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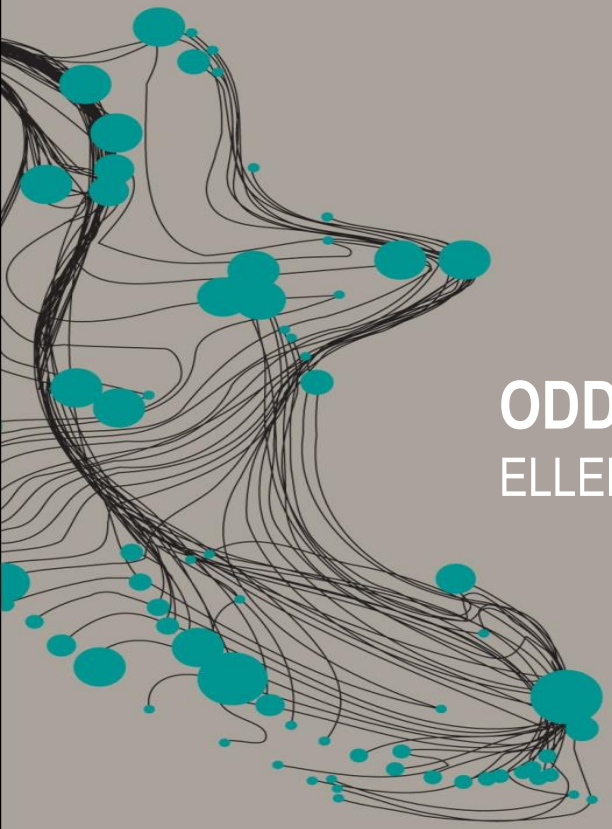
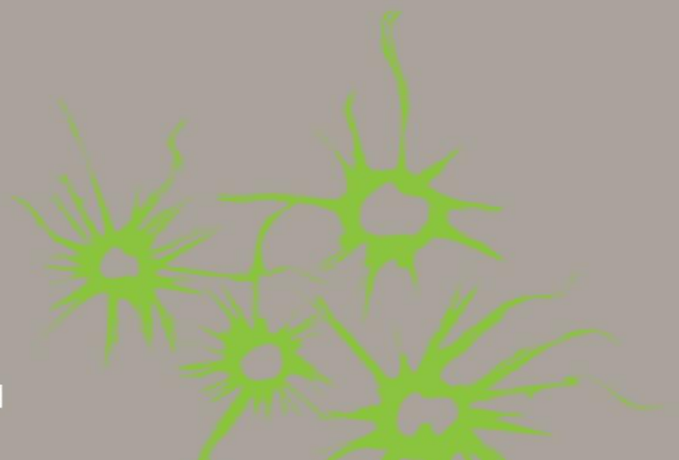


ODD PROTOCOL

ELLEN-WIEN AUGUSTIJN



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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?

software independent

- 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

DESCRIBE YOUR MODEL IN GENERAL TERMS

goal should be not-so-global and specific
goal should be measurable

boundaries should be defined clearly -> not so ambitious

predictive model should be validated

- 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.

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

to see if patterns emerge with change in wolf/sheep
reproduce emerging patterns from the existing complex system

