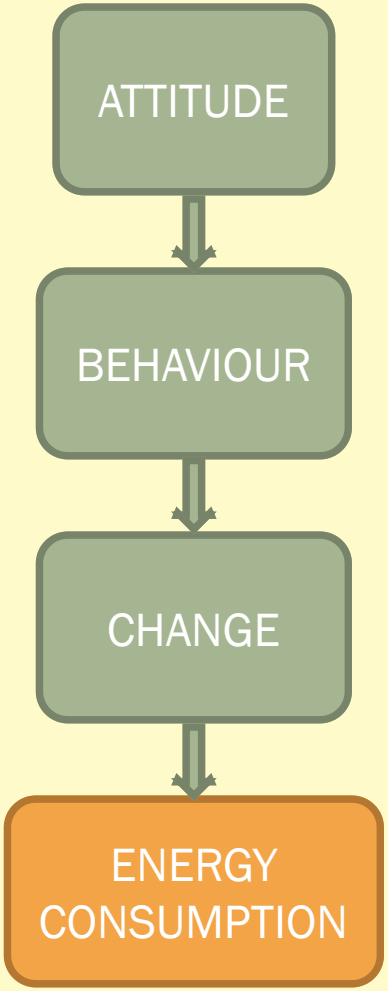
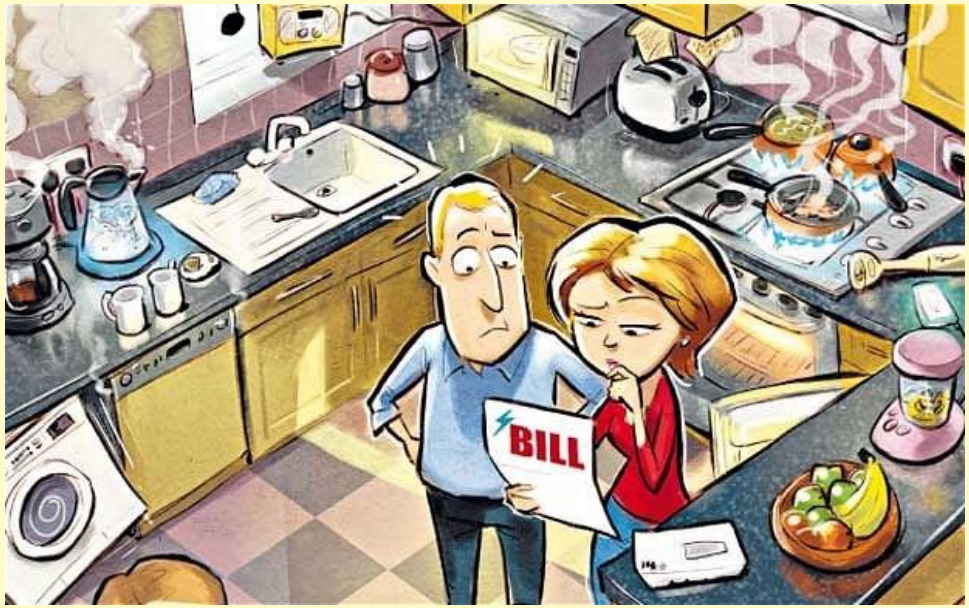
MODELLING ENERGY USE IN HOUSEHOLDS: A PRACTICE THEORY APPROACH

Dr Kavin Narasimhan
@kavinpreethi
Centre for Research in Social Simulation
University of Surrey

Background

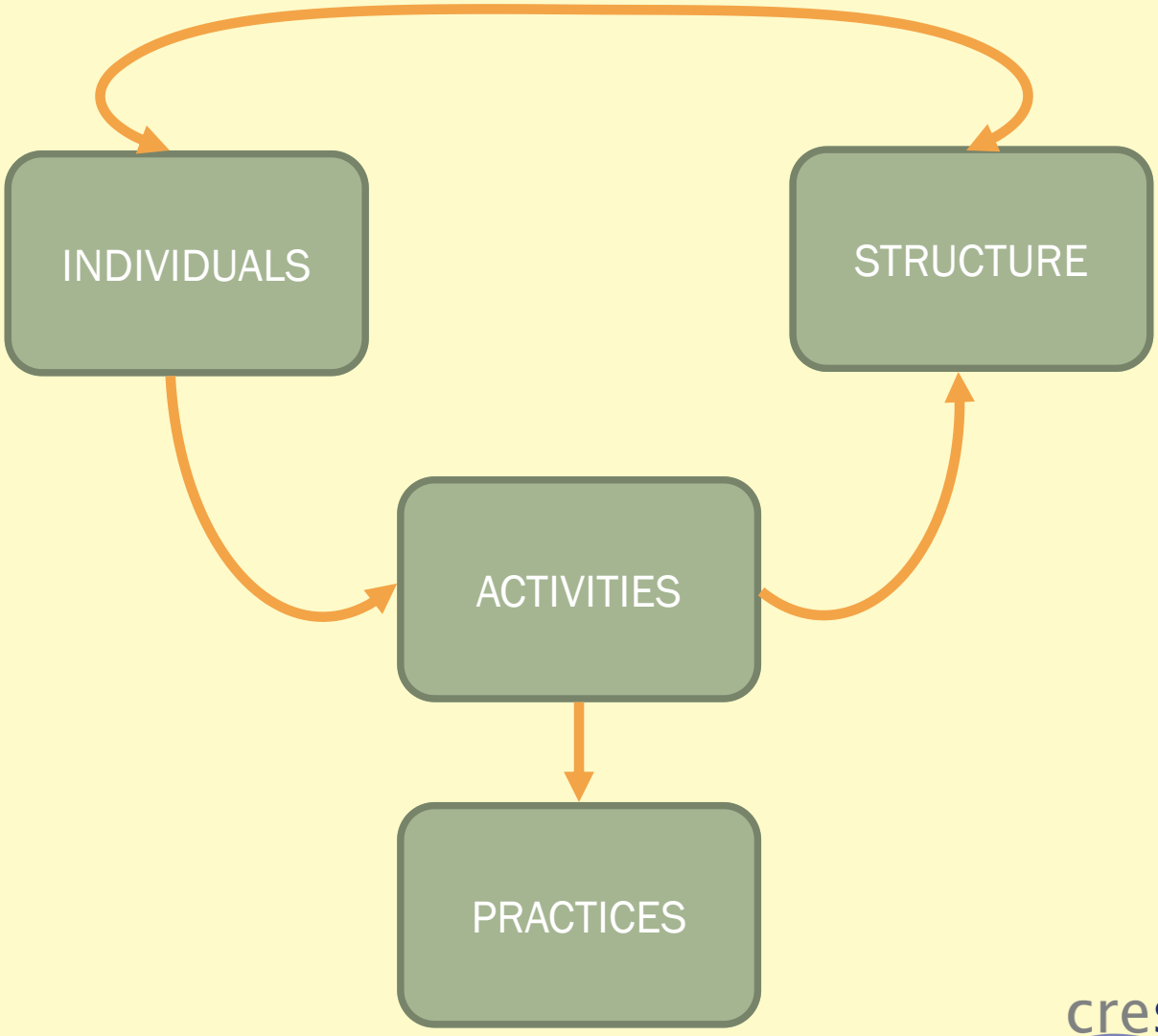


An alternative approach

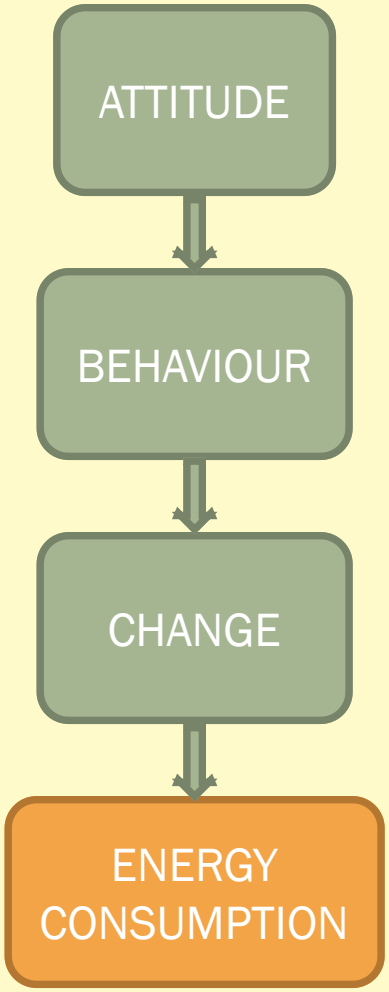


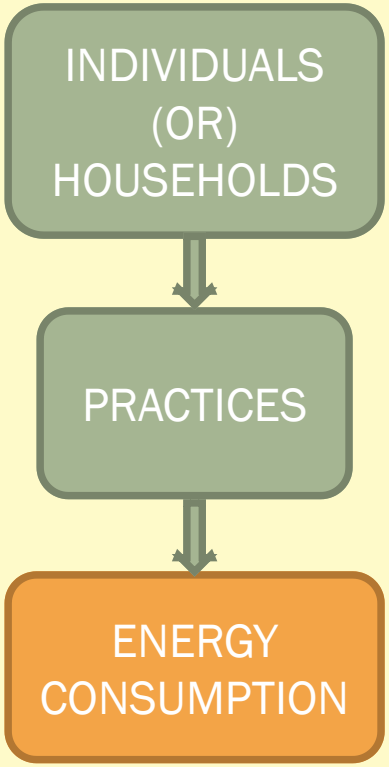
"Need to understand the patterns of household energy consumption by taking into account the practices that people perform in the service of normal everyday life"

