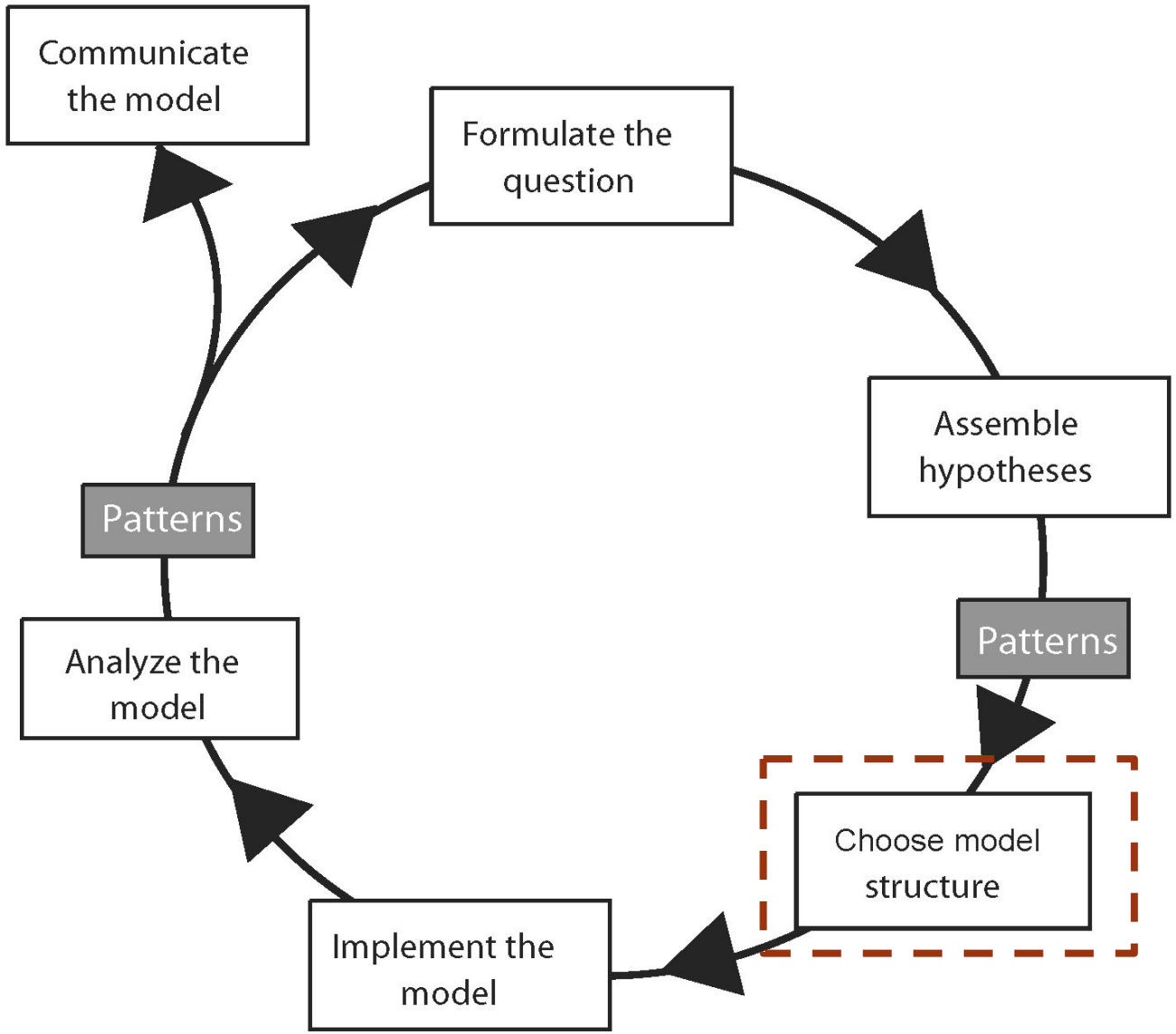
DESCRIBING AND FORMULATING ABMS

The ODD Protocol


Communicate the model
Formulate the question
Assemble hypotheses
Patterns
Choose model structure
Implement the model
Analyze the model
Patterns

