ODD Protocol-Summary

Introduction

The ODD (Overview, Design concepts, Details) protocol is a structured format for documenting Agent-Based Models (ABMs) to improve clarity, reproducibility, and understanding.

It was developed by Grimm et al. (2006) and has since been widely adopted in various fields, including ecology and social sciences.

Comparison to Traditional Models

Traditional equation-based models benefit from well-established notations, such as differential equations in mathematical modeling and Bayesian theory in statistical modeling.

Similarly, the ODD protocol provides a systematic way to describe ABMs, ensuring transparency and completeness in model descriptions.

What is the ODD Protocol?

ODD stands for:

- **Overview**: General description of the model.
- **Design concepts**: Theoretical and conceptual foundations.
- **Details**: Specific implementation details of the model.

The primary objectives of the ODD protocol are to make model descriptions more understandable and complete, thereby reducing criticism related to irreproducibility.

Although initially developed for NetLogo, the ODD protocol is applicable to other simulation software as well.

Overview

1. **Purpose**:
    - The general aim of the model. For example, an evacuation model might aim to evaluate how pre-evacuation time and exit choice affect total evacuation time.
    - Boundaries and scope are defined to simplify the model, such as simulating only one floor of a building and not the cause of the evacuation.
2. **Entities, State Variables, and Scales**:
    - **Entities**: The components of the simulation, such as agents (leavers, followers, officers), environments (walls, walkable spaces), and time.
    - **State Variables**: Attributes that distinguish entities or trace their changes over time. For example, agents' status (not evacuating, evacuating, evacuated).
    - **Scales**: Temporal and spatial scales, including the duration of the simulation and the resolution of the spatial environment.

3. **Process Overview and Scheduling**:
    - Dynamics and behavior of model entities, including movement, interaction with the environment, and communication. The sequence of actions is crucial for understanding how entities interact and change over time.

Design Concepts

The design concepts section explains how the model addresses key theoretical and conceptual issues relevant to ABMs. The ODD protocol defines several specific design concepts, including:

- **Basic Principles**: Fundamental theories underlying the model, such as mass panic theory or affiliation model.
- **Emergence**: How complex patterns or behaviors emerge from simple interactions between agents.
- **Adaptation**: How agents adapt their behavior based on changes in the environment.
- **Objectives**: Goals of the agents and how these goals influence their behavior.
- **Learning**: Mechanisms through which agents learn and improve their behavior over time.
- **Prediction**: How agents predict future conditions based on past patterns.
- **Sensing**: How agents perceive their environment and other agents.
- **Interaction**: The types of interactions between agents and between agents and their environment.
- **Stochasticity**: Elements of randomness in the model, such as random initial positions of agents.
- **Collectives**: Formation and behavior of groups of agents.
- **Observation**: Data collected from the model for analysis and validation.

Details

1. **Initialization**: Initial conditions of the model, such as the number and location of agents and their initial state variables.
2. **Input Data**: External data required to drive the model, including spatial data and agent characteristics.
3. **Submodels**: Detailed descriptions of submodels, including their rules, algorithms, and equations.

Critique and Extensions

While the ODD protocol has been praised for its systematic approach, some social scientists have critiqued it for not providing enough detail to describe complex agent behaviors and interactions. Extensions like ODD+D and ODD+2D have been proposed to address these limitations by incorporating more detailed descriptions of decision-making processes and empirical data integration.

Conclusion

The ODD protocol is a crucial tool for documenting ABMs, ensuring that model descriptions are clear, comprehensive, and reproducible. It provides a structured approach that facilitates the understanding and evaluation of complex models, contributing significantly to scientific rigor in modeling practices. Continuous updates and adaptations of the ODD protocol will further enhance its applicability and effectiveness across various disciplines.

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ODD PROTOCOL

ELLEN-WIEN AUGUSTIJN

What can we compare ODD to?

- If you have an equation – like in traditional equation-based models – you are transparent
- What we lack in Agent-Based modeling is a traditional notation
- Just as *differential equations* provide a way of thinking in mathematical modeling,

and *Bayesian theory* in statistical modeling,

$$x^2\frac{d^2y}{dx^2} + x\frac{dy}{dx} + (x^2 - \alpha^2)y = 0$$

- *ODD* provides a way to describe ABMs

What is the ODD protocol?

- ODD stands for "Overview", "Design concepts" and "Detail" – relating to the three main components of the protocol
- The primary objectives of ODD are to make model descriptions more *understandable* and *complete*, thereby making ABMs less subject to criticism for being irreproducible.
- ODD is not the only way to describe your model in a systematic and understandable way there is also UML
- Although ODD is a protocol developed for Netlogo it is also useful when implementing a simulation in other software.

