Automatic Simplification of District Heating Network Models

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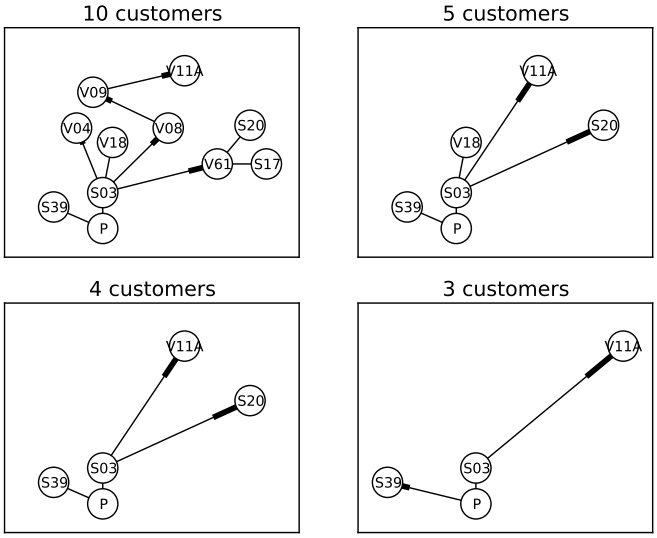
Optimizing the production of district heating plants has substantial benefits, both economically and environmentally. This optimization requires a model of the power plant and pipe network, but constructing and maintaining the model can be laborious. The `dhn` software package automates the process of creating these models from network data, requiring minimal effort from the user.

District heating plays a central role in heat delivery in urban areas, thanks to its ability to provide heating at a lower cost and with lower environmental impact than decentralized production. This is done by heating water at one or a few central heating plants and distributing it to the consumers through a network of pipes. Each consumer is connected to this network through a heat exchanger, which transfers the heat from the supply pipes to, for example, tap water and radiators.

The owner of a heating plant must balance the production level so that all consumers recieve enough heat but the over-production is minimal, to avoid wasting resources. To aid in the decision of a suitable production level, a mathematical model of the power plant and network can be used together with a prognosis of the heat demand. Using these, a computer can find a production level which maximizes the profit for the producer. The required calculations are non-trivial, however, and a complete model of the distribution network becomes too large to use with today's technology. To get around this problem, a simpler but less accurate model is used. The network is simplified by restructuring the model, lumping together customers based on their location in the network to reduce the amount of components and thus the overall complexity. Simplification is based on the standard operating conditions of the network in terms of temperatures, flows and customer heat demands, and these are used in combination with information on the network layout and pipe dimensions to produce a reduced model which behaves identically if all conditions remain the same. Deviating from the default conditions will create increasingly large model errors, but as nominal values are used, the network should stay reasonably close to them.



Successive reductions in size of a district heating network. The heating plant is denoted by P.

While the theory behind the simplification is rather simple, creating a reduced model by hand is tedious work. An alternative to hand-crafting the models is provided by the `dhn` software package, created to produce a computable model directly from data on a full network. The appeal of using `dhn` instead of creating the model manually is that once the network is specified, it only takes about five lines of code to reduce it to a desired size and translate

the model to Modelica code for use in simulation or optimization. The framework is also implemented to facilitate extension by an end user. If, for example, the component models used in code generation in the standard implementation need to be replaced, new code can be written for the necessary parts of the model translation, but the rest of the automation can be retained.

The software is still in the early stages of development, and additional work remains before it is ready for use in real-world applications. The two main areas in need of improvement are model accuracy after simplification, and further automation of the workflow. Ideally, the entire process should require only a data file, a network layout specification and a few lines of additional code, allowing model generation to be carried out quickly and efficiently.