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

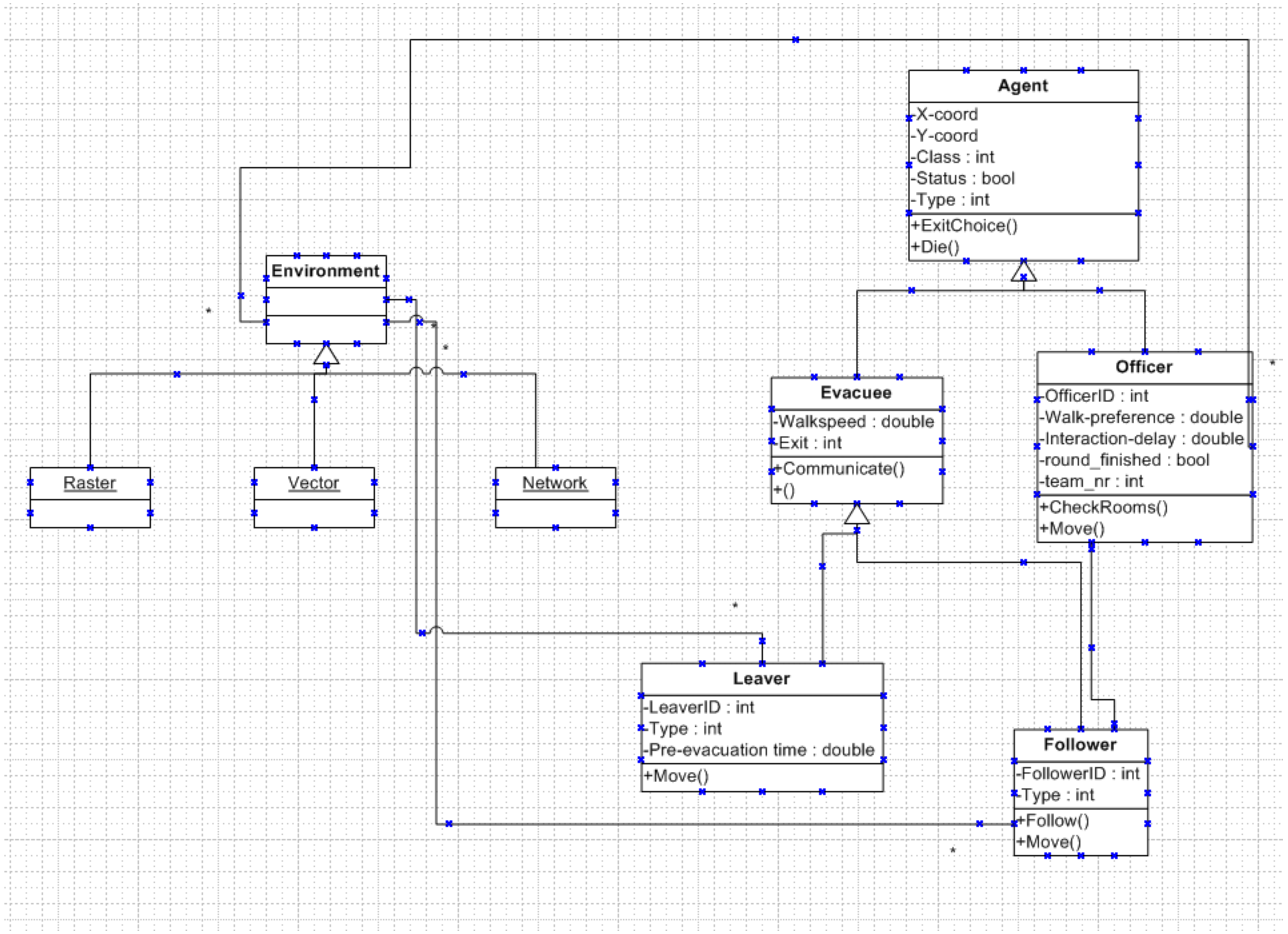
GENERAL TERMS

global overview of the model but not too much details like the interactions between each agent

