AAQC - Autonomous air quality control

Group 16 - Tobias Haller, Jonas Hofer, and Christian Müller

Service Computing Department, IAAS, University of Stuttgart

1 System Introduction

Increasing the well-being of people is an important topic of research. Especially for office spaces, when companies want to increase the efficiency of their employees. In general, with good air in terms of proper temperature, humidity and air purity, people feel more comfortable and can be considered healthier and more productive than with poor quality air.
Another application could be retail stores where customers stay longer if they feel more comfortable, which could lead to higher revenue for the retail business. Of course, businesses also face great competition from online retailers and other stores where air monitoring and customer comfort could be the difference or advantage.
Since we are participating in the lecture "Smart Cities and IoT", we want to gain practical experience in addition to the theoretical basics taught in the lecture. In our project, we will consider a single office space that controls heating, air conditioning, ventilation and air purifier according to several sensor measurements, thus monitoring the air quality. Since this example can be easily scaled up to large enterprises with many office rooms, we can easily test the system using a single room as a POC. Moreover, we only need to change some thresholds to extend the scope to retail stores or other buildings. Based on this basic problem definition and the main scope of our work, in the following we will specify our use cases and requirements for a system that should automate such tasks as well as some additional tasks for a user.

2 System Analysis

There are some core requirements and functionalities a user wants from this autonomous system. Given the described scenario we want to improve the situation of users by providing an autonomous way to control and adjust the air quality of a given room. In addition we want to improve comfort of users by also regulating temperature or humidity of a given room based on environmental factors. Another part of our system is to identify human presence or out of office time and adjust the functionality of the system accordingly.

The core system functions will be separated into both functional and non-functional requirements according to ISO 25010. All requirements will be priorized by - - / - / 0 / + and ++, where all requirements with + or ++ are considered to be mandatory for our project. All other requirements are considered desirable or optional.

2.1 Functional Requirements

Name FA-1
Title Autonomous temperature regulation
Description The system should be able to regulate the temperature of the room based on system information and human presence
Dependencies FA-8 FA-10
Priority +

Name FA-2
Title Autonomous humidity regulation
Description The system should be able to regulate the humidity of the room based on system information and human presence
Dependencies FA-9 FA-10
Priority +

Name FA-3
Title Autonomous air quality regulation
Description The system should be able to regulate the air quiality of the room based on system information and human presence. Particle count (Particulate matter) and CO_2 concentration are the basis for measuring the air quality.
Dependencies FA-6 FA-7 FA-10
Priority ++

Name FA-4
Title Night regulation
Description The System should reduce its functionality to a minimum during night time.
Dependencies FA-1 FA-2 FA-3
Priority 0

Name FA-5
Title Display system activity to User
Description The System should be able to show its activity and monitoring information to the user
Dependencies Everything else
Priority - -

Name FA-6
Title Recognize stale air
Description The System should be able to recognize when the air has gone stale. This is based on the CO_2 concentration indoors.
Dependencies None
Priority ++

Name FA-7
Title Recognize increased particulate matter concentration

Description The System should be able to recognize when the air contains an increased concentration of particulate matter.
Dependencies None
Priority ++

Name FA-8
Title Monitor indoor and outdoor temperature
Description The System should be able to recognize the temperature indoors and outdoors of its operating location.
Dependencies None
Priority ++

Name FA-9
Title Monitor indoor and outdoor humidity
Description The System should be able to recognize the humidity indoors and outdoors of its operating location.
Dependencies None
Priority ++

Name FA-10
Title Detect human presence
Description The System should be able to detect human presence indoors.
Dependencies None
Priority -

2.2 Non-functional Requirements

ID NFA-1
Title Realworld application
Description The system should be able to be easily transformed to a real world running smart home system.
Dependencies None
Priority -

ID NFA-2
Title Automation with minimal user intervention
Description The system should utilze AI-planning in order to automate its autonomous functionalities with minimal user intervention.
Dependencies None
Priority ++

ID NFA-3
Title Loosely coupled system
Description The system should be loosely coupled regarding its communication between devices.
Dependencies None
Priority ++

3 System Architecture Design

In the following we will specify our main components that execute our main functionalities. All components are separated into the following Layers according to ISO/OSI Model.

