Smart Spaces: Aware of users, preferences, behaviours and habits, in a non-invasive approach

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Introduction

The aim of this work is to take advantage of emerging technologies available in the market that support the so-called wearable devices [1], and the non-invasive particularity of these to, in an autonomous way, adapt the environment to the comfort parameters of each user (e.g. thermal, acoustic, air quality, light, sun exposure) [2]. Provide comfort according to the preferences of each individual, is a challenge and an opportunity to create innovative solutions and new paradigms in the context of Intelligent Environments [3].

Currently this challenge has as main difficulties, the people's mobility, the disparity of habits, schedules and the individual comfort preferences. The same is aggravated when depending on physiological conditions, derived from a large number of factors (tiredness, mood, etc.), user preferences often suffer significant changes, that current systems can not measure.

Figure 1, shows the development environment of this work. Explaining this figure, it can be seen the user who through its different devices (smartphone, wearable, and other compatible) communicates with the system, using technologies, like Near Field Communication (NFC), Bluetooth Low Energy (BLE) or Wi-Fi Direct. Next, the system performs communication with the Cloud, to validate the information. And the system will perform the management of the different components in the environment (climatization systems, security systems, other smart systems).

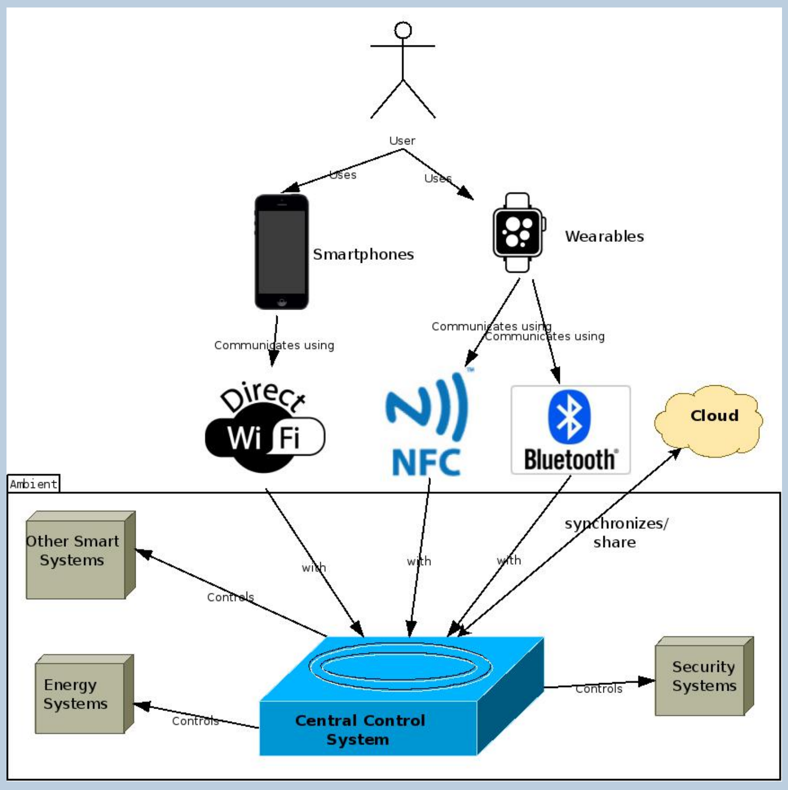

Figure 1: Problem Statement

Materials and Methods

The aim of this project is to create a solution that takes advantage of emerging technologies on the market that support wearable devices (e.g. smartwatches, smartphones, fitness trackers) and the non-invasive characteristic of these, for collecting data in an autonomous and transparent way and without any need of intervention by the user. And with that information assist the decision-making process of comfort systems to adapt the environment to suit the comfort preferences of each user (e.g. thermal, acoustic, air quality, lighting, sun exposure).

In figure 2 (right), an example of an environment is illustrated to demonstrate the use cases described above. Note that the communication processes, represented in this figure on arrow format, is expected to be transparent to the user and completely independent of its intervention.

