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APMonitor: Modeling Platform for Dynamic Optimization

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Abstract

A significantly condensed modeling approach to planning and scheduling optimization is to pose the problem as differential and algebraic equations (DAEs) with either continuous or discrete variables. The APMonitor modeling language solves large-scale and complex systems of DAEs not only for dynamic optimization but also for model reconciliation to data. Some of the recent applications in APMonitor include computational biology, unmanned aerial systems, chemical process control, solid oxide fuel cells, grid-scale energy storage, and oil & gas upstream systems. Highlighted in this presentation is a capacity expansion of a district heating network. This study evaluates the investment decision timing and type of capacity expansion. An optimal investment schedule is determined over a 30 year horizon with stochastic inputs (e.g. fuel prices, carbon tax costs, electricity prices) as well as daily dynamics across seasonal variations. This is formulated as a dynamic optimization problem in which an initial system configuration is modified by decisions to drive from an initial state to an optimal state. In this case, the underlying DAE model is discretized into an equivalent set of nonlinear equations with mixed-integer variables. The APMonitor Optimization Suite facilitates this transformation so that problems can be solved with capable mixed-integer (MINLP) solvers. In addition to forward predictions, there is also value in “looking backward” in time to align these same models to available measurements through state and parameter estimation. Once the system is aligned with dynamic data, the model with updated parameters is projected forward in time and solved as an MINLP problem to solve capacity planning scenarios. The solution of this MINLP problem drives the system along a desired trajectory or best meets multiple objectives. Recent progress with parallelization, web services architecture, and remaining challenges with large-scale and complex dynamic systems are reviewed.