AI & Mobility Day · 2026

Active inference in traffic

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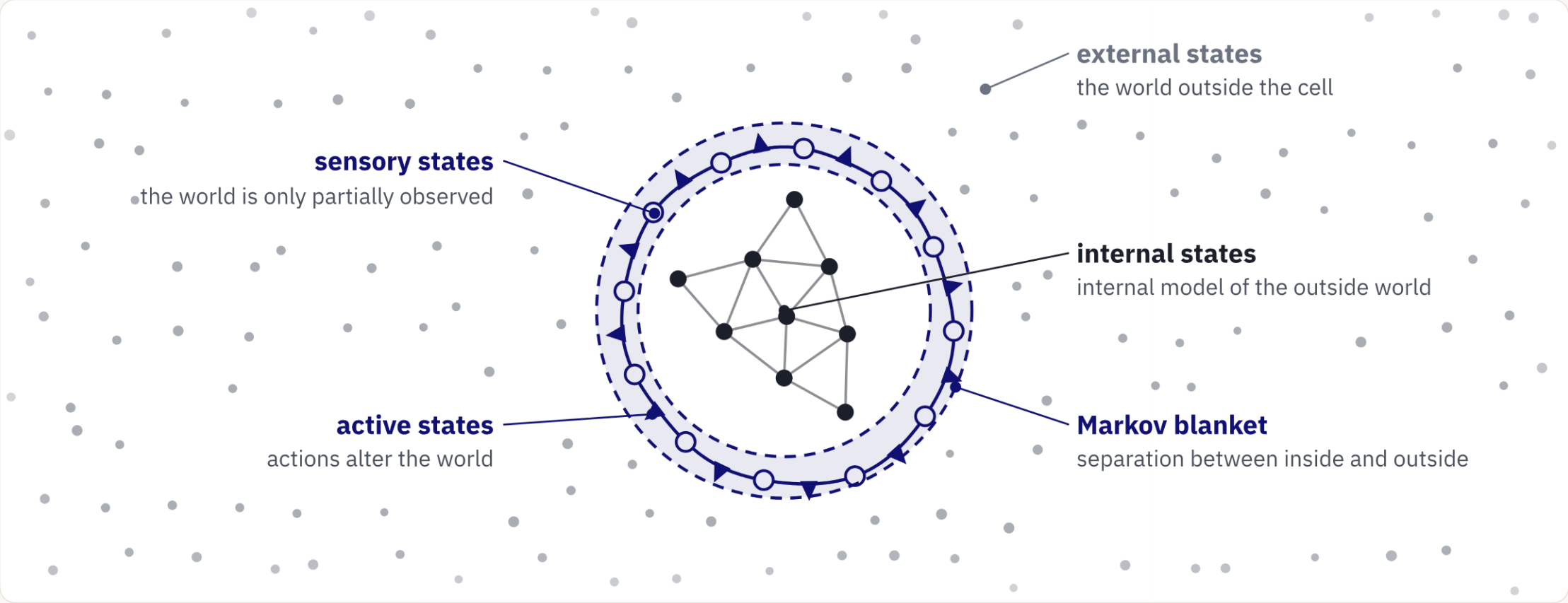
THE PRINCIPLE

What is active inference?

A framework for intelligent agents that describes perception-action loops across multiple scales.