Social practice theory

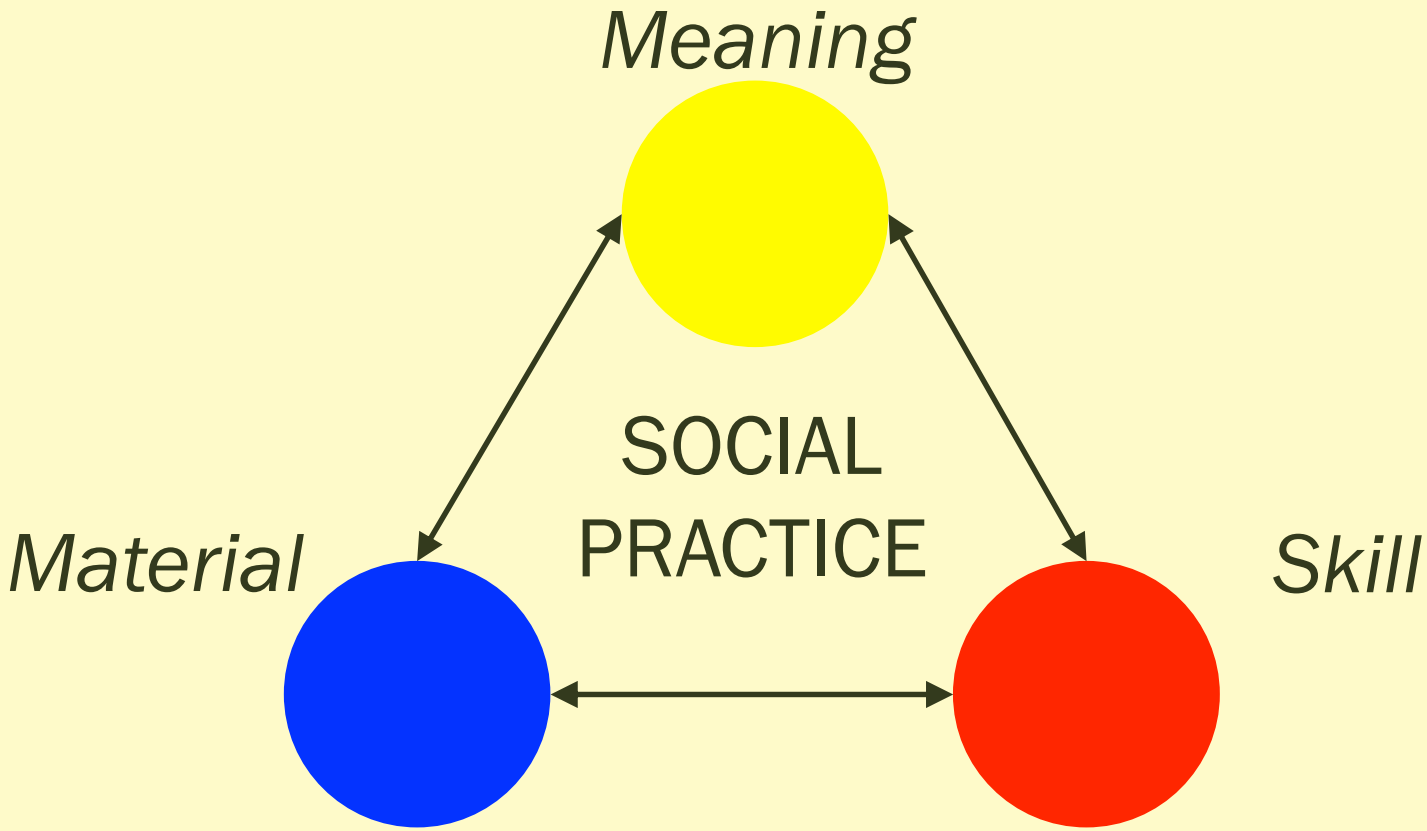


Shifting perspective



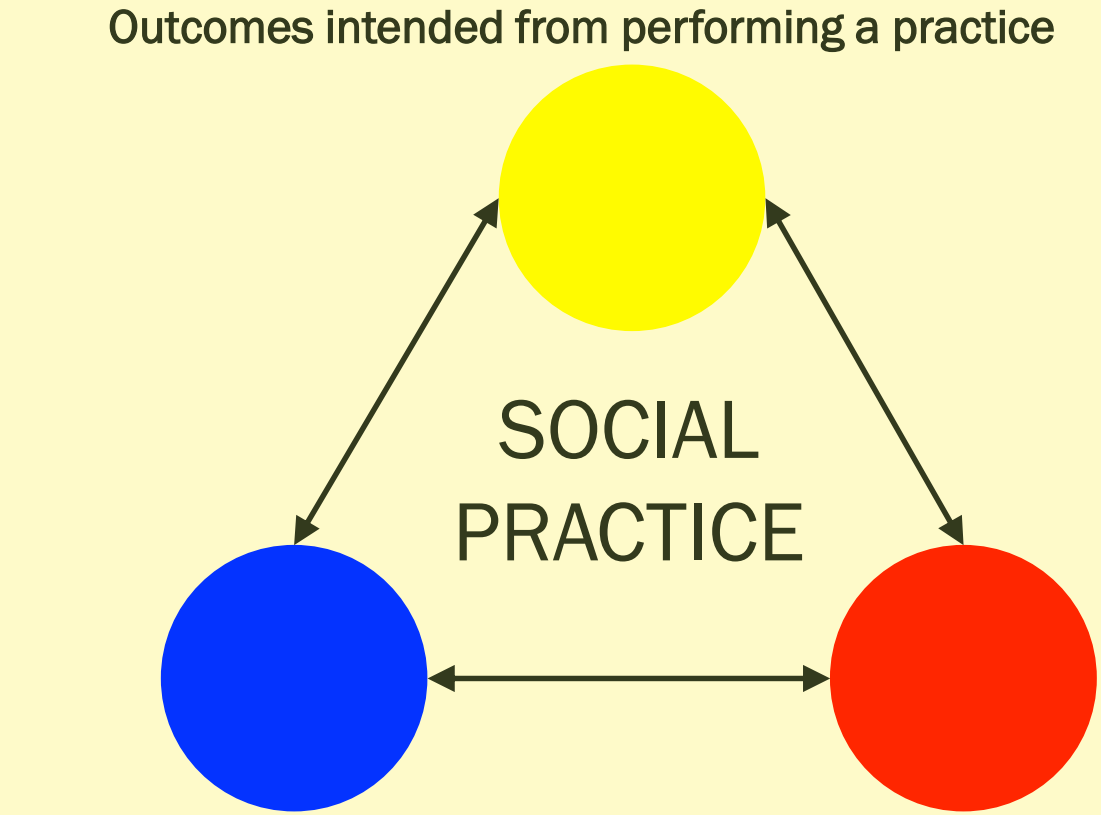


Social Practice Theory: Concept 1

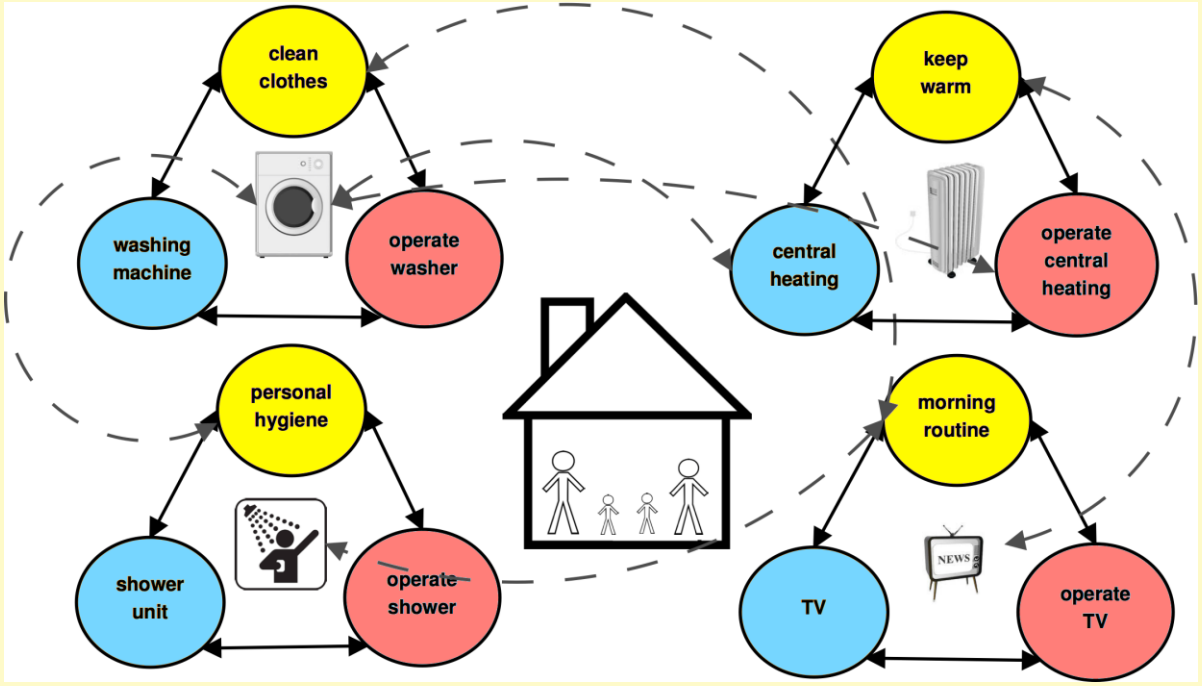


Combining meaning, material and skills leads to the performance of practices

Social Practice Theory: Concept 1

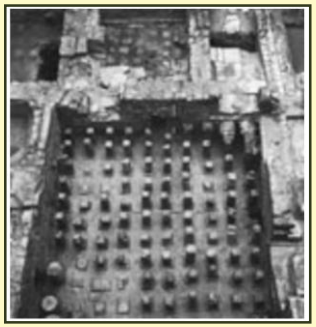


Social Practice Theory: Concept 2



Linked performance of practices and sharing of elements between practices

Social Practice Theory: Concept 3



Ruin of a hypocaust underfloor heating system

An ornate cast iron stove used in 1840s

Modern day space heater

Comfort heating is not just for people, but for pets, too

Elements have changed ~ Practices and the spread of practices have also changed

Social Practice Theory: Concept 3

PCs in the 90s

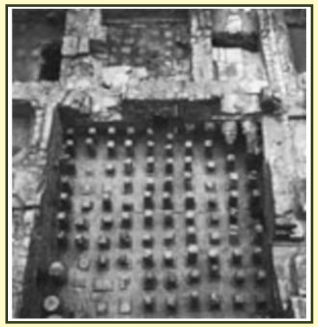
PCs in 2000

Laptops

Tablets

Blurring of lines between ICT and Visual Entertainment practices

Social Practice Theory: Concept 3



Ruin of a hypocaust underfloor heating system

An ornate cast iron stove used in 1840s

Modern day space heater

Comfort heating is not just for people, but for pets, too

Not only have appliances changed over the years, but the ways in which appliances are used have also changed over the years.

