Simulating household activities to lower consumption peaks (Demonstration)

ABSTRACT

Energy experts need fine-grained dynamics oriented tools to investigate household activities in order to improve power management in the residential sector. This paper presents the SMACH framework for modelling, simulating and analysis of household activities. It provides experts with a guided graphical interface easing the modelling of the household, its inhabitants and their activities. It also includes inhabitants adaptation capabilities to dynamically response to occasional and/or build emergent habits.

Categories and Subject Descriptors

I.6 [**Simulation and Modelling**]: Simulation Support Systems

General Terms

Experimentation, Human factors

Keywords

Agent-based modelling, Social simulation, Energy

1. INTRODUCTION

Energy management is an important challenge for our society, especially in the residential sector which represents a large part of the final energy (*e.g.* 37% in the USA). The most important challenge in residential energy management is the peak consumption reduction. So far, ESCOs (energy supplying company) and DNOs (distribution network operators) have been forced to complement their baseload stations with carbon-intensive peak plant generators (*e.g.* using fuel or coal). These consumption peaks are short and rare, yet they have a large impact on the overall system.

In order to limit the consumption peaks (level and frequency) the most efficient measure is to alter household consumption patterns [3]. Automatic control of home domestic appliances [2] is an efficient mean to attain this goal but at the expense of the comfort of inhabitants. Another mean is to motivate inhabitants to adapt their activities. For instance, inform people of extremely cold weather for them to lower their indoor temperature or adaptation of electricity tariff to demand level (to reduce the typical 7 to 9 *pm* peak for instance).

We develop the SMACH modelling and simulation framework [reference removed]to enable field-experts to investigate how inhabitants can adapt their electricity demanding activities in response to various incentives and events. In this paper we introduce the agent meta-model then we present the simulation execution and analysis interface (the video demo is available at `http://youtu.be/DViBg3-crxM`).

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2. SMACH

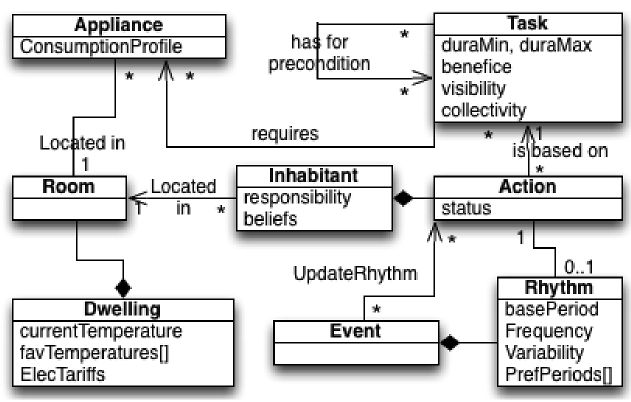

Figure 1: SMACH meta-model

The SMACH metamodel includes the following key elements : Home, Appliance, Inhabitant, Task, Action and Event. In addition, we consider a time period with variable energy tariffs (see Fig. 1). The simulator is complemented with an external thermodynamical model [1] that determines internal temperature (according to an objective temperature).

More precisely, inhabitants behaviour are defined in terms of actions which are instances of a task coupled with a rhythm. For instance, Jack and Gill can both conduct *eating dinner* actions which are derived from a generic task and associated with the same rhythm of 7 times/week. In addition, inhabitants are located in a room. Each room contains a set of appliance and those can be needed to conduct certain action (see Sec. 3 for an example). The nominal dynamic of the household, which is represented by the combination of each individuals' actions set, can be altered through the definition of events which modify actions' rhythm and possibly add or remove actions also.

3. MODELLING AND EXECUTION

The SMACH framework is a standalone tool including guided modelling, simulation (single or batch mode) and visual analysis. This tool has been developed in close collaboration with experts from our ESCO partner. It has been programmed in Java and takes 10 min to simulate 1 month of a typical scenario on a 2.2Ghz cpu. The timestep is one minute and models of up to 12 months simulated time have been used.

