Emergent Properties for Data Distribution in a Cognitive MAS

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Emergent Properties for Data Distribution in a Cognitive MAS

overview

Emergence – essential issue in the engineering of multi-agent systems.

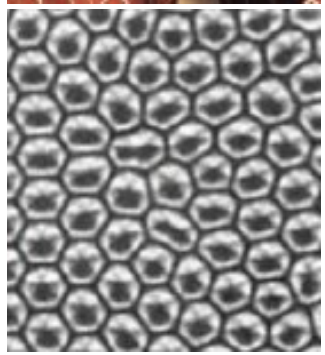
· lower (micro) level – simple entities that interact.
· higher (macro) level – complex behaviour of the system as a whole.

· Most studies of emergence use reactive agent systems.

· Cognitive systems are more capable.

· Emergents in cognitive agent systems may be more complex and, therefore, more useful.

Purpose: Create a multi-agent system for the storage and distribution of data, formed of cognitive agents, designed so that it would manifest the said emergent behaviour.



Emergence is:

· the concept of some new phenomenon arising in a system that wasn't in the system's specification to start with.

[Standish, 2001]

· coherent emergents at the macro-level that dynamically arise from the interactions between the parts at the micro-level. Such emergents are novel with respect to the individual parts of the system.

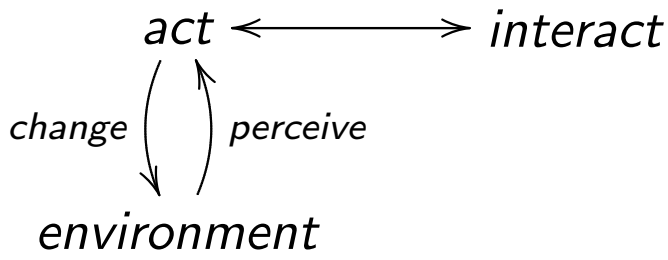
[De Wolf and Holvoet, 2005]

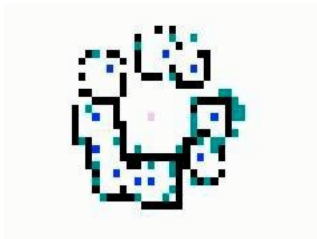
· in the context of an interacting set of agents whose dynamics are expressed in a vocabulary D, a global phenomenon – static or dynamic, but nevertheless invariant – that is observed by the agents or by an external observer and can only be interpreted in a vocabulary D' that is different from D.

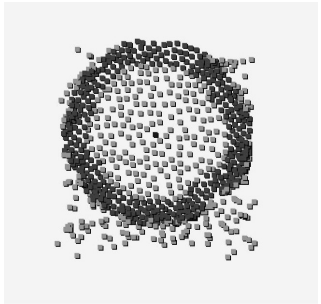
[Beurier et al., 2002]

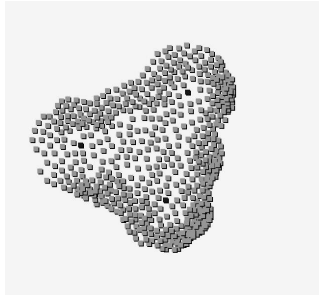
Important: emergence allows obtaining a function / behaviour of higher level from the interaction of lower level entities.

· Reactive agents – simple behaviour:

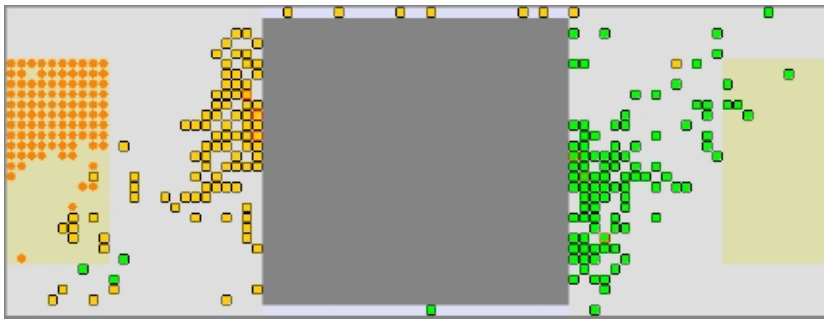








[Beurier et al., 2002] [Zambonelli et al., 2004]



[Picard and Toulouse, 2005]

· emergents are of the same nature as the properties of individuals, but at a higher level

