beyond agent-based and spatial interaction

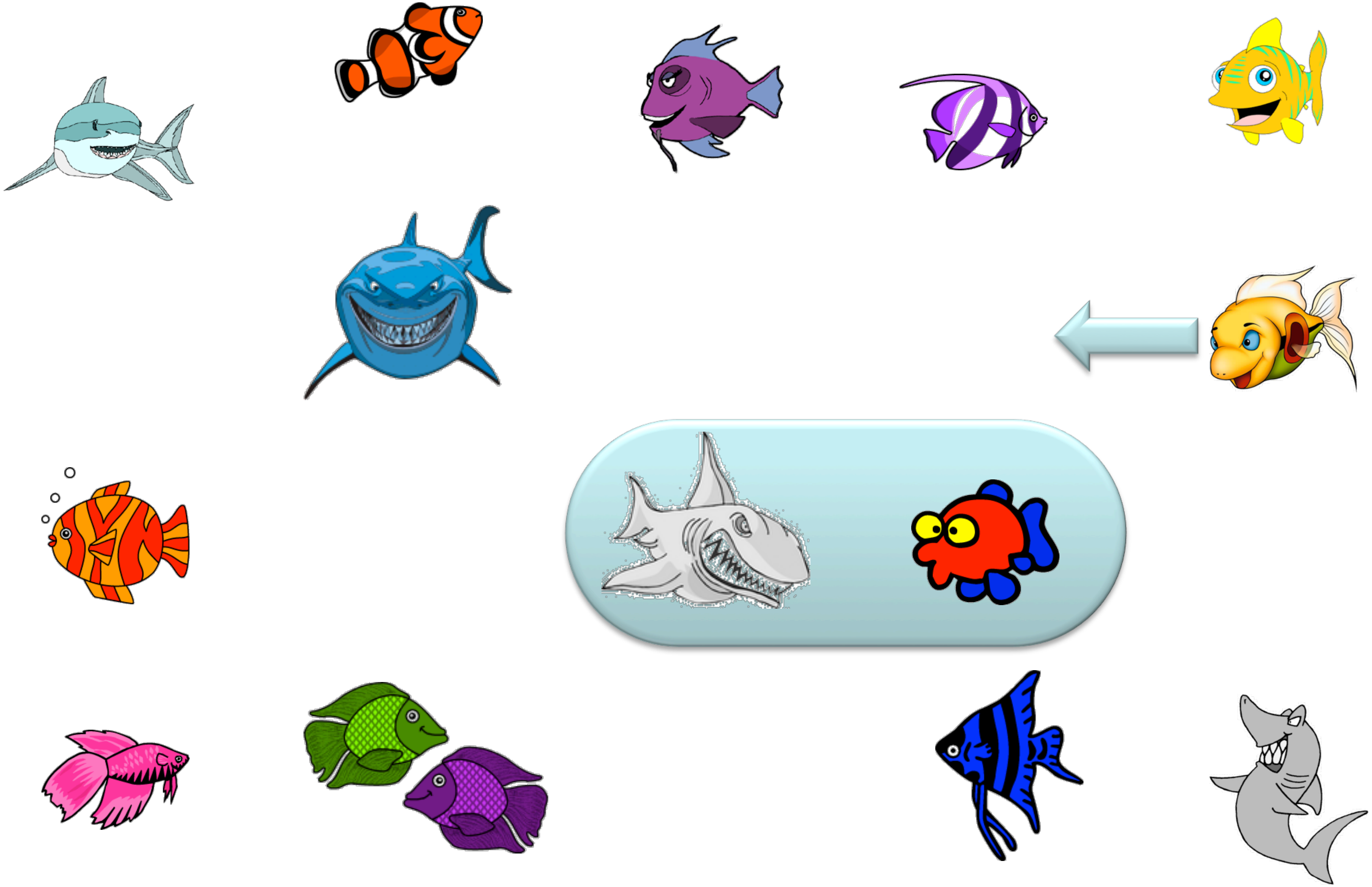
INTERACTION BASED COMPUTING

(in the previous example of languages there are)

