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### **VARIOUS TYPES OF INTERACTIONS**



Adapted from Batty (2005)



### **SETUP OF THE LECTURE**

- 1. What is agent-agent interaction?
- 2. Which different types of agent-agent interactions are possible
- 3. What happens when agents interact?
- 4. What is the difference between direct and indirect interactions
- 5. How can interactions be conceptualized?



# WHAT ARE AGENT-AGENT INTERACTIONS?

- Agent-agent interactions in ABMs encompass various forms of communication, cooperation, competition, and adaptation.
- These interactions can involve sharing information, exchanging resources, competing for limited resources, coordinating actions, adapting behaviors based on others' actions, and influencing each other's decision-making processes.

Bandini et al. (2009)



### ITCEvacuation\_Gima - NetLogo (C:\EAUN\Netlogo\ITC\_model\_Myran)



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### Blue: leavers Brown: followers Orange/Yellow/Purple/Green: officers

# **HOW DO AGENTS INTERACT?**

1. The agents are at the same location



3. An agent broadcasts information to all other agents



2. The agents belong to the same group

4. The agents are connected via a social network











# **AGENTS ARE AT THE SAME LOCATION**

- Agents are at the same cell
- · Agents are within a threshold distance of each other
- · Agents can see each other
- Agents that belong to the same neighbourhood or in the same room





# THE AGENTS BELONG TO THE SAME GROUP

Groups in ABM models are also referred to as collectives.

In many cases, information is **automatically** shared within these collectives.

### Examples:

- farmer organisations
- classes in school
- households
- families







Household

Household







# **BROADCASTING OF INFORMATION**

- In some cases, interaction is one-sided, so the information that is shared is forced onto all other agents. The agent that broadcasts this information does not "know" the other agents and does not take actions ensuring that a specific agent will receive the information.
- **Examples:** media, television, governments, etc.





# **SOCIAL NETWORKS**

- Communication in both directions
- No physical contact needed (e.g. social media).
- New links can be formed (people get to know each other) and links can be broken





### WHAT HAPPENS TO AN AGENT WHEN THERE IS INTERACTION?

### ... that depends... what the interaction is about...

- When the interaction is about sharing information, the information will be stored
- The state of the agent can change. In a disease simulation, when an infectious agent meets a susceptible agent, the state of the second agent may change to infected.
- When a child gets infected, one of the parents must return home (stop working) to take care of the child. This will change the behaviour of the parent. This applies to a single agent that is part of a group.
- When the government agent broadcasts information about going into a lockdown, the behaviour of all other agents will change.





## DIRECT OR INDIRECT INTERACTIONS

- Direct interactions: interactions in which individuals encounter and affect others.
- Indirect interactions: the agent perceives the actions of another agent and the possible impact this has on their own situation

Grimm et al. (2020)



### HOW CAN AGENT-AGENT INTERACTIONS BE **CONCEPTUALIZED?**

- UML Sequence diagram interaction model, shows interactions arranged in time.
- Can be used for interactions between agents but also interactions between agents and environments or environments and environments.





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### Agent-Agent Intersection-Summary

The topic of today is interactions in agent-based models. Like behaviour, interactions are super important in ABM models.

### Agent-based models are one of the few simulation methods that can actually model agentagent interactions.

### When you think about yourself, you interact with many people in many different ways.

### The same applies for agents.

Today we will dive into interactions in our simulation models.

### As an example, I will use an evacuation model for the building in which I used to work.

In case you want to know more about it, you can go to the publications that you see on the slide.

There are various type of interactions in agent based models. Including:

- environment-environment interactions
- agent-environment interactions
- environment-agent interactions
- agent-agent interactions

In this lecture we will focus on agent-agent interactions only.

There are several questions I want to address in this lecture.

- 1. What is an agent-agent interaction?
- 2. What happens when agents interact, the differences between direct and indirect interactions, and how can interactions be conceptualized?

Agent-agent interactions encompass various forms of communication, cooperation, competition and adaptation.

