Agent-based Inter-Company Transport Optimization

(Extended Abstract)

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ABSTRACT

In previous work we [1] and other authors (e.g. [2]) have shown that agent-based systems are successful in optimizing delivery plans of single logistics companies and are meanwhile successfully productive in industry. In this paper we show that agent-based systems are particularly useful to also optimize transport across logistics companies. In inter-company optimization, privacy is of major importance between the otherwise competing companies. Some data has to be treated strictly private like the cost model or the constraint model. Other data like order information has to be shared. However, typically the amount of orders released to other companies has also to be limited. We show that our agent-based approach can be easily fine tuned to trade off privacy against the benefit of cooperation.

Categories and Subject Descriptors

I.2.11 [**Computing Methodologies**]: Distributed Artificial Intelligence—*Multiagent systems*

General Terms

Algorithms, Economics

Keywords

transport optimization, inter-company collaboration, agents

1. INTER-COMPANY TRANSPORT OPTIMIZATION

The problem solved here is a set of dynamic multi-vehicle pickup and delivery problem with soft time windows (dynamic m-PDPSTW) [3, 1]. In a dynamic m-PDPSTW a fleet of vehicles of a logistics company has to transport goods from various pickup locations to various delivery locations within specified time windows that may be missed to some degree and are hence called soft time windows.

Apart from pickup and delivery time constraints, the optimizer has to take other constraints into account like vehicle load and weight constraints, legal drive time regulations or order-vehicle and order-order compatibility. In inter-company optimization constraints may differ in type or parameterization. Especially, constraints that define a quality of service like the parameters used for defining soft constraints of pickup and delivery times vary. Also some constraints differ in type between companies like some companies enforcing LIFO loading/unloading or enforcing a maximum amount of empty kilometers by constraints. Partnership negotiations before setting up inter-company optimization will include agreements on boundaries of these parameters to assure a certain quality of service.

The goal is to find optimal plans for each fleet of trucks with respect to the costs involved. Two types of cost models are typically distinguished: fix-variable for own vehicles and matrix-based for subcontracted vehicles. Matrix based cost models specify costs classes for each kilometer and loading meter in a matrix. In the context of this paper, two distance classes and thirteen load classes have been used. In inter-company optimization cost models of different companies may vary in type and parameterization. Some logistics companies solely manage own vehicles applying a fix-variable cost model. Others are only subcontracting vehicles or have a mixture of own fleet and subcontractors. In general, the cost parameters used in the above models are different from company to company. In any case, the cost model and specifically the cost parameters are considered strictly confidential. The agents representing the companies have to keep this information private.

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2. AGENT DESIGN

Inter-company exchanges require the collaboration of distributed optimization platforms. It is therefore perfectly suitable for an agent-based approach. In our approach, every participating company is running its own local agent system. Cost model and constraints are adjusted to the needs of each company. Local optimization of transport plans can be done by classical planners or by an underlying agent system as described in [1] with the latter having the advantage of just having to add agents. A company optimizer agent (COA) on each local system cares for the interaction with other companies. COAs identify each other through yellow pages. Whenever local optimization is idle, the COA tries to identify orders with bad utility for example by looking at low utilization trucks or the revenue/loss the order produces, if available. Then it checks for a partner company to offer the order for exchange. Companies participating in inter-company exchanges are assumed to be usually competitive (see below) wishing privacy of their data as much as possible. In a competitive setup the only information necessary

Setup	Cost Savings	Exchanges
Homogeneous	0.3%	23
Heterogeneous	2.2%	65

Table 1: Cost savings achieved by homogeneous and heterogeneous companies.

to exchange are orders. But companies will also hesitate to offer the whole set of orders to their competitors. Therefore, the company agents have to be able to limit the number of orders sent to balance privacy with the potential for cost savings. This is achieved by introducing a factor p_c that limits the selection of orders to be sent to company c to a subset of p% of the orders.

The order is passed to the COA of a partner company to check if an exchange of orders is possible The agents have to be able to distinguish two types of partnership: competitive and collaborative. In a competitive partnership only exchanges are performed that produce a win-win situation, i.e. both companies have reduced costs after the exchange. Collaborative partnership additionally allows to have win-lose exchanges or order moves, i.e. getting an order without returning another back if the overall costs are reduced. In a competitive partnership, no cost information is necessary to be sent to other companies while in collaborative partnerships cost information is required in order to assure that an order exchange reduces the overall costs of both companies. If COA2 identifies such a possibility to exchange or move orders it suggest it back to COA1. If COA1 accepts they perform the exchange.

3. RESULTS

Empirical results are based on real data of two logistics companies operating in Europe. The data included 876 orders of company1 and 2134 orders of company2. Considerable effort was spent to make sure that the resulting plans are executable in real world. Manual plans have been reproduced to reduce differences in the underlying distance maps or cost calculations to a minimum. Resulting plans have been inspected by experienced transport planners.

The available data allowed us to evaluate the cost saving potential of inter-company transport optimization with respect to company type, partnership type and privacy.

In our example company1 has a majority of own trucks while company2 is mainly subcontracting. In order to evaluate the cost saving potential of inter-company exchange between homogenous companies the set of orders and trucks of company2 have been randomly split into two subsets and setup as two separate 'companies'. For the heterogeneous case a subset of 212 orders from company2 have been used to match the region and time slots of company1's orders. In both setups the type of partnership was competitive and privacy set to be not limited. Table 1 shows the results.

In our experiments we distinguished competitive and collaborative partnership. Not surprisingly the cost savings potential in the latter is higher as shown in table 2. In the collaborative case both companies profit in our example data which can, however, not be guaranteed in general.

As described in section 2 company agents have to control the number of orders sent to another company. The impact of this to the cost-saving potential is shown in table 3.

Setup	Competitive	Collaborative
Inter-Company	1.6%	3.8%
Company1	1.6%	6.2%
Company2	1.5%	1.2%

Table 2: Cost savings achieved by partnership type.

p_c	Cost Savings	Exchanges
20%	0.00%	0
40%	0.48%	20
60%	0.74%	30
80%	1.20%	39
100%	2.17%	65

Table 3: Impact of privacy factor p_c to cost-savings.

4. FUTURE WORK

One factor that is still ignored by this work is that in a dynamic m-PDPSTW the company agent does not only have to decide if an order should be offered for exchange, but also when. Offering an order too late will reduce the chances that a partner will profit from it. Offering an order too early bares the risk of more orders arriving that would have fit to the already exchanged order.

Finally, the optimization described in this paper is cost-based. This is suitable for intra-company optimization where the assumption holds that all orders have to be transported and produce a certain income. Reducing costs in an inter-company exchange only increases revenue, if an order is given away that would have produced loss or if a more suitable order is received instead. It is expected that revenue-based optimization bares even higher optimization potential.

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