After user validation in the Cloud, the respective preferences card is downloaded into the system, and the control is made automatically by the local system, adjusting all the preferences existing in the environment. In this example, will be adjusted lighting, and HVAC system.

In this project, the user identification, is one of the essential tasks. In a first approach, it is planned that there are two situations, explained below:

- **User ID sharing:** in this situation, when the user enters in the environment, the devices that are with him (smatphone, wearables, etc) pass the user ID to the system that controls the environment. The system, validates the ID in the Cloud, and from this gets the user's preference card. The system will then use the card information received, to adapt the environmental comfort conditions, using the automation available in the environment.

  In this case the system is permanently connected to the Internet, so that is allowed access to the Cloud.
- **User preferences card sharing:** In this case the user when enter the environment, share directly with the system, its preferences card, with the card available in the compatible device (smartphone, wearable, etc.).

  The system collects data from these preferences and adapts, as in the previous case, the environment comfort conditions, using for that purpose the automated systems available in the environment.

  In this case, the system does not require an Internet connection, all the process may be performed offline.

Both situations assume that the user has no part in the process, which is completely transparent to him.

The use case diagram present in figure 2 (left), illustrate the operating modes provided for the implementation of the user detection process, and sharing of his preferences card with the system on the environment.

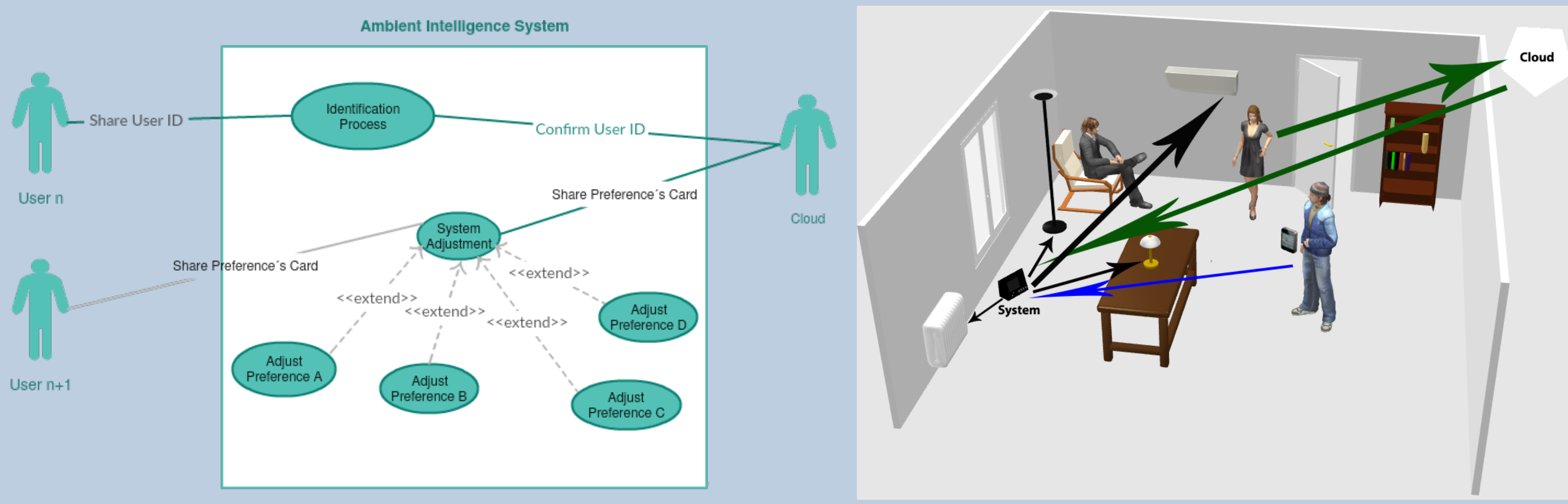

Figure 2: AmI System - Use Case diagram (left); AmI System - Communication process (right)

Proposed Solution / Results

The process and learning model proposed to the system, is intended to be scientifically innovative, taking advantage of the latest research in this field and combining multiple factors and the technologies described below:

