WASP - Windows and Shutters Project

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1 System Introduction

Quality of Life and well-being is an essential factor for work performance and employees in modern office environments [**?**]. One prominent problem regarding indoor office buildings is a high CO_2 concentration which can lead to impaired work performance and negative health symptoms [**?**]. Further possible disturbances in office environments include ambient noise and sunlight [**?**]. Both elements distract the concentration of office workers.
We use an intelligent windows and blinds and heating management system to address the problems outlined above. This system uses sensors to monitor the CO_2 concentration, ambient noise level, and sunlight intensity. Based on the observed information, the system can then react by adjusting the windows, shutters, and heating accordingly.
The goal is to control the office's windows and shutters to maintain high air quality with a low CO_2 concentration and a comfortable temperature while avoiding distractions caused by ambient noise and blinding sunlight. The system is also equipped to adapt to environmental influences (e.g. rain and wind) that can adversely affect the indoor office space when windows are open.

1.1 System Analysis

Must have requirements

R1. Maintaining low CO_2 concentrations
R2. User has manual control of windows, blinds, and heating
R3. User can specify automation parameters
R4. Sustaining desired room temperature using energy efficient decisions
R5. Great amounts of sunlight are blocked by blinds
R6. Prevent rain through open windows

Nice to have requirements

R7. System status overview
R8. Prevent strong wind from coming through windows
R9. Prevent distracting amounts of ambient noise
R10. Plan ahead by using a weather forecast

1.2 Must have requirements

R1. Maintaining a low CO_2 concentration Ensuring the well-being of employees by avoiding high levels of CO_2 is one of the essential problems the window management system is supposed to address. Therefore, it is a core requirement that the system is able to maintain low CO_2 levels inside the office space.

R2. User has manual control of windows, blinds, and heating

U1: *As a project lead, I need a dark room so that my Power Point presentations are clearly visible.*
U2: *As a safety manager, I need to open the windows in case of an emergency.*

While the system aims at automating all windows, blinds, and heating functionality optimally, there do exist scenarios, where the manual operation of these devices is desired. Detection and response to all scenarios is not possible due to the limited scope of the system. The user stories U1 and U2 detail such scenarios where manual control is needed.

R3. User can specify automation parameters Different office environments have different demands regarding acceptable CO_2, ambient noise levels, etc. These demands can only be satisfied, by adjusting the automation accordingly.

R4. Sustaining desired room temperature using efficient decisions

U3: *As a CEO, I want the system to operate energy efficient, so that I can minimize my heating costs.*

Sustaining a desired temperature contributes to the well-being of employees in the office space. Additionally user story U3 demonstrates the need to take energy efficiency into account during the systems operation. Therefore coordination between windows and heating is necessary.

R5. Great amounts of sunlight are blocked by blinds

U4: *As an employee, I want shades to be in a position so that i am not blinded by sunlight.*

Blinding sunlight can be a distraction to workers in the office space [**?**]. The argument to block excessive amounts of sunlight is further reinforced by user story U4. The effect of sunlight can be prevented by using blinds. Considering the fact, that blinds are a part of the systems automation objective it is therefore necessary, that the system automatically blocks excessive sunlight.

R6. Prevent rain through open windows Open windows inherently create the risk of rain coming into the office and damaging the interior. In order to prevent damage to the office interior the system has to detect rain and prevent it from entering the building.

1.3 Nice to have requirements

R7. System status overview

U5: *As a facility manager, I want to be able to view the status of different system components, so that I don't need to watch them manually.*

Both the security officer (U5) and the facility manager (U6) have an interest in a system overview functionality, as it would make their respective work easier. But both of them are also able to perform their job without this functionality. It is therefore nice to fulfill this requirement but not requisite to the systems functionality.

R8. Prevent strong wind from coming through windows Although strong wind coming through windows can be a nuisance it is also a comparably infrequent and harmless problem which can be solved by manual user control. It therefore falls into the category 'Nice to have requirements'.

R9. Prevent distracting amounts of ambient noise Ambient noise can be very distracting. Closing the windows during peak ambient noise levels can reduce outside noise significantly. Ambient noise depends on the office location and is generally less essential to the system's operation.

R10. Plan ahead by using a weather forecast Being able to plan around bad weather situations would enhance the system's ability to satisfy set goals. This requirement is not needed for the systems base functionality it is therefore optional.

2 System Architecture Design

The architecture used to face these requirements is described in Figure 1. It is partitioned into four layers: the user layer, the reasoning layer, the ubiquitous layer, and the physical layer. The user layer consists solely of the user interface, which contains a manual override for windows, blinds and heating (R2), a status overview of the system (R7) and an automation configuration functionality (R3). The reasoning layer contains the decision making component, which calculates an optimal automation policy given the user goals. The knowledge base, plan execution component and weather forecast (R10) are part of the ubiquitous layer. The knowledge base contains sensor and actuator device descriptions, raw data, and the current system configuration. The weather forecast is stored in the knowledge base. The plan execution component reads current sensor data and enforces the current automation policy by sending commands to the actuators. Sensors and actuators are part of the physical layer. Both send their device descriptions to the knowledge base. Additionally, sensors send their sensor data and actuators execute the commands sent from the plan execution component and the manual user override.

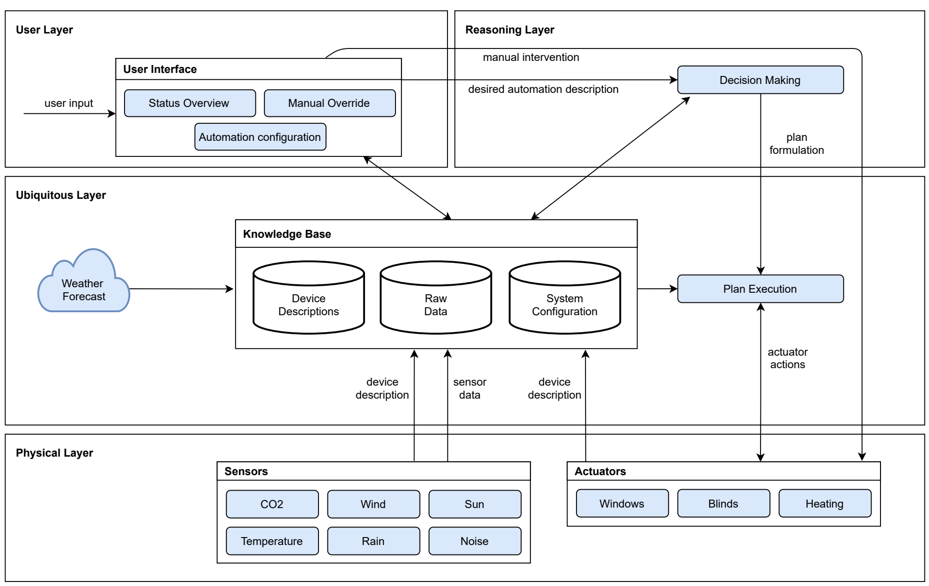

Fig. 1. System Architecture

All links were last followed on April 17, 2020.