An Agent/Landscape Modeling Framework for Simulation of Human Landuse

MedLand Project

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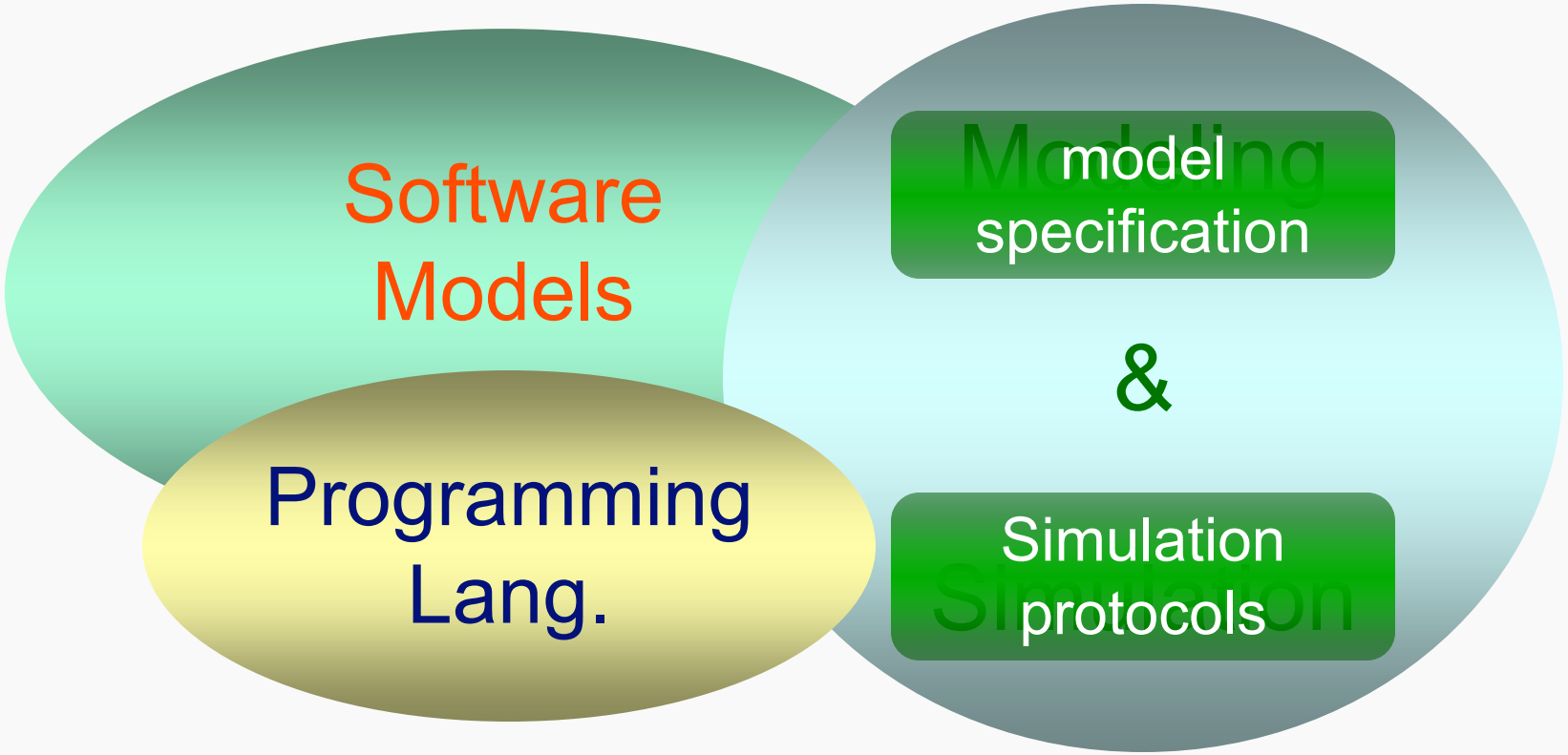
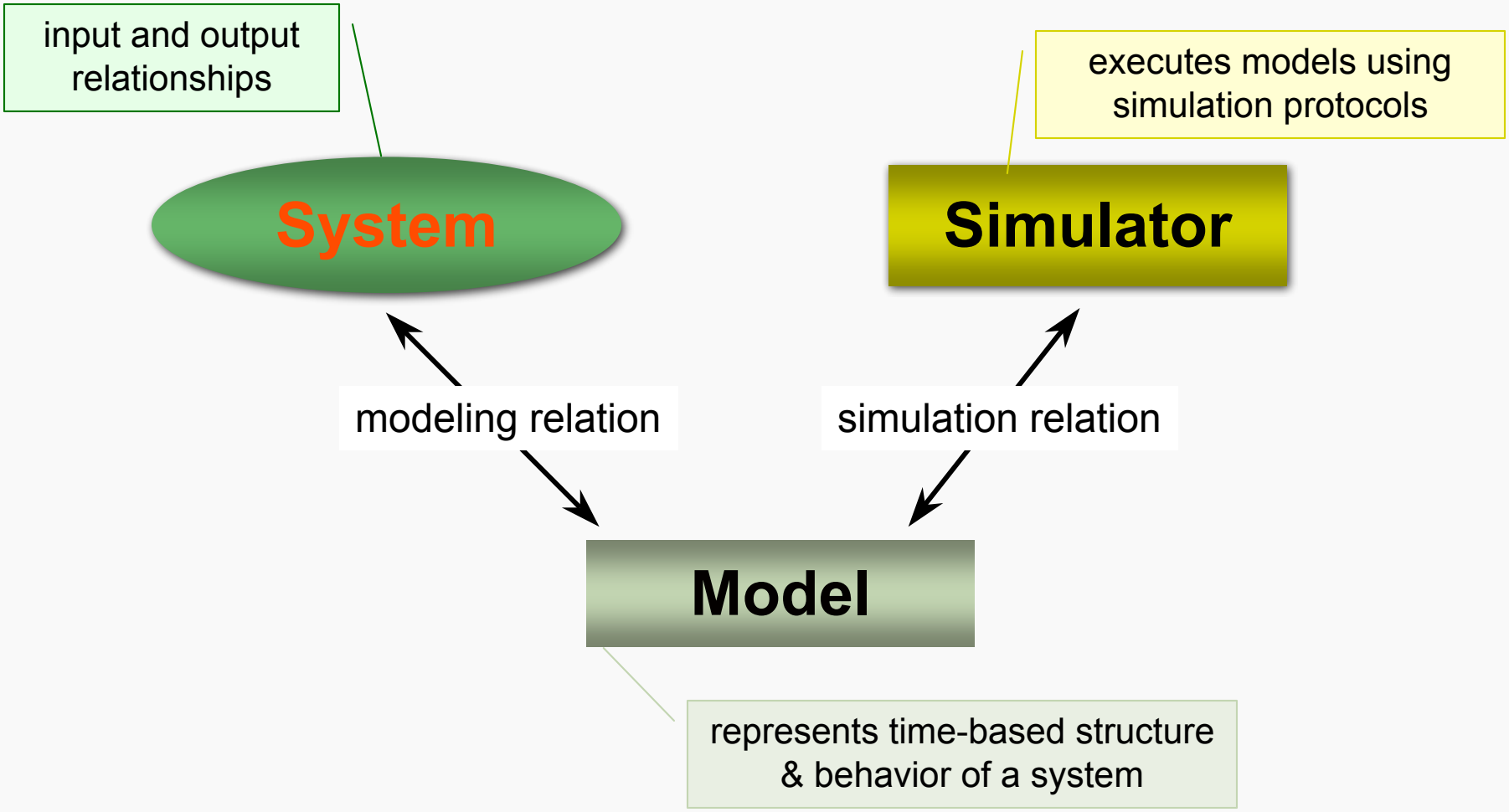
Building Modeling & Simulation Environments

