Automated Generation and Optimization of Control Strategies for Increased Energy Efficiency in Buildings

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Abstract – In the project KORE (Cognitive Optimization of Control Strategies for Increasing Energy-efficiency in Buildings) we propose a novel approach for improving energy performance of buildings. A cognitive system uses semantic knowledge about the building stored in a knowledge-base, in order to generate the control logic. This logic, instead of being manually configured and static, is generated and optimized automatically through experience by the system.

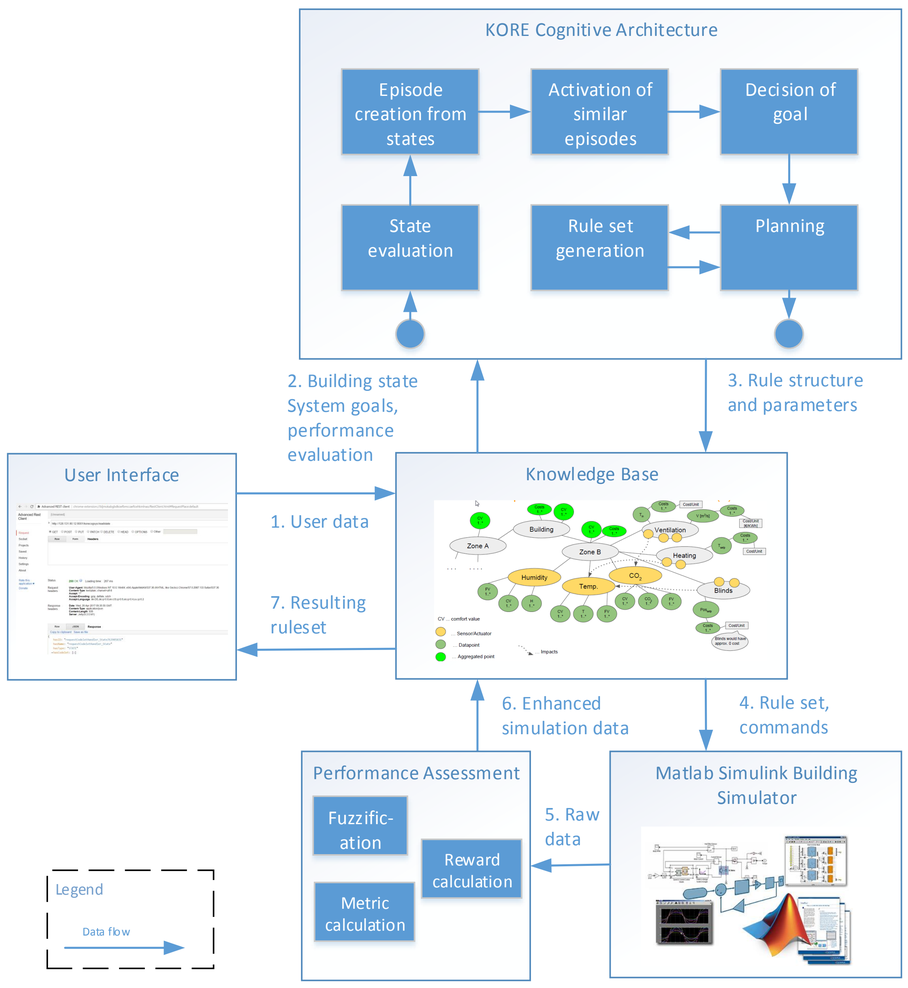
Energy Efficiency in Buildings

Building Energy Management Systems (BEMS) combine control logic and process control methods to operate building systems, to maintain **indoor comfort** and maximize **energy efficiency**. In building practice, the control logic is typically configured manually during the commissioning phase and remains static as long as no human intervention happens.

A major challenge for the near future is to develop **adaptive controls** in order to reduce commissioning effort and to enhance incorporation of volatile production. The building management system can reason in the basis of semantic representation of building services to **generate and optimize control strategies autonomously**.