PCs in the 90s

PCs in 2000

Laptops

Tablets

A model of energy consumption based on social practice theory

A model where the drawing together of meaning, material and skill elements enables the performance of practices

A model of energy consumption based on social practice theory

A model where the drawing together of meaning, material and skill elements enables the performance of practices

Performance of practices influences energy consumption

A model of energy consumption based on social practice theory

A model where the drawing together of meaning, material and skill elements enables the performance of practices

Performance of practices influences energy consumption

Changes in elements affects practices, and subsequently, energy consumption

A model of energy consumption based on social practice theory

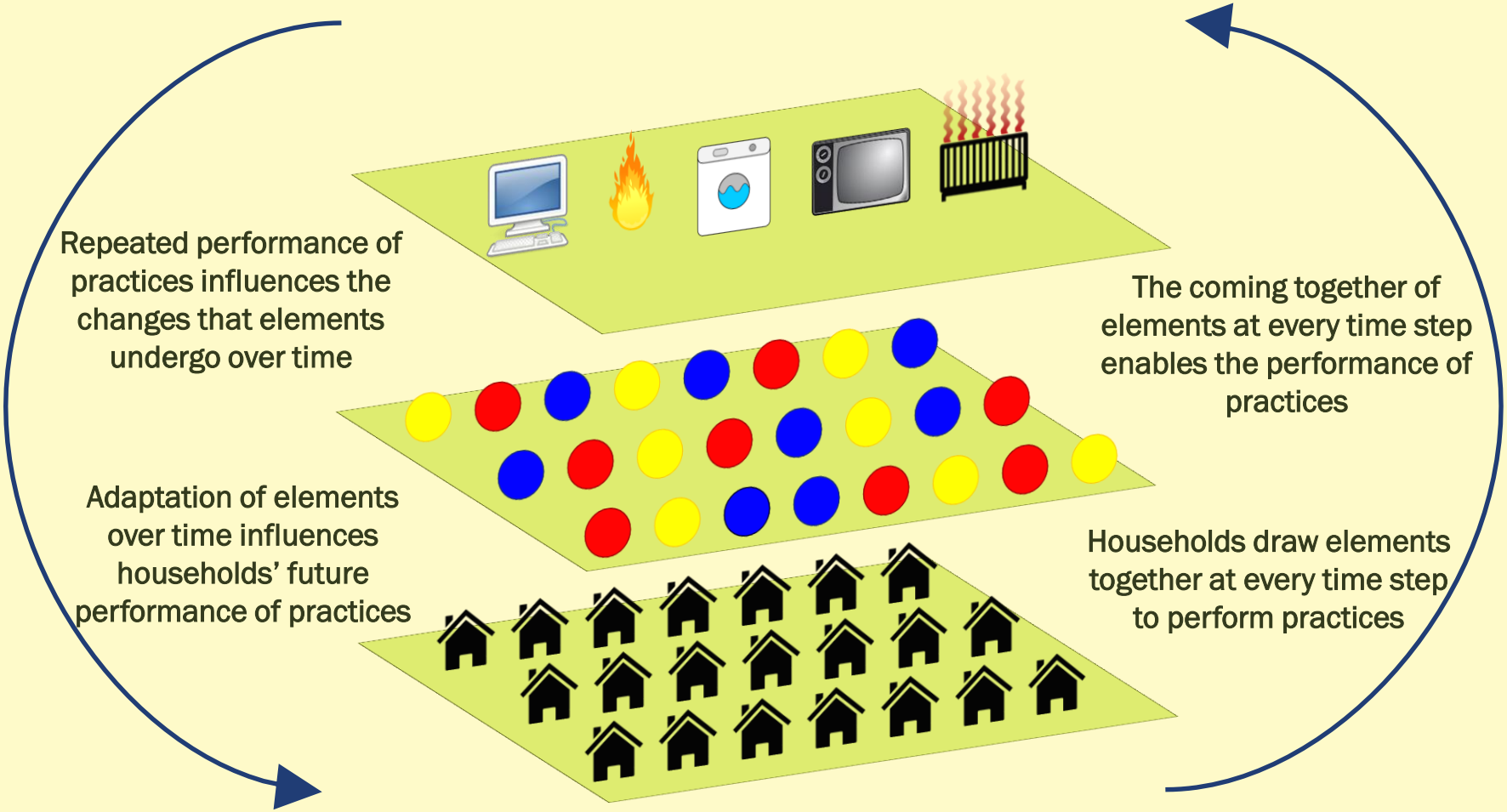
A model where the drawing together of meaning, material and skill elements enables the performance of practices

Performance of practices influences energy consumption

Changes in elements affects practices, and subsequently, energy consumption

Performance of practices may be linked

Model concept

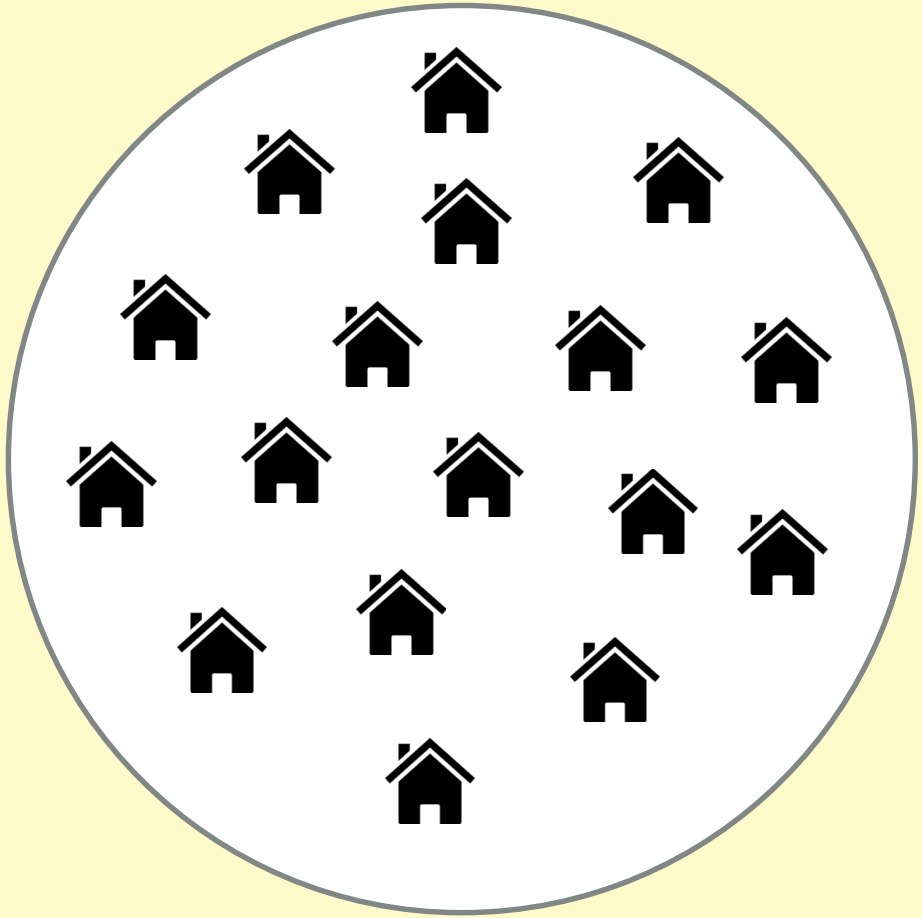


Our approach

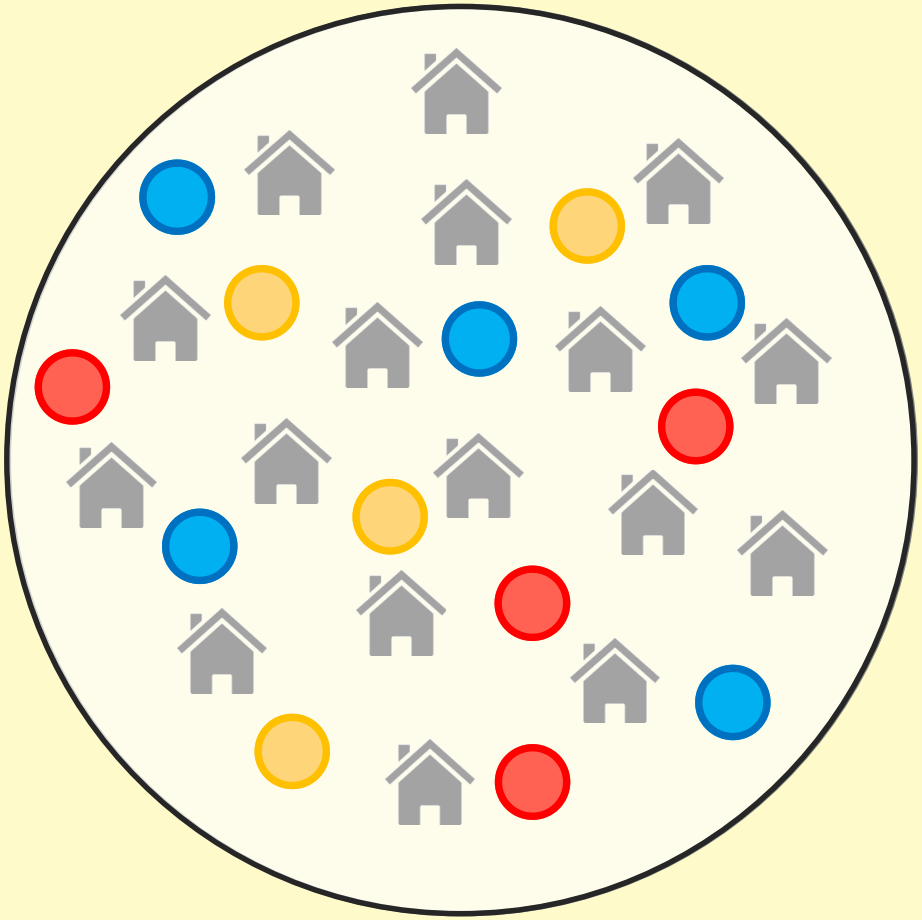
Agent-based modelling

An approach used to situate an initial population of **agents** (**autonomous** and **heterogeneous** entities) in a relevant **environment**; allow them to **interact** according to **simple rules**, and thereby **generate** (or 'grow') a macroscopic phenomenon from bottom-up. (Epstein 1999:42)