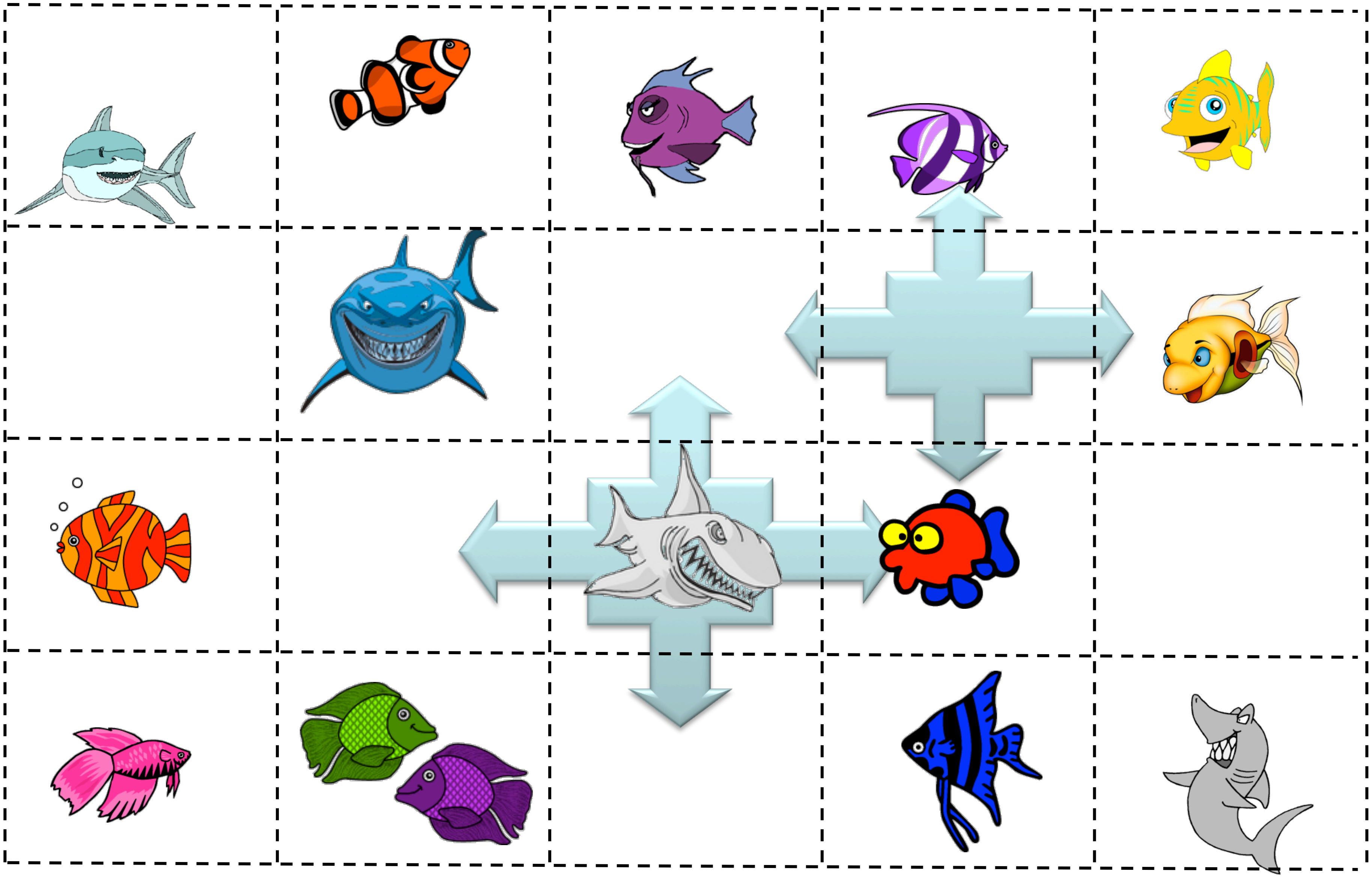
Two main modeling approaches

- agent-based
- space-based

Fish and Sharks in the sea (agent-based view)



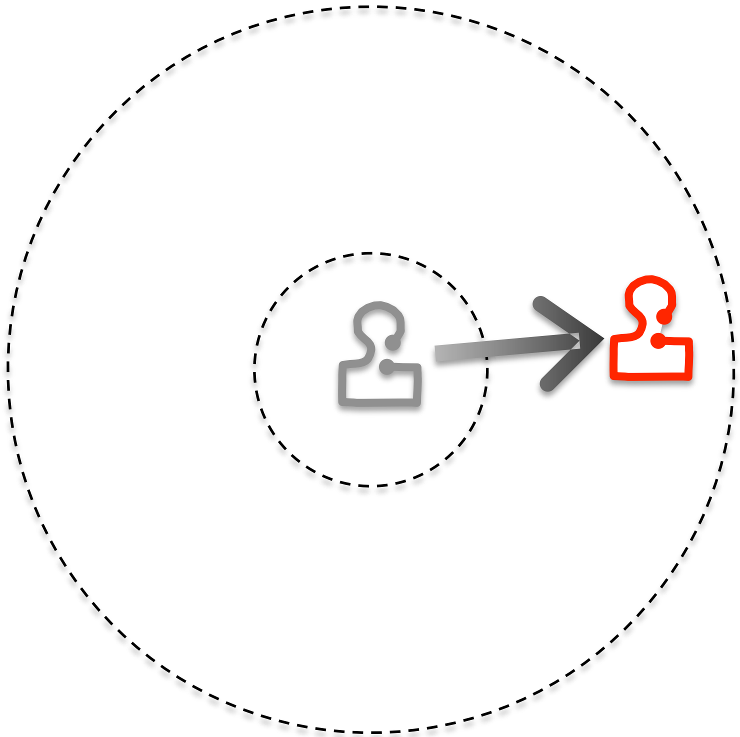
Fish and Sharks in the sea (space-centric view)



(in the previous example of languages there are)

Two main modeling approaches

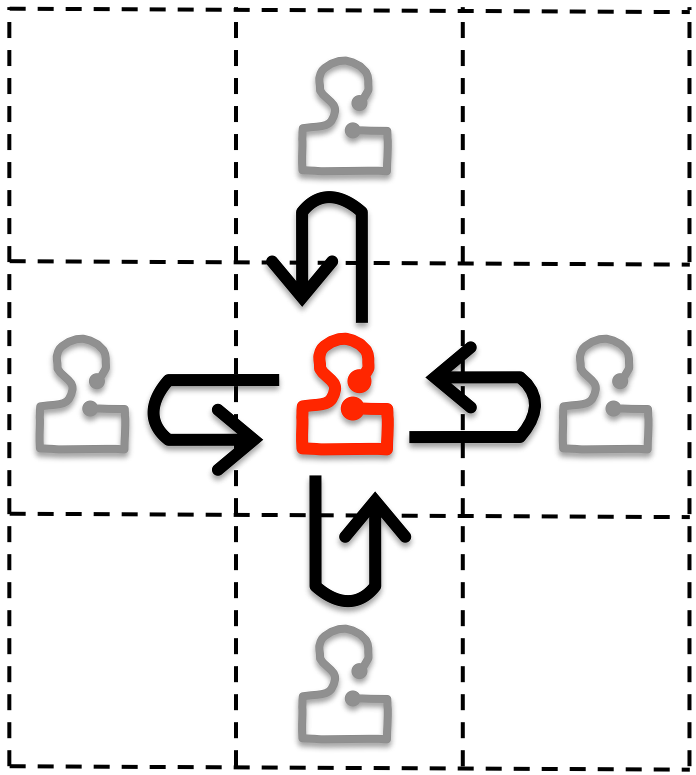
- agent-based
  - the structure of the system is described through its components (agent, entity) *not through its processes*
  - an agent evolves by receiving a message from *one* other agent