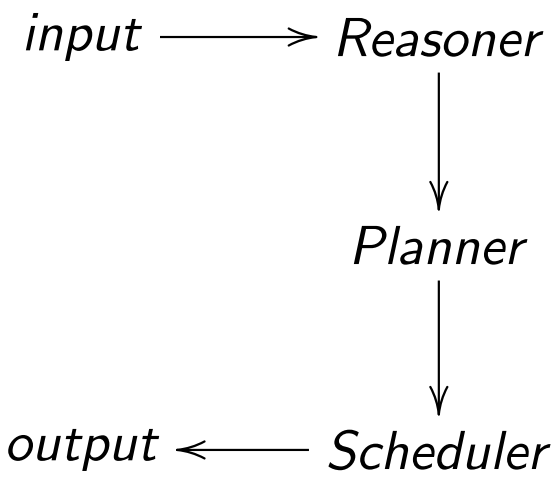
Cognitive agents feature:

- beliefs / knowledge
- desires / goals
- intentions
- plans

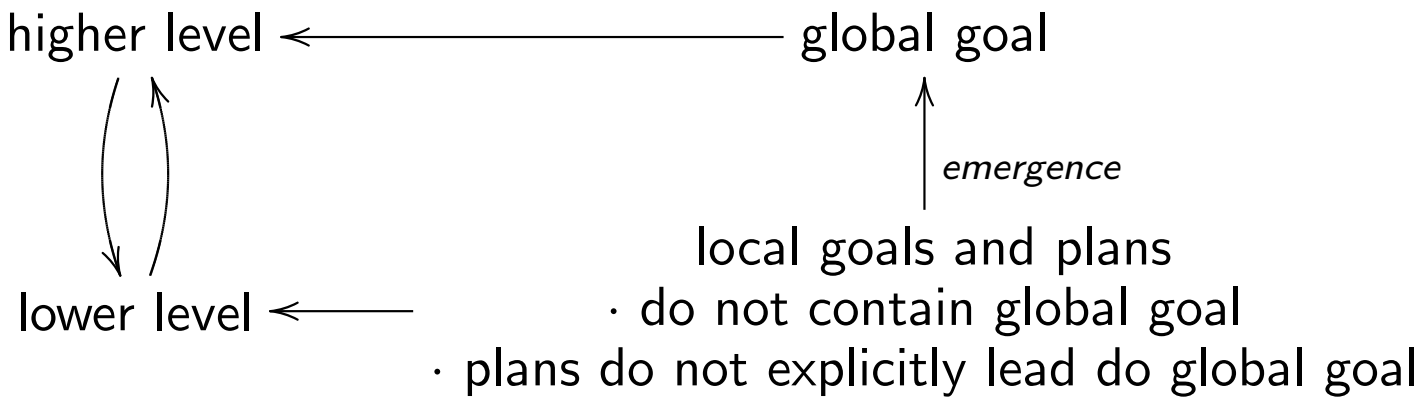
information about self

- what it wants to do
- what it is able to do
- how it can do it

Components:



Expected behaviour:



· Cognitive emergence – achieving a high level global goal through the interaction between agents that follow their own, individual, possibly selfish, goals.

· Design a multi-agent system in which neighbour (or acquainted) agents exchange information based on local goals (with no centralised control), so that, globally:

· when an agent produces a piece of information (by user input or aggregation), eventually the information is known by the agent(s) that might be interested in it.

· when an agent needs a certain piece of information, eventually it will come to know it.

System specifications:

- Cognitive agents placed in a rectangular grid.
- Agents communicate directly only with their 8 neighbours.
- Agents have a limited storage of information.