KORE Cognitive System

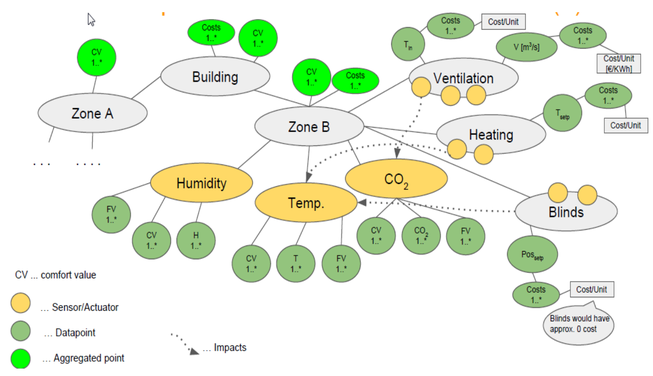
To automate the generation of control strategies of a building and underlying building systems we develop a **cognitive architecture.** The proposed architecture uses biologically inspired reasoning techniques and semantic knowledge to generate rule sets that meet defined operational goals. In a next phase, it uses learned experience to optimize the parameters of the generated rule sets.



The method used for optimization is **reinforced learning combined with case-based reasoning**. The system tests different solutions, evaluates and stores the evaluation of the solutions in a knowledge base. Since it receives constantly feedback for its decisions, its strength lies in the ability to adapt to dynamic changing environments.

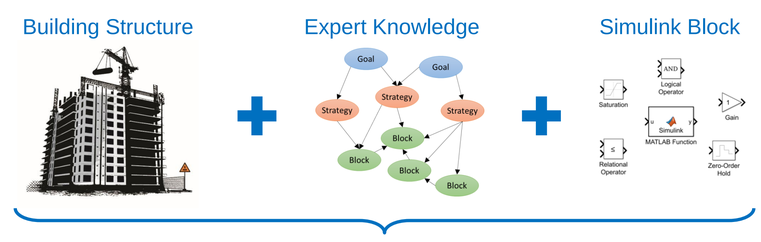
Experience Based Decision Making

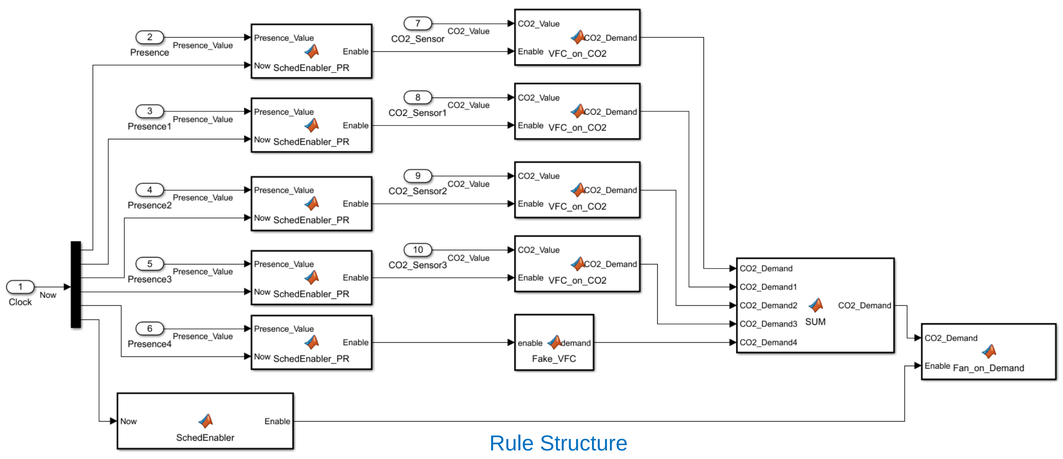
The OWL **knowledge base** (KB) forms the memory of the whole system. For each use case, a named graph is generated which initially is filled with data about the building structure (rooms, zones), and about the present building automation equipment (sensors, actors). According to this information, and by recalling other use cases, the cognitive system designs a control strategy and stores it in the KB. This control strategy is then equipped with a high-level evaluation (e.g. Humidity-, Temp.-, CO_2 – comfort level, as depicted right) derived from an automatically generated simulation model. By repeating this process, the cognitive system gathers experience to finally find an optimized control strategy.



Generating Control Strategies

First step in defining a control strategy is the generation of a rule structure. The rule structure defines which combination of control blocks will be available for the following optimization. It is generated by applying semantic knowledge provided by building experts, using a fixed set of control blocks.





Rule Structure

After the structure generation, the blocks are parameterized by varying optimization techniques and then transformed to a Simulink readable format so they can be used as a control strategy in the simulation. The simulation results are then used as feedback to the strategy generation process.

Expected Results and Upcoming Tasks

KORE is currently work in progress, with the automated rule generation step completed. The system retrieves information from the knowledge base to understand the specifics of the problem and creates a series of valid control strategies. The next step is to incorporate past experience in the reasoning process to optimize the proposed control strategies. The resulting system will be able to self-configure and optimize performance autonomously.

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