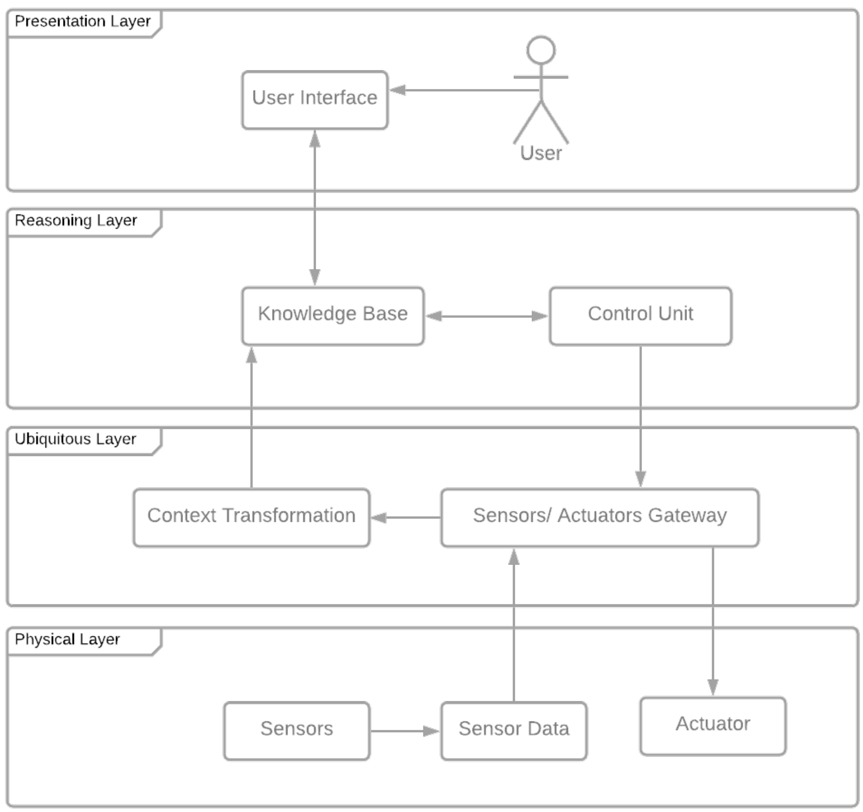

Fig. 1. The system design illustrated as a diagram

3.1 Presentation Layer

The Presentation Layer consists of the User Interface and the User itself. The (human) User interacts with our system via the User Interface which is a GUI. The user can monitor the system as described in functional requirement FA-5.

3.2 Reasoning Layer

The reasoning layer consists of the knowledge base and the control unit. The knowledge base stores all the sensor data that is generated and stores information about the individual room with the state of all the actuators. It receives all its data from the Context Transformation component in the Ubiquitous Layer. The Control Unit interacts closely with the Knowledge Base, as it receives a notification as soon as new sensor data is stored in the Knowledge Base. Based on all the data, the Control Unit decides based on AI-planning what actions it should take next. As soon as it has reached a conclusion and formulated a plan, it communicates this plan with the Sensors/Actuators gateway in the Ubiquitous Layer.

3.3 Ubiquitous Layer

The main component of the ubiquitous layer is the sensor/actuator gateway which communicates between the physical layer devices and the components of the reasoning layer. It will process commands from the control unit of the reasoning layer directly in order to relay commands to the actuators of the system. Sensor data however will be given to the Context Transformation component which has the job to take this raw data and transform it to a more precise and informative format which will then be communicated with the knowledge base of the reasoning layer.

3.4 Physcial Layer

There are two main components of the physical layer. Firstly the sensor which produces sensor data that will be sent to the gateway. Sensors will be used to satisfy functional requirements such as FA-8 and others. Secondly actuators will get instructions from the gateway and execute upon these as is described in the functional requirements.