

Using multi-agent systems to model and simulate human behaviour for energy management



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“Human behaviour is at least as important as the physical characteristics of a building in influencing energy use” [1]

“Human energy-use behaviour has been observed to be responsible for 51% and 37% disparity in heat and electricity use respectively within identical residences” [2]

[1]Scott Kelly. Energy efficiency and human behaviour. Cambridge Centre for Climate Change Mitigation Research. 2013

[2]Obiajulu Iwaka, Shuli Liu, Ashish Shukla, Da Yan. Energy and behaviour at home: A review of intervention methods and practices. Energy Research & Social Science, Volume 57, 2019



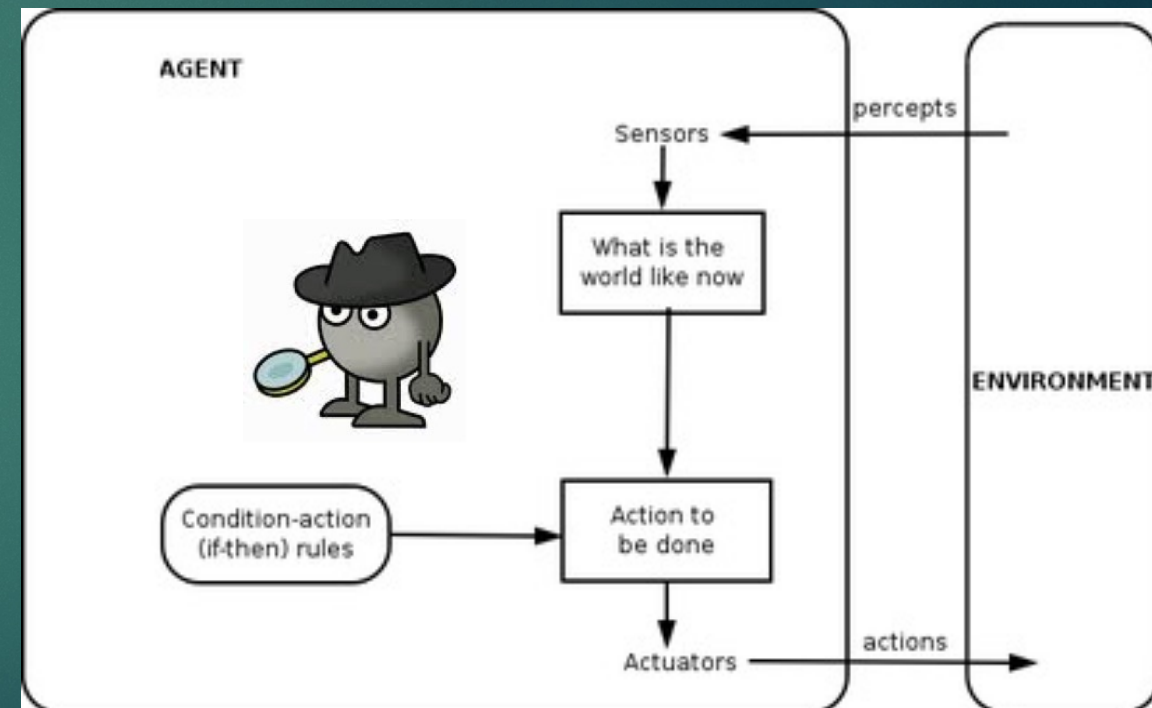
The diversity in behaviour gives rise to energy-related choices made by people, e.g.

- how often and how much time people spend in cooking, and what appliance they use
- space heating,
- use of air conditioning,
- entertainment technologies,
- lighting,
- purchasing energy efficient equipment,
- Etc.

What is agent based modelling and simulation?