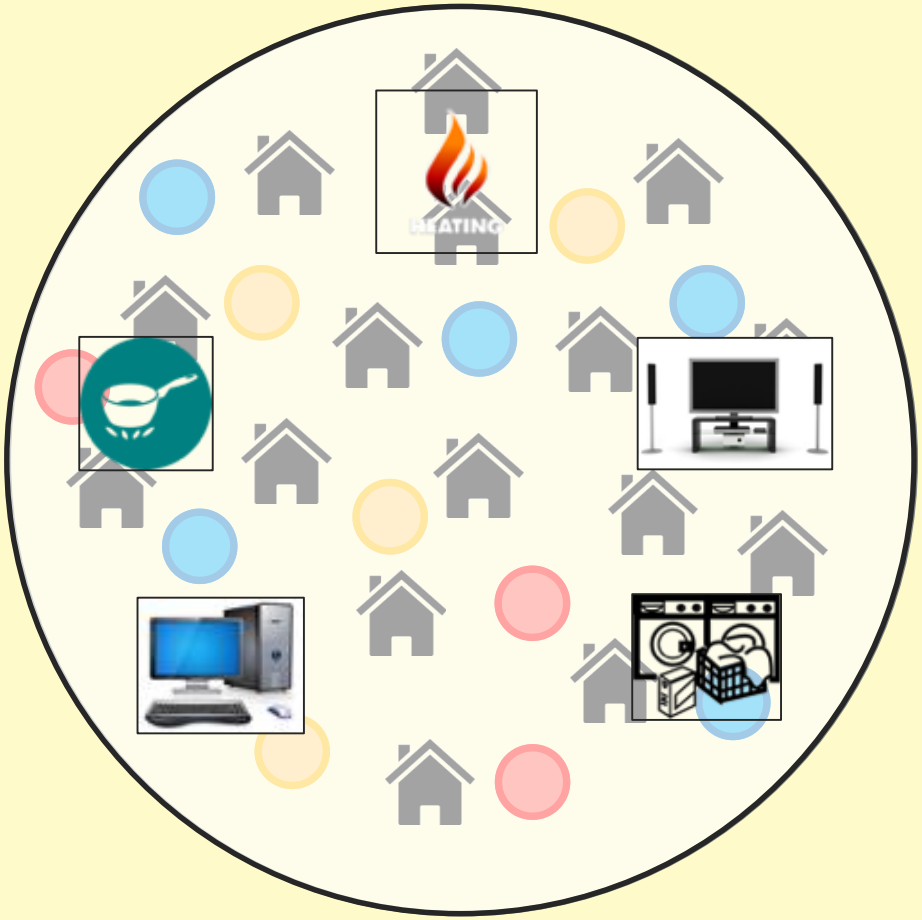
Our approach



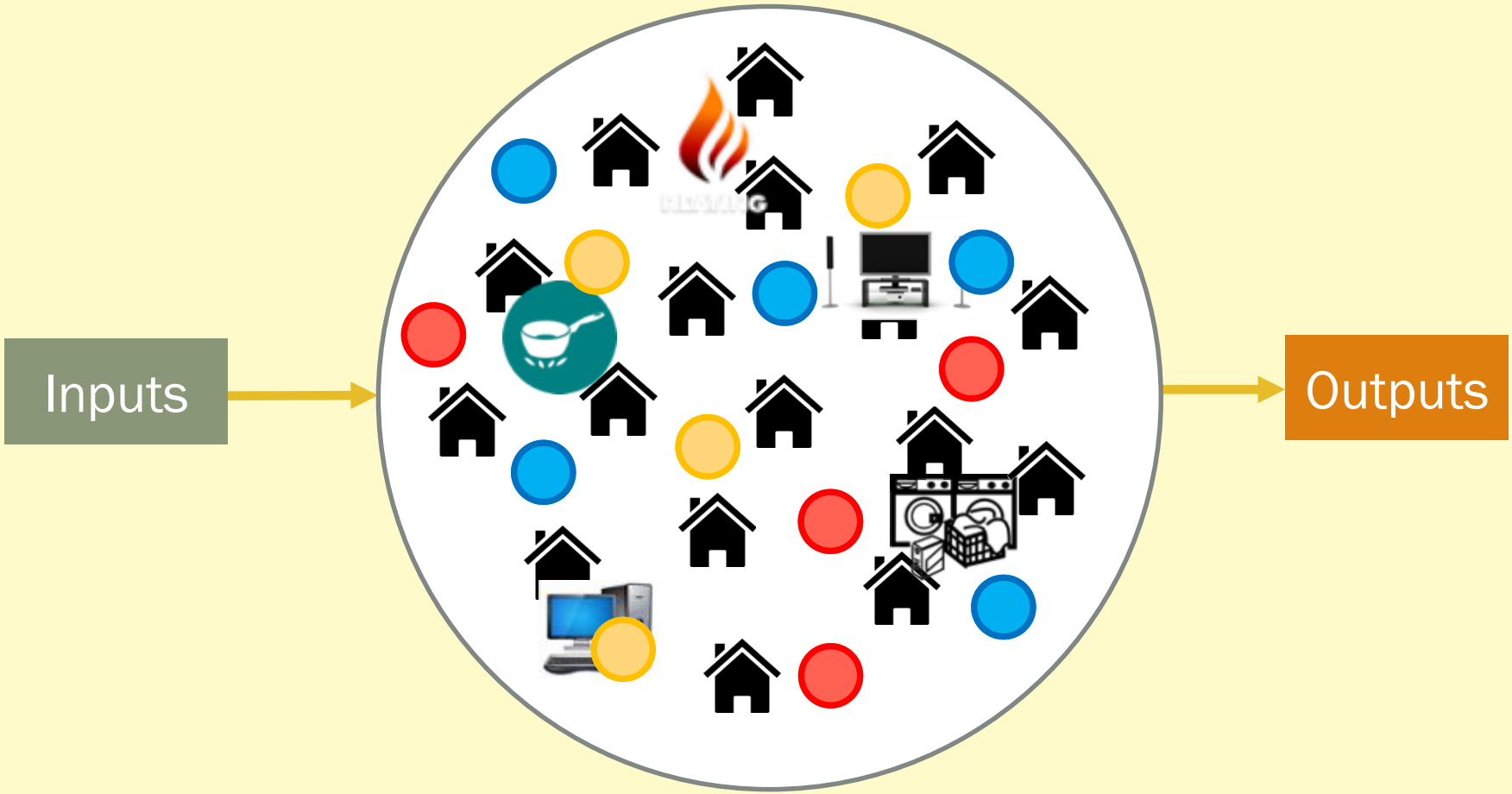
Our approach



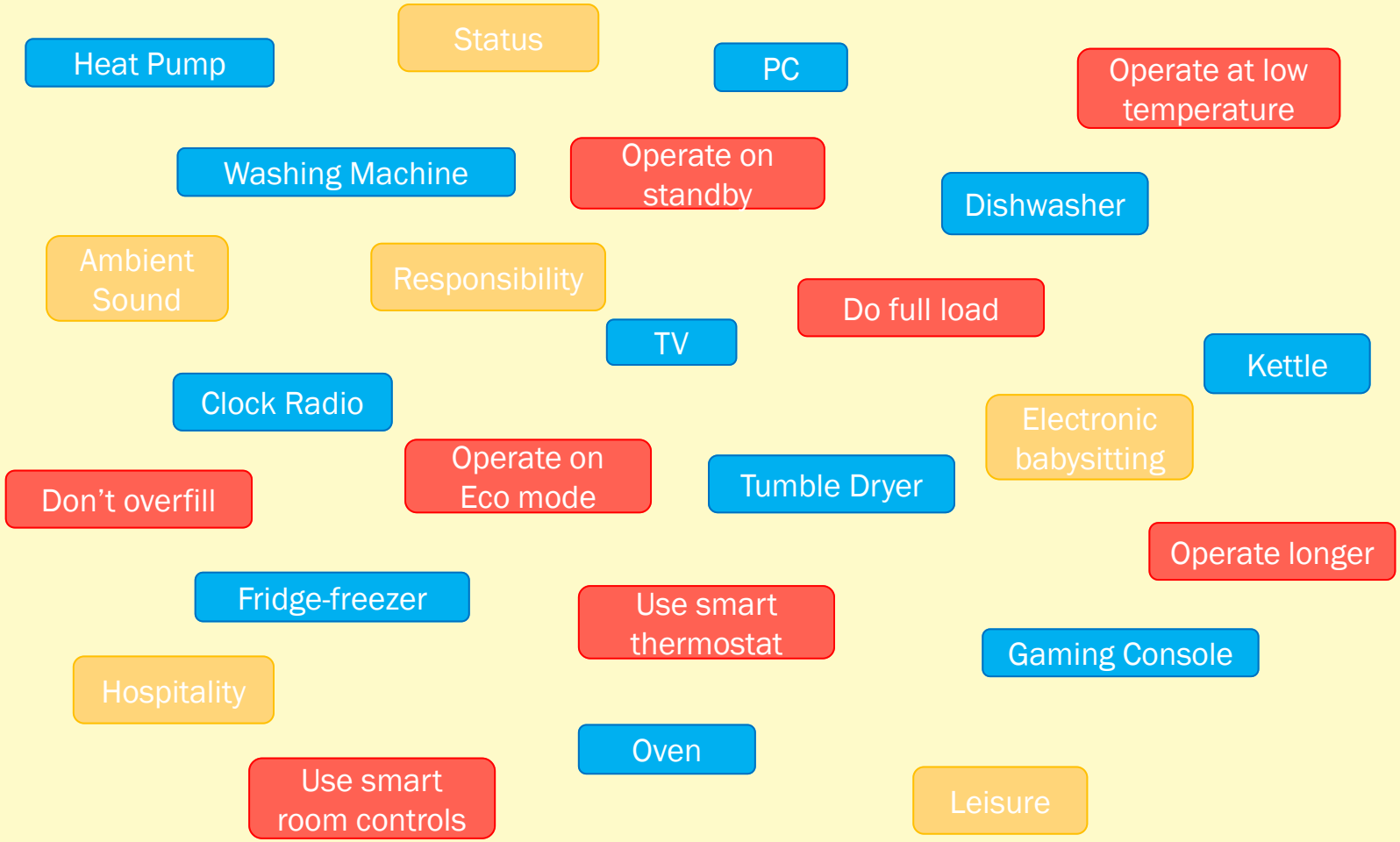
Our approach