FORMULATING ABM

- First think about the problem, data, ideas, and hypotheses, to the first formal and rigorous representation of the model.
- Helps the Models author
  - Think Clearly
  - Identify design decisions and assumptions
  - Plan for Model Implementation
- Helps others to understand the research output
  - Most importantly replicate the results

FORMULATING ABM - Objective

- Communication
- Replication
- Comparison
- Cross-Discipline Uniformity

FORMULATING ABM

- The ABM Community has thought about this
- They support universal standard for guided-documentation of the model
- OpenABM (Comses) Standard
  - https://www.comses.net/resources/standards/
- Introducing the ODD protocol!

ODD PROTOCOL

- Developed by Grimm et al in 2006
  - Along with several senior ABM researchers
- interestingly named based on the parts they contain
  - Overview
  - Design
  - Detail
  - ODD protocol
- Simple and easy
- Provides a way to think about and also describe Agent based models

ODD PROTOCOL ELEMENTS

- Overview
  - What the model is about
  - What patterns does it capture
- Design
  - How is the model designed
  - Essential Characteristics
- Details
  - Initialization
  - Inputs
  - Behavior (Submodels)

	Elements of the ODD protocol
Overview	1. Purpose and patterns
	2. Entities, state variables, and scales
	3. Process overview and scheduling
Design concepts	4. Design concepts • Basic principles • Emergence • Adaptation • Objectives • Learning • Prediction • Sensing • Interaction • Stochasticity • Collectives • Observation
Details	5. Initialization
	6. Input data
	7. Submodels

OVERVIEW – PURPOSE (1A)

- What system are we modeling and what are we trying to learn from it
  - The right level of abstraction for the model
  - The right assumptions (or acceptable assumptions)
  - Things that are safe to ignore
- Remember the designing an ABM is an iterative process
  - When we are stuck at making a design decision, we always comeback to ponder and redefine the Purpose of the model
  - This in turn will refine
    - Abstraction and assumptions

OVERVIEW – PATTERNS (1B)

- Criteria to decide the coverage (realism) of the model
  - What set of patterns would the model account for
  - The following analogy helps a software engineer to understand
    - Interface design
    - Exception handling & Unit Testing
    - TDD – Test driven development
  - Example: Agent based model to study tiger population in Chitwan national park (Carter et al 2015)
    - The model will reproduce and account for the following patterns (driven by the same processes)
    - Ranges in birth rates and Juvenile survival
    - Overlap between female and male territories
    - Negative relation between territory size and prey abundance

OVERVIEW – ENTITIES, STATE VARIABLES AND SCALES (2)

- The kind of things represented in the model
  - The variables and attributes used to characterize them
  - Agent – Entities
  - Environment – Entities
- The state variables of the entities
  - Properties (ex: age, size, opinion, etc) ….Think turtles or breeds own or patches-own
  - Global variables that affect all agents – Temperature etc.
- Temporal scale – Ticks <-> seconds/hours
- Spatial Scale – Patch <-> m/km/cm

OVERVIEW – PROCESS AND SCHEDULING(3)

- Processes represent the behavior of the agents in model
  - What does the agents do
  - What changes happen to the environment
    - Either due to time or interaction
- Not just agent processes – we need to describe observer processes which collects data
- Processes can be simple ‘move randomly’
- Processes can be complex ‘adjust speed based on preceding-car’ in which case we describe this as a submodel and explain in later sections
- Scheduling : when does these process happens
  - At every tick (or some constant frequency)
  - At night times only (i.e. based on some environment condition)

DESIGN CONCEPTS – BASIC PRINCIPLES

- What general concepts, theories, hypotheses, or modeling approaches underlie the model's design?
- How is the model related to previous thinking about the problem it addresses?
- How were these principles incorporated in the model's design?
- Does the model implement the principles in its design, or address them as a study topic,
  - e.g., by evaluating and proposing alternatives to them?

DESIGN CONCEPTS – EMERGENCE

- What are the model's important results and outputs?
- Which of them emerge from mechanistic representation of the adaptive behavior of individuals
- (Vs) which are imposed by rules that force the model to produce certain results?