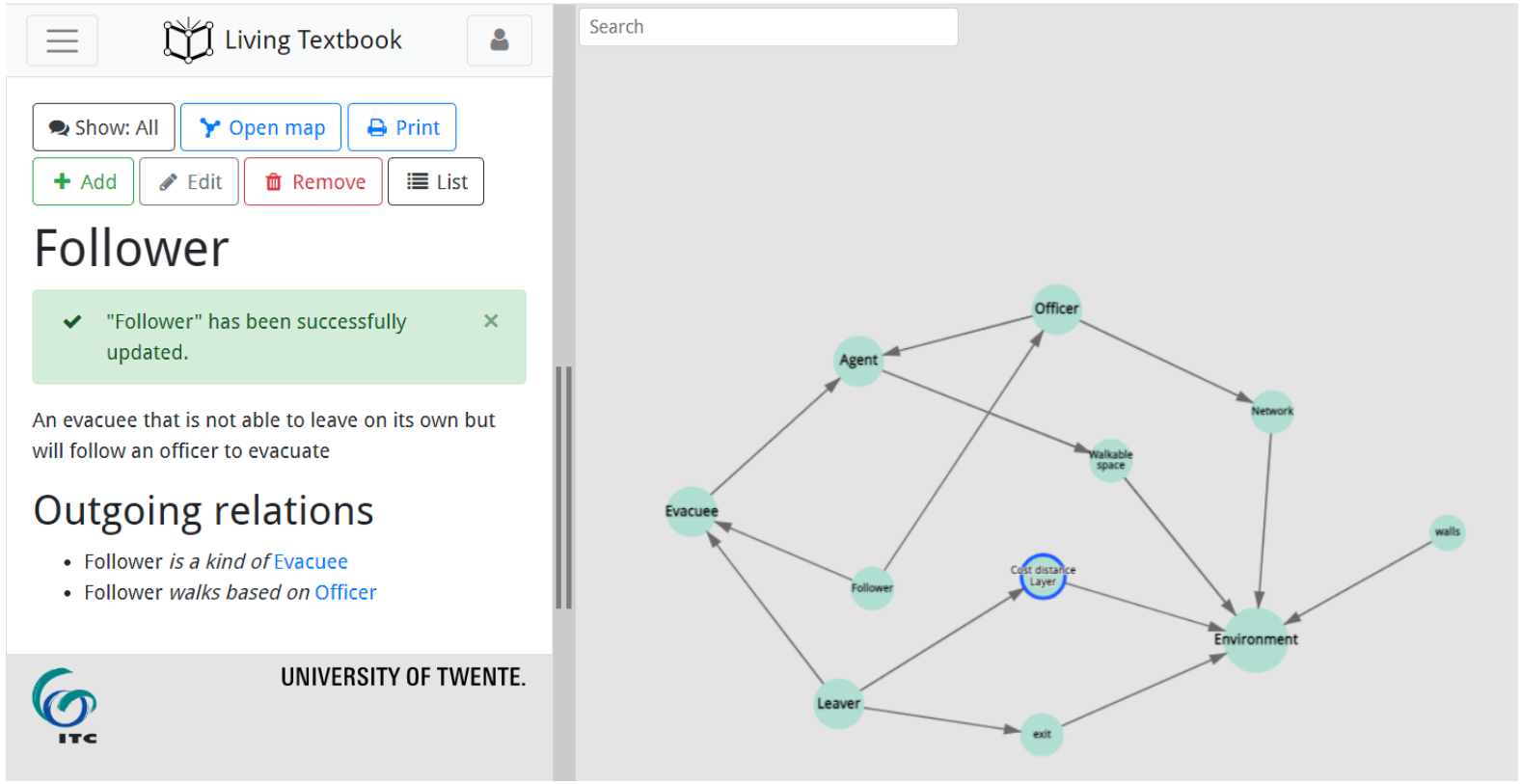
- My simulation will have three types of agents:
  - Leavers (students and staff)
  - Followers (students and staff)
  - Officers (staff)
- The Goal of both the students and the staff is to get out of the building safely (to evacuate), some of them will be able to do this on their own (leavers) some 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.