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

Grimm et al. Ecological Modelling 221 (2010) 2760–2768

1. OVERVIEW - PURPOSE

goal should be specific and measurable

DESCRIBE YOUR MODEL IN GENERAL TERMS

- Simulates an evacuation of the ITC building
- The Goal of this simulation is to evaluate if pre-evacuation time (time spend before the actual evacuation starts) and exit-choice influence the total evacuation time.
- Boundaries of this model are:
  - Only one floor of the building (to make it simpler)
  - Evacuation will start the moment the alarm sounds
  - The cause of the evacuation (fire, bomb..) will not be simulated… no fire spreading, or smoke, or explosion is being simulated, just the movement of the people
- The model will not be used to predict the evacuation time but for explanatory purposes, gaining knowledge about the behaviour and effect of change in this behaviour is most important.

ผู้ล่า กับ เหยื่อ (predators – … model)

What is the purpose for the Wolf-Sheep model??

emergence of pattern

simulate / explore

2. OVERVIEW: ENTITIES

- Entities, state variables and scales
- Entities are the components of the simulation: the agents, the environments and time.
- For the simulation of the ITC building three types of agents: leavers, followers and officers
- We also have a number of environments: the walls, the walkable space, Distance the nearest exit, distance to the main exit and the network representing the center lines of the corridors and of course the exits

2. OVERVIEW - ENTITIES

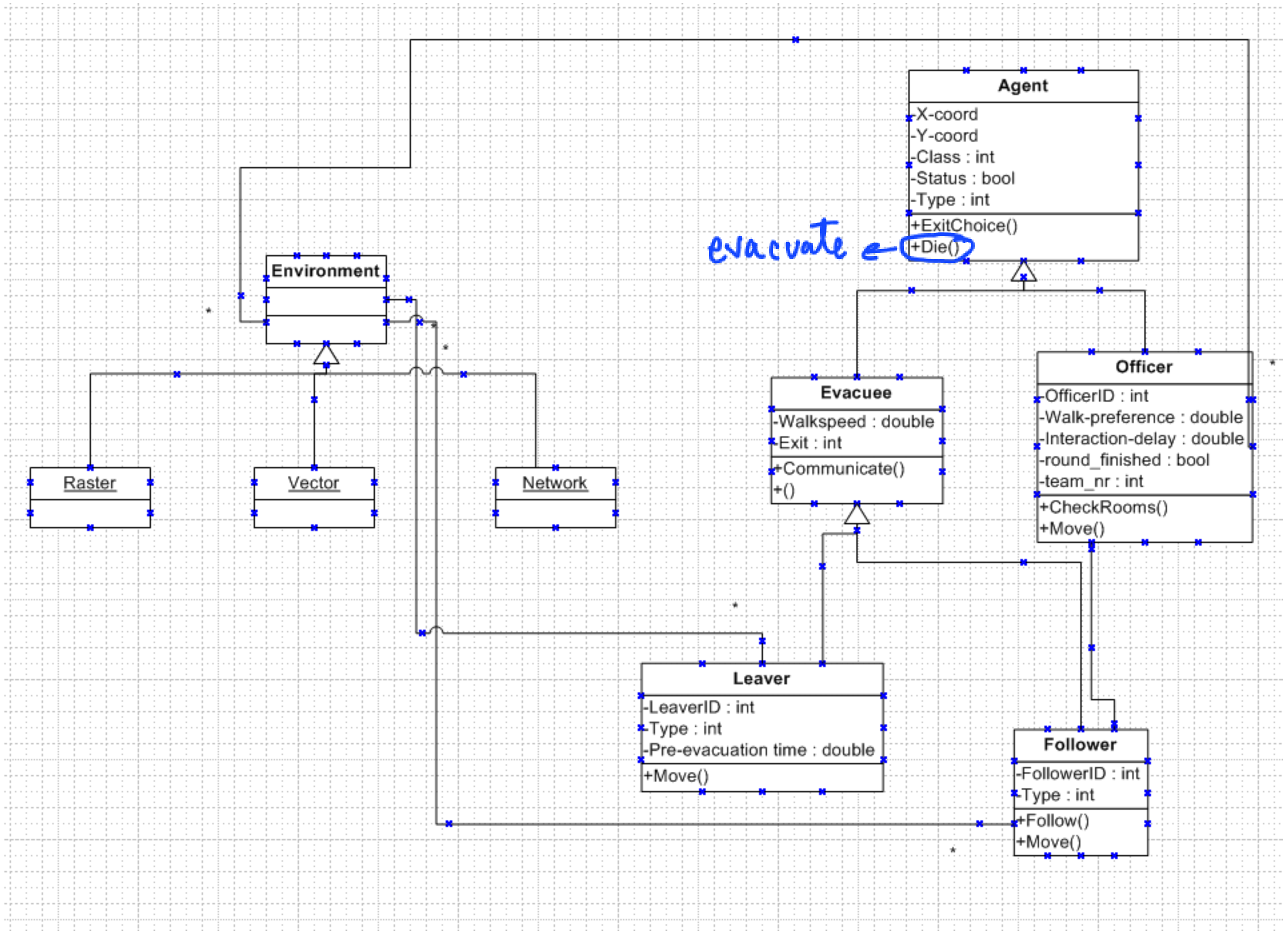
GENERAL TERMS

- My simulation will have three types of agents:
  - Leavers (students and staff)
  - Followers (students and staff)
  - Officers (staff)