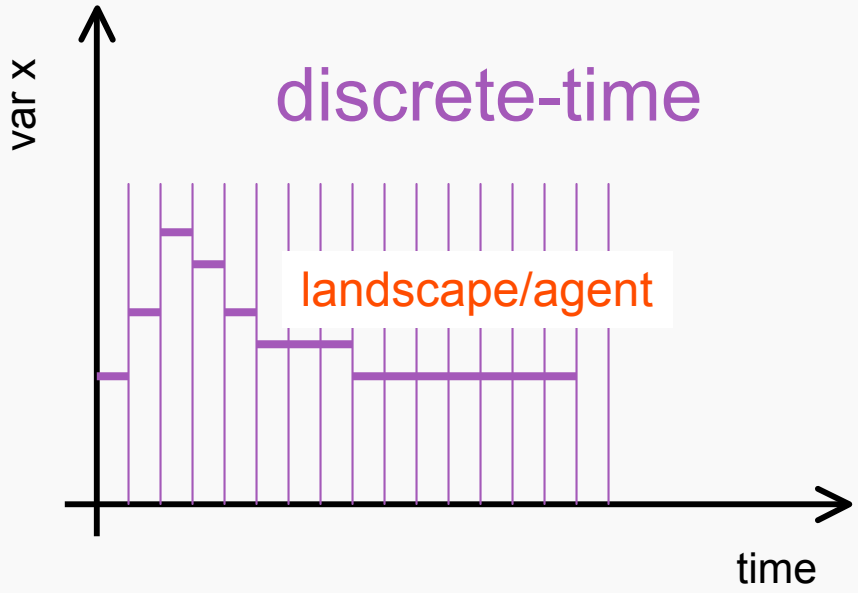


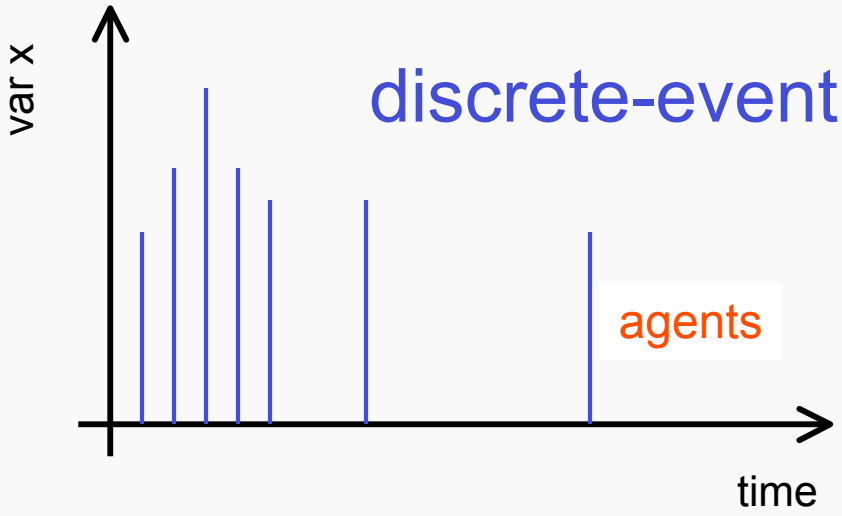
- Software models – procedural, functional, object-orientation
  - UML, CORBA, HLA, .Net, …
- Programming languages – C, C#, CLOS, C++, Java, …