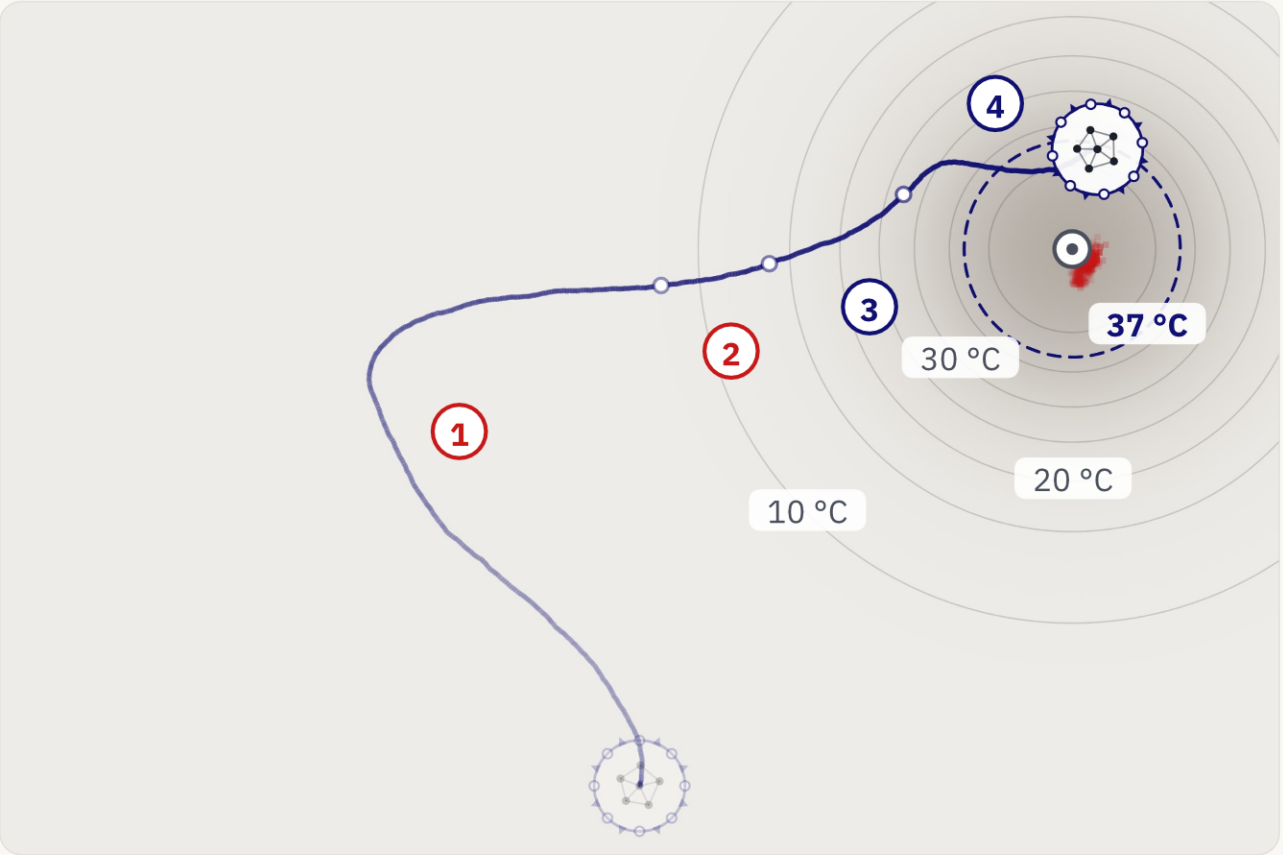
STEP 1 · THE MARKOV BLANKET

A cell separates itself from its environment



STEP 2 · MINIMIZING SURPRISE

The cell moves to minimize surprise



heat source

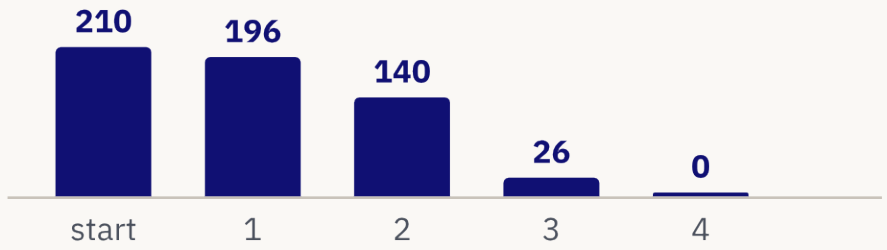
37 °C, the temperature the cell expects

its belief about where the heat source is

Explore
It tests actions to see if they reduce surprise.