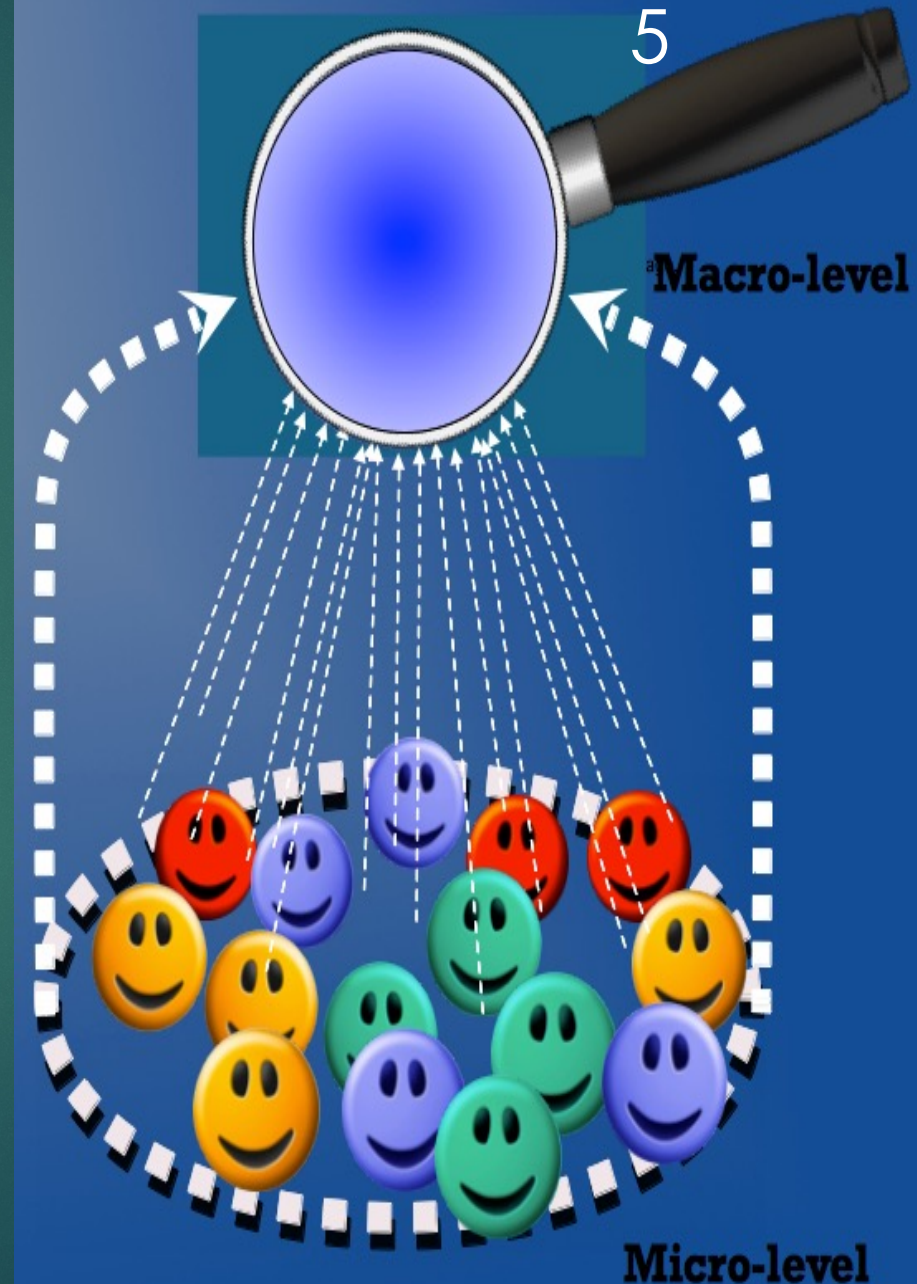
A software agent :

- ▶ Has a **set of characteristics** (attributes)
- ▶ Has a **set of actions** that it can do (behaviours or methods)
- ▶ Can **communicate with other agents** (by sending messages) the message can evoke an action in another agent
- ▶ Can also **receive information from its environment**, this may also invoke an action
- ▶ Can **decide what to do** (autonomous)
- ▶ Can be reactive, proactive, have **different levels of intelligence** (reasoning about actions can incorporate different mechanisms: neural networks, logic based, utility based, goal based, ..)



