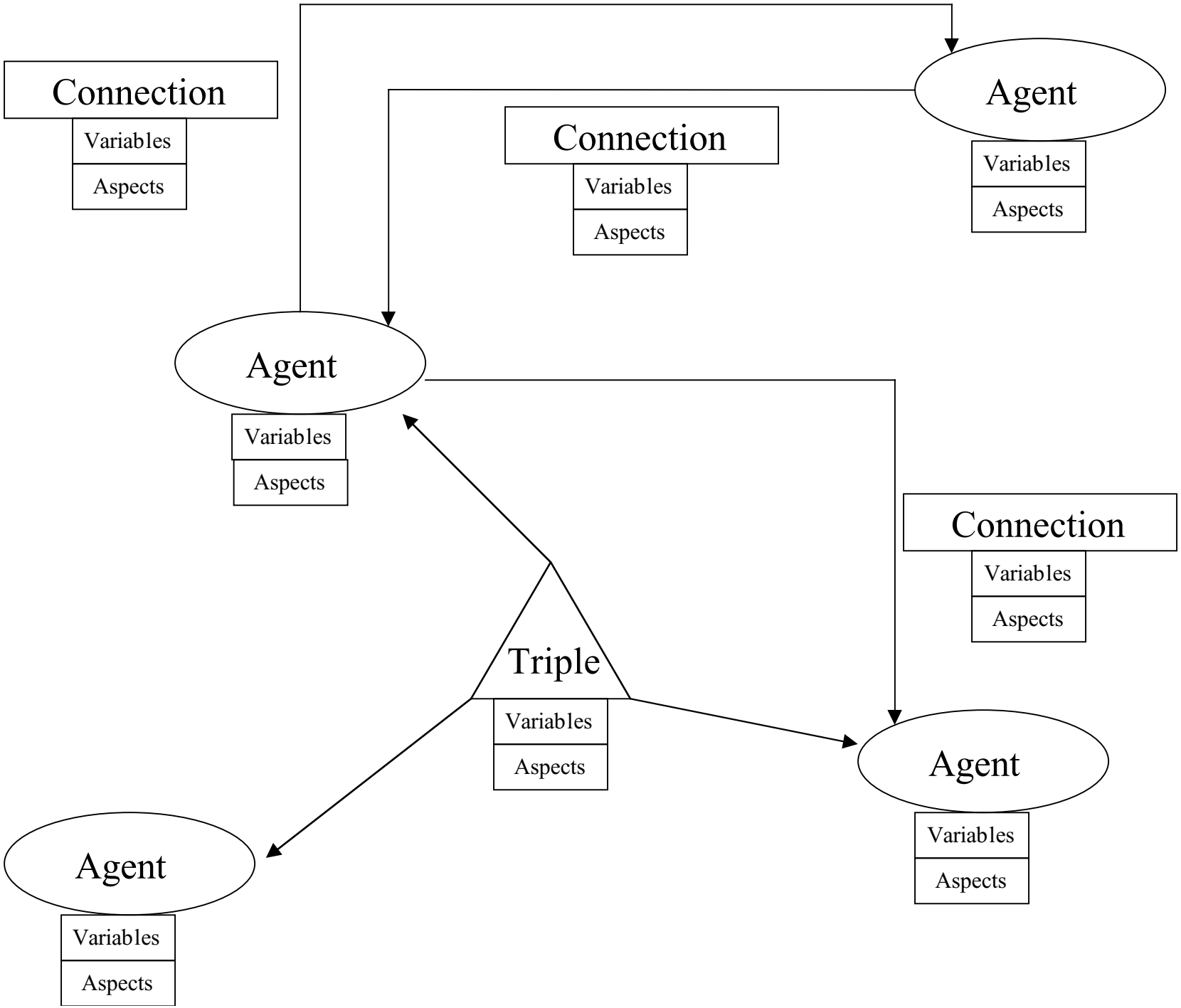
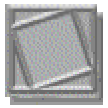

Connection
Variables
Aspects
Agent
Variables
Aspects
Connection
Variables
Aspects
Agent
Variables
Aspects
Connection
Variables
Aspects
Triple
Variables
Aspects
Agent
Variables
Aspects
Agent
Variables
Aspects

Prototype System: Archimedes Military Operations Modeling Platform

- Client (USMC) needed simulator capabilities to address problems from the modern battlefield:
  - Combatants (Agents) need to respond to perception, *not* ground truth.
  - Small Scale Contingencies
  - Peacekeeping/N-Sided Games
  - Noncombatant Evacuation
- Problem Specification very broad. Demands high flexibility and high fidelity from simulation.