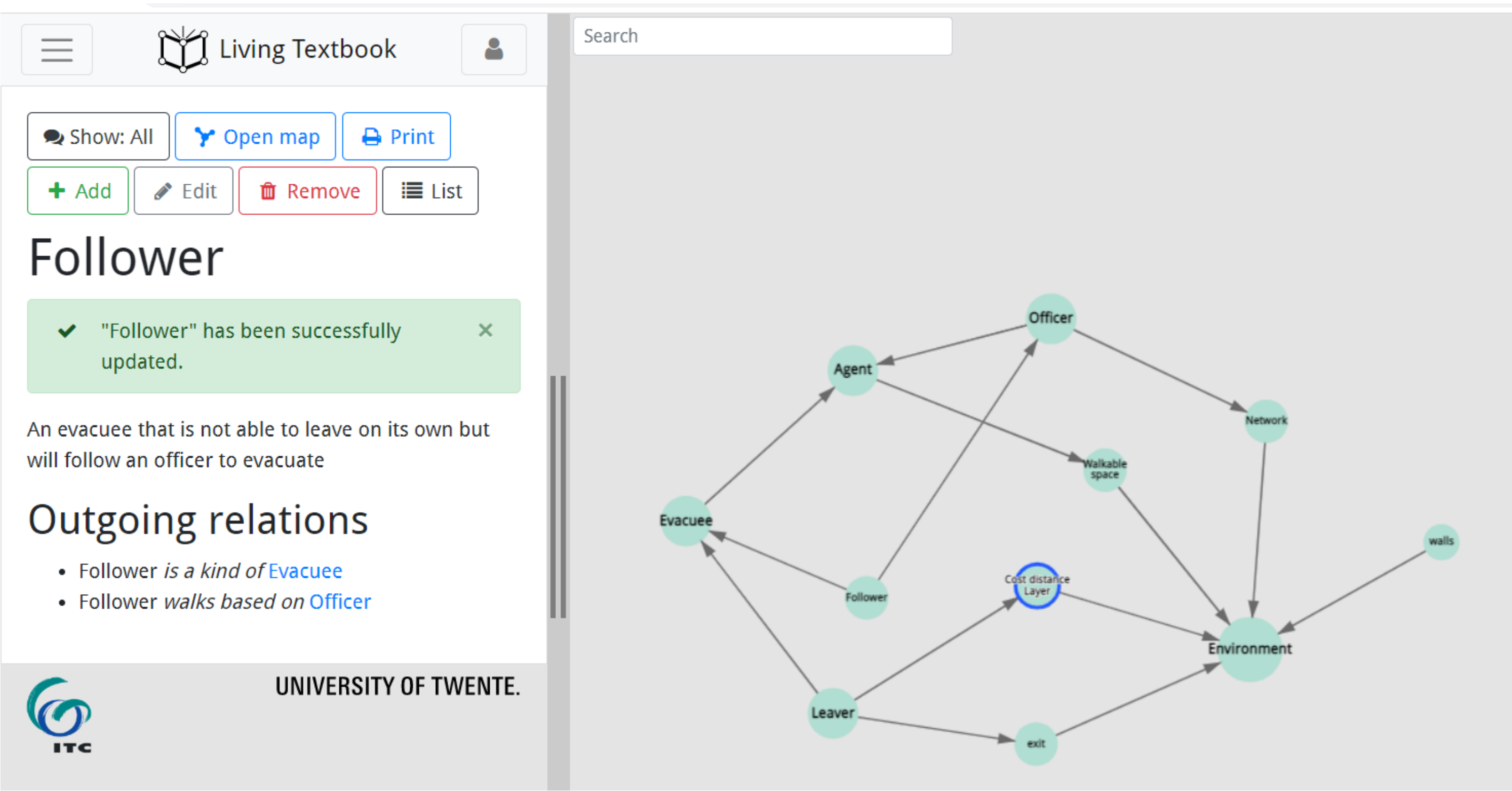
short description of behavior of agents

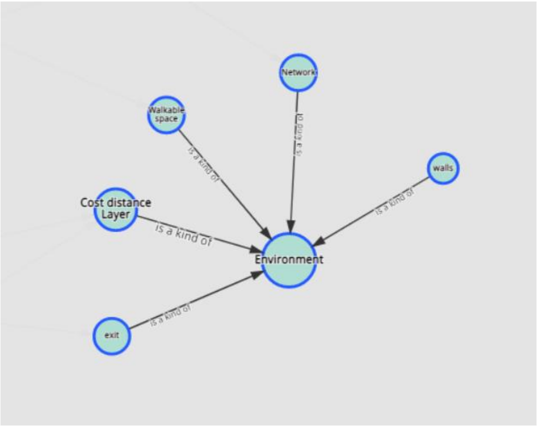
- The Goal of both the students and the staff is to get out of the building safely (to evacuate), some of them will be able to do this on their own (leavers) some others are not able to do this on their own (followers). These followers represent people that go into panic, or are unknown to the building, or are for example disabled and cannot evacuate by themselves.
- The Goal of the officers is to clear the building and only after evacuating all other people, they will evacuate themselves.