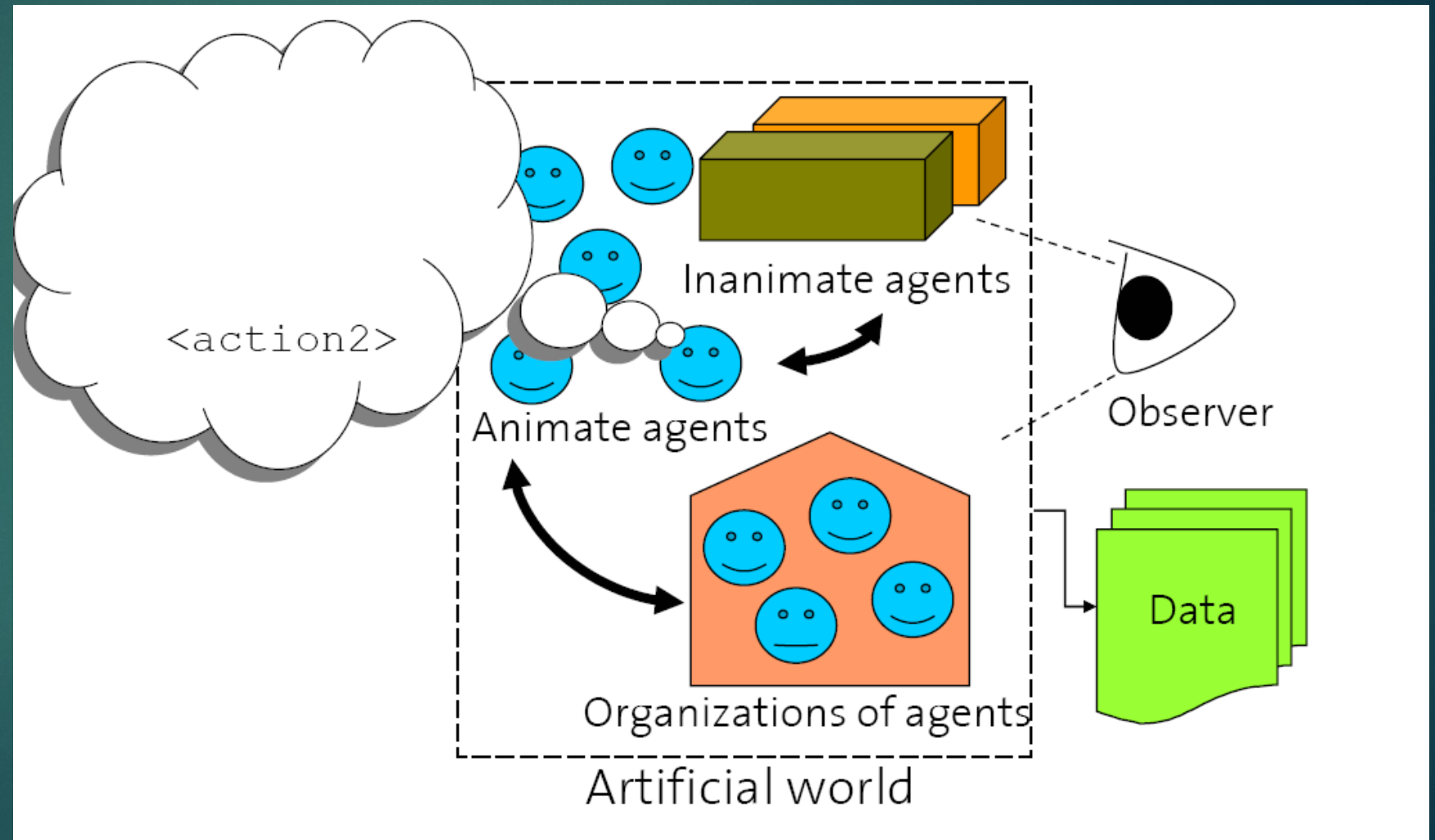
Put agents together → a Multi-agent system

