Department of Electrical and Computer Engineering
Concordia University

COEN 446 – Internet of Things

Winter 2020

Project: House Smart Heating/Cooling System

Submission: https://fis.encs.concordia.ca/eas
Submission deadline: By Friday April 06, 2020, 11:59pm

1. Introduction

The project consists of the implementation of a connected thermostat to optimize the heating and cooling system of a house. The connected thermostat should regulate the house temperature based on the users' preference. It has been proved that the use of a smart thermostat helps to save energy. For instance, Google has developed the **Google Nest Learning Thermostat** to automatically adjust the room's temperature based on the learned user's routine and preferences. On average, the Google Nest Learning Thermostat saves 10% to 12% on heating bills and 15% on cooling bills [https://store.google.com/ca/product/nest_learning_thermostat_3rd_gen?hl=en-CA]. The detailed description of the system and protocol to implement is given in the following sections.

2. Smart Heating/Cooling System

The objective of this project is to implement a connected thermostat with the basic functionality of adjusting the temperature based on the users' preference. The thermostat must obtain information regarding the people living in the house, their preferable temperature, and the house occupancy in a given moment. The MQTT protocol must be implemented in order to make the connected thermostat capable of obtaining the required pieces of information. The needed information by the thermostat, how they are acquired, and the behavior of the entities that must be implemented (see Fig.1), are described below:

- Management APP: This is one of the publishers to be implemented. This entity will be used to collect information of each resident of the house and their respective preferable temperature. As input, it should receive the name of a person and the temperature he/she prefers. Whenever a new person is added, it must contact the broker to publish that information.

- Smart door locker: This entity is responsible for publishing information whenever a new member of the family enters the house*. In a real scenario, this can be implemented with a video camera that captures the image of the approaching person and a deep learning*

model that would recognize the person and unlock the door. In this project, we will simulate this entity by providing the name of the person entering and the indication if she/he is entering or leaving the house. This information must be sent to the broker whenever this event happens.

- Connected thermostat: This entity will regulate the house temperature based on the observed status in the house, *i.e.,* the persons are in and the temperature he/she prefers. The output of this entity will be the temperature displayed on the screen. For the sake of simplicity, it should adjust the temperature as follows:
    - If the house is empty, it should set the temperature to 15° C (default temperature).
    - If there is only one person in the house, it should set the temperature to the one that person prefers (his/her preferable temperature).
    - If more than one person is in the house, the thermostat should set the temperature based on the time of arrival of the persons in the house. High priority is given to the person that arrived first.

      For instance, let us assume that at t=10, the thermostat has the following list of persons in the house:

      "John, 23 ° C, 4pm"
      "Phillip, 27° C, 6pm"
      "Sarah, 17° C, 4:30pm"
      "Alice, 19° C, 5pm"

      It means that at that instant (t=10), the temperature should be set to 23° C since John was the first to arrive (4pm). If John leaves the house, the thermostat should remove it from the list, check the person that arrived first, and update the temperature accordingly. In this example, it should set according to Sarah's preference since she arrived before Alice and Phillip.

      "Phillip, 27° C, 6pm"
      "Sarah, 17° C, 4:30pm"
      "Alice, 19° C, 5pm"

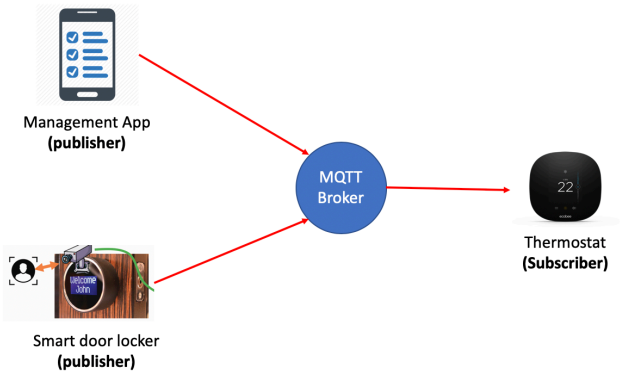

Fig. 1: Overview of the connected thermostat system

The abovementioned thermostat decisions are made whenever it receives new information from the MQTT broker. Whenever it adjusts the temperature, it should show into the screen the value it sets. We should be able to simulate the arrivals and departures at the house by providing the respective information, anytime, to the smart door locker simulated application.

3. Requirements

The project should be done in teams of 2 or 3 students. You should send, by February 21st, to rodolfo.coutinho(at).concordia.ca your group list including student names, ID numbers, and ECE email addresses. The system implementation must follow the MQTT protocol. It can be implemented in Python, C++, C, or Java and must run in a machine using Linux as OS. The four entities (management app, smart door lockers, MQTT broker, and thermostat) will be tested locally and/or in distributed computers. You should log all communication between publishers and the broker, and the broker and the subscribe. This log can be printed into a file or directly into the screen as communication happens.

A report and the code must be submitted. The report must clearly state all the assumptions and design decisions made the considered list of topics used by the publishers and subscribers and the code for the implemented entities. Moreover, it must clearly describe the technical contributions of every member of the group regarding the design and implementation of the project). A demo will be held during the Week 13 of this winter term. During the demo, all the members of the group should attend and be ready to answer questions from the instructor. During the demo, we may also go through the code and the report.