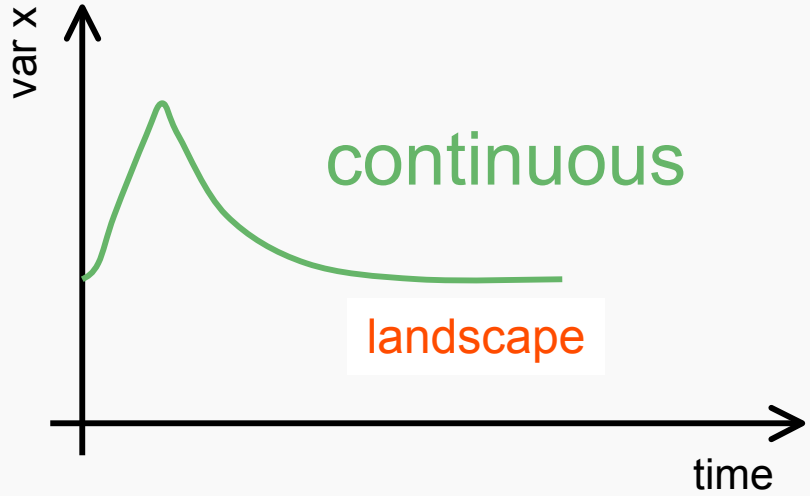
Elementary M&S Entities and Relations



System-Theoretic Model Types

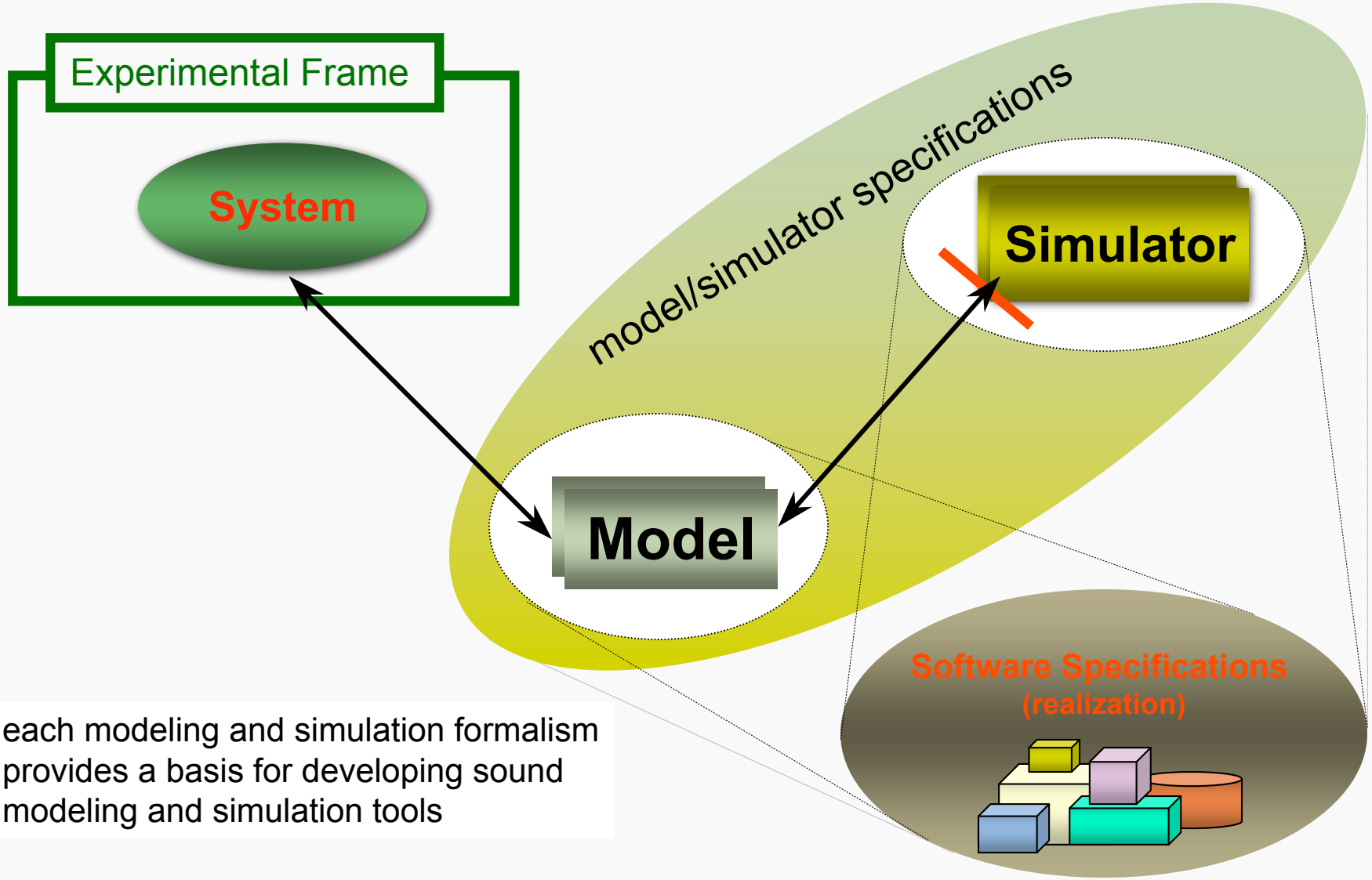






time-based, *input*, *output*, and *state* trajectories

M&S Entities and Their Software Realizations

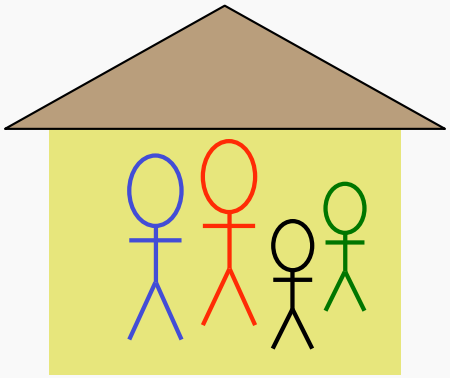


each modeling and simulation formalism provides a basis for developing sound modeling and simulation tools

