Modelica extensions for Multi-Mode DAE Systems

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The paper proposes to extend the scope of Modelica and model and simulate systems with multiple operating modes. Examples:

- Changing a controller from nominal operation to startup, shutdown or manual operation.
- Structural changes of a physical model (e.g. modeling the separation mechanism of a two or three stage rocket).
- Describing failure situations where the model structure is changing (e.g. an electrical line or a mechanical shaft breaks).
- Describing failure situations where the model is completely changing (e.g. the normal behavior of a pump is a 0D model. In case of cavitation, a 1D model is needed to describe physics, requiring to switch dynamically from a 0D to a 1D model when cavitation occurs).

In general this means that the number of continuous-time states of the model might change dynamically during the simulation. Such models cannot be described with current Modelica, version 3.3, since in this case the basic requirement is that the number of continuous-time states of a model is fixed during a simulation.

The basic idea for multi-mode modeling is to extend the Modelica 3.3 synchronous state machines to continuous-time state machines having continuous-time models as "states". Every model can be a "state" of a state machine, including acausal models, such as a capacitor, or a rotational inertia. The number of continuous-time states can change at a transition of a state machine. No new Modelica language element is needed, but a generalized semantics for state machines has to be introduced, such as "merge semantics for differential equations". The concepts have been evaluated with a Dymola prototype. Examples that can be handled with this prototype are shown in the figure to the right and below.