

# *Agent-Based Modeling (Master SIED)*

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# Unit 9

## The ODD Protocol

# Introduction

- The ODD Protocol was proposed by Volker Grimm *et al.* (2006) because:
  - Simulation models that describe autonomous [...] agents (agent-based models, ABM) have become a widely used tool [...] in many [...] disciplines dealing with complex systems made up of autonomous entities. However, there is no standard protocol for describing such simulation models, which can make them difficult to understand and to duplicate.
- The ODD is organized around the three main components (and seven “sections”) to be documented about a model:
  - Overview
  - Design concepts
  - Details

# Structure

<b>Overview</b>	Purpose
	State Variables and Scales
	Process Overview and Scheduling
<b>Design Concepts</b>	Design Concepts
<b>Details</b>	Initialization
	Input
	Submodels

# Overview

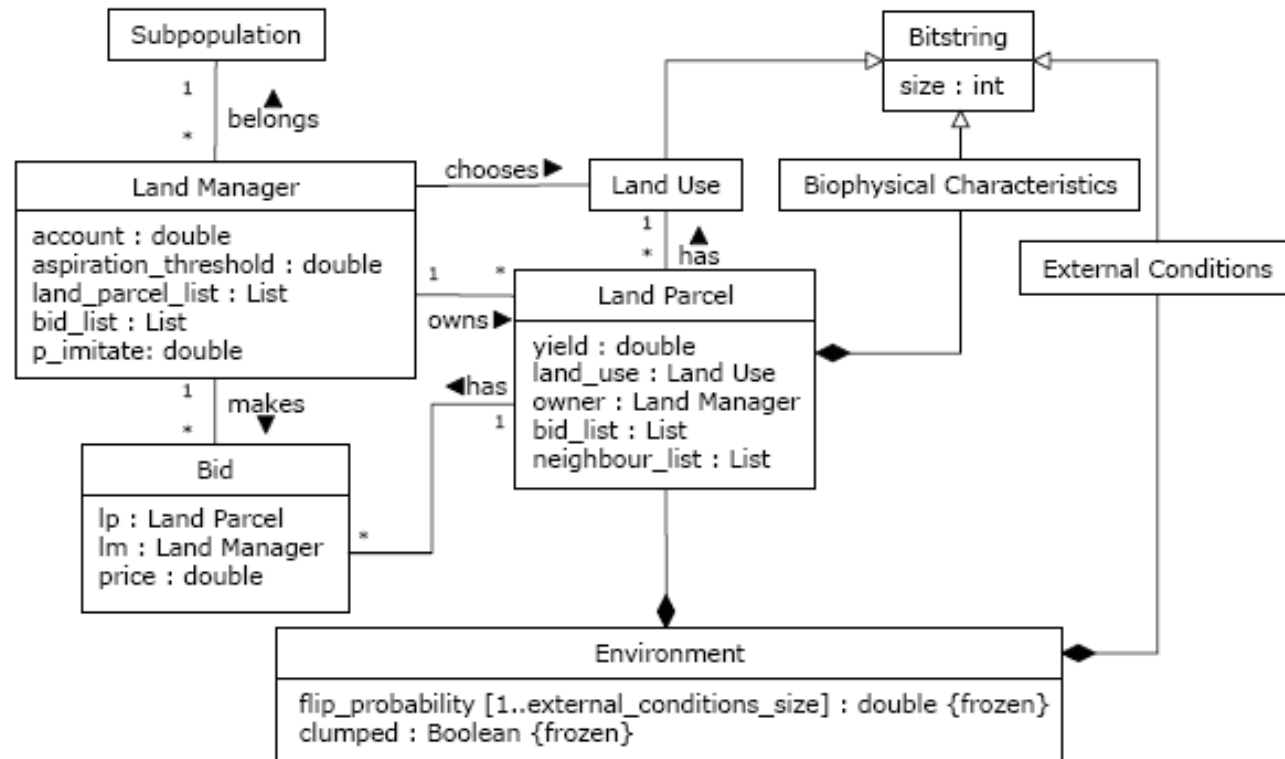
- Give sufficient detail to create an outline of the model
- Purpose:
  - explain what is to be done with the model
- State variables and scales:
  - Outline of the structure of the model
  - Specify all the state variables
  - Grimm et al. (2006) recommend the use of UML diagrams
  - Spatial and temporal scales addressed by the model
- Process overview and scheduling:
  - List all the processes that occur in the model
  - How are they scheduled? Who is doing what and when?

# Entities, State Variables, and Scales

Questions:

- What kinds of entities are in the model?
  - Agents, collectives, spatial units, global environment
- By what state variables, or behavioral attributes, are these entities characterized?
  - Age, sex, wealth, opinion, strategy; soil type, land costs; rainfall, market price, disturbance frequency
- What are the temporal and spatial resolutions and extents of the model?