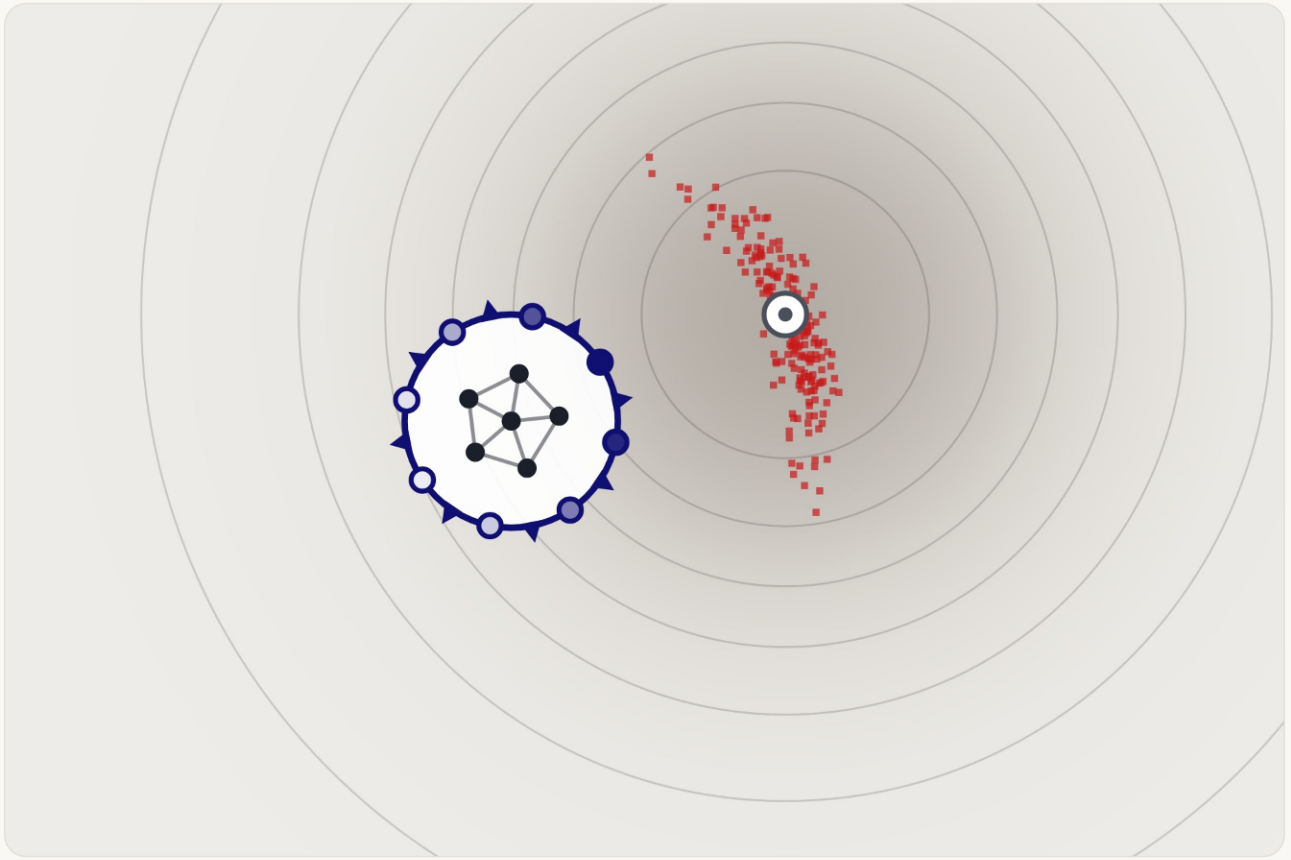
Exploit
It moves to where expectations are met (37 °C).

Surprise after each move



STEP 2 · MINIMIZING SURPRISE · PERCEPTION

Forming beliefs about the causes of observations



heat source

belief about where the heat source is

temperature sensations, darker where warmer

A *belief* is a probability distribution about a state of the world, e.g., where could the heat source be?

Perception = updating beliefs to reduce surprise, i.e., uncertainty-weighted prediction error.

