On the Formation of Operational Transport Collaboration Systems

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Abstract. This paper discusses the formation process of operational transport collaboration systems. The actors forming this process are divided into two subgroups: potentially participating hauliers and a system provider offering the technical and cooperative framework. As such the formation process is characterized by two decision making problems – that of the hauliers and that of the system provider. Goals pursued when instituting operational transport collaboration are derived from research on strategic alliances and a heuristic procedure capable of supporting both decisions is introduced.

1. Introduction

With idle transports making up for 20-30% of transport distances in road age in Europe and average utilizations of loading spaces of around 60% planning improvements may lead to higher rentability and sustainability for enterprises competing in the road haulage sector [10]. Two observed business trends aiming at a reduction of the aforementioned problems for small and medium sized prises are electronic freight exchange systems, such as Teleroute[1], and business cooperation, such as TimoCom or IDS Scheer in Germany, respectively[2]. iers' motivations for entering either system are improved planning for less-than-truckload (LTL) freight as well as competitive advantages in the dynamic and competitive transport market. With LTL freight, idle trips occur when the truck is completely unloaded at one destination and the next pick up location or the depot has to be reached. Statistical data for Germany shows that idle trips accounted up for approximately 20% of all road transports – or 5.7 billion kilometres – in 2007 [10]. For all trips with loaded trucks the same statistic shows average utilization rates of 57% for transport performance (in ton kilometres) and 62 % in terms of load capacity. The opportunity to exchange individual requests with other hauliers

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[1] www.teleroute.de

[2] www.timocom.de and www.ids-logistik.de

in order to achieve reductions in idle trip distances and increases in load capacity utilization can create significant cost savings for the hauliers.

The option of using electronic market places has been pointed out as solution to such problems for the transport sector [3]. A popular option already used in practice are the above mentioned freight exchange systems. Those systems act like market places offering individual hauliers, customers and freight forwarders the option to acquire or sell cargo. The other option is cooperation. Here, a special type of cooperation, so called operational transport collaboration, will be cussed, for which enterprises exchange short term planning information and tomers' transport requests electronically. The term collaboration refers to this joint planning of the participants. An overview of differences and commonalities of the two options is provided in Table 1. Operational transport collaboration is also an electronic marketplace. The main difference to the freight exchange systems lies in the system setup and objectives. Freight exchange systems aim at enabling transactions between individual participants whereas in operational transport laboration the intention is to seek the overall optimal solution considering the planning situation of all participants.

Table 1. Comparison of operational transport collaboration and electronic freight exchange

	Electronic freight exchange systems	Operational transport collaboration
Objectives	Platform for freight exchange or exchange of individual transport orders	(Close to) Optimal planning solution for all participants, market-based exchange of individual or bundled transport orders
Participants	Open system, anonymous	Closed system, well known
Transactions	One to one (negotiation or fixed price)	Many to many (re-allocation and pricing mechanism)
Organizational embedding	Between different organisations, vertically or horizontally embedded into transportation market	Between different organisations, horizontal cooperation in transportation market

Operational transport collaboration is organisationally embedded into a cooperative framework that establishes rules for the exchange of information, requests and payments. This framework creates security and trust between the participants. The aim of this contribution is to discuss and describe the formation process of a framework for the system of operational transport collaboration.

We focus on the operational transport collaboration as cooperative system that includes the exchange of transportation requests on an operational level and aims at better planning solutions with reduced idle trips and increased utilization of trucks. Research on operational transport collaboration is introduced in Section 2. Looking at the formation process of such a system, we split the strategic decisions into two separate but related decision making problems: the decision making of individual hauliers on whether to enter such a system and the decision of a system provider on which form of operational transport collaboration system to offer in the market. We describe both decision making problems and a suitable heuristic decision making process in Section 3.

2. Operational Transport Collaboration

Operational transport collaboration is established between several hauliers in the market cooperating in their operative planning. The hauliers receive transport quests from their customers on short notice and then plan the execution by solving the vehicle routing problems. The hauliers' route planning is subject to restrictions such as load capacity of the truck. As such the planner might be able to identify requests that if planned conforming to those restrictions increase the operative costs of the haulier significantly. The idea of operational transport collaboration is that some or all of the requests that have been identified as unsuitable are ted to a central pool of which other hauliers can acquire requests and fulfil them in the name of the submitting haulier. At the same time, the submitting haulier has the chance to acquire herself requests from that central pool in order to increase the profitability of her existing tours by improving utilization and increasing nues. The purpose of this request re-allocation in operational transport tion can then be described as a levelling of capacity amongst the participating hauliers with the overall objective of creating a cost minimal allocation of the customers' transport requests to hauliers. The general idea of operational transport collaboration can be found in [12], [14], [1], [2] and [8].