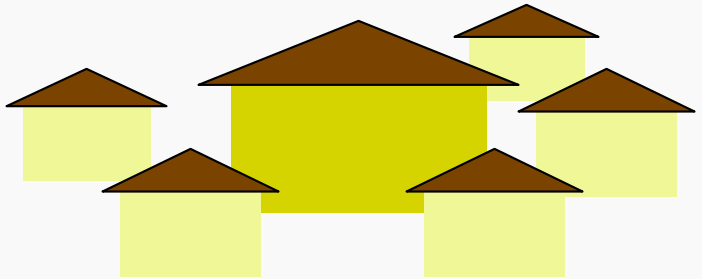
Model Abstractions

- A modeling framework is important for modular model development and composition.
  - Important for specifying agent and landscape models
    - devise model structures and behaviors consistent with available data (handle abstraction complexity and scale)
    - identifying and mapping agent attributes and actions to/from landscape data and dynamics
  - Enables specifying agent/landscape interactions
  - Individual and integrated model development including validation
- Allow alternative simulation protocols
  - Individual and integrated simulation execution including verification
- Selection of appropriate visualization of landscape processes, agent actions, and their interactions
  - Graphical user interfaces for interacting with modeling engines and simulators
  - Time-series and event-based simulation visualization

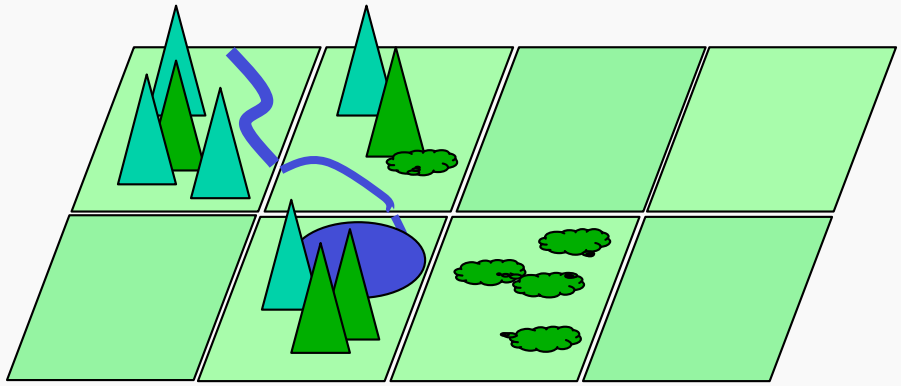
Conceptual Participants in a Socio-ecological System