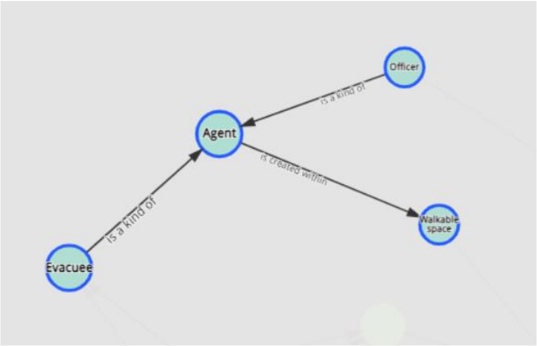
CLASS DIAGRAM



LIVING TEXTBOOK







2. STATE VARIABLES

- What are state variables?

According to Grimm et al (2010): *A state variable or attribute is a variable that distinguishes an entity from other entities of the same type or category, or traces how the entity changes over time*

- What would be the state variables for the ITC evacuation simulation?
  - *Agents: status (not evacuating yet, evacuating, evacuated)*
  - ? *As a rule of thumb state variables are variables that cannot be calculated or deduced from other variables.*

alive / die could be

What is the state variable for the Wolf-Sheep model??

state of wolf and sheep remains the same

2. SCALES

- To be more precise: temporal scales and spatial scales
- Both have two aspects: extent and granularity

- Temporal scale:
  - Total duration of the simulated period (few minutes)
  - Length of each time step (second)
- Spatial scale:
  - Total map extent (ITC building)
  - Cell size (resolution) ex. 2x2 meters
  - For vector data ?

3. PROCESS OVERVIEW AND SCHEDULING

- Dynamics of model entities:
  - What is the behavior of agents?
  - What makes environments change?

Essential concept "**Action**". The simulation is a **"sequence of actions"**.

(which model entities execute which model processes in what order?)

```
Ask turtles [move]
```

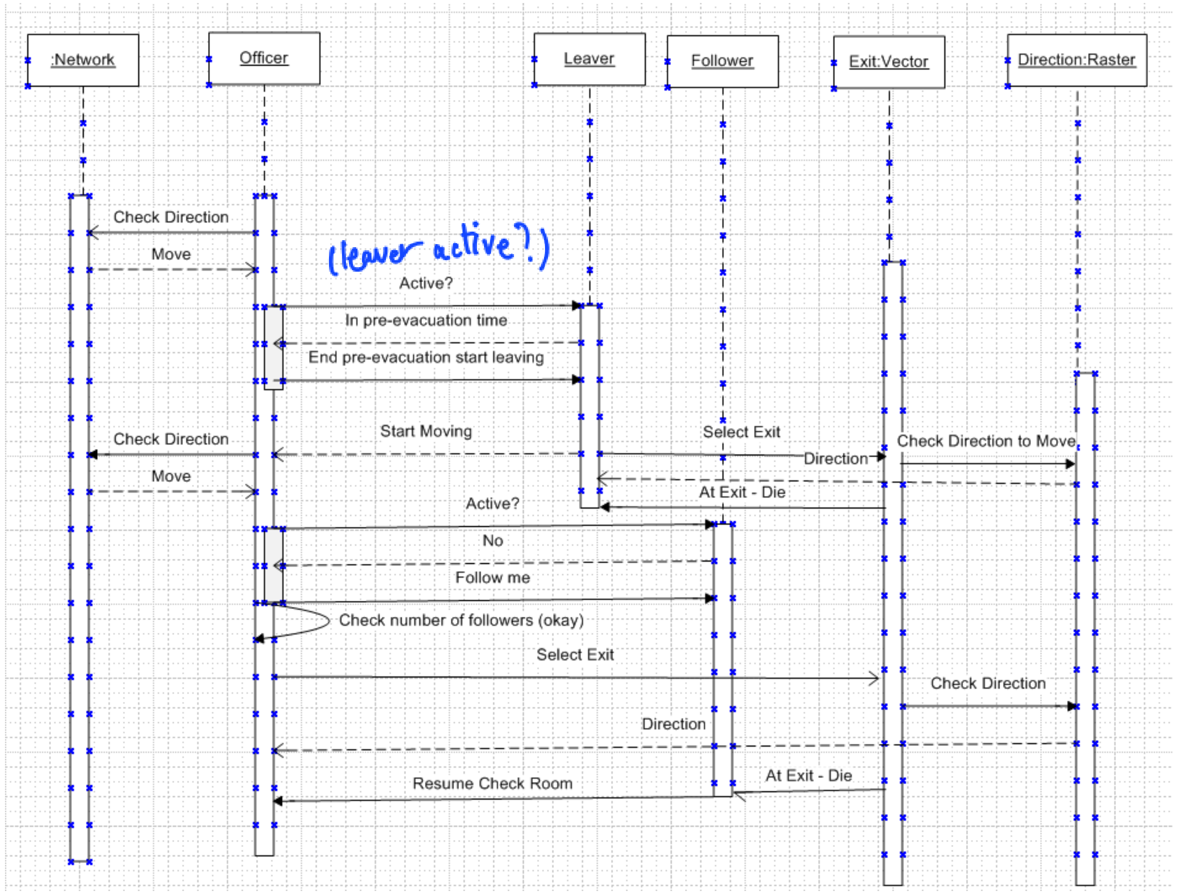
```
to go
  move-officers
  move-leavers
  move-followers
  if not any? leavers and not any? followers and not any? officers
  [
    file-print "============= simulation end ================"
    file-close
    stop
  ]

  tick
end
```