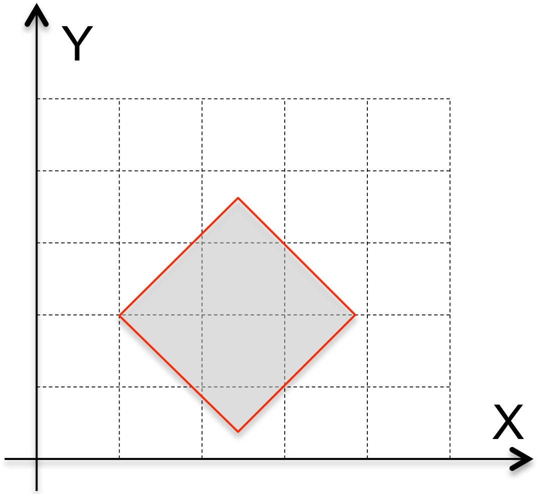
(in the previous example of languages there are)

Two main modeling approaches

- space-based
  - the structure of the system is described through its spatial domain *not through its processes*
  - an "elementary piece of space" evolves by querying the neighborhood

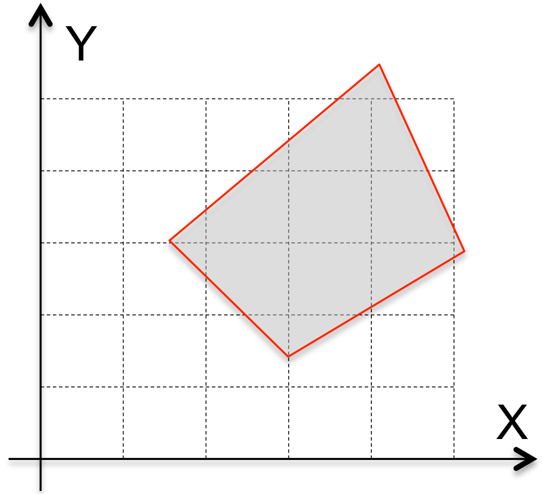


Same distinction for continuous models (fluid dynamics)



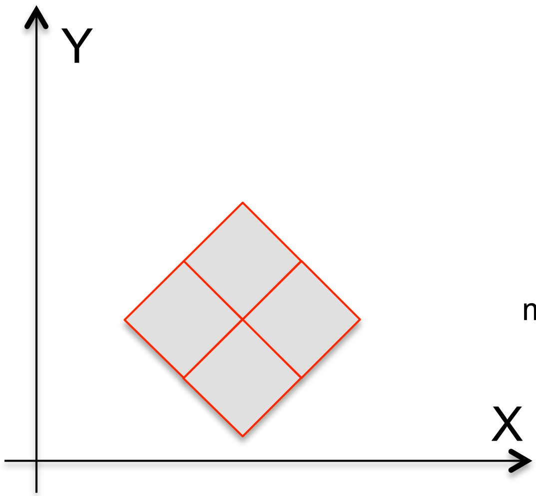
Eulerian mesh

what is occurring at a fixed point in a reference frame as time progresses (as in cellular automata)



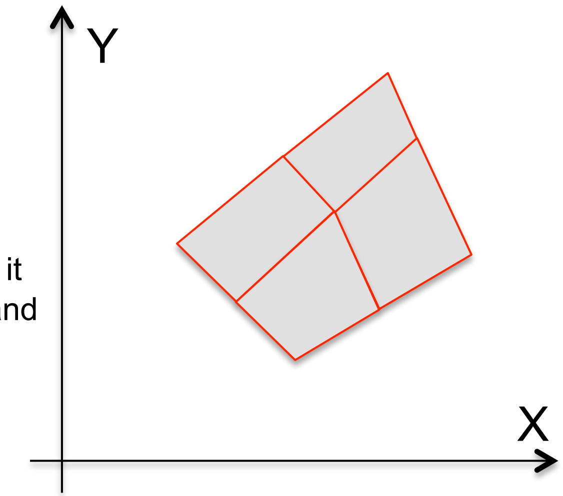
state *t*

state *t*+1



Lagrangian mesh

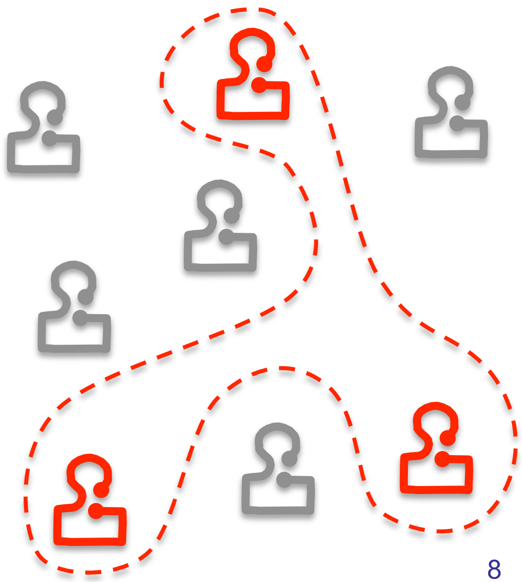
follows the position (and other properties) of a spatial element as it moves through a reference space and time (as in agent-based models)