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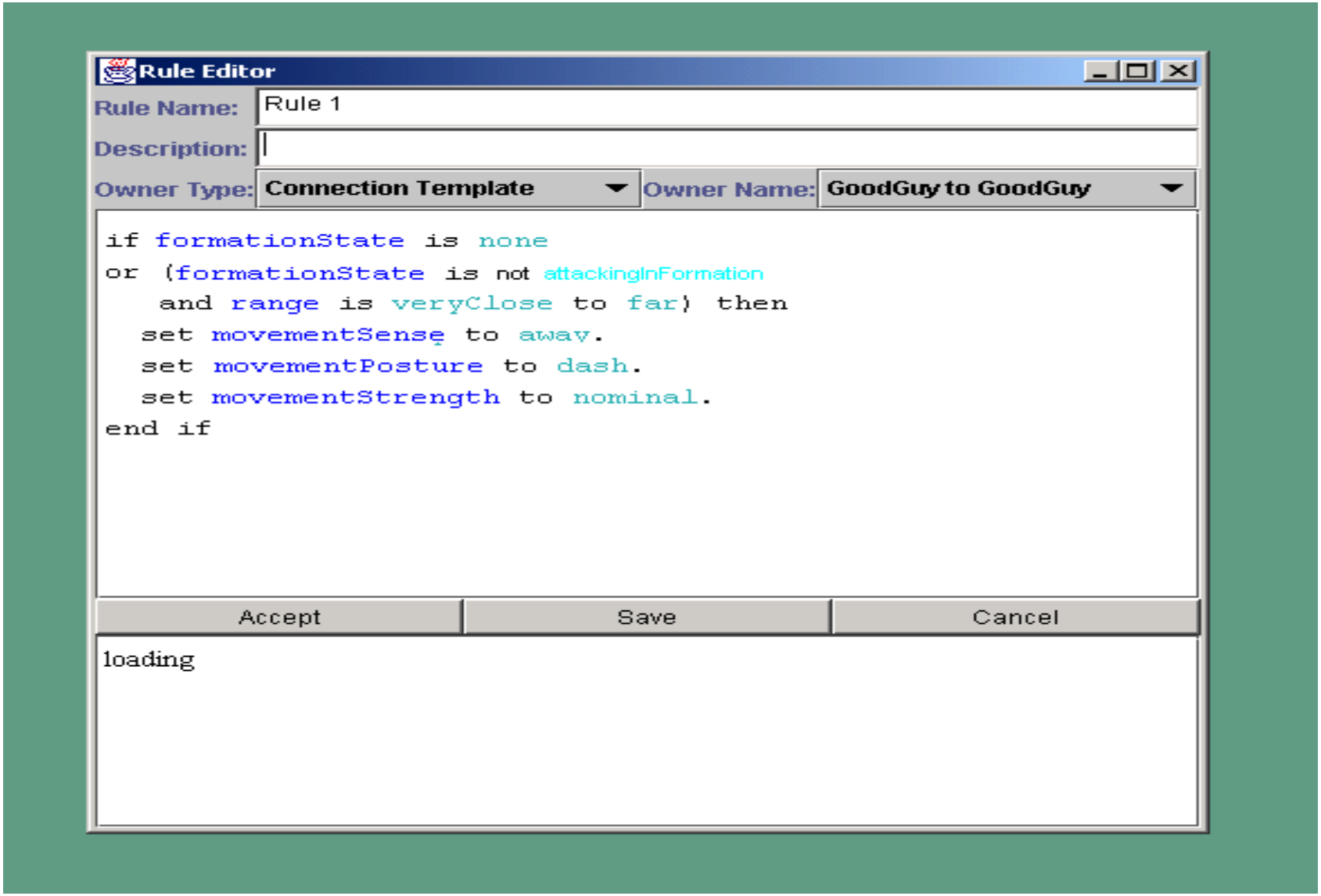
Software Features

