Virtual agent organizations to optimize energy consumption in households.

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Sadly, not everyone agrees with this scientifically proven fact; there are many skeptics around the world who deny the very existence of global warming or the idea of humans being able to positively or negatively influence these changes. However, it has been proven that this undoubtedly complex problem can be resolved to a large degree if we individually take measures in the correct direction. Simple solutions, such as saving and using our energy in a more efficient way at home will have a positive impact on reducing the adverse effects of climate change on our planet. Some proposals were aimed at using energy in buildings more efficiently. This solution makes it possible to reduce electricity bills, accounting for around 70% of the annual bill payment. On the basis of these factors temperature can be adjusted to reduce unnecessary energy consumption while maintaining the residents' comfort.

Previous works have failed to make an in-depth study of the behaviour of residents in homes. These simplistic studies are owing to the higher cost of automating a house in the past [1]. They looked at lifestyle and comfort preferences of the residents which would allow to program and accommodate systems according to user needs. The times and frequency with which users opened and closed the buildings was also evaluated, simulating occupancy in the building. It is evident that the behaviour of users has a major impact on the energy balance of a building. Some studies have carried out simulations of the user's behaviour in order to optimise the design phase of the building. In the study by Hoes *et al.* [2] the parameters that influenced the opening of windows such as season, outdoor and indoor temperature, time of day, presence was studied, however, the results cannot be applied to all buildings since the type of building, location, climate or culture have influence over these variables. For efficient energy management, Bayesian networks were used to predict user behaviour from a multimodal sensor.

In order to be able to manage all the factors involved in energy consumption, data acquisition through sensors and communication between the sensorisation and the platform and data analysis, it is necessary to use a methodology that allows for these activities to be carried out in a simple, transparent and modular way. For this reason, the use of virtual agent organizations is the option adopted for system design. Features such as extensibility and flexibility make it possible to add new characteristics or include other algorithms and sensors [3]. Due to these advantages many researchers have opted for using VOs. Agent systems are often applied in the field of building automation because of their ability to deal with more complex systems. Various agent systems were developed for HVAC process management with the aim of optimising energy consumption. The proposed system made it possible to manage energy without relinquishing the objective of achieving energy efficiency and creating intelligent buildings. In other works it is employed an agent system for building management in centralized air-conditioning systems. In this work, the optimization problem was reformulated into several sub-problems, each of which was solved by an individual agent. However, the success rate of this system would have been higher if virtual agent

organizations were used. This is because agents would have provided a range of solutions for a single problem, allowing for the choice of the solution that renders the best results. However, the proposed system lacked automation and values had to be entered manually, this limitation made it impossible to achieve large energy savings.

These characteristics allow to program gradual changes in temperature and to pre-vent sudden changes which cause high energy consumption. For this reason, the systeme aims to optimally manage the temperature of a home, including the monitoring and control of radiators and air conditioning in real time. It also establishes temperature patterns which comply with the energy efficiency frameworks and the comfort of residents.

This article proposes a new approach to the analysis of parameters that influence energy consumption in heating and air conditioning systems. The system will make decisions that optimize energy consumption based on user habits and preferences by coordinating the agents that are part of virtual organizations (VO). The main contributions of this work are the following: the non-intrusive acquisition of resident information, thanks to the use of sensors; the conjunction of the current indoor and outdoor temperature with the future temperature in order to prevent the heating, ventilation and air conditioning (HVAC) system from making drastic temperature changes, since this causes a high increase in the consumption. This system has been developed using PANGEA [4] for the technical implementation of the architecture.

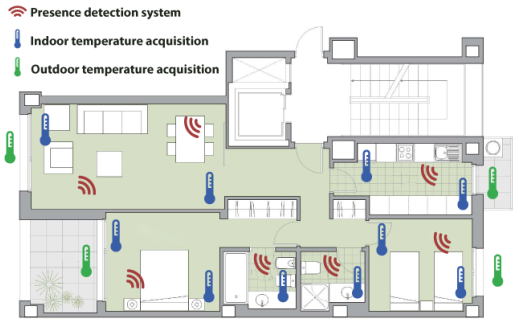

Figure 1: An example of how sensors were deployed.

In Figure 1 we can see how the sensors used for data collection were distributed in the case study's home. An outdoor temperature sensor was placed at each window of the house (The values collected by all sensors are averaged.), two sensors in each room, except the two bathrooms where only one was placed, a presence sensor in each room except the living room where two sensors were placed.

This work presented an innovative approach based on VO of agents for the optimization of energy consumption in homes. To reduce the overall amount of energy consumed by a home, our proposal focused on making air conditioning systems more energy efficient. The use of VOs was fundamental in achieving these objectives, since it provided a simple method for monitoring the home air conditioning system. The system was fed back with weather forecast and home occupancy data, a few days ahead in order to optimally configure the HVAC system.

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