A shift in perspectives

- the distinction impacts the language level
  (agent based and object oriented languages *vs.* spatial computing languages)
- The distinction vanishes for dynamic structure
  (agent and "piece of space" creation, rearrangement and deletion)
- *Neither framework is satisfactory*
  because they focus on the evolution of one entity
- A subsuming view is possible:

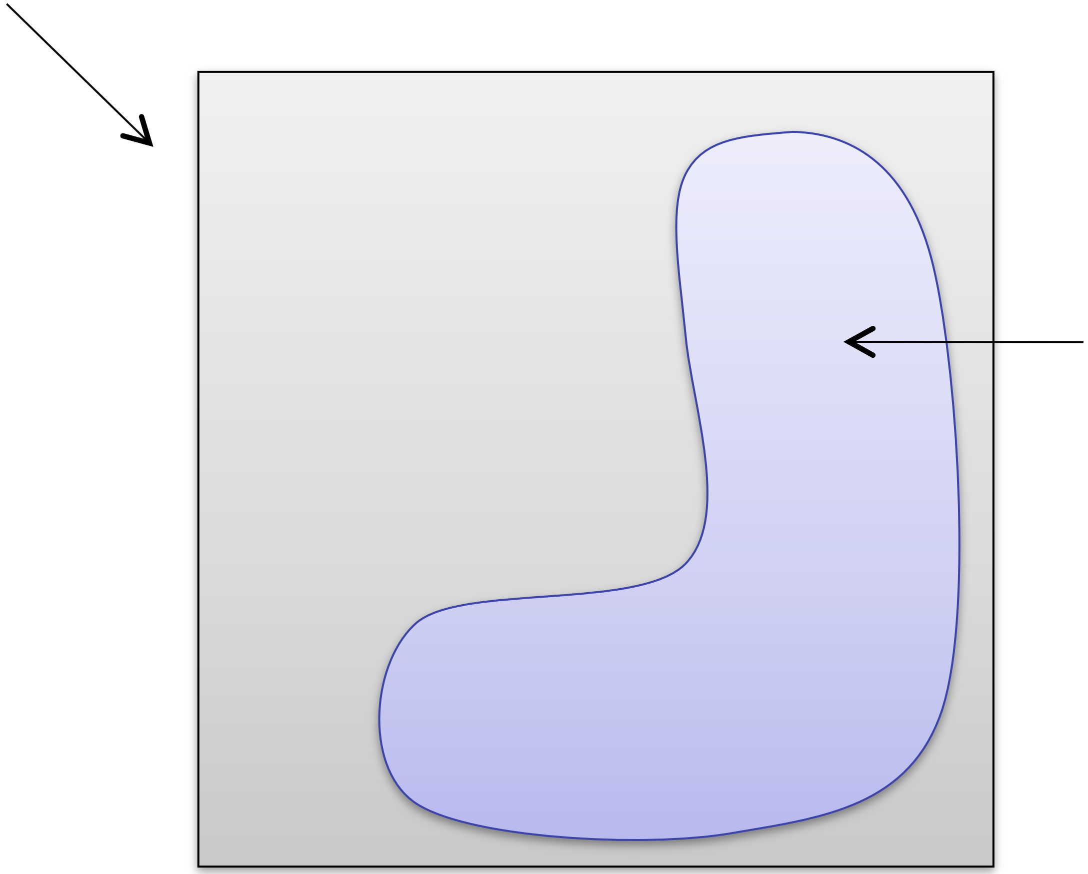
  interaction-based structuration



The Topological Structure of Interactions

Decompose a system into subsystems following the elements in interaction

A system in some state

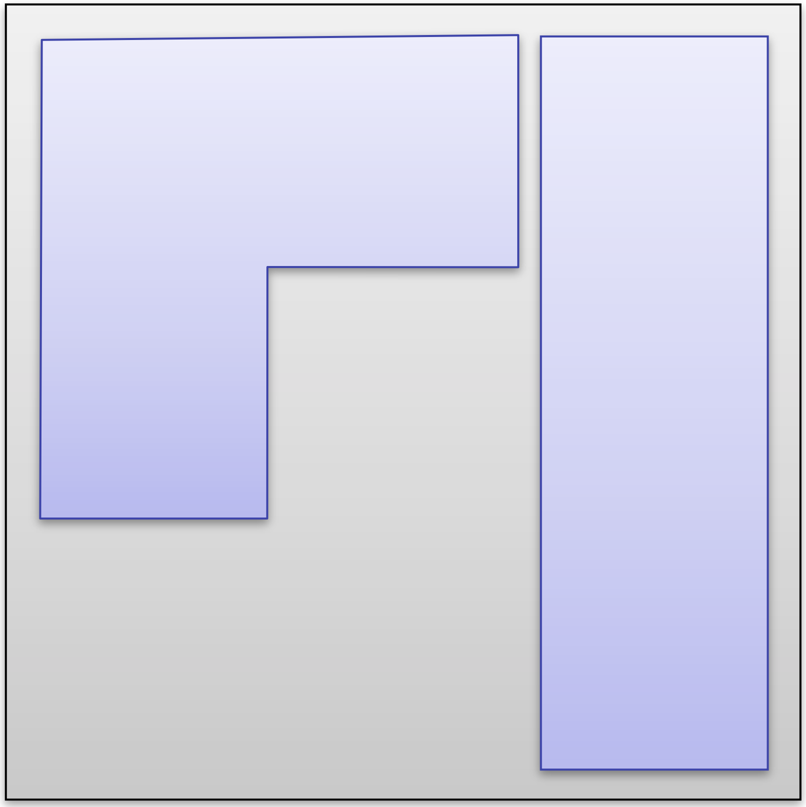


Part of a system that evolves.

