

Addressing the complexity of modeling building energy dynamics using a component-based approach

Muhammad Anas Munir and Georg Hackenberg

Chair for Software and Systems Engineering, Technische Universität München

anasmunir@hotmail.com, hackenbe@in.tum.de

ABSTRACT

Efficient building energy management is becoming increasingly important. Existing building energy management approaches range from classical optimal control techniques [1, 2] to dedicated control architectures [3]. Optimal control techniques [1, 2] typically include some form of building energy dynamics modeling, while the models usually are represented by sets of differential equations. This model representation allows to describe precisely the interactions between the physical variables (e.g. room temperature and heat exchange), but with increasing building complexity managing the variables and interactions can become difficult. Control architectures [3], on the other hand, focus on the structure of respective controller systems, e.g. using a three-layered approach including device drivers (e.g. for washing machines), prevention measures (e.g. circuit breaker activation) and anticipation strategies (e.g. user demand forecast). Together, optimal control techniques and control architectures already provide powerful tools for efficient building energy management. However, existing approaches typically are limited to a single form of energy (i.e. electricity or heat) [1, 2] and are restricted in complexity due to the underlying model representation. In this paper we address these problems using a component-based approach to building modeling (see Figure 1), which can be combined with existing model representations for expressing building energy dynamics. The approach allows one to model the building, the surrounding infrastructure (e.g. the power grid and district heating) and the environment using respective components with heat, power and information interfaces. Furthermore, the building can be decomposed into the roof, floors and rooms with supporting heat, power and communication infrastructure components. Finally, the rooms contain air and device components, while devices interact with the air as well as the surrounding infrastructure components. We evaluate the presented approach with respect to comprehensibility and completeness. To evaluate comprehensibility we perform a user study asking for advantages and disadvantages of the presented approach. To evaluate completeness, on the other hand, we map the features of existing building models to the features of the proposed approach. We conclude that the component-based approach indeed provides a comprehensive and complete building model with focus on energy dynamics.

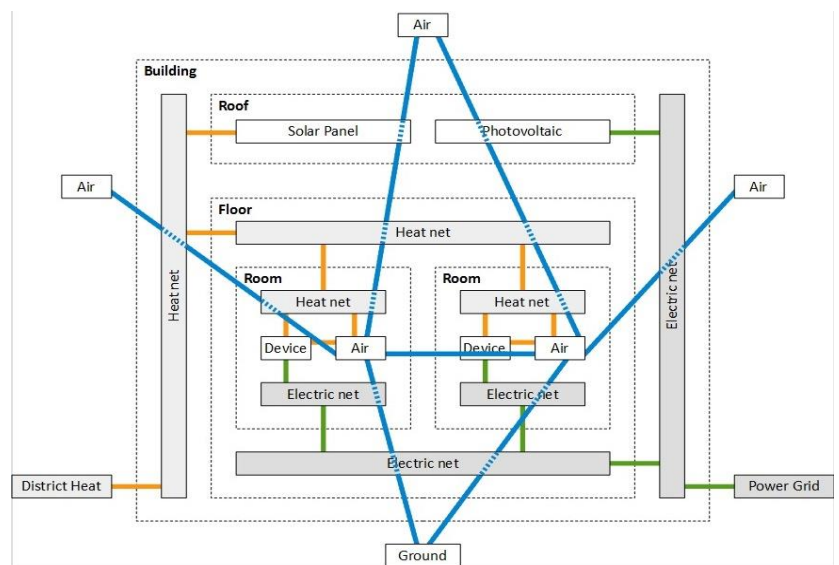


Figure 1: Overview of the component-based modeling approach including building, infrastructure and environment components as well as heat and electricity interfaces.

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