Master Project
Topology generation for Co-Design of HEV's

Marco Delgado Gosálvez, Delft Center of Systems & Control, TU-Delft
M.R.DelgadoGosalvez@student.tudelft.nl
Shengling Shi, Delft Center of Systems & Control, TU-Delft
S.Shi-3@tudelft.nl
Steven Wilkins, Mobility & Built Environment, TNO
Steven.Wilkins@tno.nl
Peyman Mohajerin Esfahani, Delft Center of Systems & Control, TU-Delft
P.MohajerinEsfahani@tudelft.nl

Context

Design processes typically follow a top-down sequential approach: Convention and rules-of-thumb tend to dominate the early stages of design, followed by the more detailed stages to optimise the design further. This approach however does not guarantee that the final design is optimal. Instead, to achieve optimal designs, rather a simultaneous bottom-up design approach is required.

Co-design enhances current design processes by automating them and enabling a simultaneous design approach instead. As shown by the example in Figure 1, starting with a set of components, the Co-Design algorithm's first step is to use topology generation in order to identify all feasible topologies. This set is then subjected to a Co-Design optimisation algorithm to obtain the optimal topology.

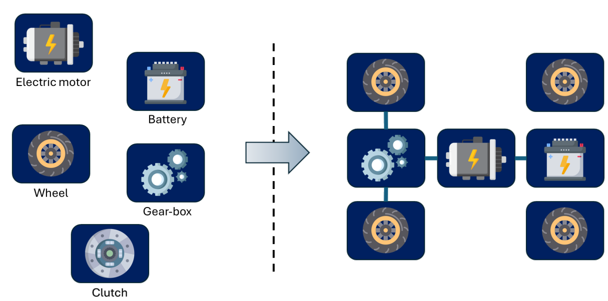

Figure 1: On the right one of the feasible topologies of a battery-powered vehicle that can be made using the set of components shown on the left.

The vehicle industry is actively exploring Co-Design to cut development costs and enhance sustainability. Platform sharing, where different vehicles for various purposes are produced from a common set of components, has been a practice for decades. The emergence of new components/technologies, which allow vehicles to be powered not just by combustion, but also electrically through the use of batteries or fuel cells, enables new topologies from which different types of Hybrid-Electric-Vehicles (HEV's) could be produced. With topology generation a minimal set of components could be found with which a company can produce different HEV's for different purposes.

Unfortunately at this moment topology generation remains very limited. To blame is the curse-of-dimensionality: Already with only 16 components, the number of topologies that can be generated are 5.7×10^{45}. Many of these topologies are infeasible, and so, with the use of constraints, the Mobility & Built Environment (MBE) department at TNO has managed to filter them out, arriving to a much more manageable number of 4779 topologies. But the curse-of-dimensionality remains, and making the topology generation work with hundreds or even thousands of components remains an open problem.

Project Tasks

This master thesis is done in collaboration with the Mobility & Built Environment (MBE) department at TNO, and is aimed at investigating ways to improve topology generation. The work will be aimed at HEV trucks, where there remains ample room to explore from the opportunity of using batteries or fuel cells. The following tasks are considered:

1. Investigate the use of SAT solvers, which solve the satisfiability problem, for topology generation.
2. Review the constraints that were employed by MBE and provide an understanding of their effectiveness.
3. Explore how the number of isomorphic topologies, (topologies that are encoded differently but turn out to be the same), can be reduced or eliminated.
4. Research exploiting more of the data that is available about each component and the requirements that need to be fulfilled.
5. Examine the possibility of completing the topology generation on parallel processes, i.e. distributed topology generation.