LESSON 5 · 5 NOVEMBER 2026

Applied Systems Sciences 1

From ODD to code: the traffic model

Last week's predictions, then a traffic jam on your own laptop

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Before and after the catch

```
stock = 10
before = stock
catch = 4

if catch > stock:
    print("not enough fish")
else:
    stock = stock - catch

print(stock, before)
```

What will be printed?

Looping over the catches

```
catches = [3, 1, 2]
total = 0

for catch in catches:
    catch = catch * 2
    total = total + catch

print(catches, total)
```

What will be printed?

Counting the big catches

```
catches = [3, 1, 2]
catches.append(4)
big = 0

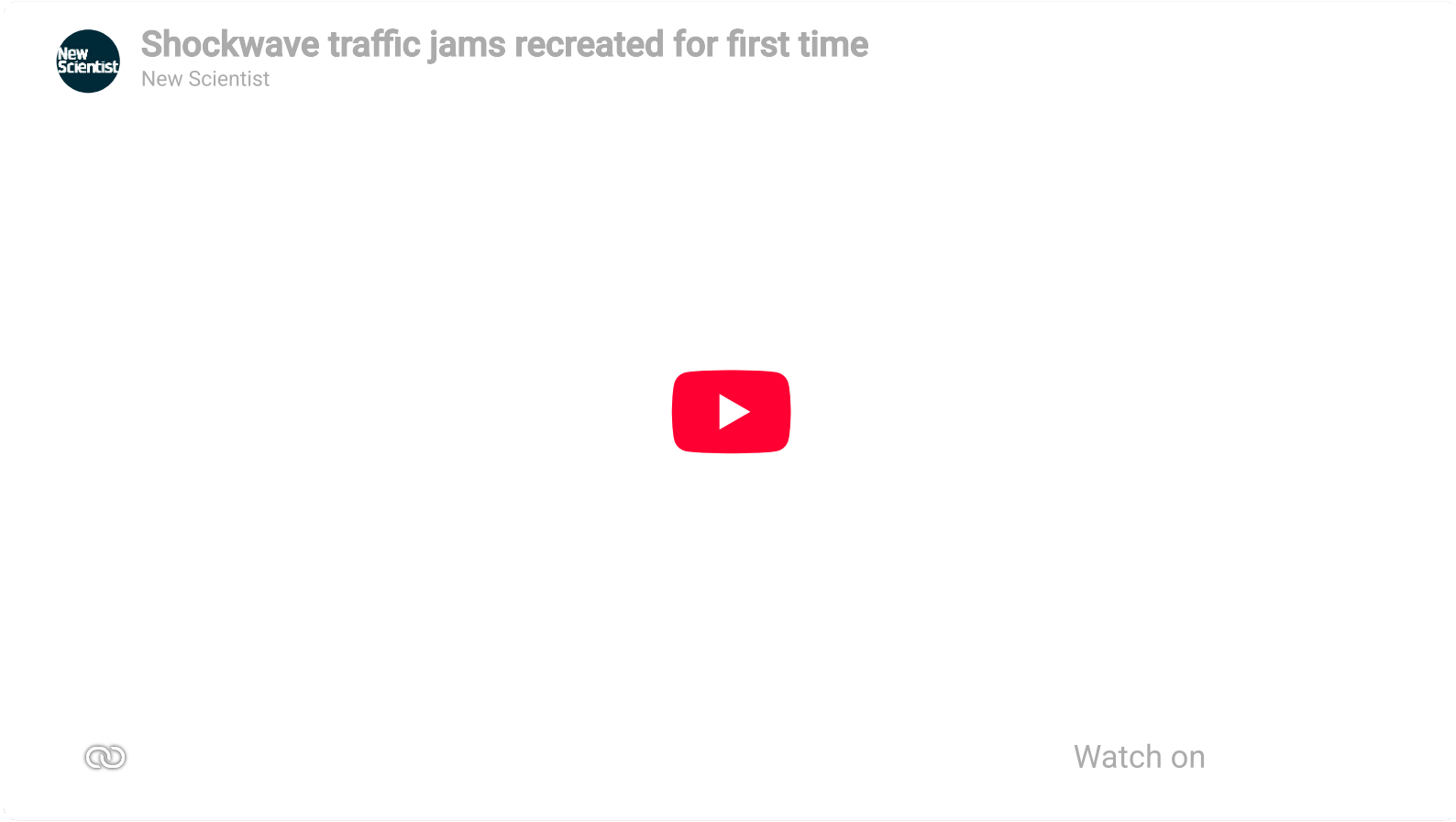
for catch in catches:
    if catch > 2:
        big = big + 1

print(big, len(catches), catches[1])
```

What will be printed?