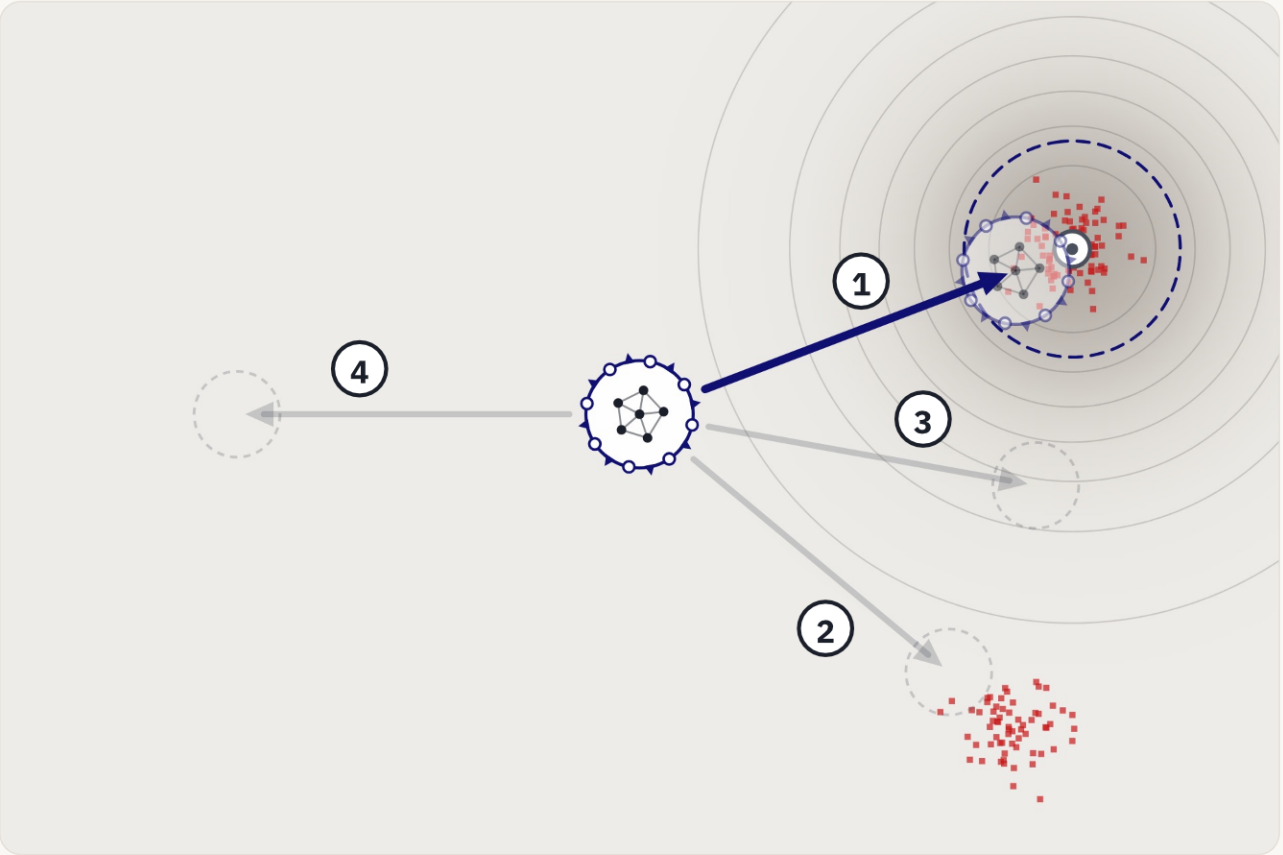
Surprise of each belief



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STEP 2 · MINIMIZING SURPRISE · ACTION

