On the economic and environmental benefits of collaborative transportation and the coalition configuration problem

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Collaborative transportation among different companies has received increasing attention in recent years. The current state-of-the-art includes collaborative approaches for a variety of transportation problems such as traveling salesman, vehicle routing and inventory routing. In a first part of this talk, I will present a brief overview on collaborative transportation comparing the inclusion of environmental and economic features in related literature. While there are numerous articles emphasizing the potential cost savings of collaborative transportation, with savings ranging from 6% to 46%, the majority do not even mention the potential benefits of collaboration in the environment. Other articles refer to environmental concerns merely as a motivation, while omitting the actual incorporation of environmental aspects into the optimization problems and the assessment of methods and solutions. A few recent experiences show that collaboration is an effective way to reduce CO_2 emissions in road freight transportation. The reduction in cases using real-world data ranges from 11% to 54%.

A problem that has received considerable attention in the literature on collaborative transportation concerns the cost allocation. This problem usually assumes that the whole universe of companies, so-called grand coalition, is formed. Then the problem reduces to allocate the total cost among the companies without creating incentives for them to break out, which follows principles well supported by cooperative game theory. While allocating costs is an important problem, a primary problem concerns the formation of coalitions. This problem has received much less attention in the transportation literature. Since today's logistics operations often involve many players, large volumes of freight and vast geographical regions, the formation of the grand coalition is hardly implementable. In fact, recent literature has argued that in practice cooperation in transportation usually involves just a few partners. In a second part of this talk, I will address a novel problem in collaborative transportation, in which a same company can collaborate in more than one coalition. This problem corresponds to what in game theory literature is known as *coalition configuration*, a relatively new concept in comparison to the more classic *grand coalition* and *coalition structure* concepts. A coalition structure is a partition of the set of players, which is more general than the grand coalition, but still restricts the players to belong to only one coalition. In contrast, a coalition configuration allows for overlapping coalitions (the resulting coalitions are not necessarily disjoint) and, therefore, a same player can be part of different coalitions. This coalition configuration concept is studied in the context of a classic transportation problem: given supply and demand points and cost per unit transported among them, find a collection of coalitions and a transportation plan such that the total cost of fulfilling demand is minimized. I will present two approaches for this problem. In a first one, it is assumed that the overall territory is divided in different areas beforehand and then partitions within each area are searched by means of integer linear models. In a second approach, the coalition configuration problem is embedded into the transportation problem by formulating a mixed integer linear model. In both approaches, the cardinality of the coalitions is restricted by upper bounds, motivated by the fact that although transportation costs are normally reduced through collaboration, as the number of partners grows coordinating the cooperation becomes more problematic. Numerical results are presented for a large case that accounts for a full year of transports in the Swedish industry of forest fuels. These fuels are transported from forest sites to district heating plants, where they serve as source of bioenergy for consumption in all major cities. The case involves 27 companies and 200,000 transports. Collaborative transportation renders about

8% of potential cost savings in this case, and may also help to increase the use of bioenergy. The coalition configuration improves substantially the results obtained by the coalition structure and is competitive with the savings of the grand coalition.