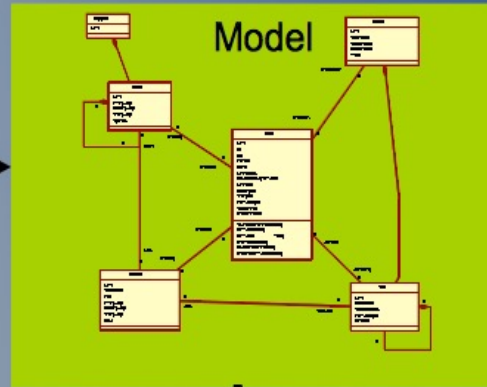
- ▶ Main idea: even when agents are programmed with **very simple behaviours** (e.g. rules), the overall **resulting behaviour** of a community of agents can be very complex.
- ▶ A bottom-up approach
 - ▶ Higher level we are interested in observing emergence phenomena at a global level (Macro-Level).
 - ▶ Lowest level we are interested in observing the individual behaviour of the agents (Micro-level)



Artificial world

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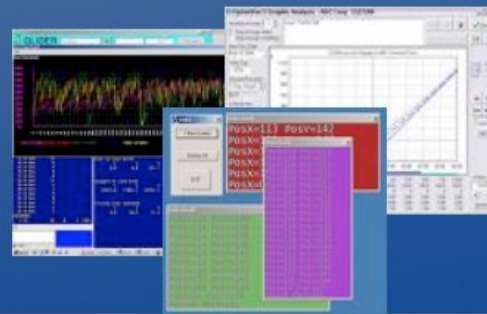




Instantiation



Generation



Model: Abstract representation of the real system

Simulation: Driving the model with input parameters

Experimentation:
Generate artificial history.
Analyse to draw conclusions about real system

Input Parameters



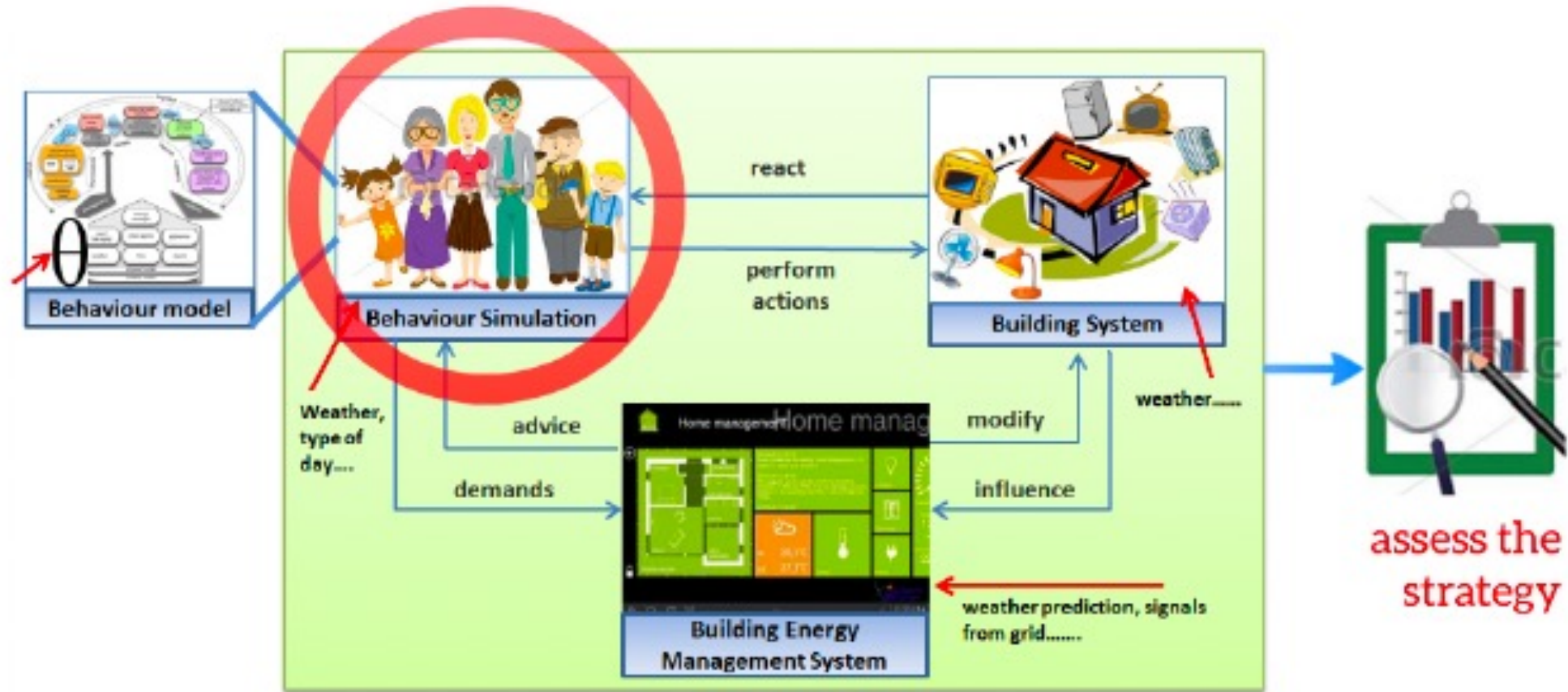
PhD Thesis: Modelling of human reactive and deliberative behaviour using a multi agent approach for energy management in home settings