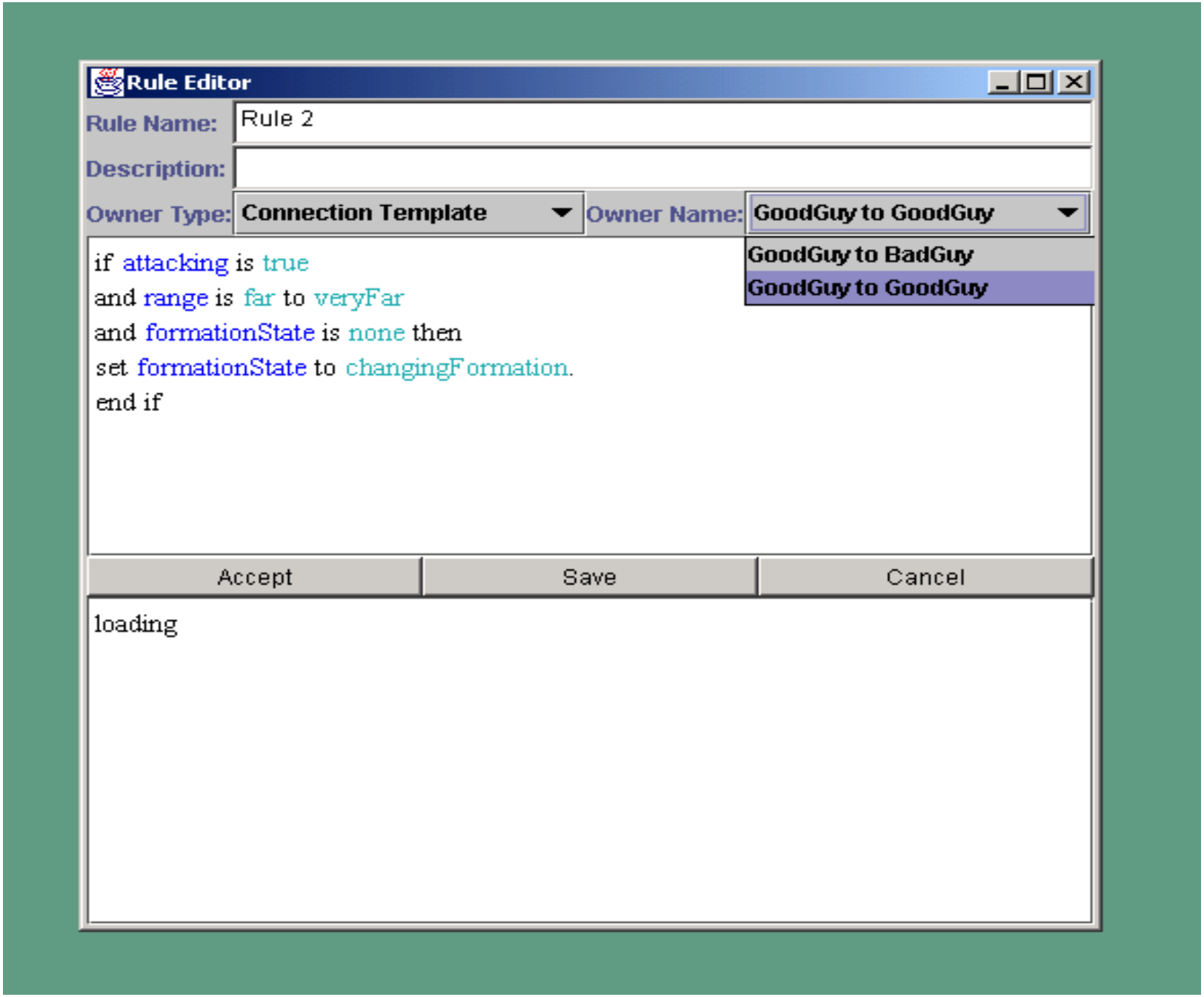
- Modular, O-O architecture. Implemented in Java.
- Data managed by RDBMS.
- GOTS code, base will be made available to other agencies.
- Early stage (5 weeks) of Phase II.