· BDI-inspired model

Beliefs: $\langle AgentID,\ DataID \rangle$

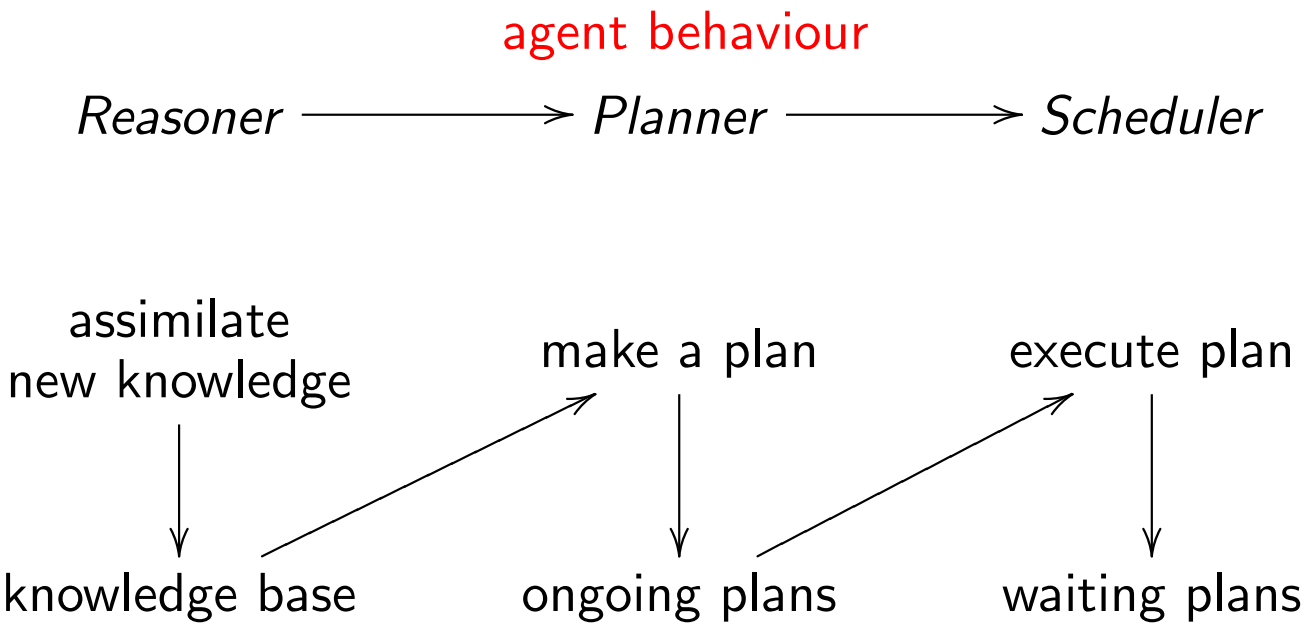
example: $\langle B,\ D1 \rangle$ = agent B has data $D1$

Goals: $\langle Goal,\ DataID \rangle$

example: $\langle Get,\ D3 \rangle$ = must get data $D3$

Actions: $\langle Action,$ related agent and belief or goal $\rangle$

example: $\langle Inform,\ C, \langle B,\ D1 \rangle \rangle$ = inform agent C that agent B has data $D1$



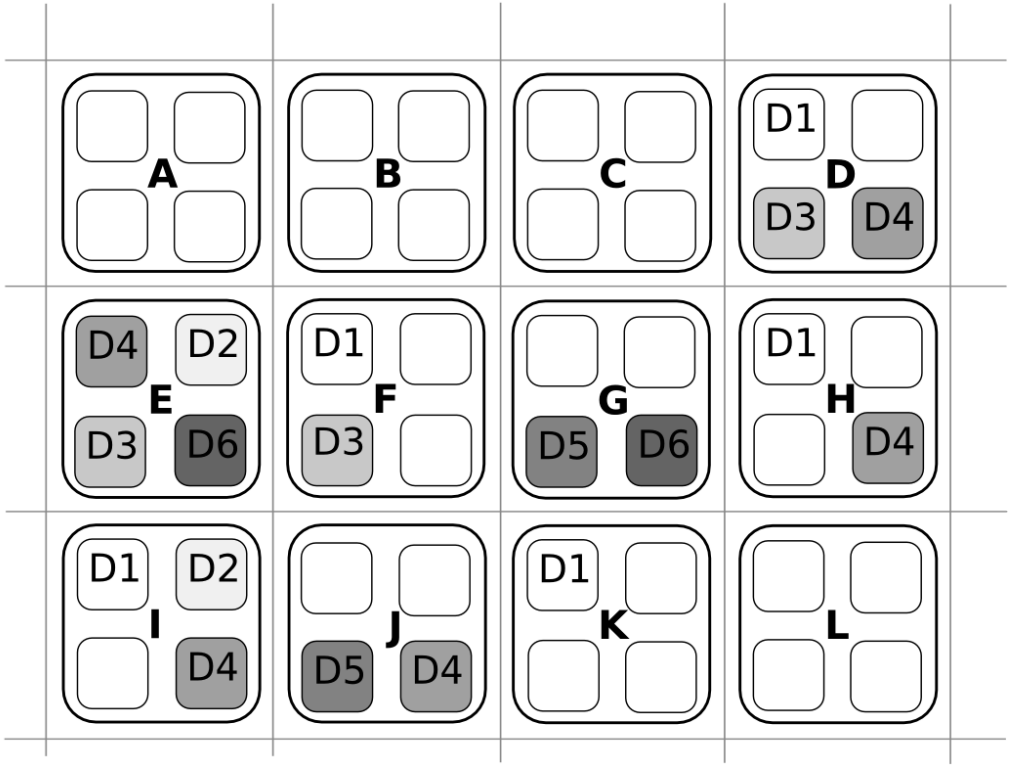
· the goals of an agent are:

- In case there is an external request for data, provide that data or try to find it in the vicinity.
- Maintain 25% of the capacity free, ready for potential data coming from the environment.
- In case there is available capacity (over 25%), request interesting data from a neighbour.
- Process and respond to messages from neighbour agents.
- If all other objectives are complete (capacity 75%, no messages), discard some data that is already contained by most of the surrounding agents.

· available actions:

- Send a request for data to a neighbour.
- Send a piece of data to a neighbour (as reply to a request only).
- Receive data or knowledge from a neighbour.
- Discard a piece of data.
- Broadcast to the all neighbours own knowledge and intentions.

· example behaviour, over one step:



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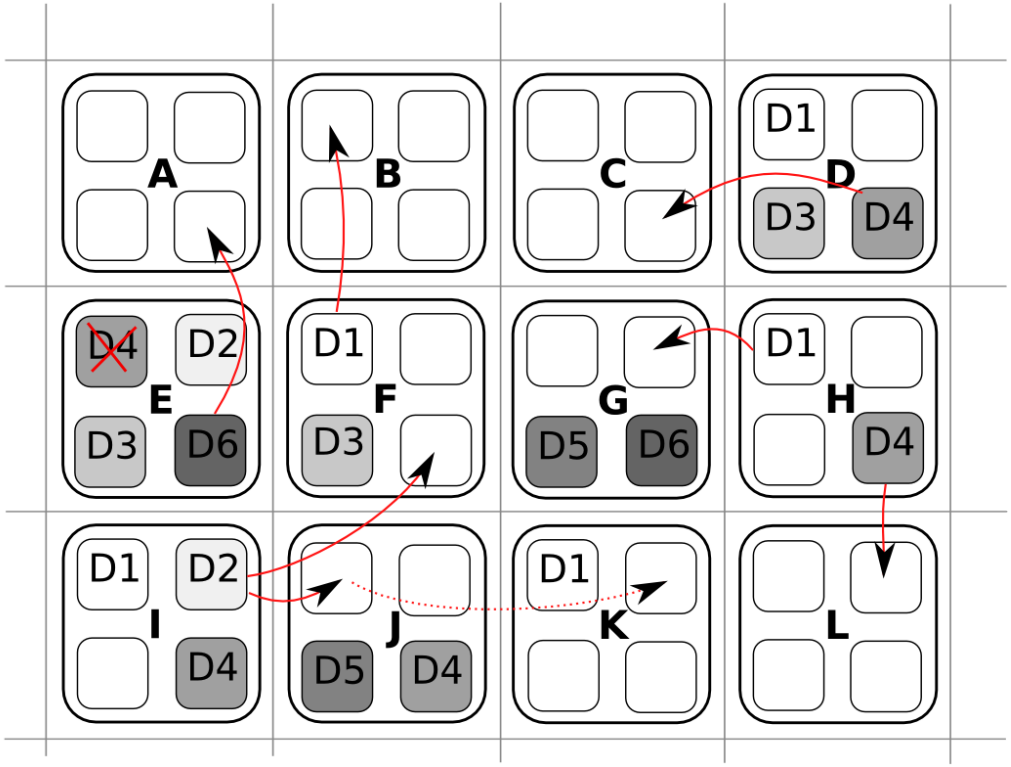