household

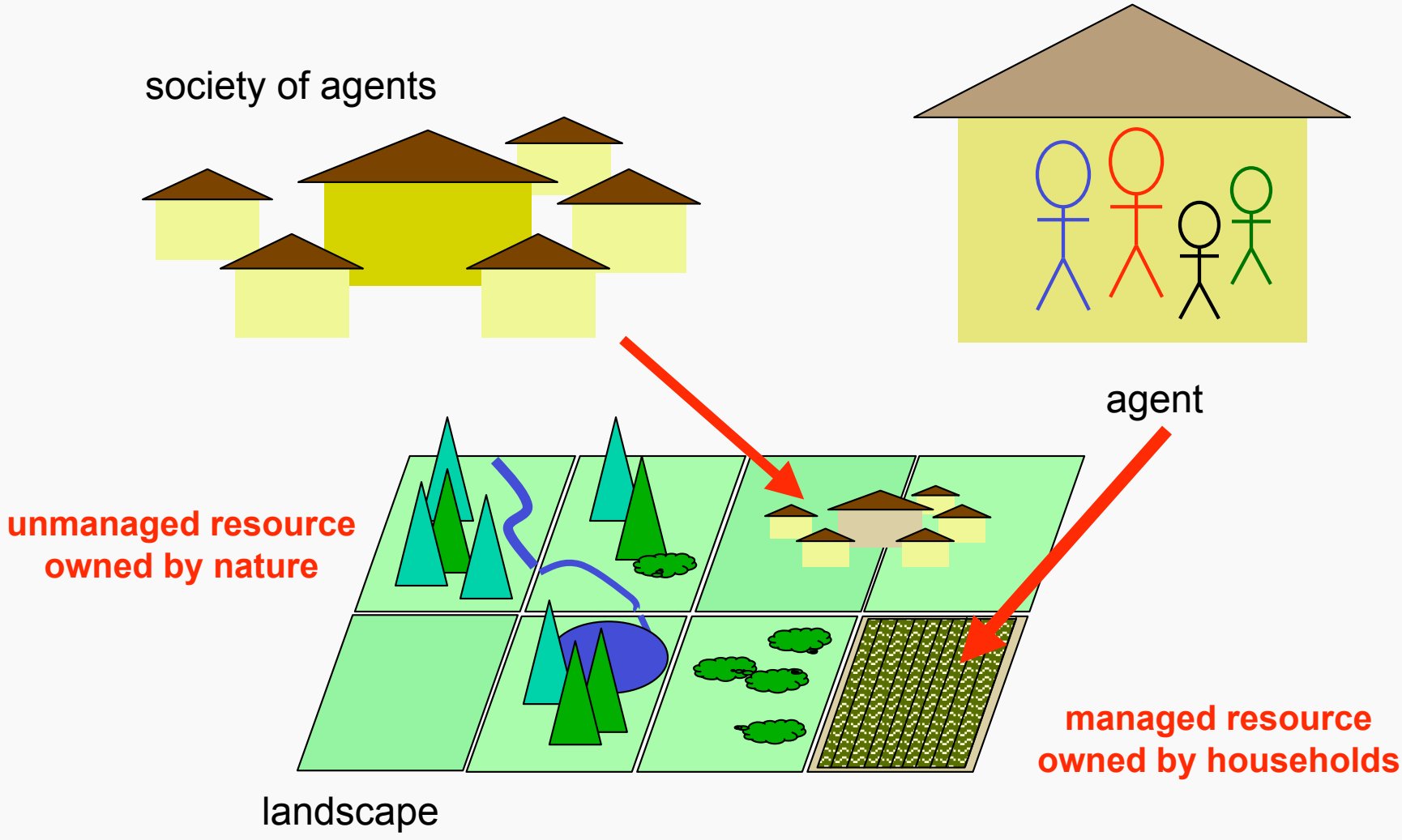


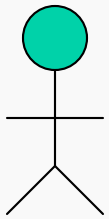
village



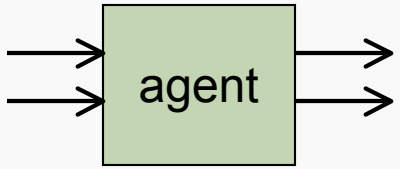
landscape

Agent and Landscape Models and Their Interactions

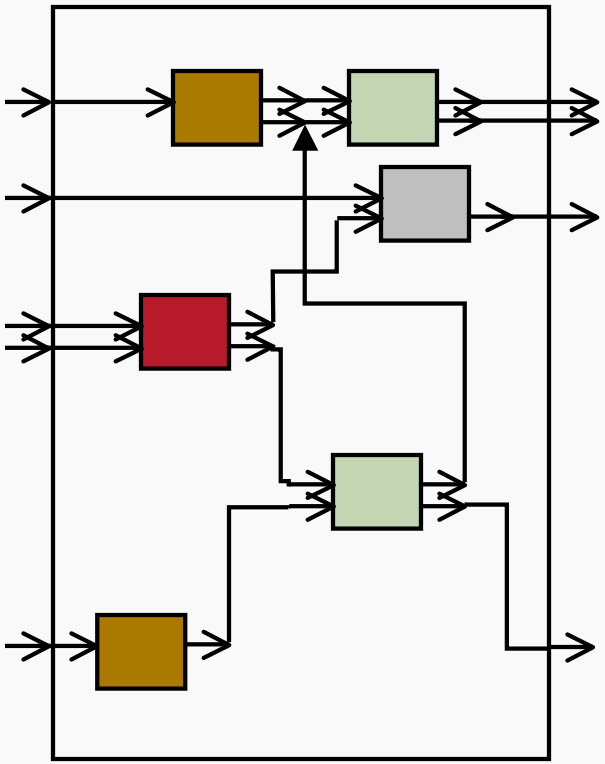




Agent Modeling

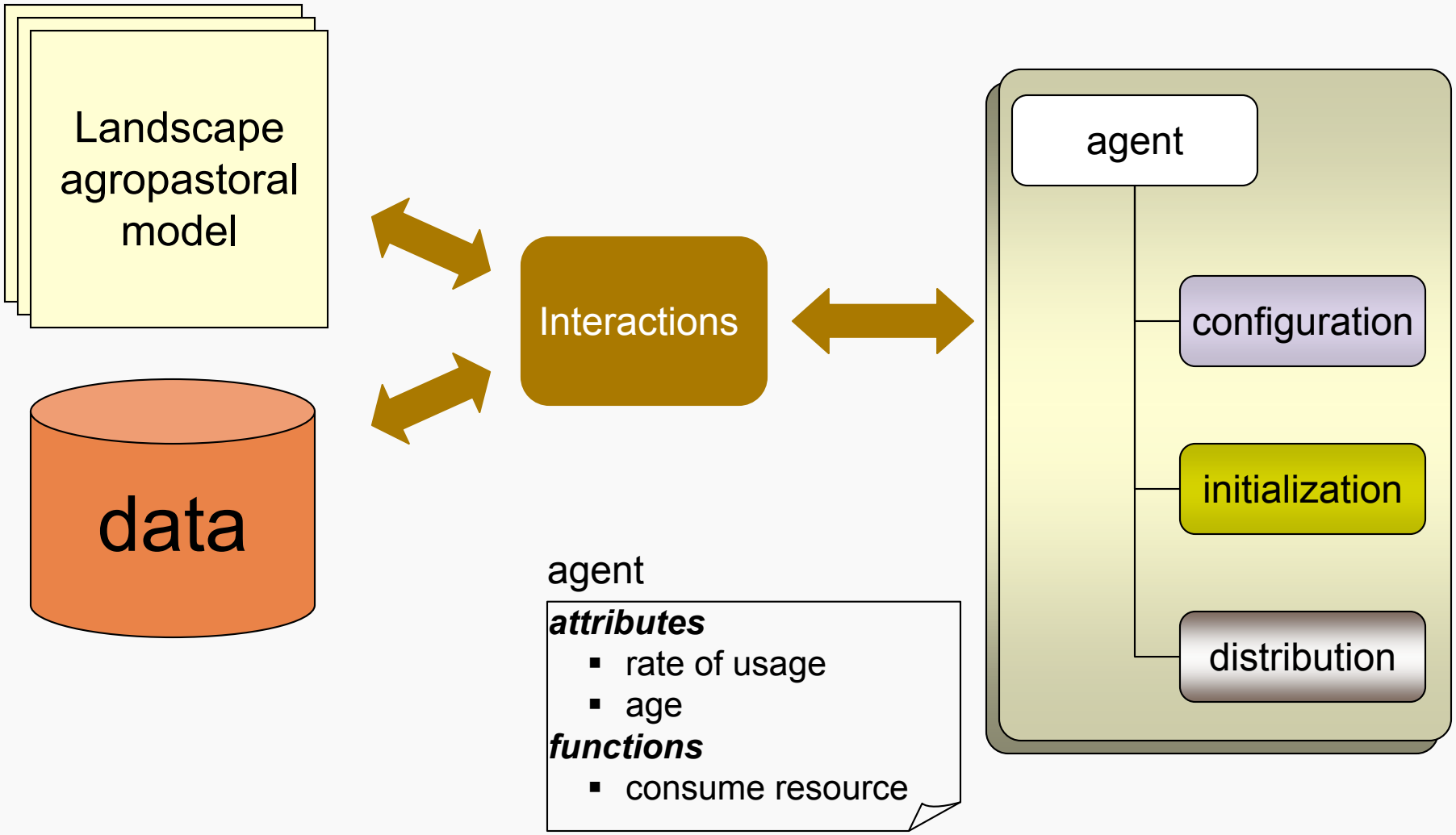


- Agent model (model specification)
  - Structure
    - component-based, object-oriented
  - Behavior
    - simple dynamics
    - complex dynamics
    - mobility
  - Complexity
    - event-based, time-based interactions
    - mobility
  - Scale
    - few tens to many hundreds of agents
    - cluster agents