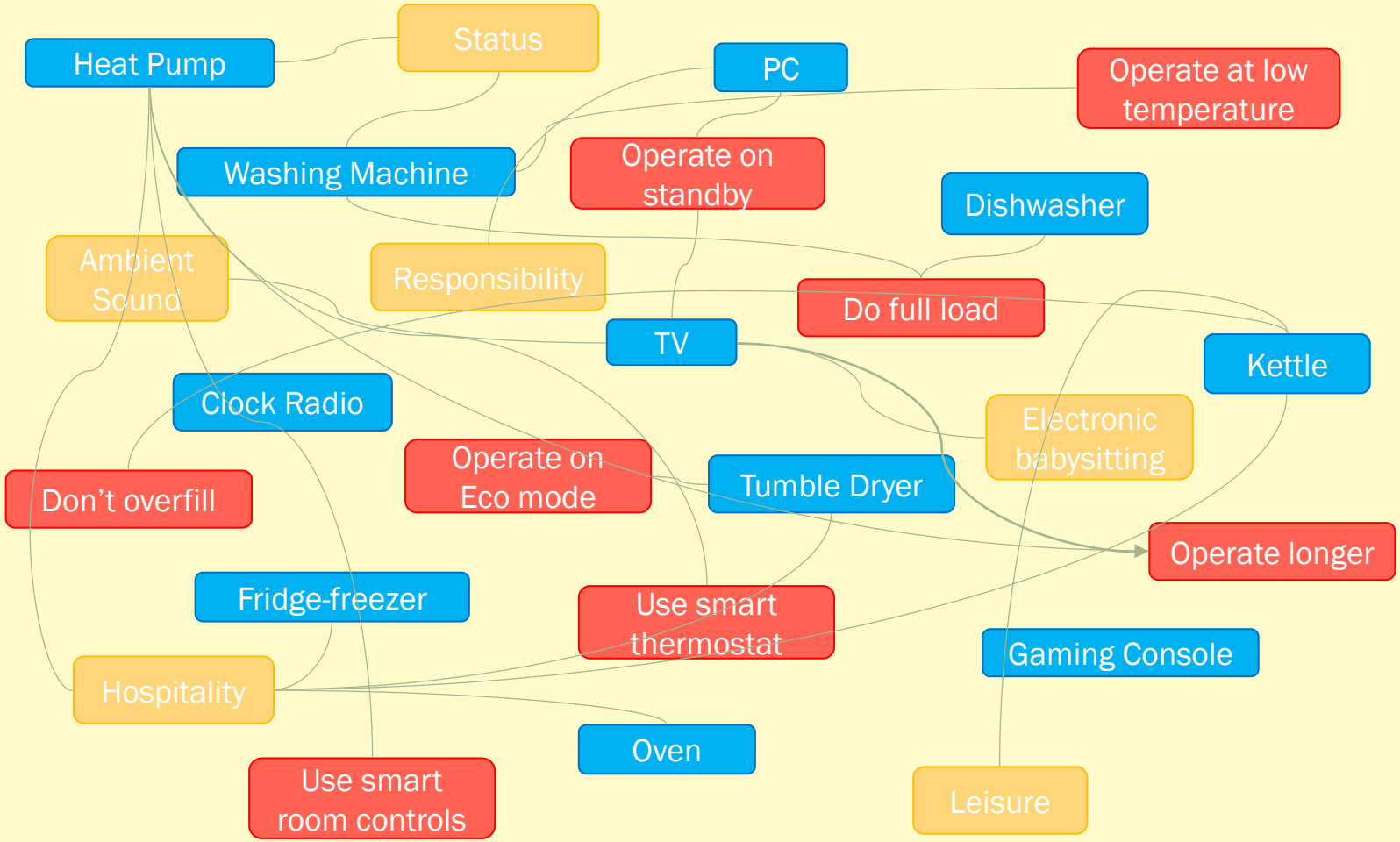
Our approach



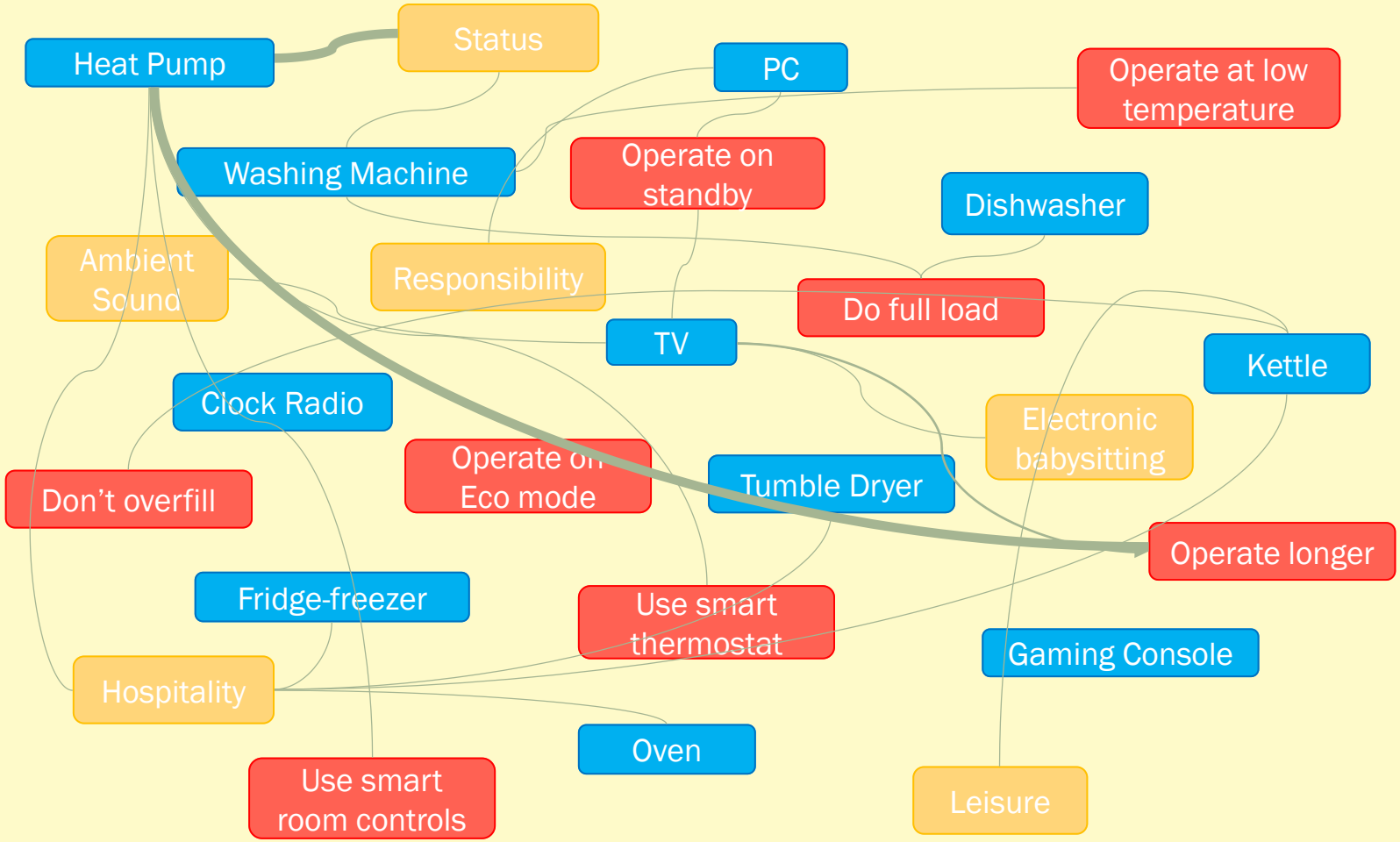
Empirically-based inputs: Elements



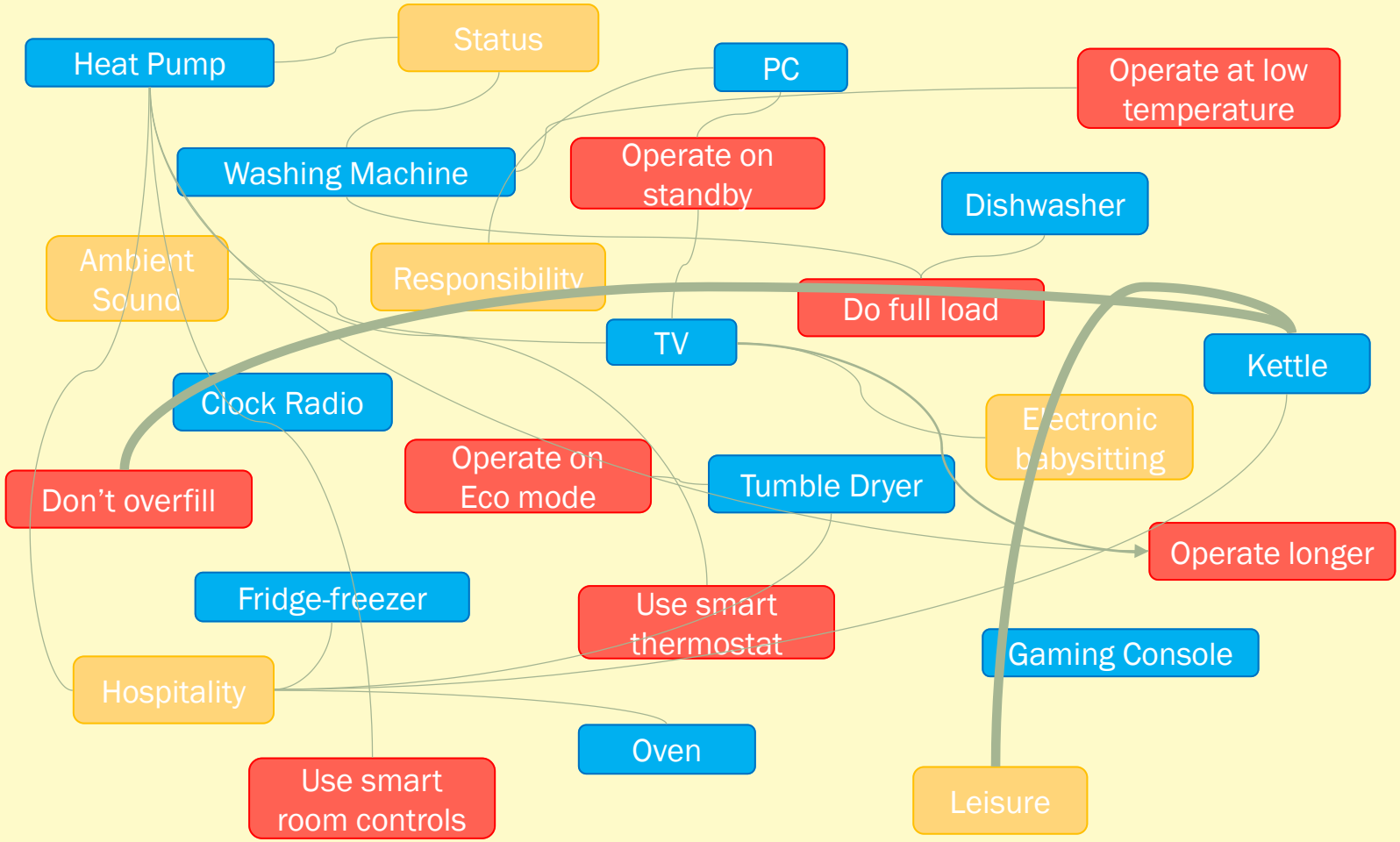
Empirically derived relationships: Practices