3. PROCESS OVERVIEW - BEHAVIOR OF THE AGENTS

- **Both staff and students have the following behavior:**
  - They can move (walk)
  - They can find the nearest exit
  - They can find their way back to the entrance where they came in
  - They can communicate
  - When they are followers, they can follow other evacuees or officers to the exit
  - They can leave the building (die)
- **Officers have the following behavior:**
  - They can move
  - They can communicate
  - They can bring followers to the exit (but not evacuate themselves)
  - They can leave the building

SEQUENCE DIAGRAM



3. PROCESS OVERVIEW - BEHAVIOR OF THE AGENTS

- **The Following interactions exist between the agents:**
  - Officers can ask the other agents to leave the building (forget about the pre-evacuation time and start the evacuation immediately)
  - Agents that are leavers or officers can take a follower to the exit – when the pre-evacuation time of the follower is over, and an officer or leaver comes along tag on and follow to the exit.
  - Agents can avoid bumping into other agents
- **The Following interactions exist between agents and environments:**
  - Agents can identify the nearest exit
  - Agents are aware of walls and other obstacles
  - Agents know how to get out of rooms (find the door)
  - Agents will know when they have reached the exit (leave the simulation)

The ODD Model

	Elements of the ODD protocol
Overview	1. Purpose 2. Entities 3. Process overview
Design concepts	4. Design concepts Basic principles Emergence Adaptation etc.
Details	5. Initialization 6. Input data 7 Sub models

Design concepts

11 different design concepts:

- Basic theories
- Emergence
- Adaptation
- Objectives
- Learning
- Prediction
- Sensing
- Interaction
- Stochasticity
- Collectives
- Observation

Basic theory

Which general concepts, theories, hypotheses, or modeling approaches are underlying the model's design?

Mass Panic Theory

- For Mawson[1], the term 'panic' refers to inappropriate (or excessive) fear and/or flight and highly intense fear/or flight.
- The 'mass panic' theory state that, since the crowd is less intelligent and more driven by simple emotions, crowd reaction to an emergency will be disproportionate regarding the danger and will spread quickly and widely throughout all the individuals gathered.

Affiliation and Normative Approach

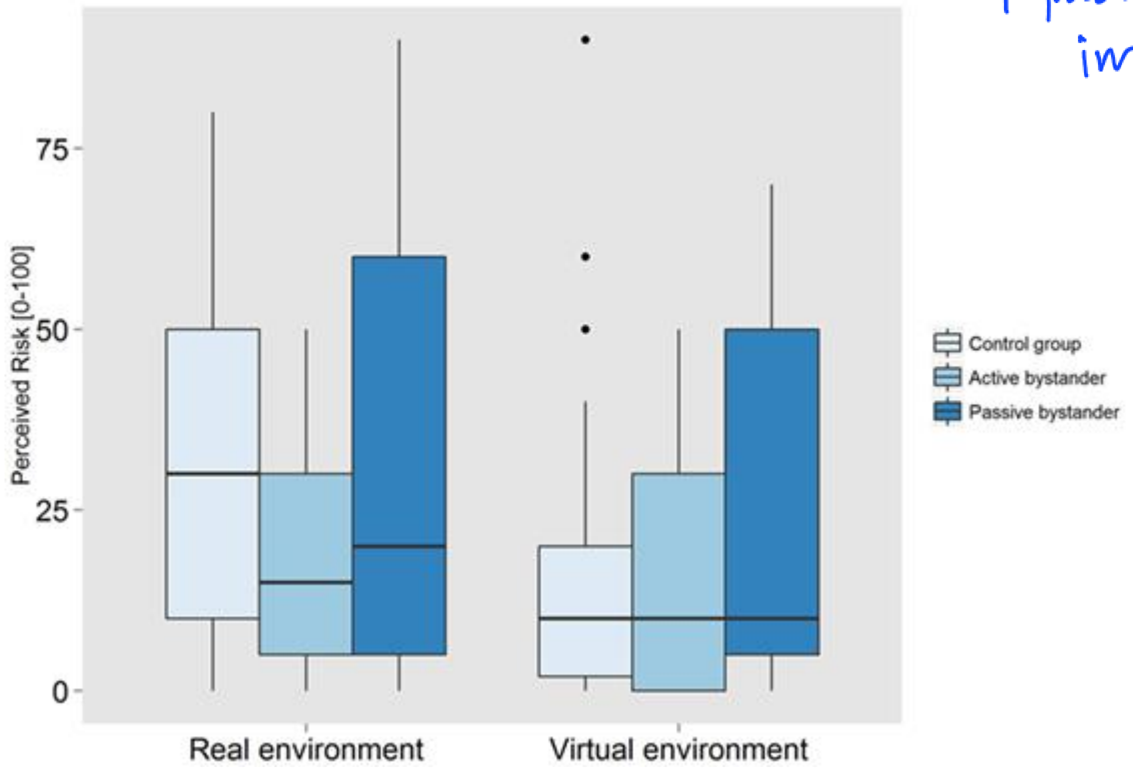
- The affiliation model state that, "In fact, the typical response of threats and disasters is not to flee but to seek the proximity of familiar persons and places; moreover, separation from attachment figures is a greater stress factor than physical danger"[1].