Can be identified by comparison with the previous global state

Decompose a system into subsystems following the elements in interaction

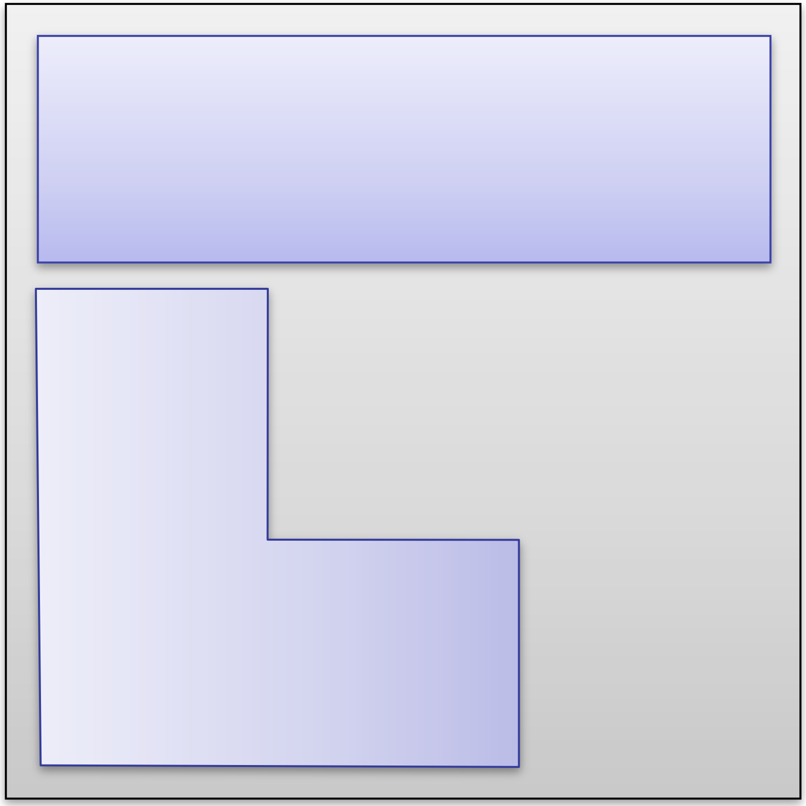
t = 1



Decompose a system into subsystems

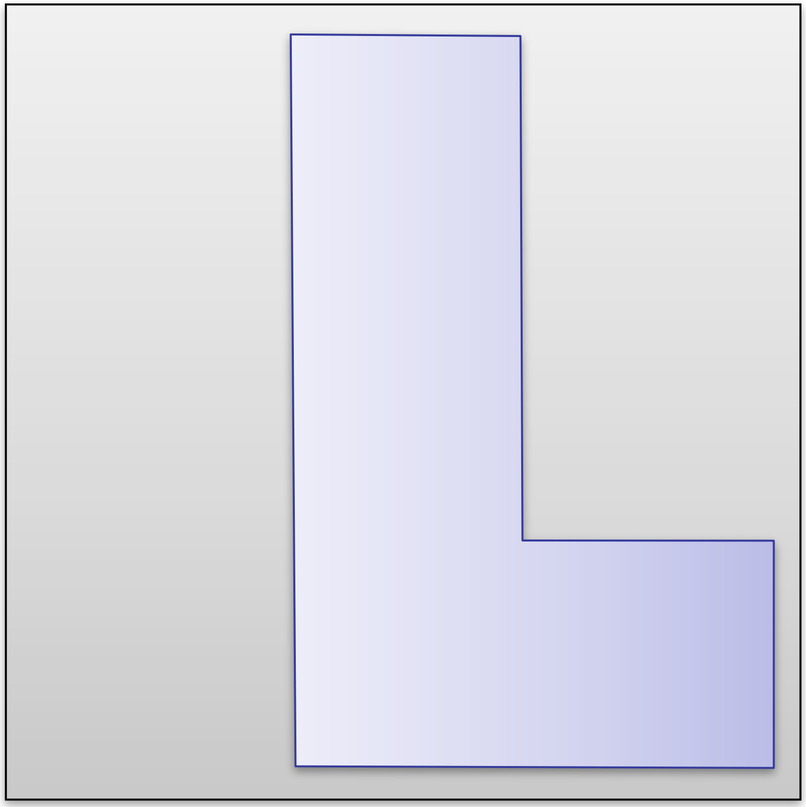
following the elements in interaction

t = 2



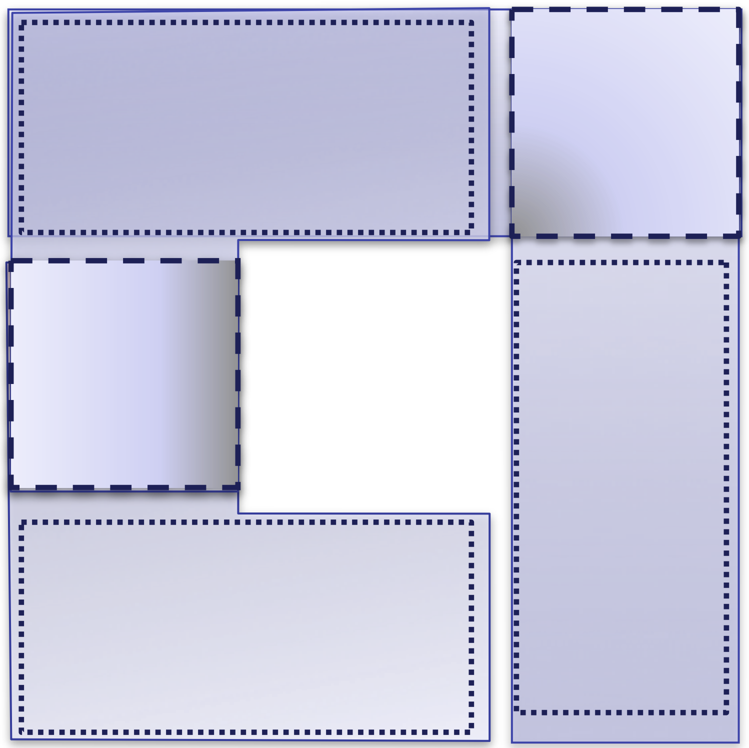
Decompose a system into subsystems following the elements in interaction