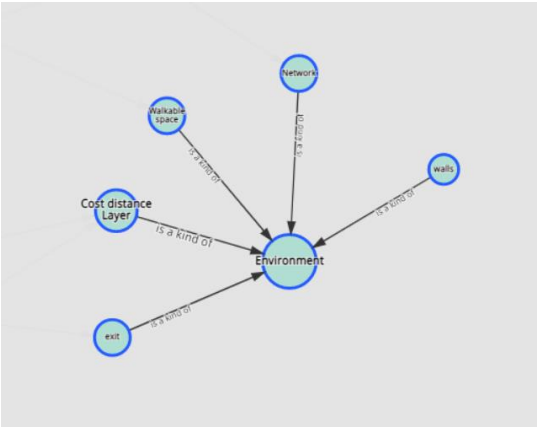
goal of entities

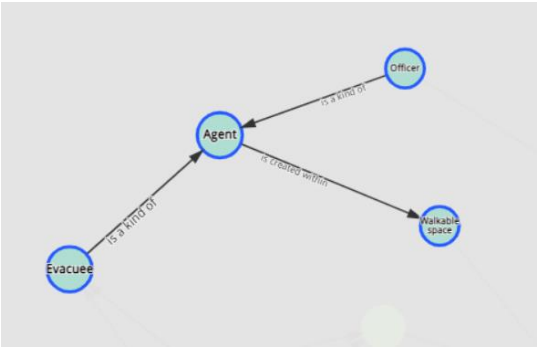
CLASS DIAGRAM



LIVING TEXTBOOK







the state variables for the tick bites are :

been bitten
not been bitten

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.*

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

alive / died but there's not much clear definition of a state value in that case

Often asked in exam about Temporal and Spatial Scale selection

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)
  - For vector data ?

scale for vector data is tricky to define

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]
```

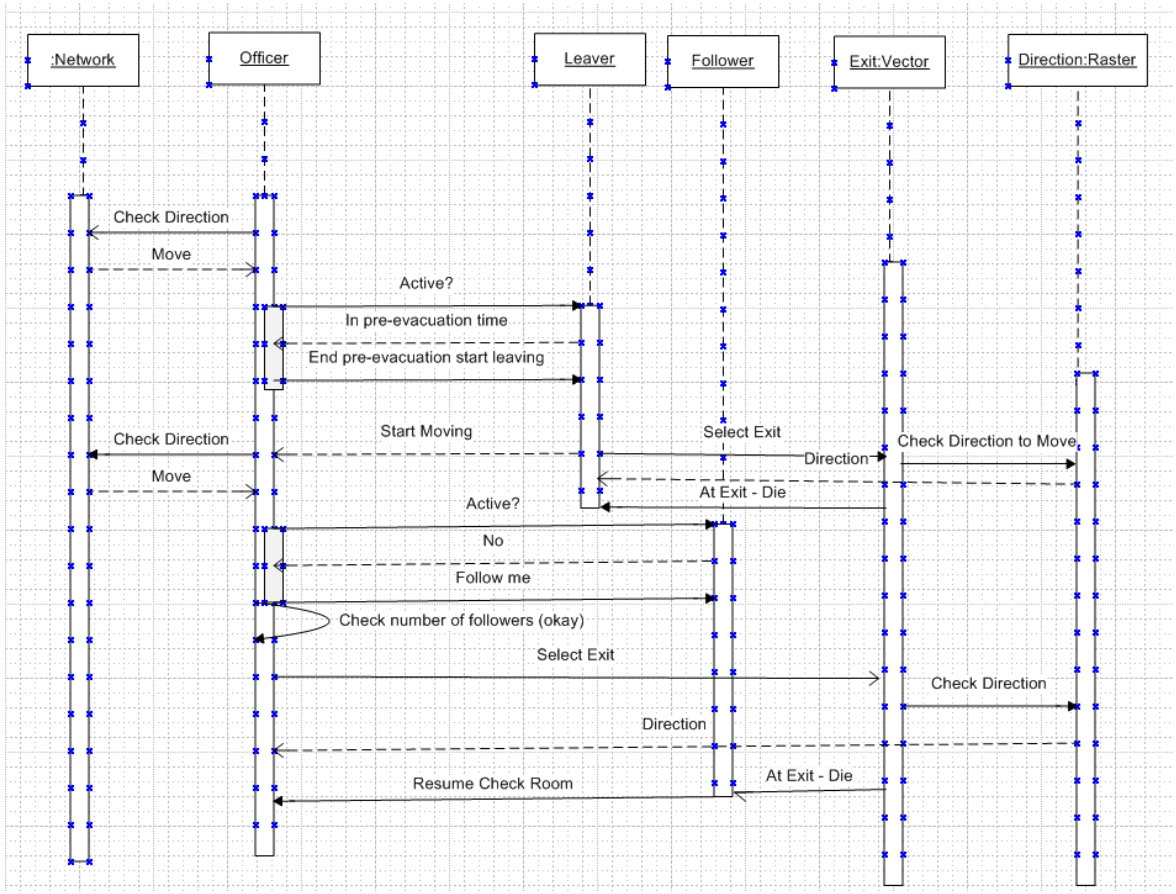
```
to go
  move-officers
  move-leavers
  move-followers
  if not any? leavers and not any? followers and not any? officers
  [
    file-print "============= simulation end ================"
    file-close
    stop
  ]

