Multi-room Heating System Modeled as a Dynamical System

Michael Kim   
*Department of Computer Science*  
*Vanderbilt University*Nashville, TN michael.kim@vanderbilt.edu

Kendra Davidson

*Department of Electrical Engineering*

*Vanderbilt University*

Nashville, TN [kendra.g.davidson@vanderbilt.edu](mailto:kendra.g.davidson@vanderbilt.edu)

*Abstract*—Everyday cyber-physical systems can be represented as dynamical systems and modeled as such. In this paper, we describe the modeling of a multi-room (four) heating system as a dynamical system using MATLAB’s Simulink add-on. Given that all our assumptions for the model hold, it can regulate all room temperatures within a reasonable range. While the model is a largely simplified version of a realistic situation, it does well to simulate the basic interactions that take place to influence the dynamics of room temperatures with a heating system.

Keywords—Dynamical Systems, Heating System

# Introduction

For modeling a multi-room heating system, we cannot use an asynchronous-only model with fairness conditions to properly illustrate all the factors that contribute to the fluctuating temperatures of each room; there would not be enough synchrony among tasks to ensure that the temperatures are updated simultaneously. We instead focus our attention dynamical system modeling, as we can better describe the changes in the room temperatures as the dynamics of such a system with ordinary differential equations (ODEs). Additionally, the time synchrony between components is a better representation of the real-world factors that simultaneously drive the changes in temperature.

Consider now a heating system that regulates the temperature over four connected rooms with two heaters. The temperature of each room changes linearly with the difference with the outside temperature , the difference with each directly adjacent room’s temperature, and a heater’s current effect on the room. Then the dynamics of the system can be represented by the following equation:

where and , and , and , and . represents the influence that rooms have on each other. If the rooms are not directly adjacent, then . Additionally, if . represents the influence that the outside temperature has on room . represents the influence that a heater has on room . if there is no heater in room or if the heater is off and if a heater is on in the room. The system is parameterized by the constant matrix , the constant vector , the constant vector , and the initial room temperatures in the vector .

Additionally, there are constant vectors that are used to determine the placement of the heaters and whether they are on or off. If a heater is in room , then the heater is off if and on if . A heater is moved from room to room if: (1) room has no heater, (2) room has a heater, (3) , and (4) .

The inputs to the system are the vector for the initial placement of the heaters and .

The scenario we examined to build our model of the multi-room heating system was parameterized as:

with inputs:

For this parameterization, we aimed to keep for all .

# Assumptions

## are reasonable starting temperatures

## Heaters can be moved instantaneously

## Only one heater can be in a room at a time

## 

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*a**b* 

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