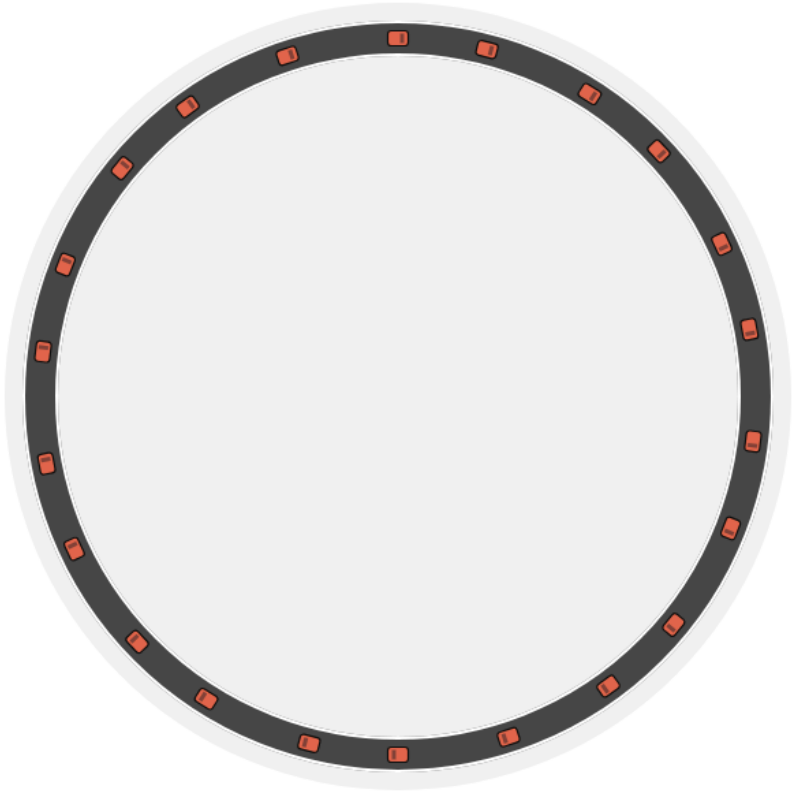
Real cars on a circle, no obstacle

22 cars on a circle of 230 m, evenly spaced, all at about 30 km/h. **Watch:** where does the jam come from, and which way does it move?



Sugiyama et al. (2008) · Video: New Scientist

A jam with no cause



The ring road from above, the cars drive clockwise

Along the road, time going down: a red stripe is a jam

Cars on the road: **22**

Chance that a car dawdles: **30** %

Top speed: **5** cells per step

Playback: **3**× real time

Slow to start: off

▶ Run | Step | New start

0.0	22	0
average speed, last 50 steps	cars standing	steps

Standing Slow Fast No accident, no road work, no traffic light.

Why describe a model in a fixed form

To think it through

Writing a model down shows you the decisions you have not made yet.

So others can check it

Many published models are described too vaguely to be rebuilt. A result nobody can reproduce is not science.

To code it

A description that is complete, in a fixed order, turns into code without guessing.

ODD (Overview, Design concepts, Details) is this fixed form for agent-based models. About 1500 published models were described with it by 2017. Your project's first presentation, P1, is an ODD.

Grimm et al. (2006, 2020) · Railsback & Grimm (2019)

ODD: three blocks, seven elements

Overview

1. **Purpose and patterns:** what is it for, which observed patterns must it show?
2. **Entities, state variables and scales:** what is in it, what does each thing know, how big is a cell and a step?
3. **Process overview and scheduling:** what happens in a step, in which order?

Design concepts

4. **Design concepts:** a checklist of eleven questions. What emerges? What does an agent sense? Where is chance? “Not used” is an answer too.