The scenario definition is typically decomposed in the following steps. (1) Definition of the simulated period and electricity tariffs. (2) Home topology and adding appliances to each rooms. To do so, the modeller simply select an appliance type from the integrated appliance consumption profiles database (obtained through the REMODECE European project, see `http://remodece.isr.uc.pt`) and localise it in a room. (3) Definition of the inhabitants, *i.e.* its responsibility level (which impacts its implication in household chores and for helped activity, *e.g.* homework) and the associated actions.

To define an action, one has to (3a) define task and a (3b) rhythm. A task requires to define: its duration, collective or personal benefit, collective or personal conduction, required appliances, pre-conditional tasks and possible rooms. For instance, an *iron clothes* task could be conducted from 10 minute to 2 hours, it benefits to the household but can be done by one at a time and it requires the *iron* appliance, a *washing clothes* task should have been conducted and it can be perform in the living room. Finally, (4) one can define the events that alters the nominal organisation of the household. For instance, the *summer holiday* event would prevent any inhabitant to conduct its usual activities and everyone will be considered to be away for two weeks once a year during July - August.

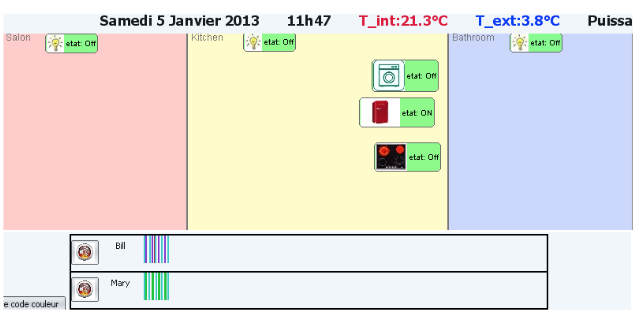

Figure 2: Simulation interface (excerpt)

The simulation interface is presented in Fig. 2. The upper panel shows the current date/time, the internal and external temperatures, the heating power and the home topology (including appliances) in order to follow the inhabitants' movements and current activity. The lower panel allow to follow inhabitants behaviour on a weekly basis (each colour represents a different activity).

4. SIMULATION ANALYSIS

The analysis mode allows experts to investigate simulation dynamics in details. First, they can have visualise energy consumption per appliances (top left pane (1) and summary indicators (1')). The activity tracking is seen by week (central pane (2)) or on a minute basis (top right (3)) along the communications (below (3')). Finally, larger activity patterns can be visualise in the overall activity tracking pane (bottom (4)) . In Fig. 3, one may see that most of the electricity consumption comes from heating (in grey) and that there is an important drop in electricity consumption (centre of pane 1) which corresponds to a 1 week *holiday* event. In panel 4, only electricity consuming have been selected in order to show the effect of a new electricity tariff. In this example, the energy price is set to a higher level between 6 and 12 *a.m.* from monday to saturday during February. As one may see, few electricity demanding activities are conducted during these slots. Later on, the previous household activity organisation is slowly getting back in place.

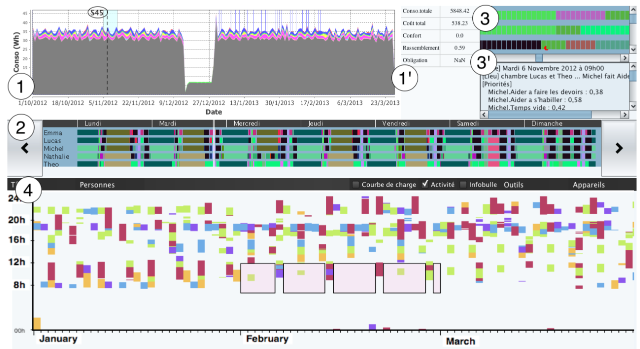

Figure 3: Analysis interface

5. CONCLUSION

The SMACH framework allows experts to model their own scenario, simulate and investigate them thanks to a set of dedicated graphical tools. This tool has already been used by experts from our ESCO partner in order to evaluate household adaptation to various consumption reduction incentives during a preliminary study. Indeed, inhabitants agents' adaptation is done in two ways: dynamic creation of habits and modification of habits in response to events (*e.g.* sickness, new work schedule, etc.). The project's perspective are: improved thermodynamical model coupling and scaling up (simulation of city blocks) in order to be able to study the impact of global events (*e.g.* sport events, holidays, etc.) at the population level.

6. REFERENCES

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