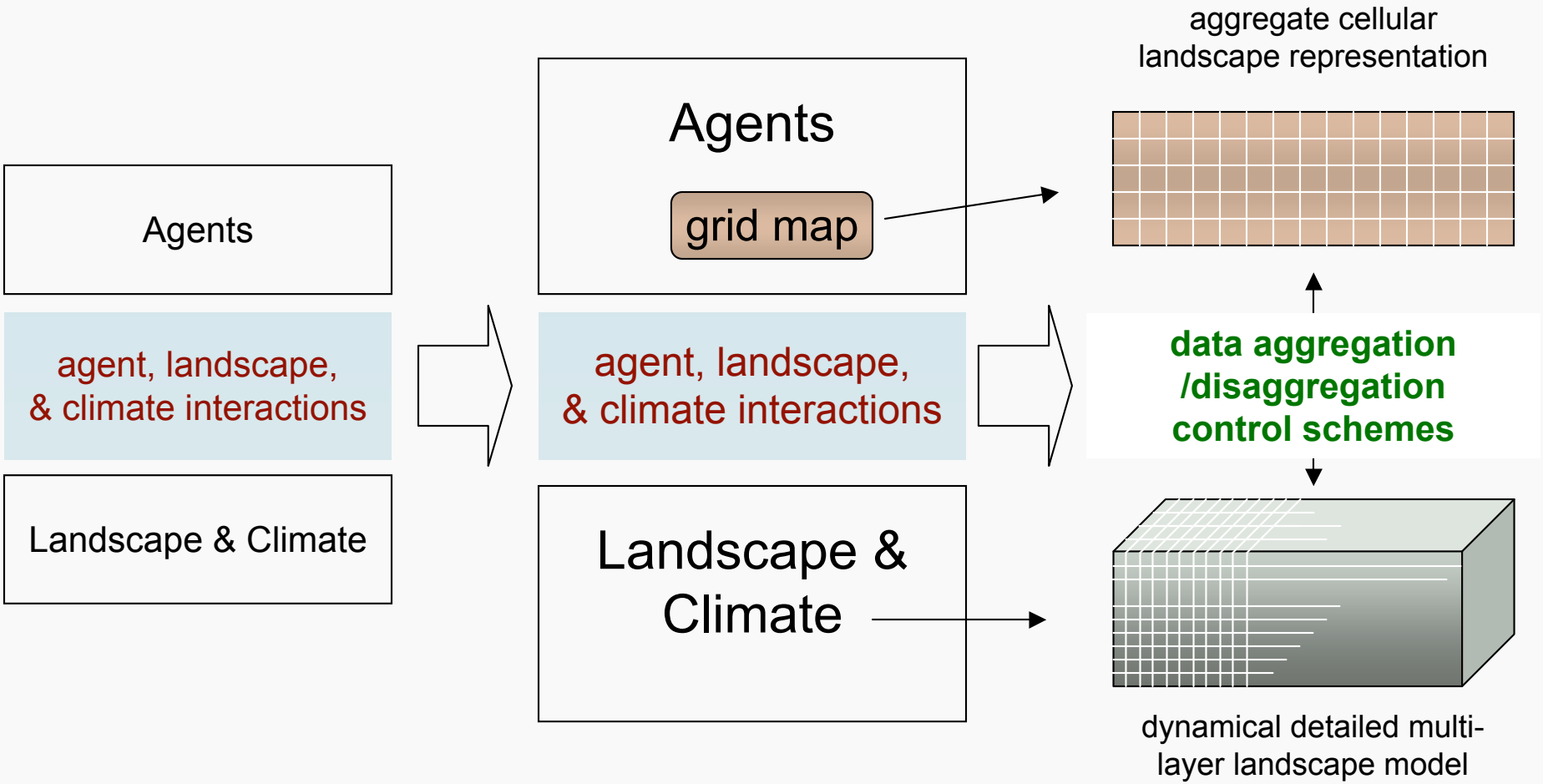


society of agents

Agent Models

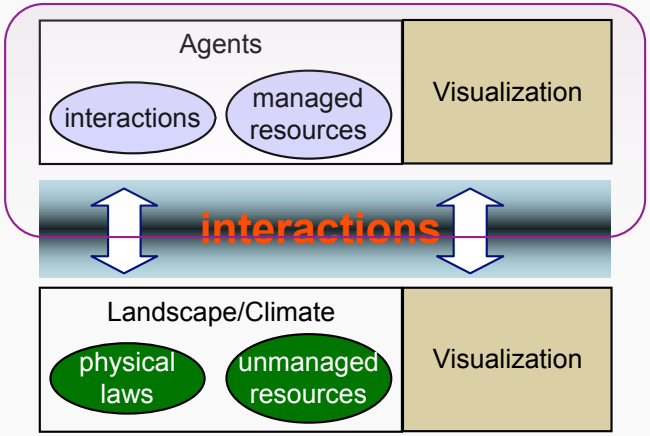


A Three-Layer Agent & Landscape/Climate Model/Simulation Framework



assumption: climate affects only landscape directly

An Approach for Hybrid Agent and Landscape Simulation Modeling



landscape and agent dynamics

Knowledge Representation

- Rules define agents and their interactions
- Equations define landscape dynamics
- Mappings define agent and landscape interactions
  - Use as few as possible simple rules for agents' interactions with landscape