These interactions can involve sharing information, exchange of resources, Competing for limited resources, coordinating actions, adapting behaviours based on other actions, and influencing each other's decision-making processes.

When we have a close look at the evacuation model, we see that it contains three different types of agents.

- The officers leading the evacuation,
- leavers that will leave on their own when their pre-evacuation time has finished,
- and followers that will only leave together with an officer.
- **1.** When an officer meets a leaver that has not started the evacuation, this officer will wait and start to communicate with that leaver.
- 2. As a result, the leaver will start to evacuate.

### To make interactions comprehensible, I split it into four categories.

Let me talk you through them one by one.

- 1. The first type of interaction requires agents to be at the same location.
- Only when this requirement is satisfied will interaction take place.
  - i. In the evacuation simulation, we see that the officer and the leaver were at the same location when the interaction took place.
  - ii. Of course, there is a lot of freedom in how you define at the same location.
  - iii. The agents can be on the same cell or within a certain distance of each other, but you can also define the location as the neighbourhood or the room in a building.
  - iv. Yet in all these cases, the locations of the agents will determine if they interact.
    - 1. In the previous group of interactions, agents can accidentally meet.
      - a. It is also possible that you have some fixed groups in your simulation that are always interacting.
      - b. Perhaps your assumption is that all students in the evacuation will live together with their teacher.
        - i. In this example, students and teachers form one group that fully interacts.
      - c. Another example of such a group are members that belong to the same household or the same family.
- 2. When information is shared, this can be done via communication and information sharing.
- A government may implement restrictions in case of a pandemic like we've seen in COVID.
- This government agent interacts with all the agents in their country.
  - i. Remember that in this case, the communication is one directional.
  - ii. You could say that this is only a one-sided interaction.
  - iii. So the government sends information to all agents, but these agents don't send any information back.
- For our evacuation simulation, let's say an intercom agent may be used to communicate with all agents in the building.

- The last type is the social network.
  - i. Within your simulation model, you can define links between agents.
  - ii. These links can represent the fact that these agents know each other and exchange information.
  - iii. Via a social network, you can communicate in both directions, and during your simulation, new network links can be established or links can be broken.
  - iv. In this case, your agents will not always interact with the same group of other agents.
    - 1. What happens to an agent when there is interaction?
      - a. Well, this depends on your model.
      - b. When information is exchanged, this information can be stored in the variables of the agent.
      - c. It can be that the state of the agent will change.
        - i. In an evacuation simulation, the state of the agent can change from pre-evacuation time to evacuating.
      - d. Interaction can also lead to a change in behaviour.
        - i. When an officer meets a follower, this follower will start to move together with the officer, and when the officer reaches an exit, the follower will evacuate.
          - 1. This changes the behaviour of the follower.
        - ii. When the intercom broadcasts information to stop the evacuation, the behaviour of all other agents will change.
- All interactions that we discussed so far are direct interactions.

- **3.** The ODD protocol defines direct interactions as interactions in which individuals encounter and affect others.
- But besides direct interactions, there are also indirect interactions.
- In the case of indirect interactions, the agent perceives the action of another agent and the possible impact this can have on their own situation.
  - i. For example, via competition for a limited resource.
- 4. How can agent-agent interactions be conceptualized?
- This can be done via a UML sequence diagram.
- You see an example in the slide. This example is for the ITC evacuation model.
  - i. In this model, there are officers leading the evacuation, and there are leaver agents and follower agents.
  - ii. These agents will have to be evacuated.
  - iii. When you follow the line of the officer, you see that this offers interactions with lever.
    - 1. This happens when the two agents meet.
    - 2. The officer will check if the lever is active.
    - 3. When the lever is still in pre-evacuation time, the officer will force the lever to end the pre-evacuation time and start leaving the building.
    - 4. The result of this interaction is that the lever starts to move to the preferred exit.
  - iv. The sequence diagram is not restricted to agent-agent interactions, but can also be used for other types of interactions.