  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

no interactions mapped between leaver and follower



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.

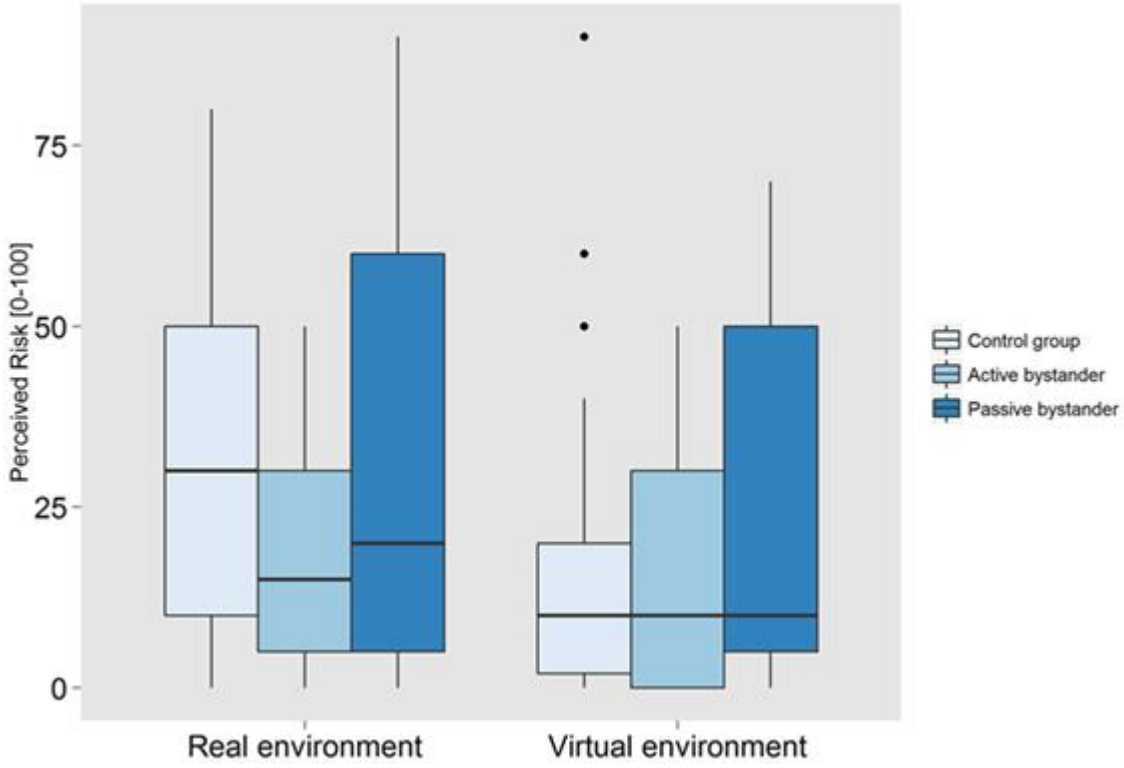
Affiliation and Normative Approach

- 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?