Details

5. **Initialization:** how does a run start?
6. **Input data:** what comes from outside while it runs?
7. **Submodels:** every rule, exactly, with its parameters.

Always in this order: the overview to understand the model, the details to rebuild it.

Grimm et al. (2020) · Railsback & Grimm (2019)

Which element is it?

> “In every step, all cars first work out their new speed, and only then do all of them move.”

Which ODD element does this sentence belong to?

1. Purpose and patterns
2. Entities, state variables and scales
3. Process overview and scheduling
4. Design concepts
5. Submodels

Get the traffic model

Live in class: the presenter's screen appears here.

Your turn: the traffic model on your laptop

1

Your copy

Open the course's traffic model on GitHub:

github.com/davemaier/traffic-model

Use this template, then Create repository.

→

2

Clone

In VS Code: Ctrl+Shift+P, **Git: Clone**, paste the address from the Code button of your copy.

→

3

Install

In VS Code: Terminal, New Terminal, then type `uv sync`

→

4

Run

```
uv run python model.py
```

A line per step: a digit is a car's speed, a dot an empty cell.

No uv or git yet? Work with your neighbour today, and finish the setup at home with lesson 3's guide.

How far did you get?

How far did you get on your laptop?

1. Not started yet
2. My copy is on GitHub
3. Cloned in VS Code
4. uv sync worked
5. model.py prints the road

The traffic model in ODD: overview

1

Purpose and patterns

Can a jam appear with no accident, no road work and no traffic light?

- a jam from nothing
- a jam that travels backwards
- slower traffic with more cars

2

Entities, state variables and scales

- **Car:** position, speed 0 to 5
- **Road:** a ring of 100 cells, the chance to dawdle
- a cell is 7.5 m, a step 1 s, so speed 5 is 135 km/h

3

Process overview and scheduling

One process, driving. In each step every car first gets its new speed from the road as it is. Then all cars move at once.

All of it is in `ODD.md` of your repository.

Nagel & Schreckenberg (1992) · Sugiyama et al. (2008)

The traffic model in ODD: design concepts

Concept	In the traffic model
Emergence	The jam. No car is told to stop, and no rule says where the jam goes.
Adaptation	A car adapts its speed to the gap in front of it.
Sensing	A car knows the gap to the next car, nothing else.
Interaction	Indirect: a car that brakes shortens the gap of the car behind it.
Stochasticity	Dawdling: a car slows down by chance, as people do.
Observation	The space-time diagram, the average speed, the standing cars.
Learning, prediction, collectives	Not used.

Emergence is the reason to build an agent-based model: the jam is in no rule.

The traffic model in ODD: details

5 Initialization

The cars evenly spread, all standing. A seed for the random numbers, so a run can be repeated.

6 Input data

None. Nothing comes from outside.

7 Submodels: each car, in this order

Accelerate	`speed = min(speed + 1, 5)`
Brake	`speed = min(speed, gap)`
Dawdle	with chance `p`, if moving: `speed - 1`
Move	`position + speed`, round the ring

> Four rules, one per line. That is the whole model.

Today, and next week

You can now

- say what an ODD is for, and name its seven elements
- find each element in a model's description
- get a model from GitHub and run it

Before next Thursday

- [ ] The traffic model runs on your laptop.
- [ ] Read the traffic model's ODD, the last three slides and ODD.md: what does each element say about this model?

Thu 12 Nov **Quiz 1, at the start.** On Moodle, closed book and without AI, on lessons 1 to 5, with what the ODD is for and its seven elements.

Sources for this lesson

Railsback, S. F. & Grimm, V. (2019). *Agent-Based and Individual-Based Modeling: A Practical Introduction.* 2nd ed.

Grimm, V. et al. (2020). The ODD protocol for describing agent-based and other simulation models: a second update to improve clarity, replication, and structural realism. *JASSS* 23(2), 7.

Nagel, K. & Schreckenberg, M. (1992). A cellular automaton model for freeway traffic. *Journal de Physique I* 2(12).

Sugiyama, Y. et al. (2008). Traffic jams without bottlenecks: experimental evidence for the physical mechanism of the formation of a jam. *New Journal of Physics* 10, 033001.

Also: Grimm et al. (2006, 2010) · Barlovic et al. (1998)