- **Use dynamically scaled priority rules**, which must have the information, considered essential for the correct functioning of the system, including the limits for the different parameters, like system reliability or user safety.
- **Use of multi-agent systems** representing the different entities involved in the negotiation process, allowing an efficient outcome in different situations.
- **Use of sensors collected information**, and using machine learning techniques, including Sequence Discovery, Fuzzy Logic, Genetic Programming, Multi-Layer Perceptron, as described in [4], get information about user's habits in the environment.
- **Context awareness**, as described above since the context is entirely relevant in such systems.
- **Use of logical sensors**, there are three types of sensors used to assess the context in such systems: physical, virtual and logical.

That said, the practical applicability of this work, has result in the complete specification of an intelligent environment. To optimize the predictions of the proposed solution, an architecture for a multi-agent system[5], was also defined. Namely the solution covers the following features:

- **User identification;**
- **Detection and characterization of the user at the space;**
- **Detection and characterization of the user in the environment;**
- **Preferences conflict management in the environment;**

Presently is already designed and implemented the first prototype of the architecture planned for the system and is currently in a testing phase. A database was designed and modeled to support the full functionality provided for the system. Figure 3 shows the overall context of the proposed architecture for the system.

The learning process, uses agents that represent the different entities and system stakeholders and some learning models, that will allow assessing the data needed for the process of predicting user preferences. At this stage all the data layer that stores the results of the learning process is already finished. The learning process has been implemented using agents and using JADE.

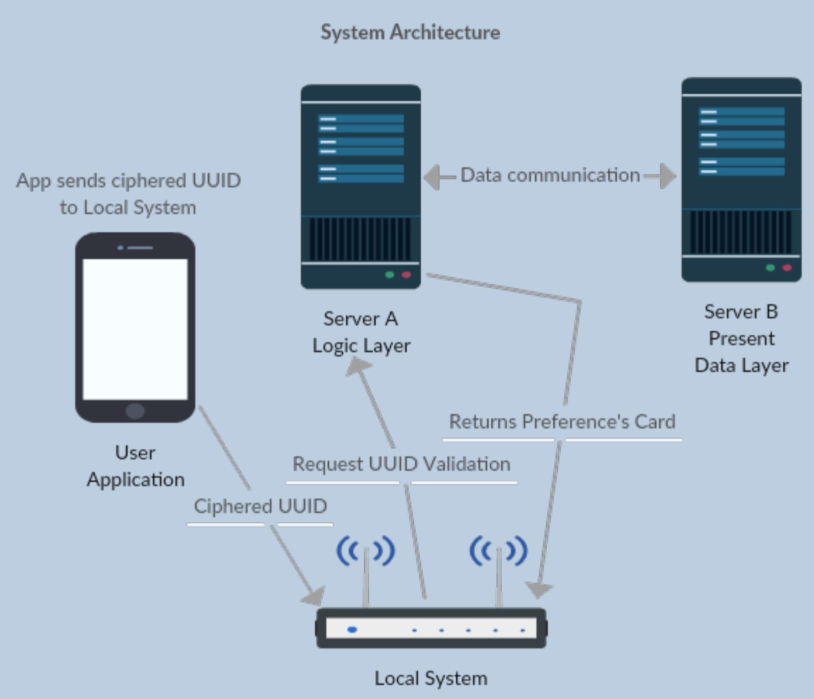

Figure 3: System Architecture System

Conclusions

This project combines the use of the latest wireless communication technology (NFC, BLE, Wi-Fi Direct) with emerging wearable devices, and therefore optimize the everyday people lives and the industrial production environments.

It is defined as a truly innovative project and fully ap plicable to industrial and domestic level. And with really high market value, such as envisage diverse reports of global reference consultants (Gartner, McKinsey, Business Insider) in its most recent reports which include projections for the (2015-2020) period.

For future work, we have identified the need to develop solutions that enable communication between the application and the local system, using different communication technologies without user interaction.

References

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