$t = 3$



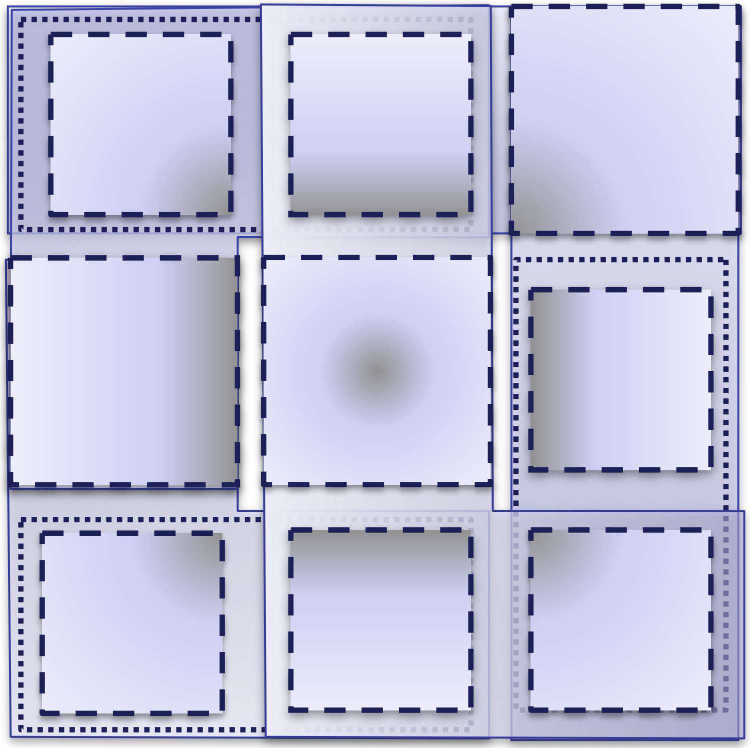
Decompose a system into subsystems

following the elements in interaction

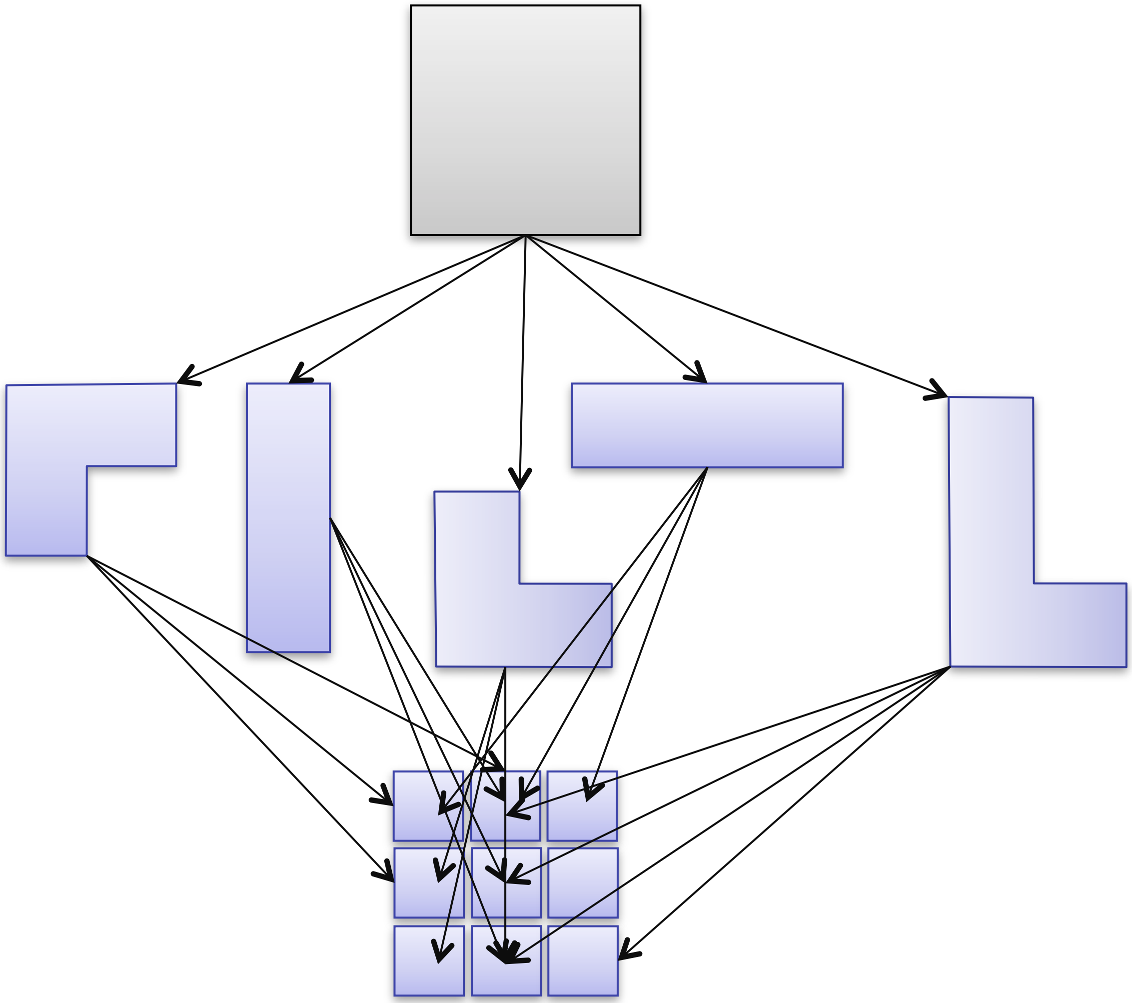


Decompose a system into subsystems following the elements in interaction

The interactions decomposes the systems into elementary parts.