Agents and Their Interactions

- agent have individual and collective roles and activities – growth and decline
- agents can manipulate managed resources such as crops – direct agent manipulation
- agents exchange managed or unmanaged resources using rules

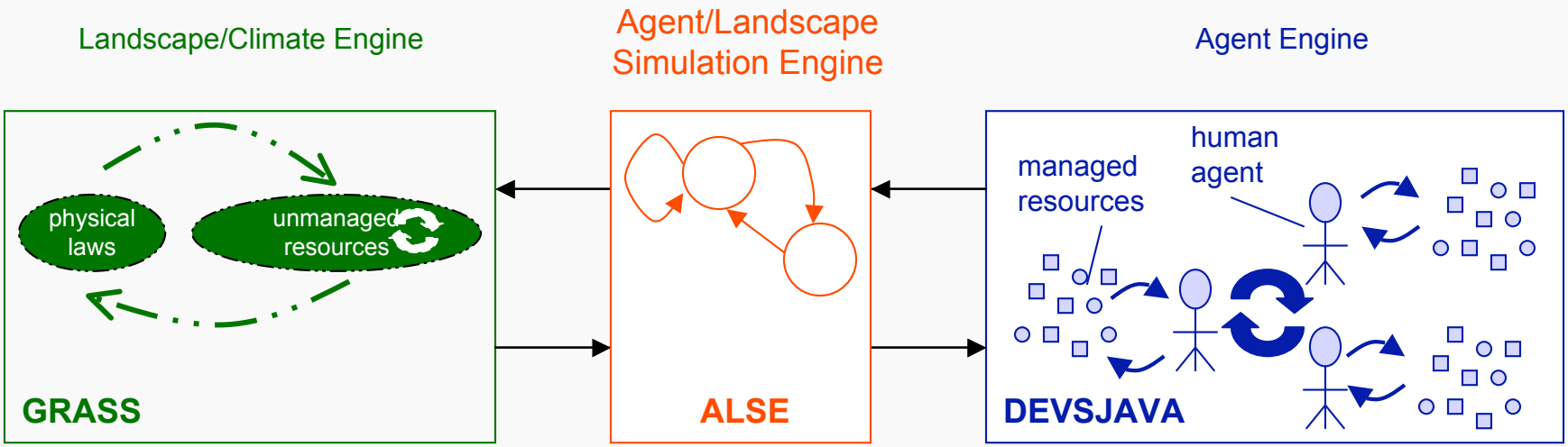
Landscape Interactions

- unmanaged resources are modeled as inter/intra-cell dynamics – direct landscape manipulation

Agents and Landscape Interactions

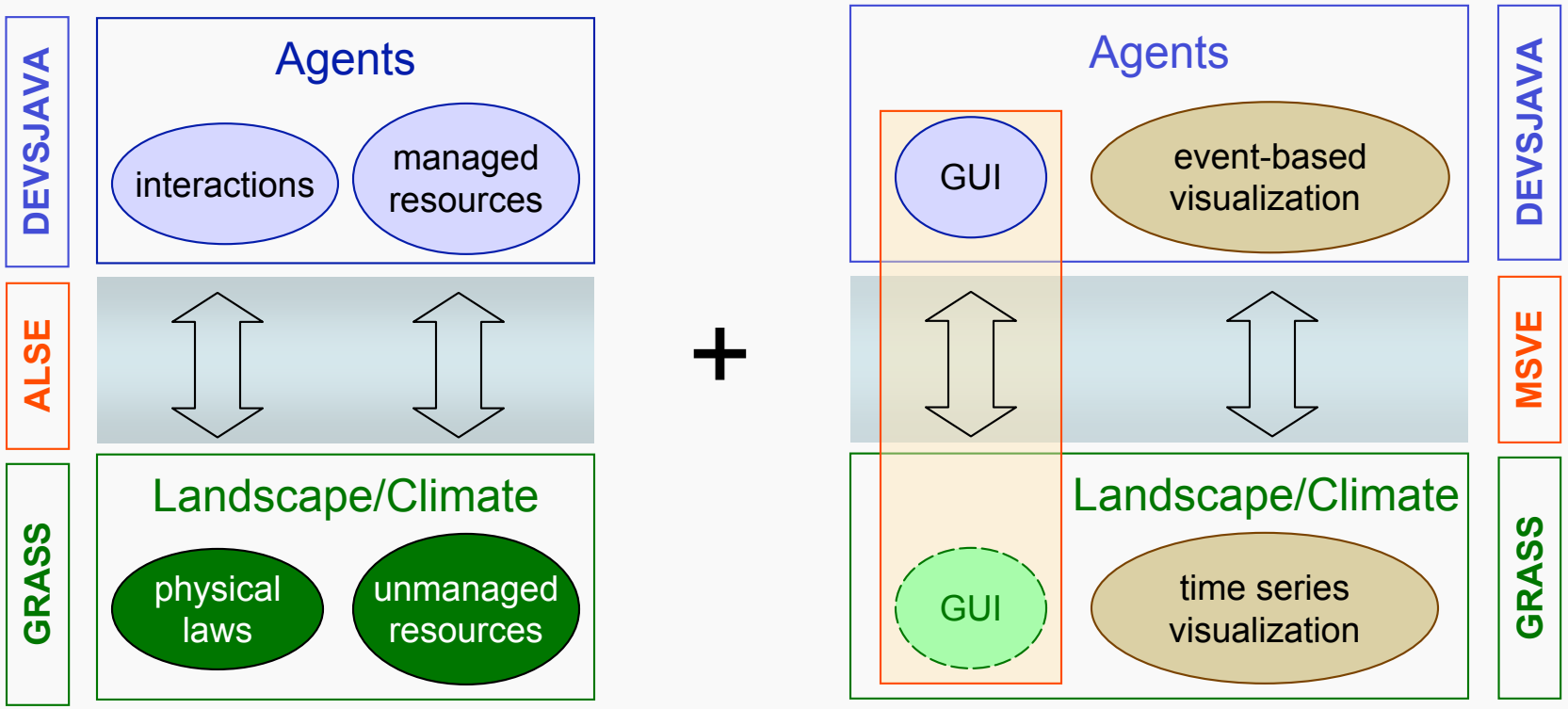
- agents can indirectly affect unmanaged resources (e.g., occupation of land)
- landscape can indirectly affect managed resources (e.g., growth of crops)