Ayehsa Kashif

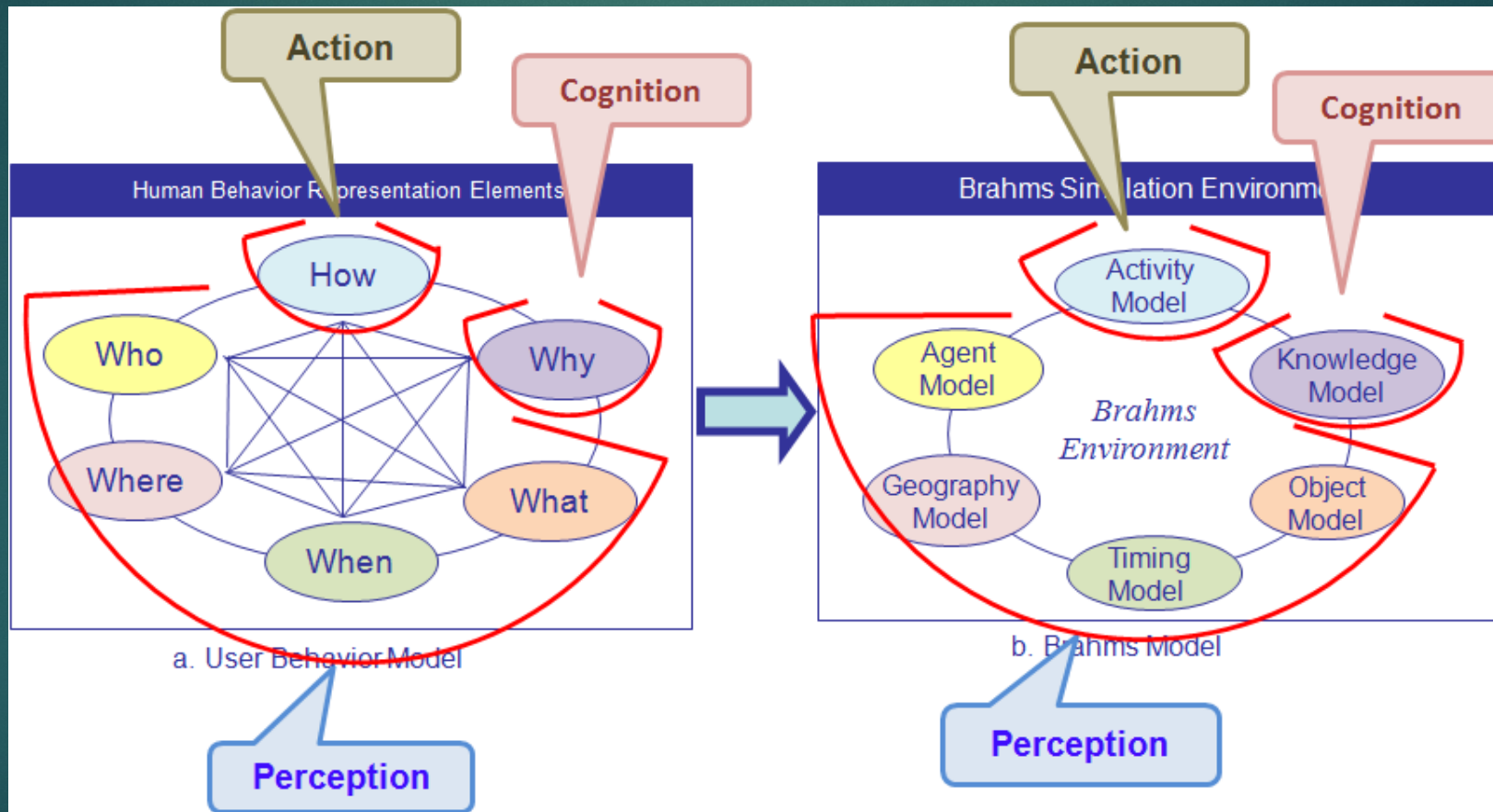
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