Emergence

What key results or outputs of the model are modeled as emerging from the adaptive traits, or behaviors, of individuals?

L happen by the model itself

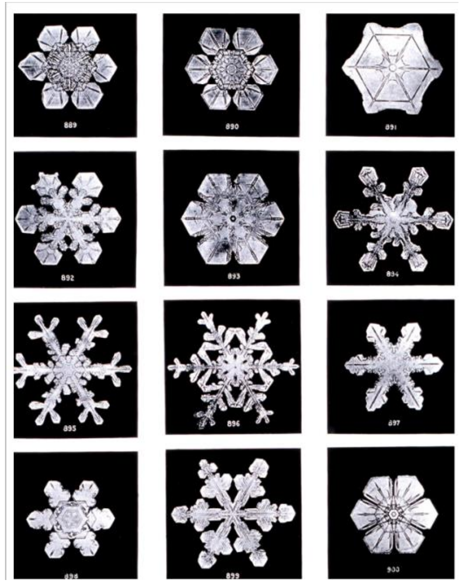
impact of building layout
impact evacuation behavior / time



Kinateder M and Warren WH (2016) Social Influence on Evacuation Behavior in Real and Virtual Environments. *Front. Robot. AI* 3:43. doi: 10.3389/frobt.2016.00043

EMERGENCE

- Emergent phenomena are characterized by stable macroscopic patterns arising from local interaction of individual entities
- The whole is more than the sum of the parts
- Similar to self organization, chaos, etc.



Picture: Snowflakes forming complex symmetrical patterns is an example of emergence in a physical system. (Wikipedia)

- What can emerge:
  - Patterns
  - Structures
  - Behavior (An **emergent behavior** or **emergent property** can appear when a number of simple entities (agents) operate in an environment, forming more complex behaviors as a collective

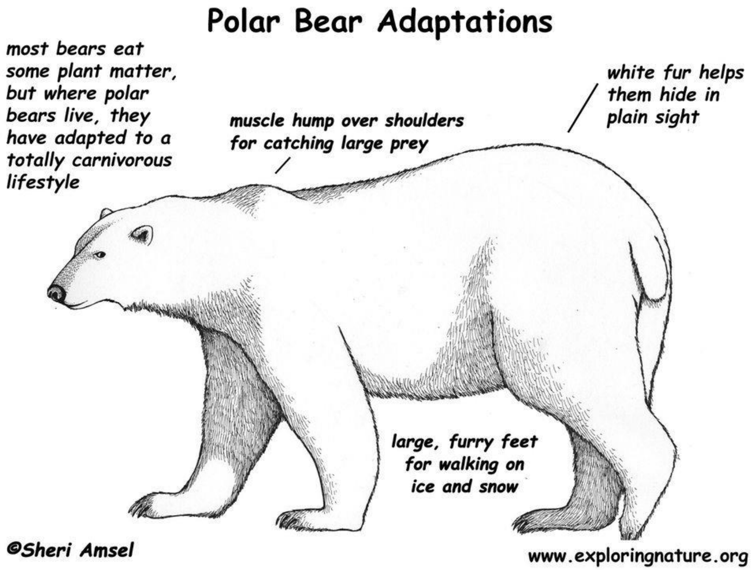
EMERGENCE – SHOCKWAVE TRAFFIC JAM

http://www.youtube.com/watch?v=Suugn-p5C1M

Adaptation

What adaptive traits do the individuals have? What rules do they have for making decisions or changing behavior in response to changes in themselves or their environment?

- In this simulation, there is not much adaptation, yet we can imagine:
- Agents adapt their evacuation route and destination exit when they approach a fire in the corridors. They adjust their behavior based on the state of their environment
- The implementation is via a ML algorithm…..



Objectives

- When the simulation already has an objective, why is “objectives” also an item in the Design part of the protocol?

If adaptive traits explicitly act to increase some measure of the individual’s success at meeting some objective, what exactly is that objective and how is it measured?

