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# An Agent-Based Model for Energy Management of Smart Home: Residences' Satisfaction Approach

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**Abstract.** Reducing the cost of energy leads to reduction in resident's comfort. Therefore, it is necessary to consider both reduction in cost and resident's dissatisfaction. Smart buildings include different systems such as communication system (CS), sensing system (SS), grid data collecting system (GDCS), building energy management system (BEMS), hybrid system (HS), temporary service systems (TSS) and permanent service systems (PSS). Considering the aforementioned systems, an agent-based model for energy management of smart buildings is presented in this work to reduce the energy cost as well as the resident's dissatisfaction.

**Keywords:** Smart home · Multi-agent system
Home energy management system

## 1 Introduction

Considering the importance of reducing the cost of energy for smart buildings a solution is needed to make a use of consumption management. This can be done by using the Building Energy Management System (BEMS) which is one of the main components of smart homes. Thus, the amount of energy consumed during the peak-hours should be shaved when electricity price is high, or the consumption can be shifted to other hours [1]. Moreover, Electric Vehicles (EVs) are used as energy storage systems to reduce the cost according to their potential of charging and discharging (buying and selling electricity) in the smart home [2]. However, it is noticeable that the above solutions may reduce resident's comfort. In this work, a solution is proposed to manage consumption in order to reduce the cost of energy with taking into account the residents' comfort.

## 2 Proposed Scheme

Energy production and consumption in smart home can be managed by the BEMS which is a decision-making agent of the smart home. The BEMS allows residents to apply several energy management mechanisms that can change the way of energy


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production and consumption to achieve less energy cost and more residents' comfort. In this work, we present the multi agent-based structure for BEMS. There are several works that implement agents in the BEMS but none of does not consider a manner to consider residents' comfort in the BEMS [3–8]. Readers can refer to [9–70] to know more about multi-agent systems. Our proposed multi-agent BEMS consists of different agents that are described in the following.

The smart home is equipped with sensors and operators to collect the data and send control commands according to the resident's activities and expectations. Sensors are including in the Sensing System (SS) that measures the parameter needed for making appropriate decisions such as inside temperature of different rooms and outside temperature. The purpose of the services at the smart home is increasing the comfort and security of the residents. As highlighted before, several load management mechanisms can be used to provide an optimal management decisions based on the criteria given to the BEMS through the existence of communication network in smart home. In this way, the Communication System (CS) conveys different signals from sensors and grid data system to the BEMS, and from the BEMS to operators. Grid data collecting system (GDCS) obtains data related to grid's parameters such as hourly electricity price. The consumption management allows residents to save money by reducing consumption in hours of high energy price- e.g. peak hours of grid- or changing the start time of operations in services where the type of consumption is such that it can be adjusted to another hour- e.g. like a washing machine. Hence, there is a necessity to find a solution that optimizes both the cost and the acceptable level of satisfaction of the residents. In this work, we want to find the solution by multi-gent system.

In addition to the above solutions, we want to assess the impact of Plug-in Hybrid Electric Vehicle (PHEV) as a hybrid system (HS). The battery consumes electricity to be charged and also it can be discharged to provide electricity for smart home. It can assist the BMES to increase energy efficiency considering satisfaction of residents.

Smart home residents use their services to improve their comfort. These are service systems. These systems can be divided into two categories: permanent service systems (PSS) and temporary service systems. Permanent services are services that are necessary to be used over a certain period of time in a day. For instance, the home heating system should operate all day along to provide an appropriate temperature. PSSs participate in the cost reduction problem by reducing the amount of their energy consumption. For example, the energy cost is reduced by decreasing the energy consumption of the heating system. On the other hand, the temperature of the house also decreases which impacts negatively on residents' satisfaction of the services.

The second category are temporary service systems (TSS) whose operation takes place in a limited and certain time- e.g. dishwasher and washing machine. TSSs participate in the cost reduction problem by moving their operation time. For example, the washing machine can be used in the late hours of the night where the price of electricity is lower. In this case, the use of services in a time that is different with the preferences of residents causes their dissatisfaction.

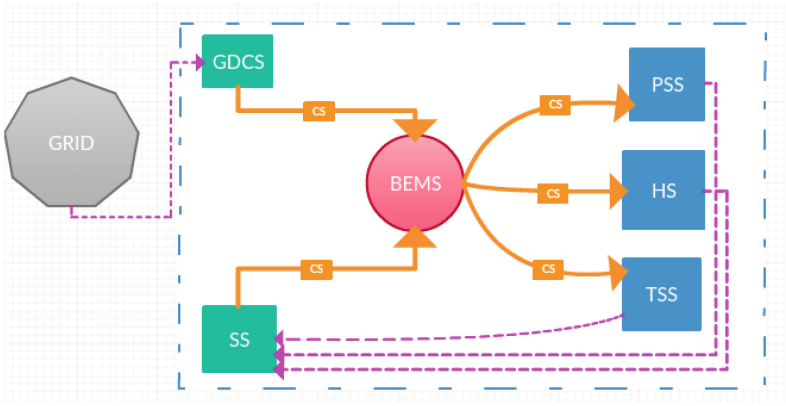


**Fig. 1.** General structure for multi agent-based smart home system.

Figure 1 shows the relation between different systems in smart home simply. SS and GDS obtains the information and inputs that are needed for BEMS and then this inputs will be sent to BEMS by CS. BEMS makes an appropriate decision and send it to the TSS, PSSS and HS agents.

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