An interaction implies one or several elementary parts.



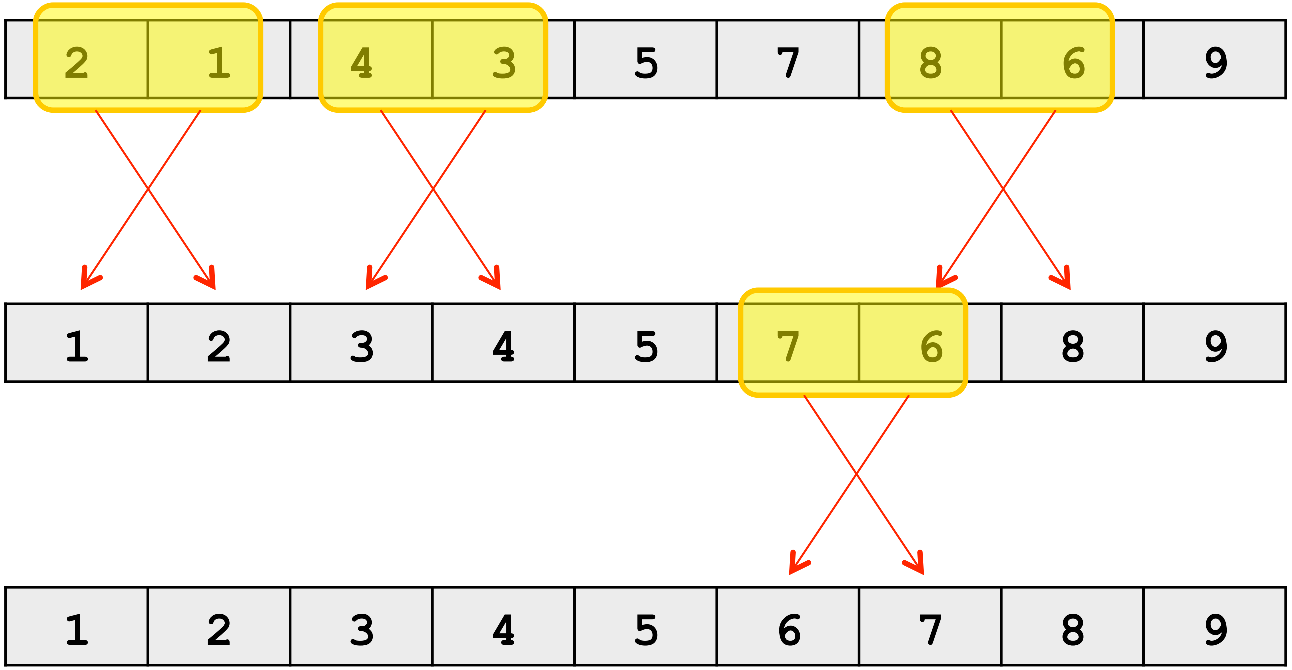
Decompose a system into subsystems following the elements in interaction



the inclusion structure between the elementary and interacting parts is **a lattice**