# Example



UML class diagram depicting part of the structure of FEARLUS+ELMM

# Process Overview and Scheduling

Questions:

- Who (i.e., what entity) does what, and in what order?
- When are state variables updated?
- How is time modeled, as discrete steps or as a continuum over which both continuous processes and discrete events can occur?
  - Except for very simple schedules, one should use pseudo-code to describe the schedule in every detail, so that the model can be reimplemented from this code.
  - Ideally, the pseudo-code fully corresponds to the actual code used in the program implementing the ABM.



# Design Concepts (1)

- Not the model itself but the general underlying concepts
- According to Volker Grimm, there are ten design concepts
- Most of them were discussed extensively by Railsback (2001), Grimm and Railsback (2005; Ch. 5), and in Railsback and Grimm (2012).
- They are summarized in the questions listed in the two following slides.

# Design Concepts (2)

- Emergence
  - What emerges from the model (rather than being imposed)?
- Adaptation
  - How do the agents adapt to improve their fitness? (Both directly and indirectly)
- Objectives
  - What are the goals of the agents?
- Fitness
  - What determines the survival of an agent?
- Prediction
  - How do agents predict the consequences of their decisions? Use of learning, memory, environmental cues, embedded assumptions, ...

# Design Concepts (3)

- Sensing
  - What are agents assumed to know or perceive when making decisions? (Environmental variables, including own variables)
  - Is the sensing process itself explicitly modeled?
- Interaction
  - What forms of interaction among agents are there?
- Stochasticity
  - Justification for any stochasticity in the model
- Collectives
  - Grouping of individuals, e.g., social
- Observation
  - How are data collected from the model for analysis?

# Example (from FEARLUS)

**Emergence.** The emergent effect for the purposes described in this paper is the performance of Land Managers employing different Land Use Selection Algorithms, i.e. pure imitation or including both imitation and innovating components (Imitation Probability = 1 or  $< 1$ , respectively). Currently, performance of Subpopulations is measured by comparing the numbers of Land Parcels owned by member Land Managers. Performance emerges from the interaction of the Land Managers with each other and the landscape. It can be influenced, but not entirely imposed, by the "External Conditions Flip Probability Array" and "Biophysical Characteristics Clumped?" parameters.

**Adaptation.** Land Managers in FEARLUS adapt by choosing new Land Uses to respond to the changing External Conditions. Adaptive strategies are not directly aimed at making more money or acquiring more Land (the measures of fitness), but are instead heuristic. Thus, Random Experimentation could be seen as an effort to try anything new, whilst imitation could be seen as hoping that neighbors are making good choices of Land Use.

**Fitness.** Fitness of individual Land Managers is determined by their Account. If the Account drops below zero, Land Managers are bankrupt, and no longer participate in the simulation.

# Details

- Puts the flesh on the skeleton outlined in the Overview
- Should enable complete re-implementation of the model
- Possibly too much information for a journal article
- May be an appendix or a linked separate document
- Initialization:
  - how the model is bootstrapped
  - references to data used to give initial values to the state variables
- Input:
  - e.g., time-series data of environmental variables
- Submodels:
  - Choice of parameter values
  - Testing and calibration of submodels

# Initialization

Question:

- What is the initial state of the model world, i.e., at time  $t = 0$  of a simulation run?
  - In detail, how many entities of what type are there initially, and what are the exact values of their state variables (or how were they set stochastically)?
  - Is initialization always the same, or is it allowed to vary among simulations?
  - Are the initial values chosen arbitrarily or based on data? References to those data should be provided.

# Input data

Question:

- Does the model use input from external sources such as data files or other models to represent processes that change over time?

# Submodels

## Questions:

- What, in detail, are the submodels that represent the processes listed in “Process overview and scheduling”?
  - What are the model parameters, their dimensions, and reference values?
  - How were submodels designed or chosen, and how were they parameterized and then tested?



# Conclusion

- ODD is a standard format for describing (and formulating) ABMs:
  - Overview first, details later
  - Design concepts
  - Easy to write, easy to read
  - Facilitate replication
  - Independent from discipline, complexity, operating system, programming language

# References

- Volker Grimm et al. (2006). *A standard protocol for describing individual-based and agent-based models*. Ecological Modelling **198**.
- J. Gary Polhill, Dawn Parker, Daniel Brown, and Volker Grimm (2008). *Using the ODD Protocol for Describing Three Agent-Based Social Simulation Models of Land-Use Change*. Journal of Artificial Societies and Social Simulation **11**(2).
- Volker Grimm, Uta Berger, Donald L. DeAngelis, J. Gary Polhill, Jarl Giske, and Steven F. Railsback (2010). *The ODD protocol: A review and first update*. Ecological Modelling **221**.