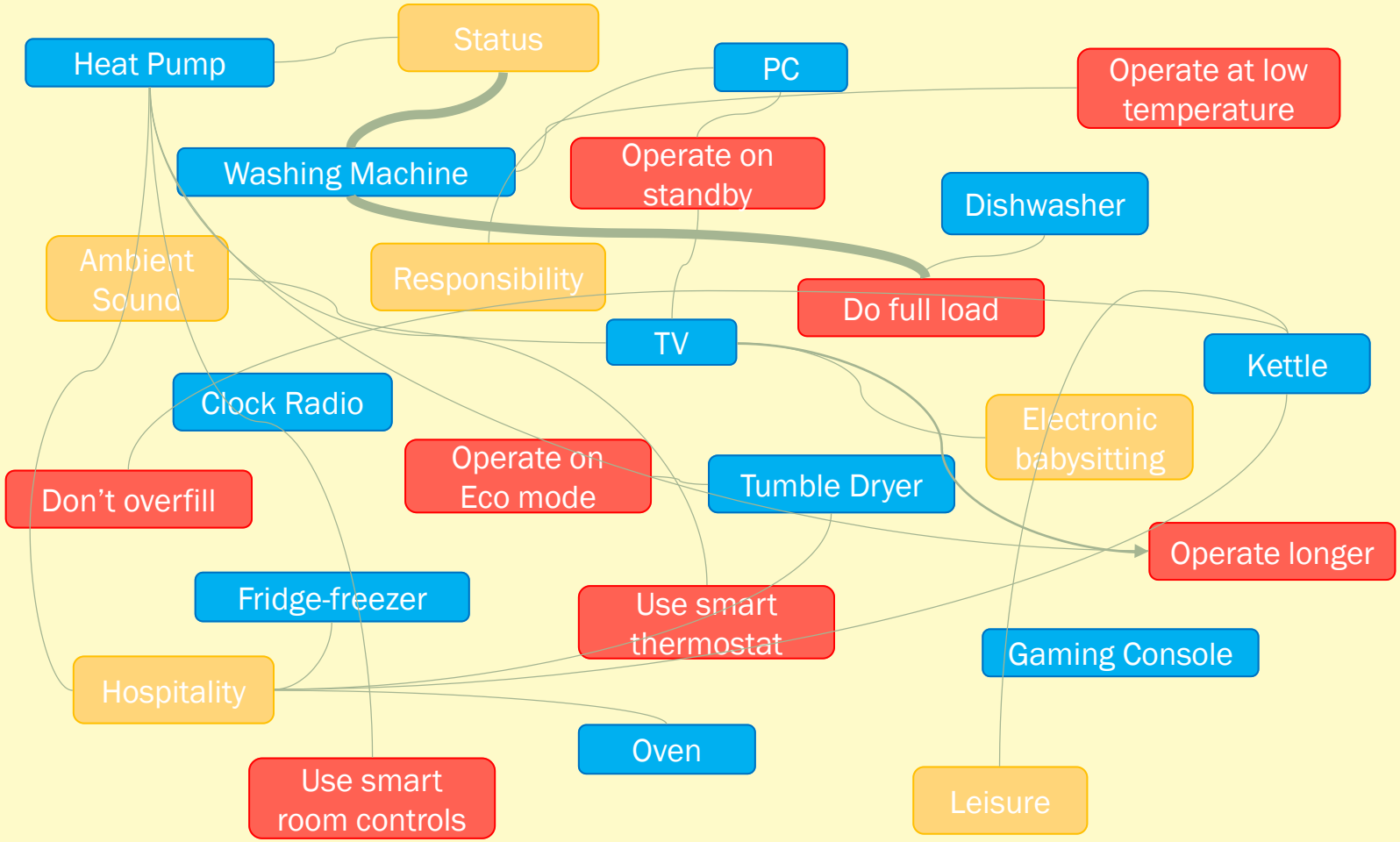
Empirically derived relationships: Practices



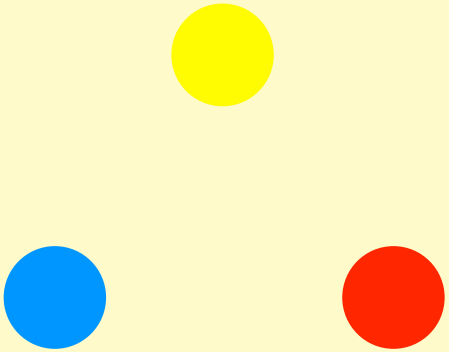
Empirically derived relationships: Practices