not programmed, should be out by itself because of the agents

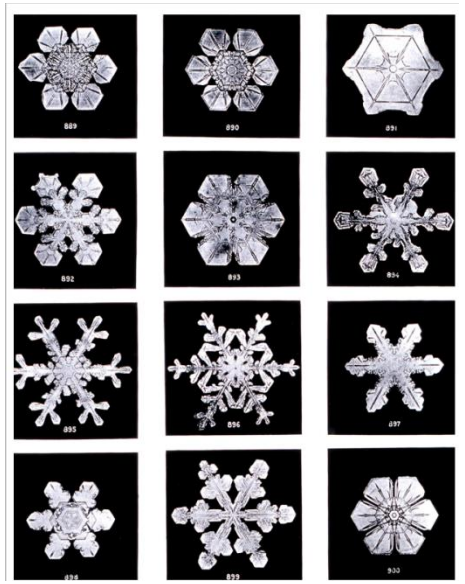


emergence is influenced by pre-existing knowledge/ conditions

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

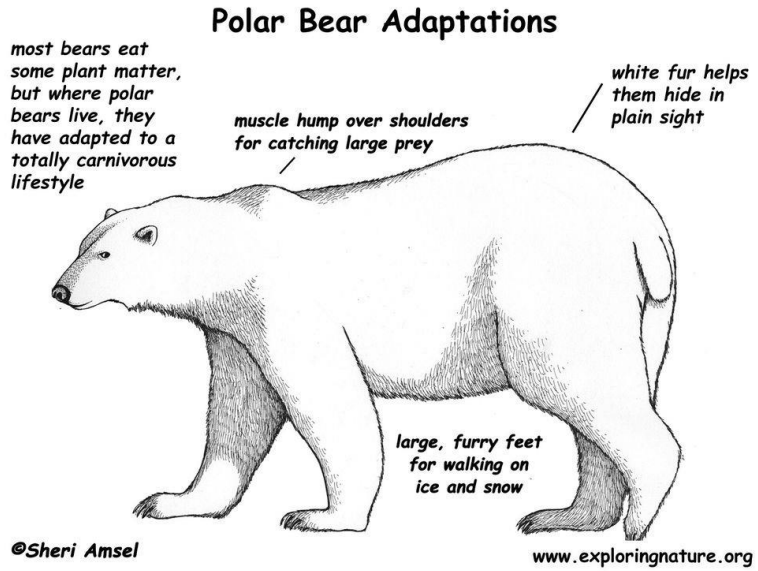
Adaptation

response to changes in the environment

***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?

it is already in the first part, but just added for our refernce

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?

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…..

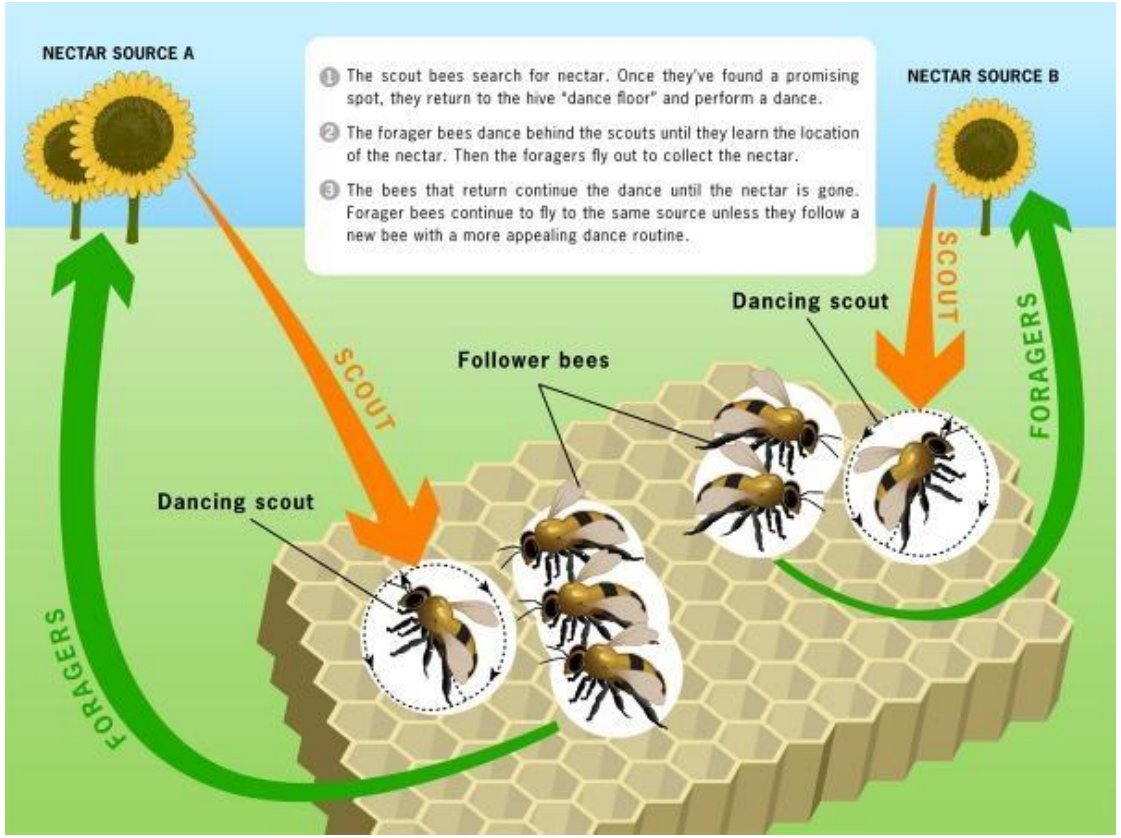
- Do they learn individually, or do they learn in groups? Think of the bee colony optimization.