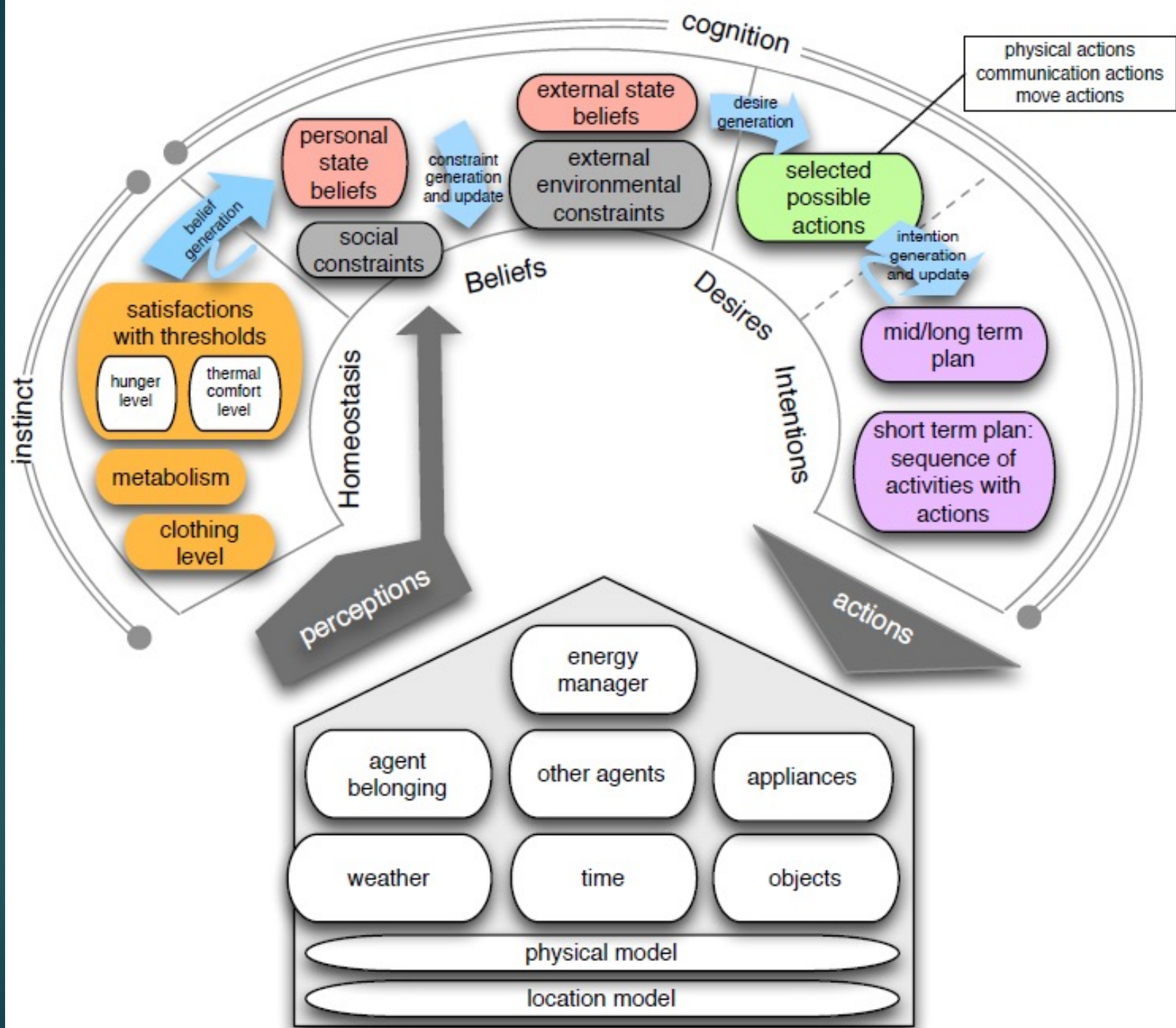
Supervisors Stéphane Ploix (GSCOP), Julie Dugdale (LIG)

