The Use of Modelica and the Functional Mockup Interface for the Building Optimization Testing Framework (BOPTEST)

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Needs for advanced and improved control strategies (CS) in building and district energy systems are growing due to requirements for reducing energy use, greenhouse gas emissions, and operating costs, providing flexibility to the electrical grid, as well as ensuring performance of novel hybrid and collective system architectures. Examples of such CS are advanced rule-based control, Model Predictive Control (MPC) [Drg20], and Reinforcement Learning [Wan20]. However, while these and other CS show promise, two challenges slow their widespread adoption:

1. The performance of each CS is typically demonstrated on individualized case studies and quantified using different performance indicators, making it difficult to properly benchmark and compare their performance, identify the most promising approaches, and identify needed further development.

2. Demonstrations in real buildings and district energy systems pose large operational risks and difficult environments for controlled experiments. The building simulation (BS) community can address these challenges by providing suites of publicly available, high-fidelity simulation models, called emulators, to be used for benchmarking CS.

Furthermore, providing a comprehensive framework to deploy, interact with, and generate key performance indicators (KPI) from these emulators would ensure their benchmarking capability and make them readily available to related control and data science fields outside of the BS community. There exists precedent for such an approach in the optimization fields (e.g. Decision Tree for Optimization Software [Mit22]) and data science (e.g. OpenAI Gym [Ope22]). Work is underway on the envisioned framework and emulators, called the Building Optimization Testing Framework (BOPTEST). It has been developed within the IBPSA Project 1 Work Package 1.2 [Wet19], with primary software development occurring open source at https://github.com/ibpsa/project1-boptest. The framework is described in [Blu21] and has been used so far in [Arr20, Arr22, Bun21, Hua18, Wal20, Yan20]. Additional development is making BOPTEST available as a web-service, providing an online dashboard to share and sort results, and creating an OpenAI Gym interface [Arr21]. The Role of Modelica and Functional Mockup Interface Key to the implementation of BOPTEST is the development of high-fidelity building emulators that can represent HVAC system dynamics in a way that can realistically emulate how building controls are implemented and perform in practice. For the implementation of these models, we use Modelica libraries developed under IBPSA Project 1 for the purposes of building and urban energy system simulation. For packaging these models in a shareable format and simulating within the BOPTEST run-time environment, we use the Functional Mockup Interface (FMI). This presentation will present the motivation, design, and example usage of BOPTEST, emphasizing how Modelica and FMI enable its core capabilities.

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