- How is learning implemented? This might be via machine learning.

LEARNING

- Bee Colony Optimization

example of learning as a group



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

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?

  it is important for the collective to have a certain behaviour

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?
- 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

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5. INITIALIZATION

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.

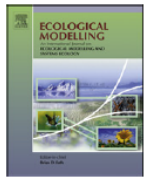
Further reading

Ecological Modelling 221 (2010) 2760–2768

Contents lists available at ScienceDirect

Ecological Modelling

journal homepage: www.elsevier.com/locate/ecolmodel



The ODD protocol: A review and first update

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ABSTRACT

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

Data to Empirical ABMs. Journal of Artificial Societies and Social Simulation, 21(2), 1-9.

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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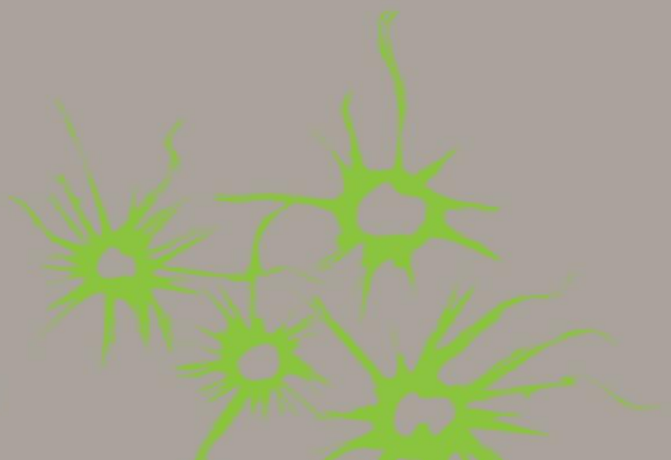
TEAM-BASED LEARNING



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copying what other agent did is an interaction but can also do on its own

WHAT HAPPENS WHEN TWO AGENTS INTERACT?

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

this could just be an answer but there is a sub-model for this model that shows if there should be alignment or not

mind that this question is when two agents interact

Not always this should necessarily happen

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.

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.

d) None of the above

e) All of the above

part of a could be the right answer but then the second part makes it wrong. coz it has interactions between two agents

but the second and third doesn't have any interactions between 2 agents

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

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

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

if we look at the whole model then it is true that both are dynamic in the evacuation model
but if we take the timestamps then the environment is static until the fire begins to expand

could be possible depending on the situation
but mostly both the interacting environments needs to be dynamic
but sometimes can also be atleast one