

Self-organising agents for ambient intelligence

Andrei Olaru (with Cristian Gratie and Adina Florea)

University 'Politehnica' of Bucharest
Laboratoire d'Informatique de Paris 6

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Self-organising agents for ambient intelligence

overview



► Self-organising systems

- large number of individuals
- based on interaction
- emergent organisation of higher level

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▶ Ambient Intelligence (Aml)

- large number of devices
- limited capability of devices
- much information exchanged by interaction
- centralized organisation is very difficult

layers:

human-machine interface – information exchange – network layer



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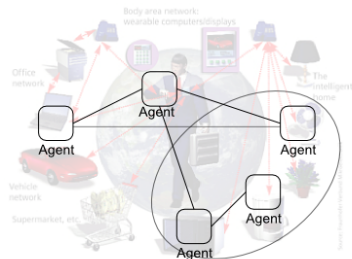
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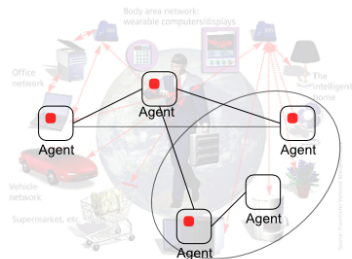
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·coherent emergents at the **macro-level** that **dynamically** arise from the **interactions** between the parts at the micro-level. Such emergents are **novel** with respect to the individual parts of the system. [De Wolf and Holvoet, 2005]

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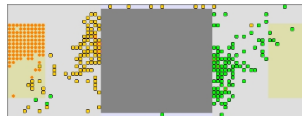
■ References



[Beurier et al., 2002]



[Zambonelli et al., 2004]



[Picard and Toulouse, 2005]

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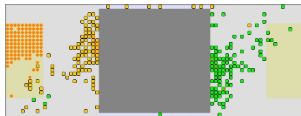
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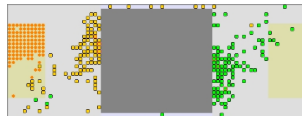
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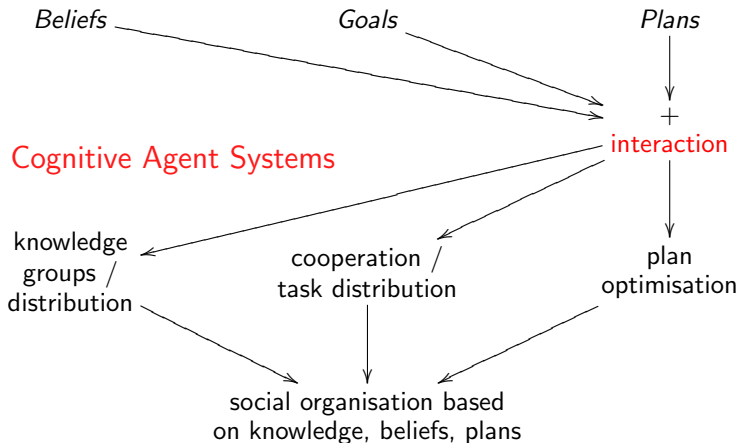
·reactive agents → space-related structure or behaviour

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[Olaru et al., 2009]





Expected emergents are based on

- ▶ components of cognitive agents
- ▶ interaction – attraction, repulsion, exchange



·Design a multi-agent system in which neighbour (or acquainted) agents exchange information based on **local** goals (with no centralized 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.

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Challenges:

- ▶ agent behaviour
- ▶ context-awareness
- ▶ knowledge representation
- ▶ system monitoring
- ▶ ...



- Cognitive agents placed in a rectangular grid.
- Agents communicate directly only with their 8 neighbours.
- Agents have a limited storage of information.
- All information (knowledge) held by the agent is held in **Facts**

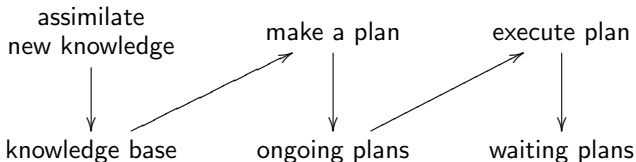
Fact ::= $\langle \text{Agent}, \text{Data}, \text{pressure}, \text{interest} \rangle$ (1)

| $\langle \text{Agent}, \text{Goal}, \text{pressure}, \text{interest} \rangle$ (2)

| $\langle \text{Agent}, \text{Fact}, \text{pressure}, \text{interest} \rangle$ (3)

agent behaviour

Reasoner \longrightarrow *Planner* \longrightarrow *Scheduler*



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Agent goals:

