Adaptive System to manage everyday user comfort preferences

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Abstract

Urban mobility brings many challenges and opportunities, particularly regarding sustainability. It is natural that we want better living conditions, we are naturally given to consuming, even when there is no need, we increasingly want to travel, socialize, enjoy and it is not easy to accept that we will most likely have to change. It is no longer a distant future, but the present that we are living. Even in the face of successful solutions, receptivity is far from being massified and in most cases it imposes compromises in terms of comfort and quality of life, sometimes even imposing new habits and ways of being.

In addition, not all of us have the same perception of the situation seriousness, or the same willingness to compromise. And this can happen for numerous reasons, namely physical or health limitations, financial limitations, different beliefs/motivations, or different ways of facing problems. It is even common that the staunchest defender of certain solutions, when faced with other equally plausible solutions, is completely insensitive or even opposed. In fact, the same individual may have different needs/preferences relatively to the place where he is or the activity he is performing, that is, preferences/needs that vary with time and place. In a broader context of mobility, in which individuals in their daily lives move and visit different places, often with the presence of more people, the situation is even more complex, the variability of preferences increases, and it is necessary to combine preferences/needs of different individuals.

Emerging technologies, within the Internet of Things (IoT) scope and smart spaces [1], allow us to aspire to capable solutions in line with the urban mobility and sustainability demands and, at the same time, to promote better conditions of comfort and well-being, without imposing sacrifices or changes in habits and considering the specificities of each individual, at different time and place.

These solutions whose success depends in part on the autonomy of operation, not requiring any direct and conscious participation of people, for the ability to make the best decisions given the current context and future expectations, the context being defined by the characteristics of the environment, including the dynamics, namely those resulting from the presence/involvement of people, but also for the transparency of action, not being evasive and, if possible, fulfilling its function without people realizing the existence of the technology/solution simply the most convenient happens. There are other factors that should not be neglected, such as those related to security and privacy. In this paper, the authors propose an architecture that considers these requirements so that, in a non-evasive way, it adapts the different spaces that the user frequents (house, work, leisure, others) to their personal preferences, such as temperature, humidity, sound. environment, etc.

The architecture includes the different devices needed, to identify users, as well as the communication technologies to be used to transfer the preferences of each user to the system. The architecture includes a multi-agent system that allows managing conflicts of preferences through a user's hierarchy and that considers safety values for each preference, to safeguard the different

actuators (air conditioning, fan coils, multimedia, etc.) present in space. It was developed, focusing on the definition of each user's preferences in a smartphone application, which allows the user's preferences to be transferred to the space, without the need to perform any interaction, they can also be passed through smartwatches, fitness bracelets and similar devices, which currently have different communication technologies such as Bluetooth Low Energy (BLE), Near Field Communication (NFC) or Wifi-Direct. It also contains a local processing solution, currently supported by a Raspberry Pi, and will be present in each space where we want to adapt to different preferences. Each of these systems constantly receives each present user preferences. Based on the multi-agent system, it calculates the optimal preferences to be applied to each space at a given time. It is also responsible for sending these to the different actuators present in the space.

The multi-agent system has different layers (simulation, data acquisition, user information, actuation) [2]. Briefly, there is an agent for each user present, containing their preferences, and there is an agent that represents the space, containing eventual constraints, such as security values and others that may exist, namely in public spaces. Each of these agents aims to represent the interests of the involved parties. For example, the agent representing the space should be focused on an efficient use of equipment, minimizing energy costs, enhancing the durability of the equipment, minimizing maintenance costs. Taking advantage of the different hierarchies, an equation was devised that meets the different preferences to define the optimal solution, which will be sent to the different actuators.

$$prefValue = \frac{\sum_{user=1}^{n} uP * uHP + (sP * sProp)}{\sum_{user=1}^{n} uHP + sProp} \qquad (1)$$

In 1, is depicted the equation for calculate the preference value to apply in the actuators present at the space. In this equation we have: n - number of users present in space; uP - each user preference for the space; uHP - each user hierarchy proportion; sP - space preference; sProp - space proportion.
For the equation, different hierarchical proportions defined to respond to different possible situations were used, namely introducing the concept of family (parents/children) for the domestic space, the concept of employee/boss in the professional space, and the concept of owner/responsible of space in different public spaces. The entire architecture was implemented at this stage in the testing process, to be able to assess its performance. Different parameters were defined to assess the performance of the multi-agent solution, namely the following: Number of agents used, Agent speed reasoning, Information filtering, Environment perception time.

The entire component referring to the privacy and security of users' information was also carried out, using anonymization techniques to eliminate any user identification possibility, as it would be critical to have the entire history of a particular person containing the information of the places that attended and respective hours. From the analysed state of art, it was concluded that there are only small and isolated projects, which aim to analyse this problem, and a solution that satisfactorily meets the needs of this new reality and its specificities has not yet been developed. It can then be concluded that this work will make a significant contribution to the field of sustainable urban mobility, achieving maximum comfort for the user in the different spaces that he frequents in his daily routine, and it is still possible to maximize efficiency.

Keywords: adaptive-system, AmI, multi-agent, IoT, actuators, preferences, constraints.

References

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