DESIGN CONCEPTS - ADAPTATION

- What adaptive behaviors do agents have, and why?
  - In what ways can they respond to changes in their environment and themselves?
- What decisions do they make?
- How are these behaviors modeled?
  - Do submodels of adaptive behavior assume agents choose among alternatives by explicitly considering which is most likely to increase some specific objective (direct objective-seeking),
  - (Or) do they simply force agents to reproduce behavior patterns observed in real systems (indirect objective-seeking)?

DESIGN CONCEPTS – OBJECTIVES

- For direct objective-seeking
  - what measure of agent objectives (for example, “fitness” in ecology, "utility” in economics) is used to rate decision alternatives?
  - This objective measure is the agent’s internal model of how it would benefit from each choice it might make.
  - What elements of future success are in the objective measure (e.g., survival to a future reproductive period; probability of staying in business for some period; profits at the next reporting period)?
  - How does the objective measure represent processes that link adaptive behaviors to important variables of the agents and their environment?

DESIGN CONCEPTS – OBJECTIVES (CONTD)

- How were the variables and mechanisms in the objective measure chosen, considering the model's purpose and the real system it represents?
  - e.g., risks of mortality or going out of business, the conditions necessary for reproduction or profitability
- How is the agent's current internal state considered in modeling decisions?
- Does the objective measure change as the agent changes?

DESIGN CONCEPTS – LEARNING

- Do individuals change how they make adaptive decisions over time as a consequence of their experience? If so, how?

DESIGN CONCEPTS – PREDICTION

- How do agents predict future conditions (environmental and internal) in their submodels for adaptive behavior?
- What assumptions about, or mechanisms of, the real individuals being modeled were the basis for how prediction is modeled?
- How does simulated prediction make use of mechanisms such as memory, learning, or environmental cues?
  - Or is it "tacit," i.e., only implied in simple rules for adaptive behavior?

DESIGN CONCEPTS – SENSING

- What variables of their environment and themselves are agents assumed to sense and therefore be able to consider in their behavior?
- What is the basis for these assumptions?
- What sensing mechanisms are modeled explicitly, and which sensed variables are agents instead assumed simply to "know"?
- With what accuracy or uncertainty are agents assumed to "know" or sense which variables?
  - Over what distances (in geographic, network, or other space)?

DESIGN CONCEPTS – INTERACTION

- How do the model's agents interact?
- Do they interact directly with each other (e.g., does one agent directly change the state of others)?
- Or is interaction mediated, such as via competition for a resource?
- With which other agents does an agent interact?
- What real interaction mechanisms were the model's representation of interaction based on?
  - At what temporal and spatial scales they occur?

DESIGN CONCEPTS - STOCHASTICITY

- How are stochastic processes (based on pseudorandom numbers) used in the model and why? Are stochastic processes used:
  - To initialize the model?
  - Because it is believed important for some processes to be variable but unimportant to represent the causes of variability?
  - To reproduce observed behaviors using empirically determined probabilities?

DESIGN CONCEPTS - COLLECTIVES

- Are collectives—aggregations of agents that affect the state or behavior of member agents and are affected by their members—represented in the model?
- If so, how are collectives represented?
- Do they emerge from the behaviors of agents, or are agents given behavior submodels that impose the formation of collectives
- Or are the collectives modeled as another type of agent with its own behaviors and state variables?

DESIGN CONCEPTS - OBSERVATION

- What outputs from the model are needed to observe its internal dynamics as well as its system-level behavior?
- What tools (graphics, file output, data on individuals, etc.) are needed to obtain these outputs?
- What outputs and analyses are needed to test the model against the criteria for usefulness—usually, a set of patterns—defined in the "Purpose and patterns" element?
- What outputs are needed to solve the problem the model was designed for?

EXAMPLES & TEMPLATES

- https://www.sciencedirect.com/science/article/pii/S0304380015002574
- http://www.railsback-grimm-abm-book.com/E2-Downloads/Chapter03/ODD_GuidanceChecklists_2020.pdf