L why they adapt

Learning

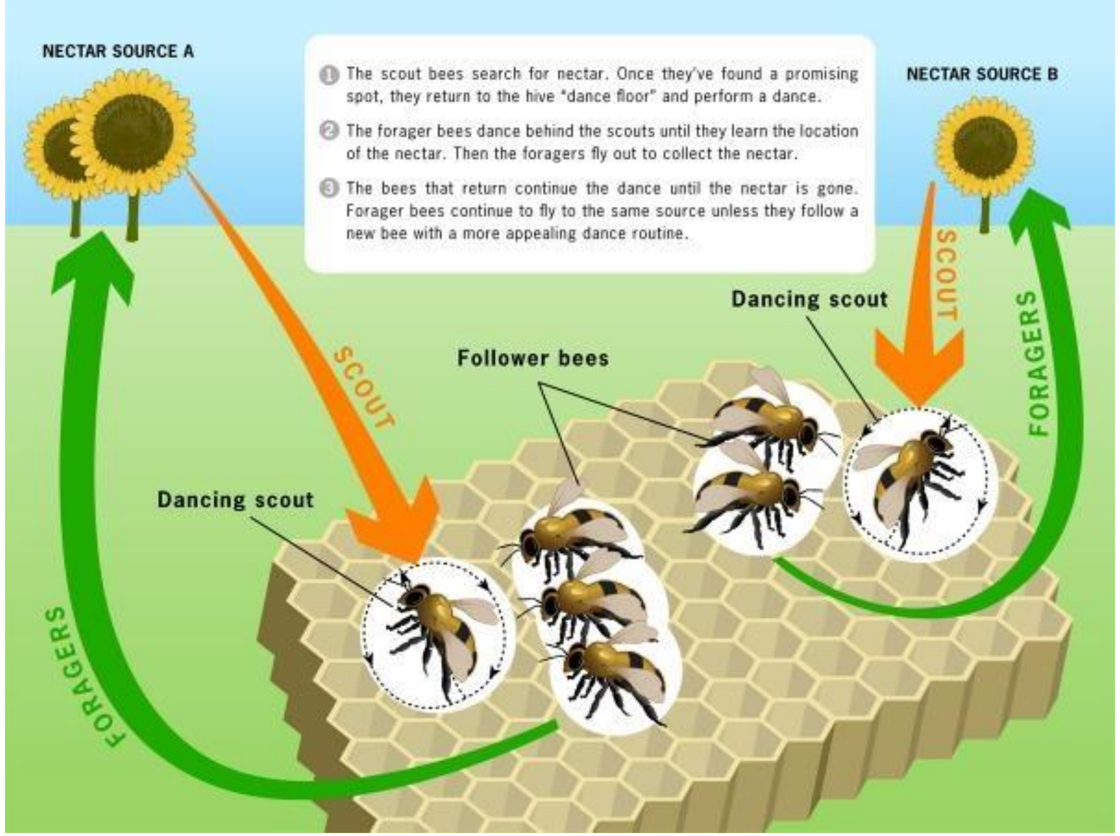
Many individuals or agents (but also organizations and institutions) change their adaptive traits over time as a consequence of their experience? If so, how?

- How do your agents learn?
- **Re-enforcement learning:** they repeat a certain task and get a penalty when they do something wrong. They try to improve their own score.
- Optimization…..
- Do they learn individually, or do they learn in groups? Think of the bee colony optimization.
- How is learning implemented? This might be via machine learning.

learning vs. adaptation ?

LEARNING

- Bee Colony Optimization



Prediction

if an agent's adaptive traits or learning procedures are based on estimating future consequences of decisions, how do agents predict the future conditions (either environmental or internal) they will experience?

- Sometimes it is important for agents to predict a certain value. For the evacuation simulation it might be important for agents to predict the time it will take to reach the exists.

- Prediction can be based on previous patterns. If a stock market always reaches a peak, and then drops, to continue raising again, this pattern can be used to predict if stocks will go up or down in price.

Sensing

Lagents aware of env.

What internal and environmental state variables are individuals assumed to sense and consider in their decisions?

- How do your agents sense their environments.
- In the case of the evacuation simulation, agents sense:
  - obstacles in their environment (walls)
  - doors they can use to reach another room
  - other agents, as they cannot walk through other agents
  - other agents in case they need to communicate

Interaction

What kinds of interactions among agents are assumed?

- Agents interact:

  - Officers sense agents and in case they are not evacuating yet, they will urge them to start to evacuate

  - Regular agents sense each other to help others evacuate (leavers help other agents and take them along to an exit)

  - Officers can take other agents along when they go to an exit

- Agent – Environment interaction:

  - Agent does not change the environment

Stochasticity

What processes are modeled by assuming they are random or partly random?

- At initialization (setup) new agents are created at random locations
- Agents are assigned a pre-evacuation time (this contains randomness)
- Agents have a certain preference for an exit (random element)

- Question is: how many new populations versus how many simulation runs?

Collectives

Do the individuals form or belong to aggregations that affect, and are affected by, the individuals?

- At initializations there are no collectives, only individual agents
- During simulation, an agent can help another agent to evacuate. In such a case these agents will have the same evacuation behavior and may be regarded as a group.

- Question: are groups only collectives when the group has behavior, and this behavior differs from the individual behavior of the agents?

Observation

What data are collected from the ABM for testing, understanding, and analyzing it, and how and when are they collected?