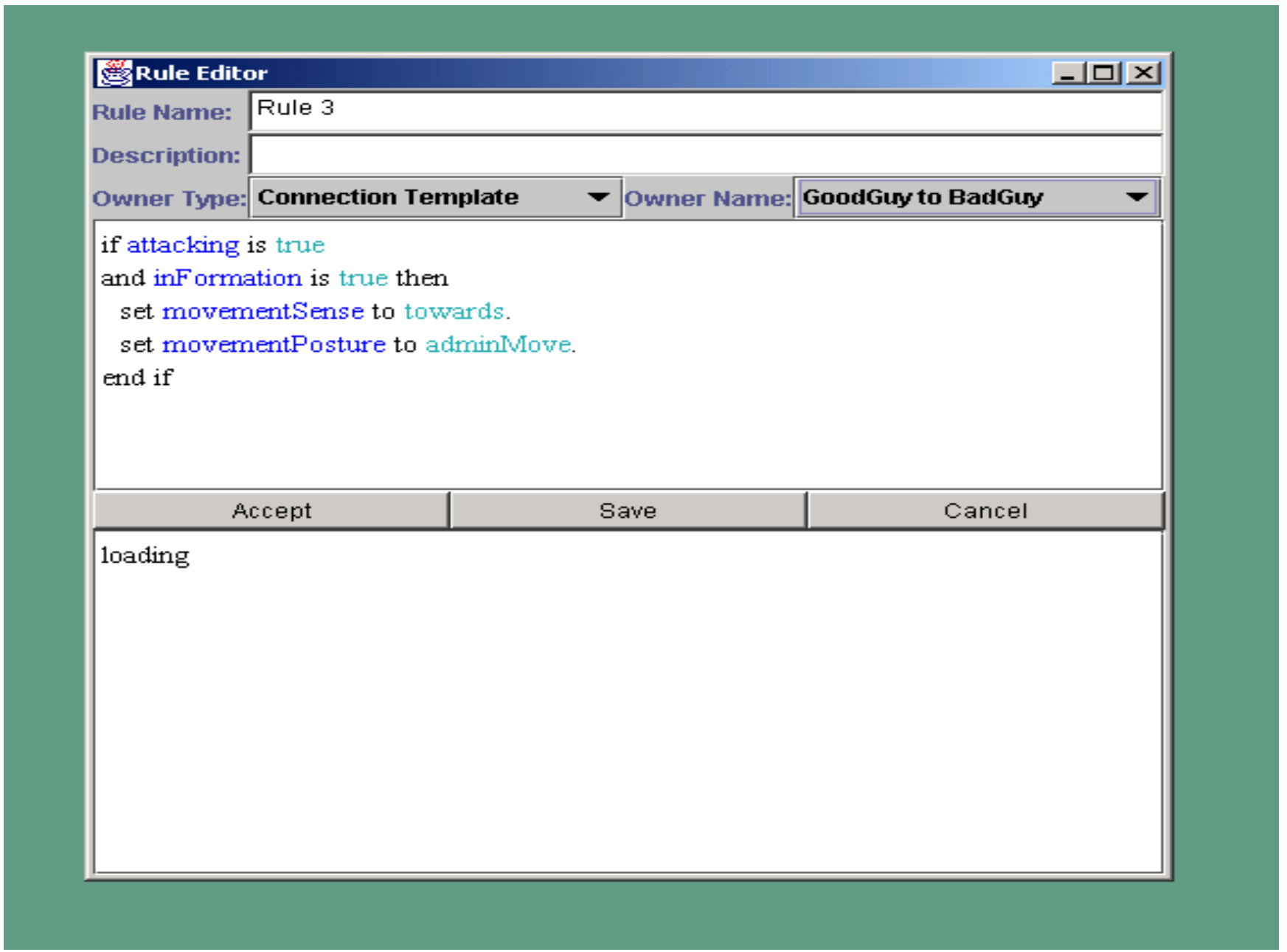
Archimedes Problem Subtasks

- *Behavioral State:* Tactical doctrine of units on the battlefield, including behaviors of friendly units, non-combatants and other entities with varying goals and levels of aggression.
- *Physical State:* Interaction of units on the battlefield with their environment, including position, movement, detection, communications and combat.

Behavioral Rule Examples




Rule Editor
Rule Name:
Rule 2
Description:
Owner Type:
Connection Template
Owner Name:
GoodGuy to GoodGuy
GoodGuy to BadGuy
GoodGuy to GoodGuy
if attacking is true
and range is far to veryFar
and formationState is none then
set formationState to changingFormation.
end if
Accept
Save
Cancel
loading


Rule Editor
Rule Name:
Rule 3
Description:
Owner Type:
Connection Template
Owner Name:
GoodGuy to BadGuy
if attacking is true
and inFormation is true then
set movementSense to towards.
set movementPosture to adminMove.
end if
Accept
Save
Cancel
loading

- Additional Interfaces (not shown) endow agents with aspects and initialize physical and behavioral state.

(demo)