Empirically derived relationships: Practices



Rules of interaction

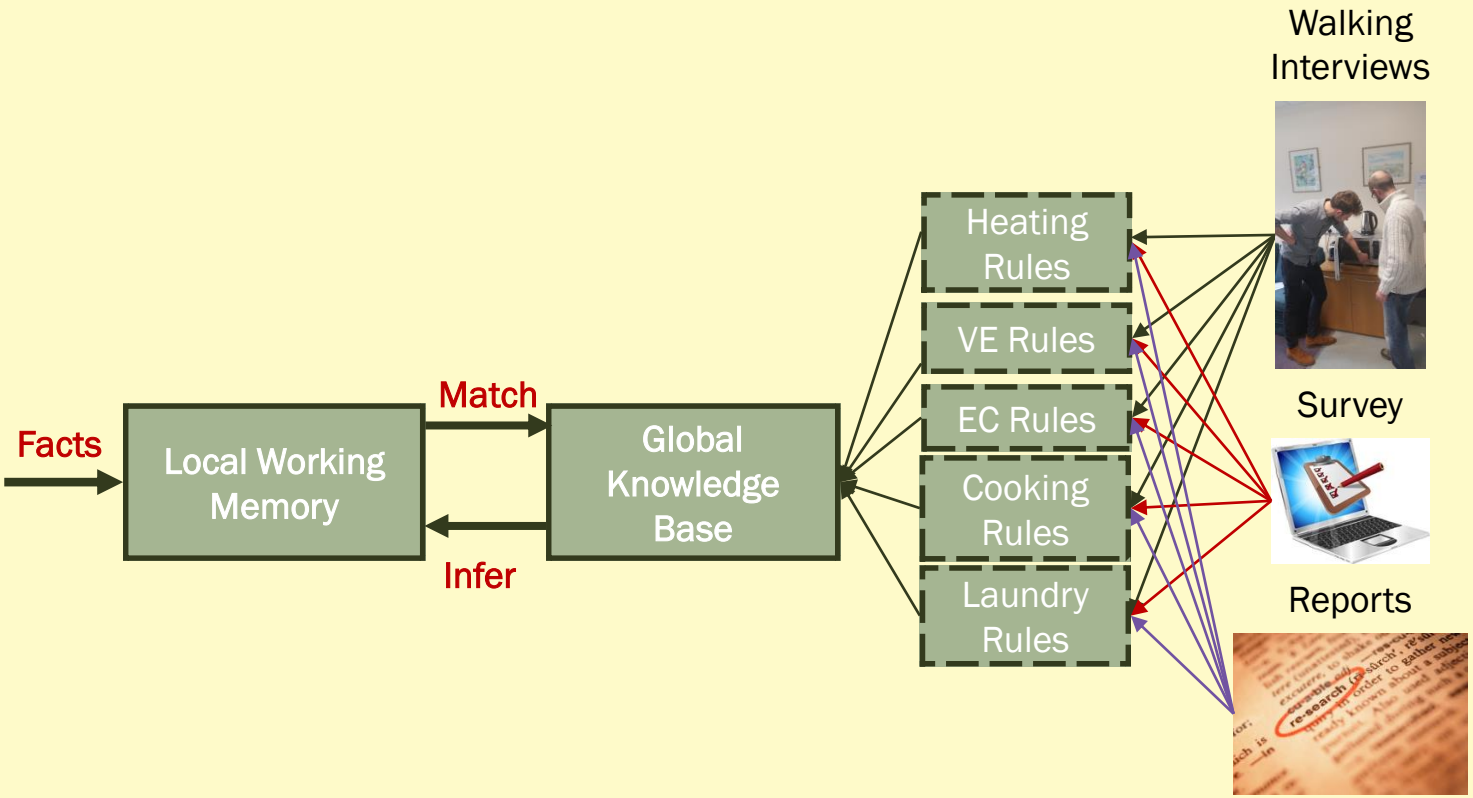


Rules that allow households to choose elements for performing practices

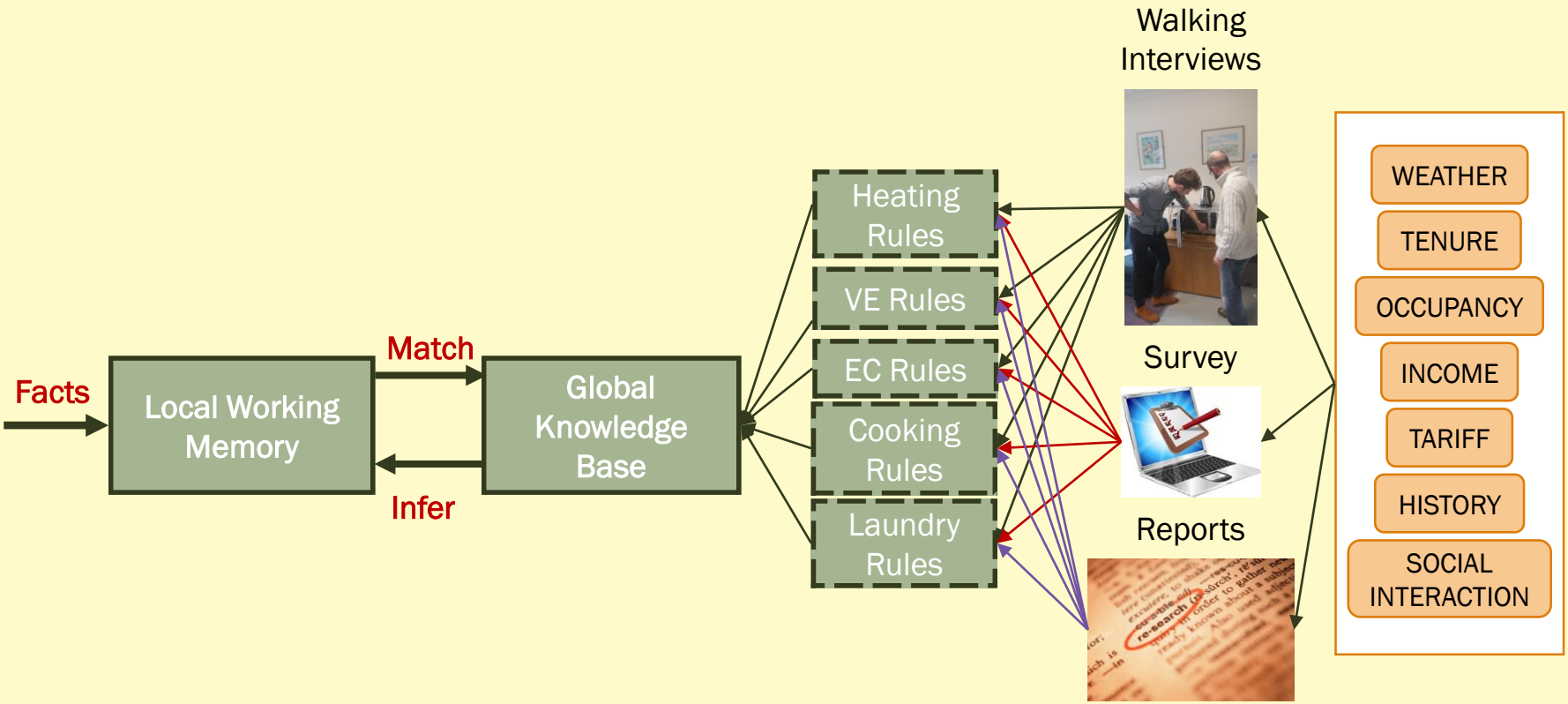
Rules that allow linking of elements to enable the performance of practices

Rules that allow the adaptation of elements

Process: Choose-Elements



Process: Choose-Elements



Process: Perform-Practices

The decision whether or not to perform a practice at *t* is ultimately based on which of the three aspects (**comfort/energy/tariff**) happens to be a priority for each household at *t*:

If **priority is comfort**, then households perform practices using the elements they currently have and disregarding any concerns about tariff or the energy efficiency of the materials used for performing practices;

If **priority is energy**, then households seek to perform practices using energy efficient/renewable/non-energy consuming (e.g. using a sweater for thermal comfort) materials;

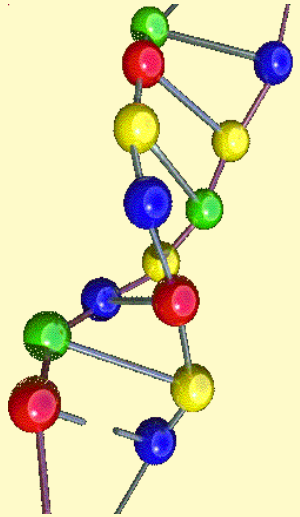
If **priority is tariff**, then households seek to perform practices when tariffs are cheaper;

Process: Adapt-Elements

Adapt elements based on evolution

The state attribute of an element is updated based on how successfully it has been used to perform practices:

- Elements used frequently -> active
- Elements used less frequently -> dormant
- Elements that remain dormant for long -> inactive
- Inactive elements -> removed from the system