In [12], the authors describe operational transport collaboration as a three phase process. In the first phase, the pre-processing, all hauliers determine the execution cost of all their acquired requests by determining the monetary difference of the planning solution with and without the respective request. Based on those tions they then select those requests they want to offer to collaborating partners plus those requests to be entered into a third fulfilment mode, namely that of subcontracting. In the second phase, the coalition profit optimisation phase, the actual exchange takes place by accepting bids from all hauliers for all requests but their own available in the central pool. The re-allocation problem in [12] is formulated as combinatorial auction problem, similar to those in the models of [14] and [8]. An alternative for which only individual requests are sold in a Vickrey auction is introduced in [2]. In the third phase of profit optimisation and profit sharing the resulting payments from the request exchange are determined and the monetary benefit of collaboration is divided between the participants.

The system of operational transport collaboration, as described above, needs to be embedded into an organisational framework that regulates legal and monetary matters between the participants. We refer to this framework as cooperation. cording to [9] cooperation is established by legally and economically independent partners for the purpose of commonly achieving better results than the partners could achieve individually. As such, cooperation can be seen as a framework der which independent partners operate parts of their businesses jointly in order to fulfil a joint purpose for their mutual benefit. Because of the resulting interdependency of the participants' businesses, the cooperation has a mid- to long-term orientation.

3. Strategic Decision Making Problems

A decision making problem arises whenever a discrepancy between goals and tual performance is discovered or whenever a new possibility for better ance in existing goals is discovered. The first situation can be described as the risk of failure whereas the second situation refers to the discovery of a chance for improvement [7].

The **formation process of a system of operational transport collaboration** in the transportation market can be described as two separate decision making lems. The decision of each haulier is on whether to enter a system of operational transport collaboration or not and if so which system for which conditions. The decision on the system's design and set-up is made by potential providers of such systems in the market. Both decisions are based on a long time horizon and as such they are strategic. To our knowledge, the problem of the formation of tional transport collaboration has not been studied so far. However, a similar lem in the airline industry for strategic alliances exists. Strategic alliance tion has been studied in general and for special industry sectors and the results of those studies provide valuable insights into the formation of operational transport collaboration.

Technical procedures exist that support the decision making process by fying and evaluating alternatives. As discussed in [7] two main categories of sion procedures exist: analytical and heuristic. Common to both types of dure is that the decision process aims at solving an existing problem by selecting an alternative that improves or at least maintains the current situation. The main difference between analytical and heuristic procedures is that analytical dures have to comply with restrictive prerequisites, follow restrictive formal ria in order to find optimal solutions and only support decisions with regards to quantitative goals. Examples of analytical procedures are cost-benefit analysis or solving allocation problems in production planning. Heuristic procedures, in trast, can incorporate qualitative goals in the decision making and are adapted to each problem individually. As such, heuristic procedures are better suited for supporting strategic decisions.

A **decision on participation** in operational transport collaboration and the decision on the collaborative system's design can be based to a large degree on quantitative data such as expected revenues or efficiency of the re-allocation mechanism. However, in case of entering the cooperation, the decision maker will also make qualitative considerations regarding trust in partners and the security of customer data before agreeing to a cooperative system as discussed in [15]. Then, heuristic procedures have to be chosen.

Following the suggested heuristic procedure of [7] we characterize the decision making of hauliers that might lead to participation in operational transport laboration. Therefore, we assume a situation in which independent providers in the market exist that offer platforms for the operational exchange of transportation requests. The situation is similar to that of strategic alliances that operate flights jointly. A customer may book a flight with one of the participating airlines but the flight might be operated by one of the partner airlines in the name of the original provider. In the case of operational transport collaboration, the platform providers then offer the technical solution for a re-allocation of requests, such as an online combinatorial auction [8]. Because of the similarity to airline alliances we use isting studies on strategic alliances in order to describe the decision making lem and process.