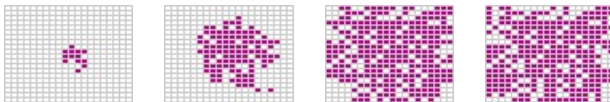
- ▶ ready for incoming data \Rightarrow keep capacity $\leq 75\%$
- ▶ get interesting data (if capacity $< 75\%$)
- ▶ inform other agents of new data
- ▶ inform other agents of goals
- ▶ get data requested from the exterior



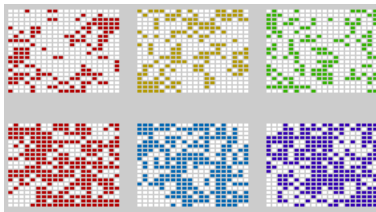
Results: data storage, distribution and availability

Output:

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



·distribution for 6 chunks of data, after stabilisation:

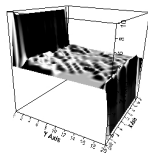


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- allows for adequate action, according to the conditions
- context should influence not only the choice of actions, but the internal metabolism of agents
- for a self-organising Aml system for information exchange, context measures should be **simple**, and **generic** enough.
 - ▶ **Pressure**, considered in the interval $[0, 1]$ represents the **urgency** of a piece of information (a Fact), i.e. how important it is that other agents get know this fact and how quick the fact should be spreading
 - ▶ **Interest** – relatedness of one piece of data to different **domains of interest**.

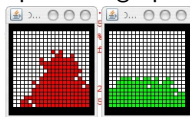
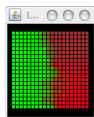


·Complex systems are difficult to monitor. Tools are needed for the tracking of the systems evolution.



agent grid

pressure graph



combined
interest

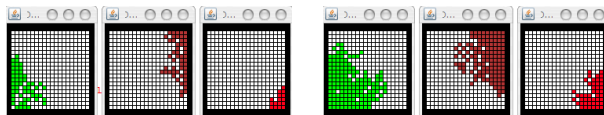
domain interest
(for 2 domains)

fact distribution
related to 1 data

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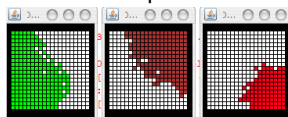


·scenario – part 1: insertion of 3 new pieces of data in 3 different corners of the grid.

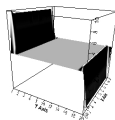


step 5

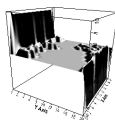
step 10



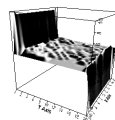
step 20



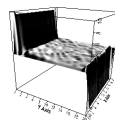
step 0



step 5



step 10



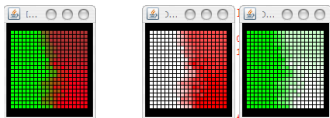
step 20

- ▶ higher pressure makes facts spread more, and faster
- ▶ "busy" agents are more reluctant to new facts



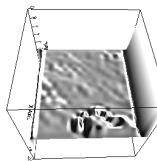
·scenario – part 2: after the stabilisation of the system, insert two more new facts, in the same initial area

·current interest (step 39):

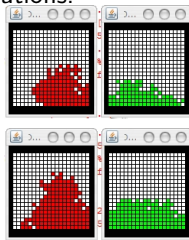


combined individual domains

·evolution of fact distributions:



pressure at
step 35



step 47

step 54

- ▶ facts spread according to the indication of interest
- ▶ high pressure makes facts spread more



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- ▶ decentralisation – an essential element for the viable implementation of Ambient Intelligence
- ▶ information must be exchanged in a self-organising manner, considering notions of context awareness
- ▶ two measures of context-awareness have been developed, that influence the direction and speed of the spread of information
- ▶ the implementation showed promising experimental results



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