Capacitated Multi-Commodity-Flow Cuts

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Many general mixed integer programs in practice contain a block-structure coming from multi-commodity-flow (MCF) formulations. There might be as many network matrices as there are commodities. These network matrices all represent the same graph and they are usually coupled by some "capacity"-constraints, restricting the "flow" on arcs (or edges) of this graph.

It is known that for certain network-dimensioning problems it is possible to dramatically reduce computation times and gaps when generating cut-inequalities (and similar network based inequalities) within the branch & cut procedure. There are mainly two reasons for this. First, these inequalities are strong in the sense that they might define high dimensional faces. And second, state of the art MIP solvers (such as CPLEX or SCIP) are not able to detect network structure within general mixed integer programming formulations.

Our work focuses on automatically detecting such MCF structures together with the coupling of the commodities by capacity constraints in general MIP instances. We identify the underlying network and derive cutting planes based on the network structure. We currently concentrate on network cuts. Given a cut in the network, we aggregate flow conservation constraints for one of the two shores and capacity constraints corresponding to cut arcs. This yields base inequalities which can then be used (following the c-MIR approach (Marchand & Wolsey 1998)) to generate cut-set inequalities (Atamtuerk 2002), flow-cover inequalities (Padberg 1985, Van Roy & Wolsey 1986, Louveaux & Wolsey 2003), and the like, depending on the type of capacity constraints. These inequalities then correspond to a chosen network cut. Our implementation uses SCIP (scip.zib.de) and already shows promising results on pure network-design instances.