a (simplicial) complex is a better (topological) equivalent representation

The space of bubble-sort



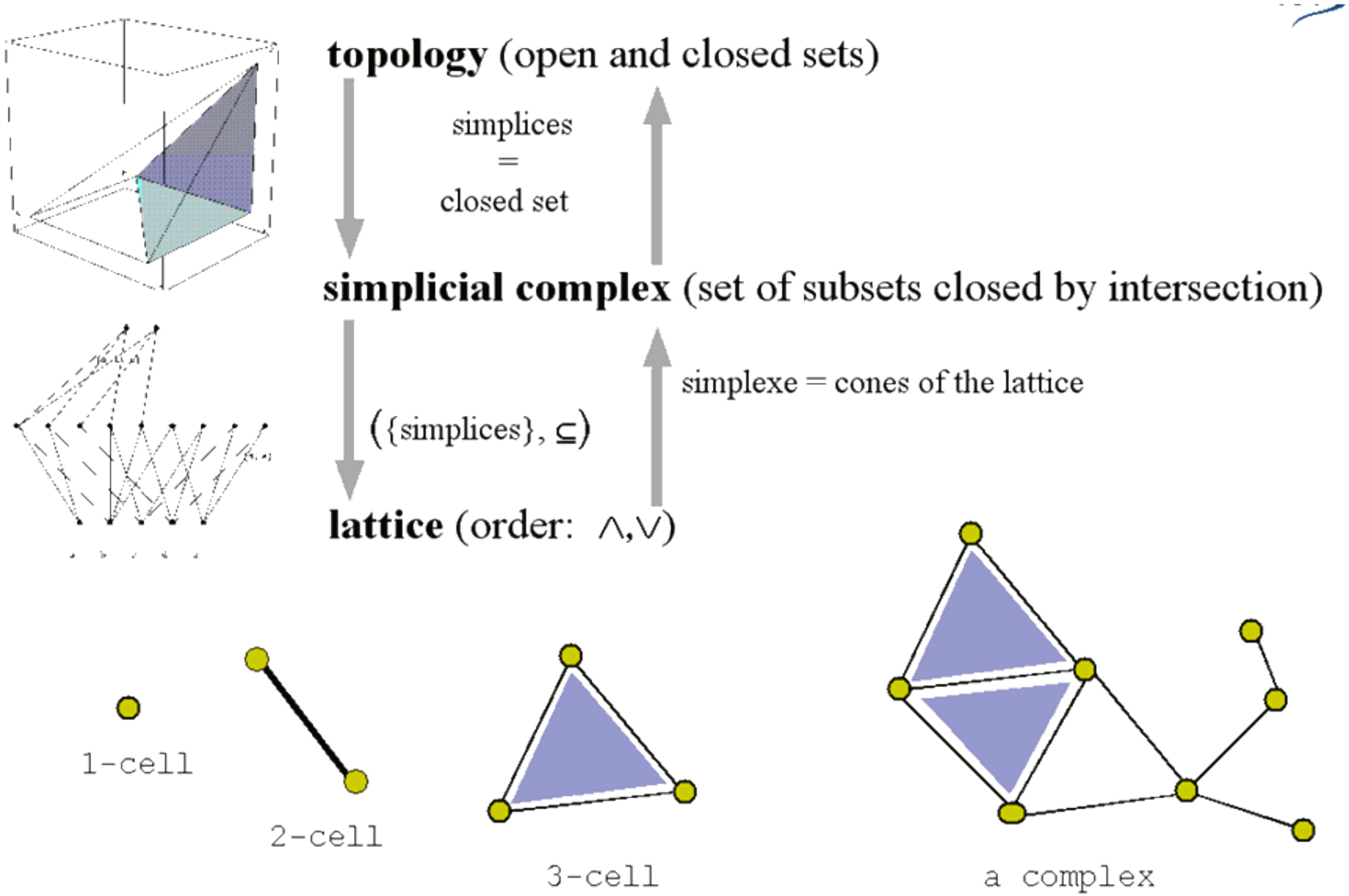
Bubble-sort is a process where:

- the state of the system is a sequence of numbers
- an interacting part in the system is a pair of adjacent decreasing numbers
- the transformation of an interacting couple exchanges the couple's elements
- the topology of the interacting parts is build upon the topology of the sequence

or

- the topology of the sequence can be recovered from the possible element's swap

Topology, simplicial complex and lattice



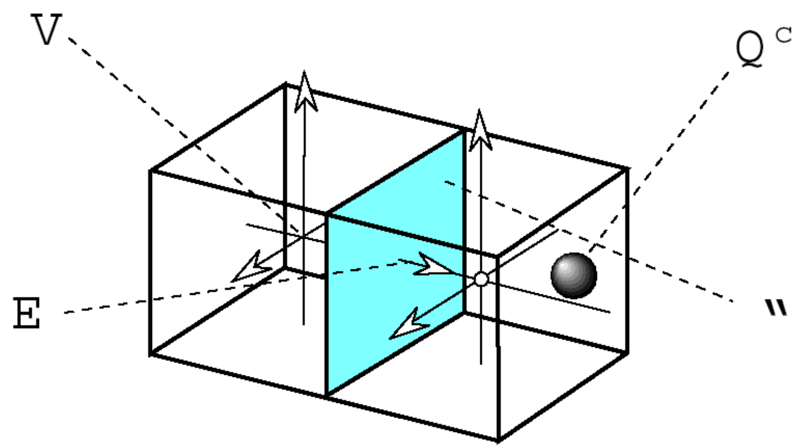
Higher dimensional objects for complex simulations

Example of electrostatic Gauss law [**Tonti** 74]

- Electric charge content ρ : dimension 3
- Electric flux ***Φ*** : dimension 2
- Law available on a arbitrary complex domain

$$\phi = \oiint w \cdot dS = \frac{Q^c}{\varepsilon_0} = \iiint_{(V)} \frac{\rho}{\varepsilon_0} d\tau$$

electric field in space:
- V: electric potential (dim 0)
- E: voltage (dim 1)
- w: electric flux (dim 2)
- Qc: electric charge (dim 3)



<u>*A Direct Discrete Formulation of Field Laws: The Cell Method*</u>

The grand picture

1. Describe a dynamical system following the interaction of its parts
2. Each part is characterized by a (local) state
3. The global state of the system is the “sum” of its local state and their topological organization
4. An interaction makes evolve a (small) subset of local states
5. An interaction potentially changes the topological organization of state

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