- ▶ **Q1:** *How to identify the energy impacting behaviours?*
- ▶ **Q2:** *How the complex (reactive, deliberative, social and group) behaviours can be co-simulated with the thermal model of the building and physical models of appliances in residential buildings?*



- ▶ Detailed behaviour representation, particularly the cognitive, reactive, and deliberative mechanisms.
- ▶ Communication with other inhabitants.





From households to neighbourhoods and communities

- ▶ BDI approach does not easily scale
- ▶ Possible to adopt archetypes approach (Current work on Wildfires in Australia)

Archetype	Key Characteristics	Evacuate or Remain
Responsibility Denier	Believe they are not responsible for their personal safety or for their property	Highly committed evacuator but expect others to direct and assist
Dependent Evacuator	Expect the emergency services to protect them and their property because they are incapable of taking responsibility for themselves	Highly committed evacuator but expect others to direct and assist
Considered Evacuator	Having carefully considered evacuation, are committed to it as soon as they are aware of a bushfire threat	Committed to self-directed evacuation
Community Guided	Seek guidance from neighbours, media and members of the community who they see as knowledgeable, well informed and providing reliable advice	Committed to evacuation on community advice

Worried Waverer	Prepare and equip their property and train to defend it but worry they lack practical experience to fight bushfire putting their personal safety at risk	Wavering between evacuating and remaining
Threat Denier	Do not believe that their personal safety or property is threatened by bushfire	Committed to remain at their property as perceived lack of threat makes evacuation unnecessary
Experienced Independent	Are highly knowledge, competent and experienced and are responsible and self-reliant fighting bushfire	Highly committed to remaining to defend their property because they are highly experienced and well prepared

Energy use Profiles:

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Energy use Profiles:

- *Environmentally conscious and well-informed energy consumers,*
- *Concerned but comfort-oriented energy consumers,*
- *Concerned but lacking awareness energy consumers,*
- *Materialistic energy consumers escaping personal responsibility,*
- *Prone to social influence energy consumers, and*
- *Indifferent energy consumers.*



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Thank you! Questions?

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