Choosing actions to avoid surprise in the future



heat source

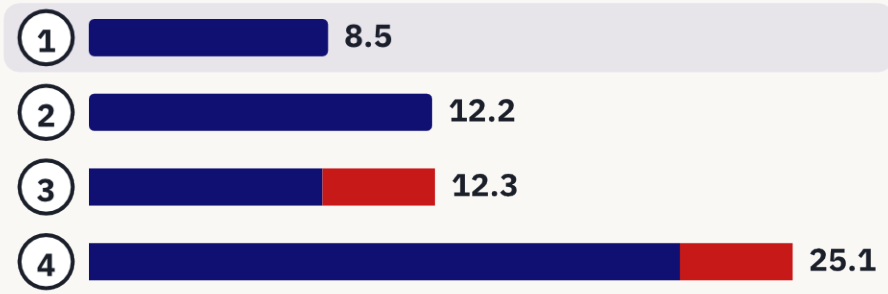
its belief, two places where the heat source could be

37 °C, the temperature the cell expects

Future surprise of each move

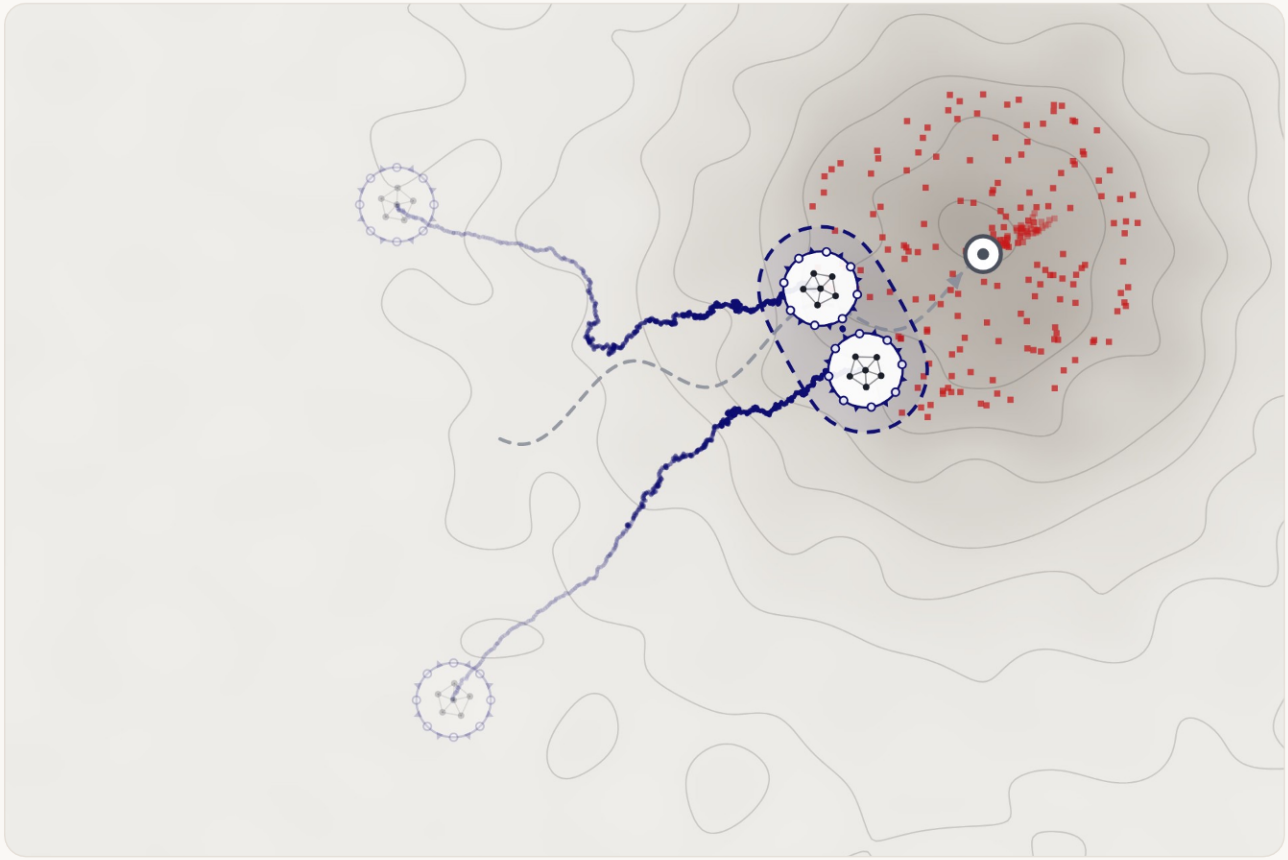
Does it realize expectations about the future?