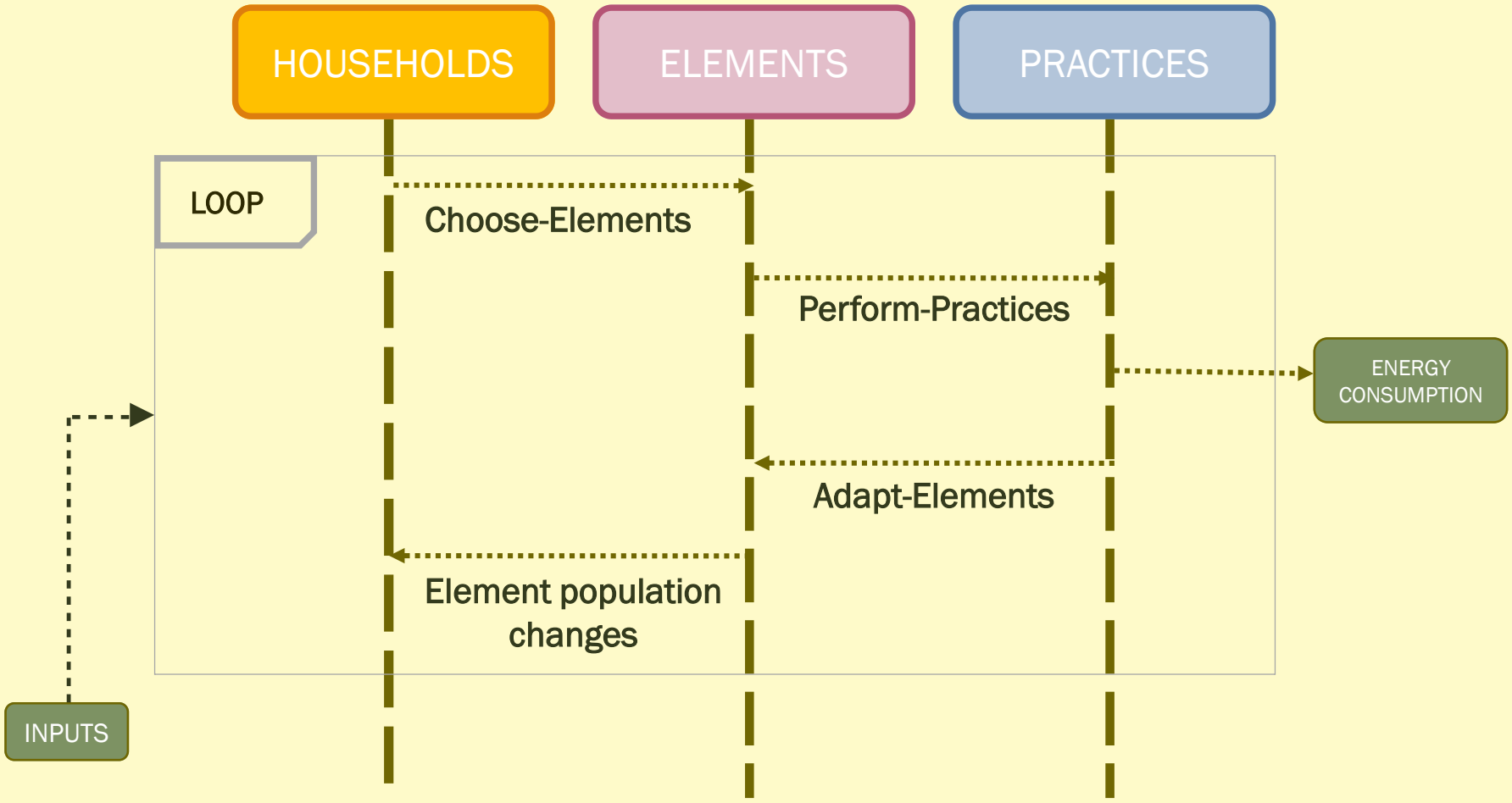
Adapt elements based on crossover

The value attribute of an element is updated based on its state

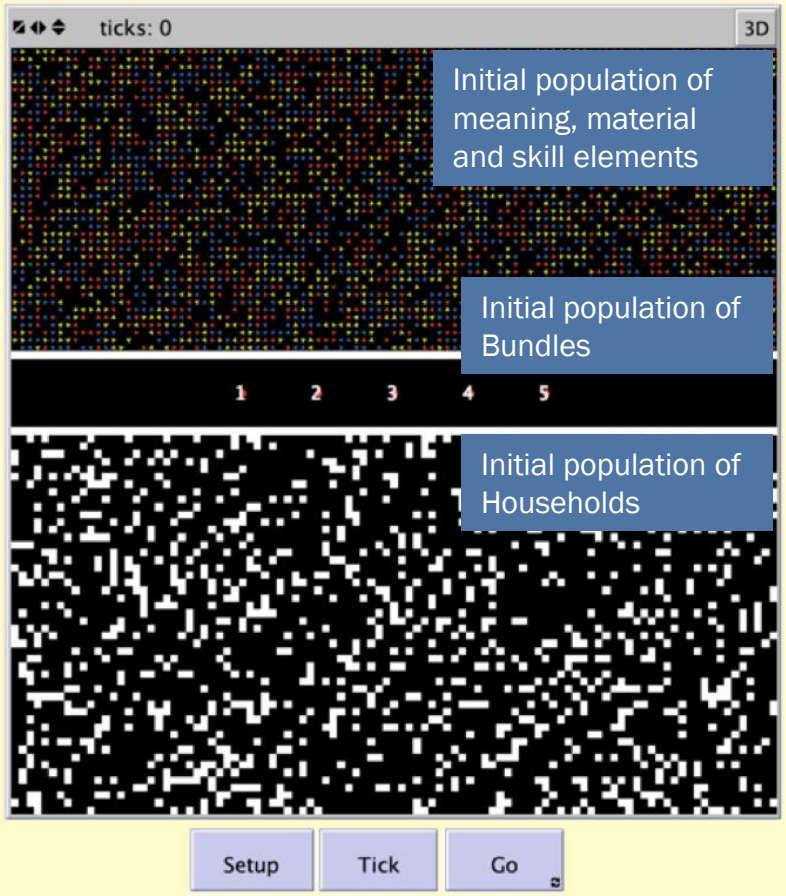
Values are updated using a **biologically inspired genetic algorithm approach**

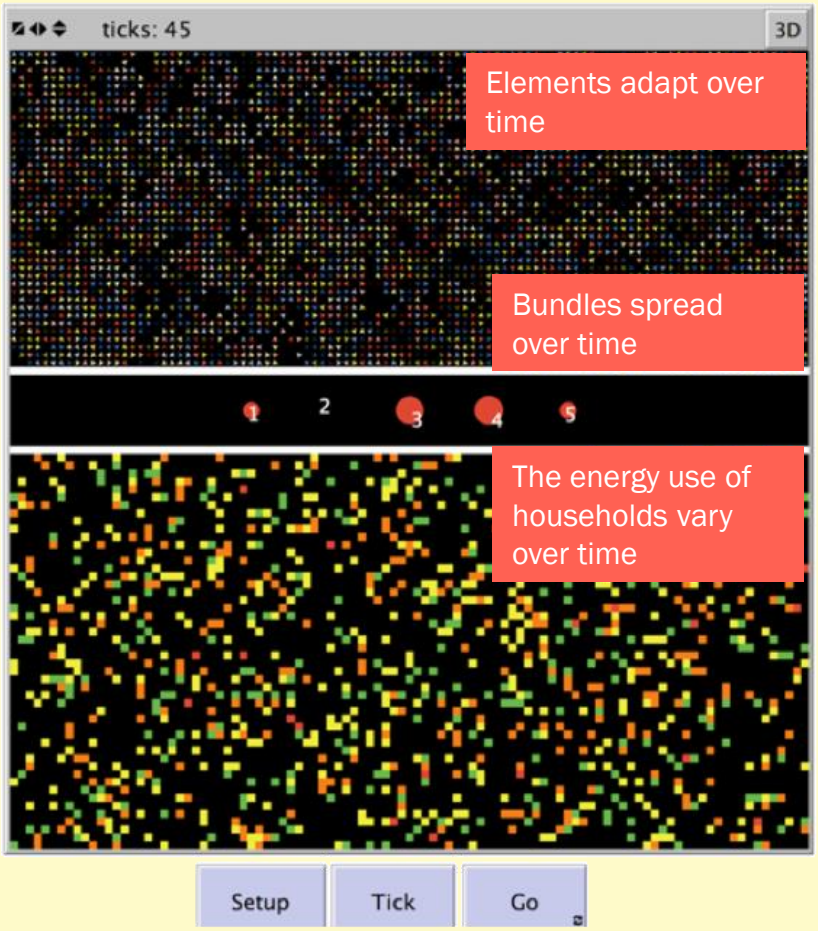
Elements belonging to the same type are crossed over to produce newer elements

Sequential ordering of processes



A NetLogo Simulation



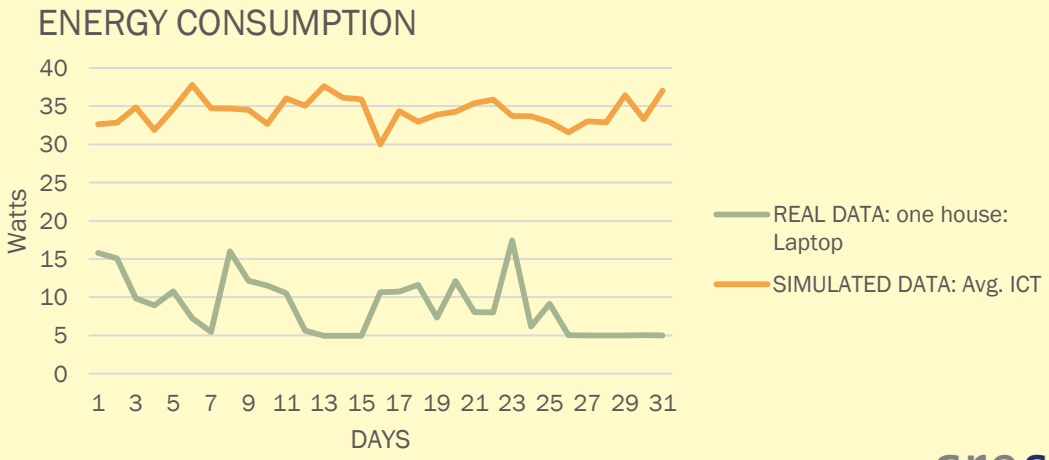


Plan for Validation

We are collecting energy usage data from 20 households on:

- Internal temperature in the room where the monitor is installed
- Electricity consumption of individual appliances
- Whole house electricity consumption
- Gas consumption

We are monitoring individual appliances such as:
Washing machine / washer dryer
TV
Computer
Phones, tablet PCs
Tumble dryer
Dish washer etc.



Some interesting challenges along the way

- The added complexity of having **Elements** in the mix:

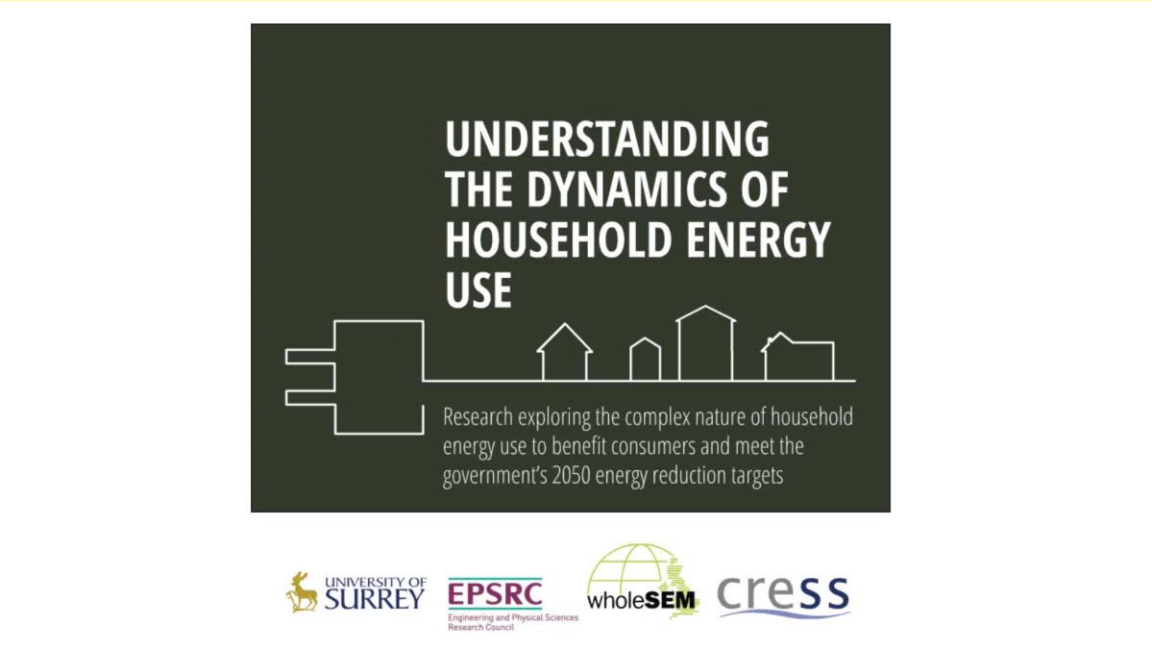
  A two step process: Factors (weather, tenure, income, etc.) -> performance of practices

  versus

  A three step process: Factors -> meaning + material + skill -> performance of practices

- Need lots of data to model the rules for each practice – *Laundry example*
- Modelling Co-existing practices – *Showering–Entertainment example*
- Finding suitable data for validating outcomes

Thank You



Kavin Narasimhan*, Aimie Hope, Thomas Roberts, Maria Xenitidou and Nigel Gilbert
Centre for Research in Social Simulation (CRESS)
University of Surrey

The UK Engineering and Physical Sciences Research Council (EPSRC) supported this work through the Whole Systems Energy Modelling Consortium (WholeSEM) project (grant EP/K039326/1)