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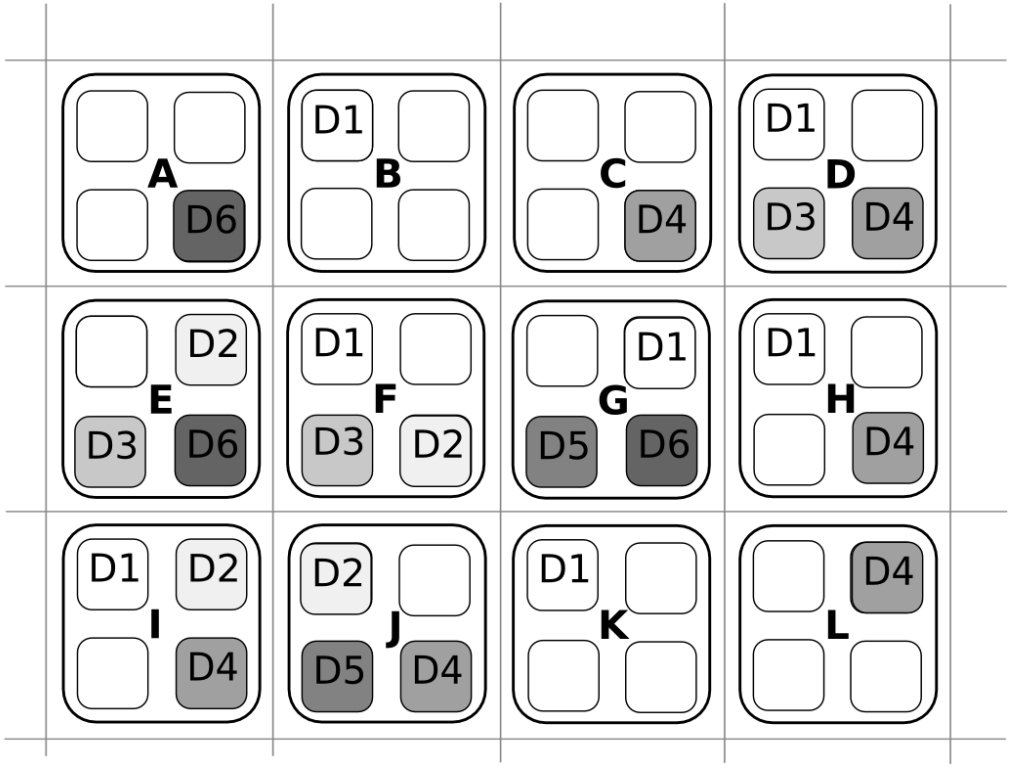
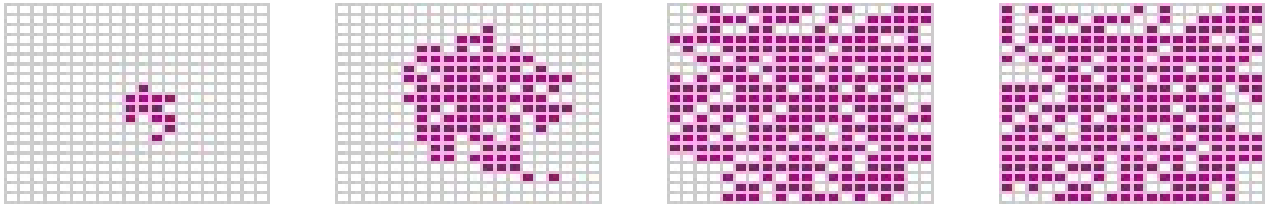


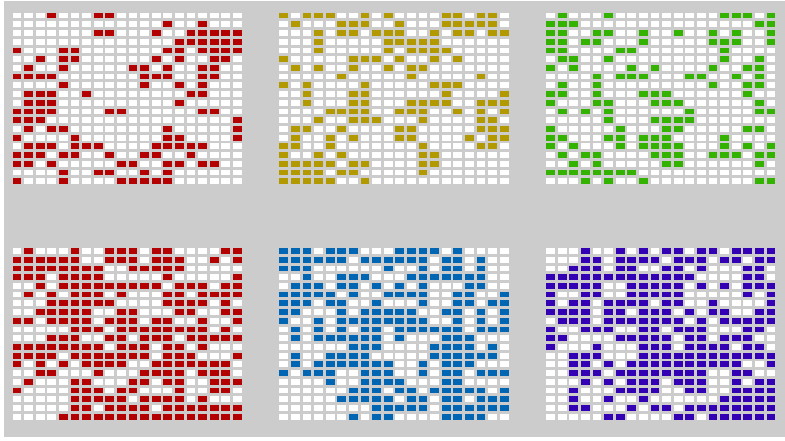
Results: data storage, distribution and availability

Output:

· distribution of one data chunk in a system with 6 chunks:



. distribution for 6 chunks of data, after stabilisation:



· Emergence is a key issue in the study of multi-agent systems.

· As computing capabilities grow, even for small devices, the cognitive approach becomes a promising direction of development.

· A cognitive multi-agent system has been designed in which the agents' interactions allow the emergence of specific properties required for solving the problem of data storage and distribution, by giving the agent local goals that naturally lead to the global, desired, goal of the system.

· An application has been developed demonstrating that replication and a uniform distribution of data may be obtained, without explicitly encoding these properties in the agents' behaviour.

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Thank you!

Any Questions?