- What are you going to record? What we are going to collect from running model?
- At the level of the individual agent:
  - The exit choice
  - The pre-evacuation time
  - The time of evacuation
  - If leaver or follower or officer
  - The evacuation path of each individual agent

- At the global level:
  - The total evacuation time
  - The number of agents
  - The number of followers, officers, and leavers
  - The number of evacuees per exit

The ODD Model

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5. INITIALIZATION

L run the set up

Initial conditions: conditions at the start of the simulation

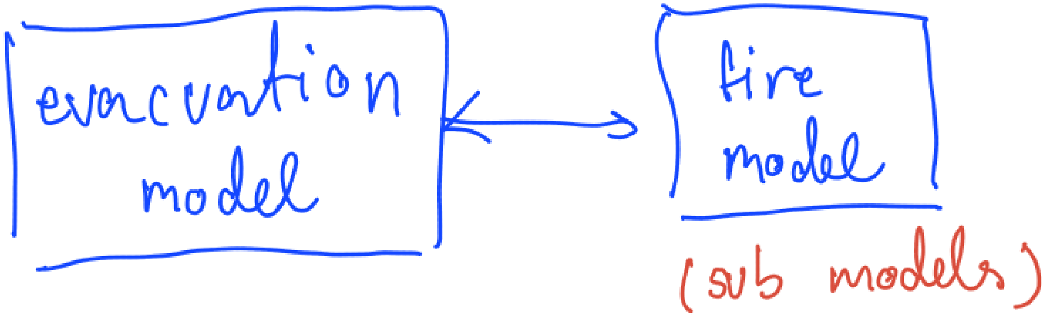
- How many agents are created?
- What is the location of these agents at the start of simulation?
- How do agents get a preferred exit?
- How do agents get a pre-evacuation time?

6. INPUT DATA

- Spatial data: all environments require data
- Number of agents to create: variable - Number of officers
- The speed with which people move when evacuating
- Information on min. and max evacuation time

7. SUB MODELS

- Sub model is a model of one process that can run almost independently for design and testing.



Further reading

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ELSEVIER

The ODD protocol: A review and first update

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A R T I C L E I N F O

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A B S T R A C T

The 'ODD' (Overview, Design concepts, and Details) protocol was published in 2006 to standardize the published descriptions of individual-based and agent-based models (ABMs). The primary objectives of ODD are to make model descriptions more understandable and complete, thereby making ABMs less subject to criticism for being irreproducible. We have systematically evaluated existing uses of the ODD protocol and identified, as expected, parts of ODD needing improvement and clarification. Accordingly, we revise the definition of ODD to clarify aspects of the original version and thereby facilitate future standardization of ABM descriptions. We discuss frequently raised critiques in ODD but also two emerging, and unanticipated, benefits: ODD improves the rigorous formulation of models and helps make the theoretical foundations of large models more visible. Although the protocol was designed for ABMs, it can help with documenting any large, complex model, alleviating some general objections against such models.

Critique

ODD+D

ODD was developed for ecology, and social scientists think that there is not enough detail to describe agent behavior and interactions

ODD+2D

More and more models are data-driven (empirical). There is a group of scientists that believes that ODD is not detailed enough to descrie the different ways data is used in the modelling process.

Laatabi, A., Marilleau, N., Nguyen-Huu, T., Hbid, H., & Babram, M. A. (2018). ODD+ 2D: An ODD Based Protocol for Mapping

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Müller, B., Bohn, F., Dreßler, G., Groeneveld, J., Klassert, C., Martin, R., Schlüter, M., Schulze, J., Weise, H., & Schwarz, N. (2013). Describing human decisions in agent-based models–ODD+ D, an extension of the ODD protocol. Environmental Modelling & Software 48: 37-48.

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TEAM-BASED LEARNING

WHAT HAPPENS WHEN TWO AGENTS INTERACT?

Regard the following example: In the simulation of the informal settlements, new houses align with other existing houses.

a) Information exchange occurs between house owners who have already settled and new settlers to ensure the new settlers know that their houses should align with existing buildings. - Not correct, because hypothesis is agent can randomly from settlement or align with existing house.

b) The state of the agent changes from extension (find a random place to settle) to infilling (align with existing houses).

c) The behaviour of an agent changes during the simulation to ensure that it can sense the direction of existing buildings. - It could based on other interactions (not agent-agent)

d) None of the above

e) All of the above

AGENT - AGENT INTERACTIONS

When ants find food, they return home leaving pheromones in an environment where other agents can find this food. This is an example of:

a) Direct and one-directional interaction

b) Direct interaction in both directions

c) Indirect interactions in one direction - Can it be considered agent-environment interaction?

d) Indirect interaction in both directions

INTERACTIONS WITH ENVIRONMENTS

Which of the following statements is/are true?

a) Interactions between agents and environments can only happen when the environment is dynamic - Environment can be static as well

b) Interactions always lead to behaviour change in the agent

c) Interactions can lead to a change in the environment

d) For environment-environment interactions, both environments need to be dynamic - At least one environment should be dynamic? Or probably both should be dynamic...