The generic decision making process is depicted in Figure 1. The process starts with the discovery of the decision making problem, e.g. a challenge for future business operation such as the long-term successful operation in the transportation market by entering cooperation. Research on operational transport collaboration and strategic alliances identifies various **drivers to establishing cooperation**. Coming from a marketing perspective, [15] identifies firm internal motives or drivers to forming alliances. The firm internal motives are further divided into the categories market, product, resource, knowledge, and transaction risk. **Market lated** drivers include chances such as entering new markets or protecting the pany's position in markets already served. Increased competition seems to be the main driver in the transport sector [9, 6, 1]. This increase is due to globalization (the EU enlargement for Europe) and the cabotage right extension. With higher competition hauliers are forced to reduce their costs in order to offer competitive prices. The motive of entering new markets is also thinkable and found in port cooperation. Hauliers might strive for a geographical extension by setting up cooperation with hauliers of different geographical markets in order to offer transports into those regions at competitive prices. This motive finds empirical support in the study of [16] on future trends in the transport sector conducted by the phi method where the experts rated the two options for small and medium sized enterprises of extending the geographical area and extending the customer base by cooperation on average as 'successful' strategy.

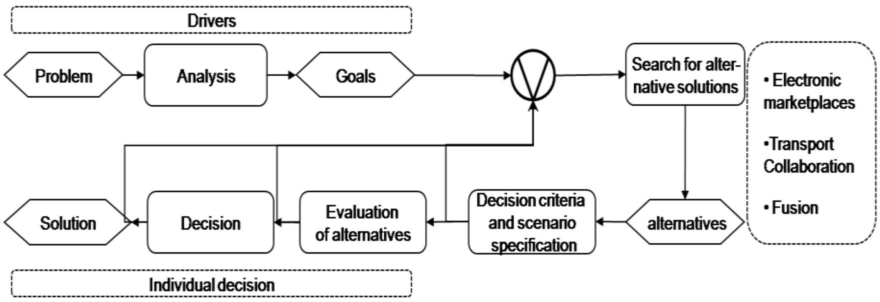

Fig.1: Individual haulier's decision making depicted as Event-driven process chain

As [15] states, the **product related** motives include "filling in gaps and broadening current product lines". The transfer to the transport industry is supported by the study of [16] which identifies demand trends to make the conditions of delivery the most important factor in future buying decisions. The most crucial factor identified in terms of the conditions of delivery is the ability to deliver within strict time windows. This trend might lead to even more idle transports, if the time windows do not match well into the planning of the haulier. The option of tional transport collaboration however extends the decision space since it also cludes the incorporation of the order into other hauliers' plans. With an extension of the decision space more efficient solutions can be found while fulfilling the customer's service requirements.

Since we assume the cooperation to be based solely on terms of operational planning, an obvious influence on **resources** is not assumed here. Regarding **knowledge**, organisational learning is identified as one of the motives for tion in contrast to one-off arrangements in [15]. Organisational learning offers the possibility to create trust among the participants and to understand the mechanism and the resulting request re-allocations. Trust and knowledge of the system can also lead to a reduction in transaction risk. **Transaction risk** in terms of tional transport collaboration lies in the non-fulfilment of transferred requests or the failure to comply with the specified requirements (such as time windows) as well as in hauliers enticing customers away from their cooperation partners. other driver to be added to the motive of knowledge is the protection of tional knowledge and information. Entering operational transport collaboration implies the exchange of customer data which may be highly sensitive. For the cision process this means that one of the goals may be related to the highest ble degree of protection of the hauliers' information and knowledge.

For the decision making process it is crucial that the haulier identifies the reason for a strategic change first. These reasons will also determine the goals pursued and as stated, those goals are individual and differ from haulier to haulier. If the goals are known a search for alternative solutions starts, leading to a list of existing and available solutions. After listing the alternatives, a specification has to be made of how goal achievement can be measured. This leads to a statement of decision criteria and related potential parameter values (e.g. continuous scales for monetary outcome). In a dynamic business environment, chances and risks can turn up frequently. The realization of new chances and risks within the decision process may require an adjustment of the goals set and as such, the procedure leaves the formulation of quantitative goals and the specification of qualitative goals to the latest possible moment. Therefore, the decision procedure proceeds with the search and analysis of alternative solutions before deriving the decision criteria of the goals and possible future scenarios based on the latest developments.