Will it improve beliefs?



STEP 3 · SELF-ORGANIZATION

Two cells become one system



The water turns turbulent.

The heat source starts to drift.

Two cells appear, far apart.

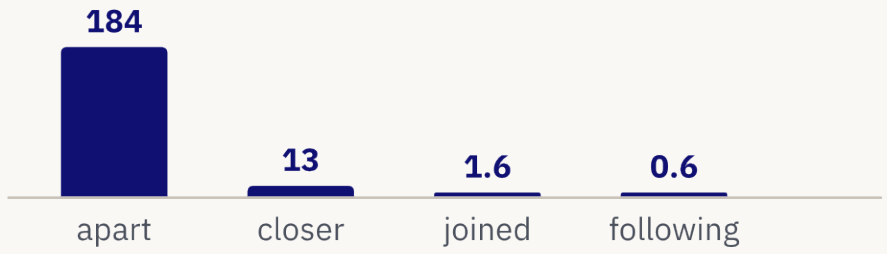
They predict each other and share what they sense.

Their joint belief tracks its shape and drift.

They form a joint Markov blanket.

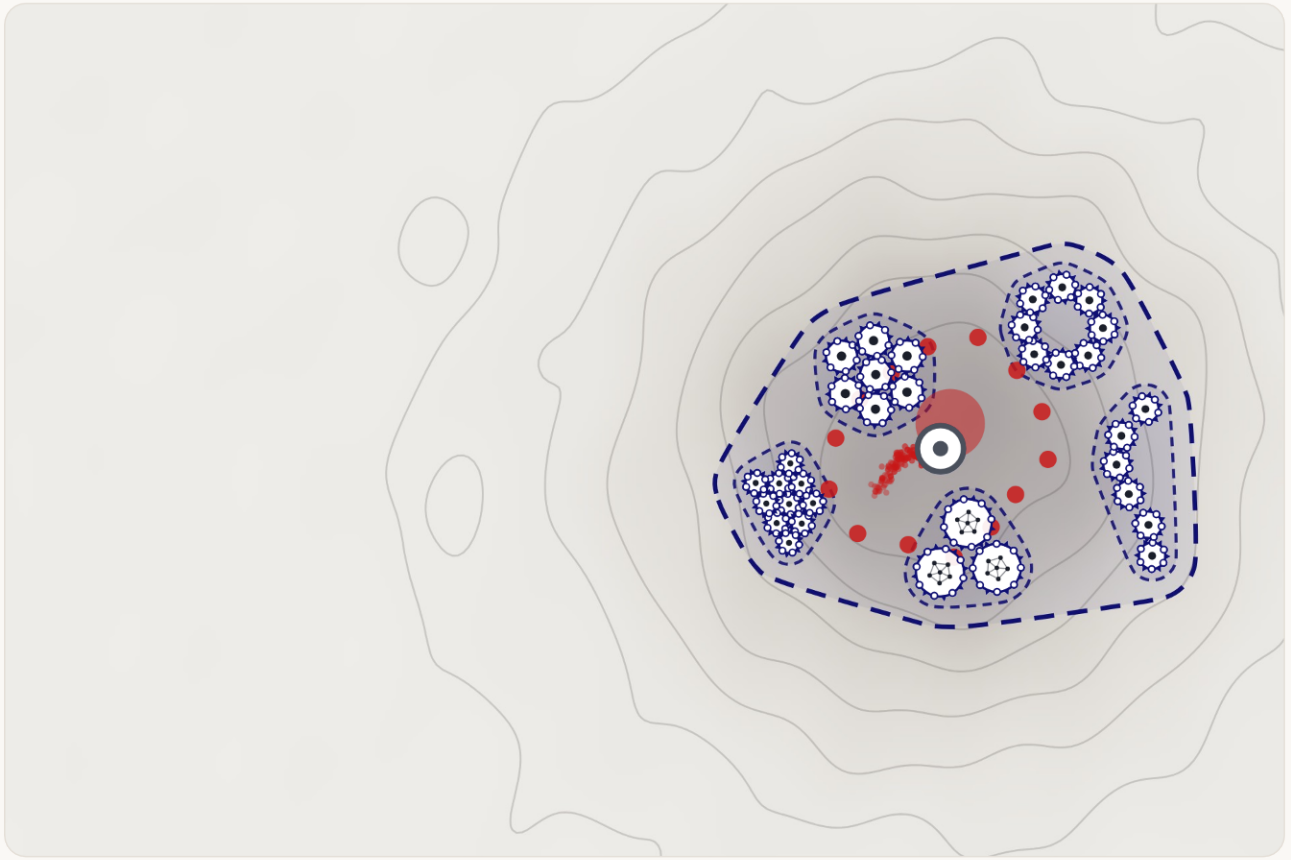
Together they follow the heat source.

