Edge Computing in the IoT

Requirements and Specification Example – Home smart temperature control system

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The goal is to design a system that controls air conditioning in a house in a smart way. The system not only considers temperature settings by users, but also presence in the rooms, and learns habits of users.

Requirements

The house temperature control system must have the following main characteristics:

- Temperature is measured and controlled independently in the different rooms of the house
- Temperature is set by considering user preferences, but also by considering presence in the different rooms and, globally, in the house
- The system can be controlled by using a dedicated control panel
- The system relies on an air conditioning system that is capable both of cooling and heating.

The temperature control system is meant to be smart and oriented to reducing the use of energy required, yet providing an adequate level of comfort to users. Users will have the option of setting the desired temperature in the different rooms or to let the system learn about the temperatures. A user staying in a specific room, will be able to override the system by forcing a certain temperature. Furthermore, the system will control the temperatures in the rooms by considering room occupation (e.g., no need to heat a room if it is not used for a long time), user habits (e.g., every evening at 19:00 somebody is in the kitchen), and presence in the house (e.g., nobody is in the kitchen but somebody is in the house vs. nobody is in the kitchen and nobody is in the house). Temperature control should also consider hysteresis of the heating/cooling system, i.e., the time required to change the temperature by a certain amount of degrees.
The system must provide an intuitive user interface that is available as a smartphone app and as a stand-alone device. Users will be able to check and set temperatures in the different rooms as well as see statistics on temperatures, presence in the rooms, and functioning time of the A/C system. The app must work locally (i.e., no connection to a remote server necessary) and connect to the temperature control system from any room of the house. The app must provide the ability to control the temperature in the room from which it is used; the app will also provide the ability to control the temperature in other rooms.
The different elements of the system are powered by batteries; batteries must last at least for one year.
Communication among different devices should be wireless, to allow for an easier installation. Security must be taken into account to avoid unintended uses of the system (e.g., change the temperature settings or use the system to monitor the presence of persons in the building).
Cost of the system must be lower than 150CHF per room.
The A/C system can be composed of independent devices (one in each room) or of a single device with capabilities of controlling air distribution in the different rooms.

Your turn…

High-level specification

Write the high-level specification for a system that meets the given requirements, describing its expected behavior and addressing the major technical design choices. The following information should be present, plus any additional information that you think would be necessary to implement the given system: propose an overall architecture for the system, describe its components and their detailed behavior, the communication technologies you plan to use, the information that the components must exchange with one another, how to encode the information for transmission.

State machines

Design a state machine that describes the behavior of the A/C unit in one room of the house. The A/C unit should determine whether to turn on its heater or its cooler based on the current temperature and the temperature setpoints provided by the user. Take hysteresis into account to avoid switching rapidly for slight temperature changes.

Extend the previous state machine to also consider room occupation. The A/C unit should completely turn off once a room has been left unoccupied for a given amount of time, then it should turn on again as soon as someone enters the room. For simplicity, we don’t consider predicted occupancy here. You might find that a statechart is a better representation for the system of this exercise, but a regular finite state machine can also be used.