Separation of Concerns



- Separatation of agent and landscape/climate models
  - agent models is described using state, transitions, and time
    - use simplified abstractions of environment (land, vegetation, climate models) – limited knowledge of the environment should be included
- Separation enables simpler modifications of agent, landscape & climate models
- Model agents as having distinct *managed* and *unmanaged* resources helps with building “configurable” agent/landuse simulation models

Visual Component-based Model Development and Simulation Execution

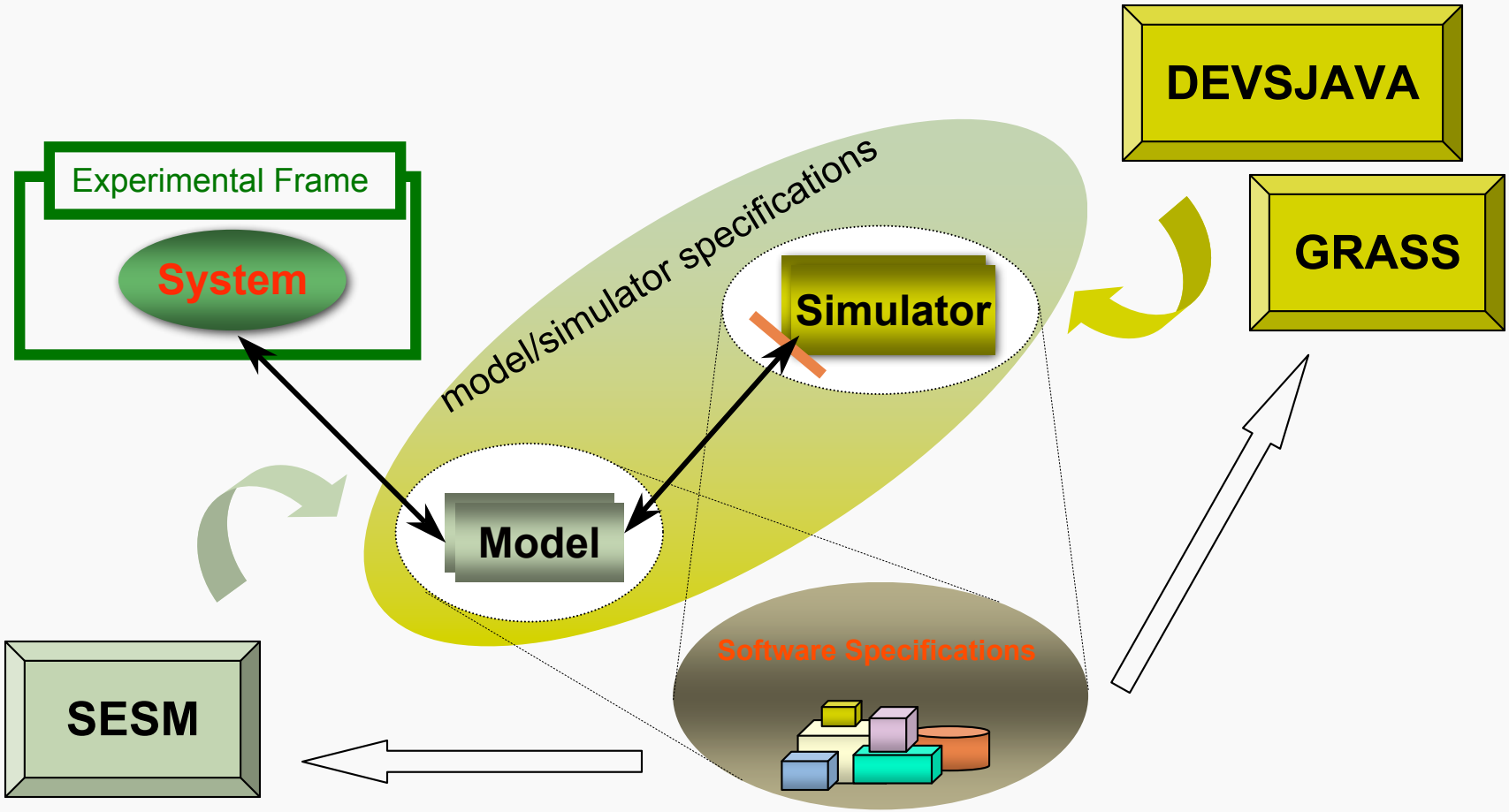


Integrated gent and landscape structural and behavioral dynamics

visualization of individual and combined agent and landscape dynamics

ALSE: Agent/Landscape Simulation Engine
MSVE: Modeling and Simulation Visualization Engine

An Agent/Landscape Modeling & Simulation Environment



SESM: Scalable Entity Structure Modeler

Model Composability & Sim. Interoperability

- Domain knowledge
  - Complexity and scale (heterogeneity and resolution)
  - Reuse (model vs. software)
  - Standardization (time and cost)
- Modeling & Simulation Frameworks

visualization **formal** **persistence**

- Model composition using the concept of Knowledge Interchange Broker (KIB)
  - Reactive Action Planning (xRAP)
  - Optimization (Opl-Studio)

⇒ MedLand …