Joint surprise of the two cells



STEP 4 · HIERARCHY

Many cells form a hierarchy across scales



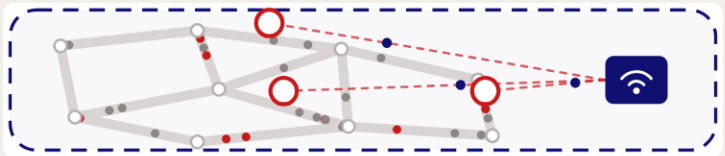
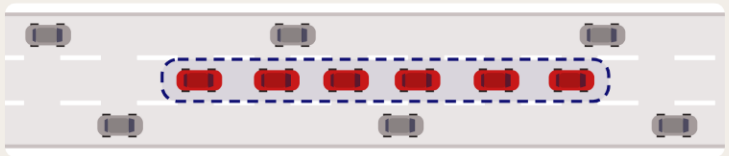
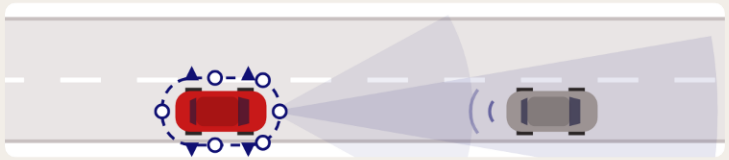
Body
Predicts where the whole collective goes.
seconds · the whole body

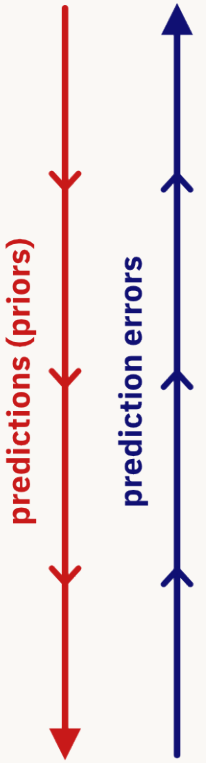
Organ
Predicts the shape and motion of its group.
about a second · a group of cells

Cell
Predicts its own sensations.
under a second · one cell

STEP 5 · TRAFFIC

Traffic is a hierarchy of self-organizing agents

IN A CELL	IN TRAFFIC	WHAT THIS LEVEL PREDICTS	TIME · SPACE
a body		**Traffic network** Predicts flows across a region. Sends priors down, such as speed limits.	**minutes to hours** 10 km and more
an organ		**Platoons and road segments** Predict the speed and spacing of the group. Small disturbances stay inside.	**seconds to minutes** about 1 km
two cells		**Car following** Predict the car ahead, and stay predictable for the car behind.	**about 1 s** about 50 m
one cell		**Vehicle** Its sensors and actuators form its Markov blanket.	**about 0.1 s** about 10 m



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