At the same time, scenarios for alternative future states have to be made. Based on the decision criteria and the alternative scenarios the alternative tions can be evaluated which finally leads to a decision and the realization of the preferred solution. The last three steps of decision criteria and scenario tion, evaluation and the final decision are omitted here since these steps are individual to each haulier and cannot be discussed in general. These three steps can also result in a new or additional search for solutions if criteria or possibilities previously not considered are found. This can be seen as strength of the heuristic procedure in dealing with strategic decisions since the underlying problems are complex and dynamic and alternatives might only be discovered in later stages of the process. Further, on the level of deciding on participation the possibility to negotiate conditions with the platform providers and other potential participants offers the chance to influence and adjust the alternative solutions.

Although the process of designing an operational transport collaboration system is like a black box to the hauliers, the criteria considered and to be fulfilled for deciding on a system have to be the same for hauliers and providers in order to establish a cooperative system jointly. In consequence, we describe the process of setting up a cooperative system of operational transport collaboration next.

For considerations regarding the **design of cooperative systems**, again search on strategic alliances is considered. Strategic alliances can be defined as "voluntary interfirm cooperative agreements, often characterized by inherent stability arising from uncertainty regarding a partner's future behavior and the sence of a higher authority to ensure compliance" [13]. This definition rates the most important aspects, namely those of opportunistic behaviour and the ability (or inability) to enforce the agreement. Opportunistic behaviour is the attempt of individual participants to manipulate the alliance or cooperation outcome towards an improvement of their own situation. The analysis of opportunistic haviour may be conducted by means of Game Theory which is capable of ing monetary incentives to cooperation as well as incentives to strategic behaviour that result in compliance or deviation with the agreement. In [13], three sions of explaining the establishment of cooperation from a game theoretic point are derived: the pattern of payoffs, the perception of future outcome and the number of players. The dimensions are illustrated by the Prisoner's Dilemma, in which two criminals are questioned separately by the police and can decide on whether to cooperate, that is not to confess the crime, or to deviate and thus fess. This scenario can be transferred and extended to operational transport laboration. Then, two or more players decide individually on whether they act in conformity to the intended mechanism or whether they try to manipulate the results with their behaviour. The pattern of payoffs is then the monetary outcome the haulier expects from collaborative planning. The shadow of the future is related to the repetition of the collaborative planning and the effects a haulier's action has on future rounds. This leads to the aspects of trust in the exchange mechanism and its robustness against opportunistic behaviour and to trust in the partnering hauliers. The third dimension, the number of players, is not further discussed in [13], since the author only refers to a two person game. However, for operational transport collaboration, more than two participants are thinkable and realistic since proved planning through an extension of the decision space is sought. The sion omits any self-interest the provider might have in setting up operational transport collaboration. However, for the system provider monetary goals are relevant and may well influence the selections made.

Using the existing models of operational transport collaboration and the three structural dimensions of [13], we suggest a split of the decision making problem of system design into three parallel subproblems. The decision making problem of system design is depicted in Figure 2.

The first subproblem relates to the **cooperative framework** which specifies the participating partners, the duration, and the possibility of accepting new partners later on. In a first step possible frameworks are created. A potential framework could for example be a maximum of five participants, an exclusive cooperation, and a contract based on the duration of ten years. Then the decision criteria are determined, such as stability, robustness to strategic behaviour, and their evaluation is specified (for example score-based rankings of alternatives by senior management for qualitative criteria). The decision then leads to the preference of one of the frameworks as solution to the subproblem.

The second and third subproblems are solved in a similar manner. The second problem aims at finding a good **mechanism for re-allocating** customer requests. Alternative mechanisms include e.g. Vickrey auctions, Generalized Vickrey tions or reverse auctions [5]. Decision criteria can be derived from economic siderations [4]. The third subproblem compares different schemes for **profit ing** such as the Shapley value or subsidies to cooperation participants as discussed in [11].

Solutions to the individual subproblems influence each other and have to be combined carefully for the overall system design. The three subproblems have been suggested to simplify the decision making; however, the overall problem of system design requires one solution and as such compatible solutions to the subproblems. For example, if the solution to the first subproblem is an exclusive cooperation of two hauliers, then using a combinatorial auction is not likely to be a good solution to the second subproblem anymore since solving the combinatorial auction problem adds additional and unnecessary computational steps to the practical collaboration. Also, the solution to the third subproblem (profit sharing) will influence participants' behaviour and these changes might lead to changed performance regarding the efficiency of certain mechanisms. The resulting solution to the platform provider's decision problem is then an offer of a system for operational transport collaboration in the market. This offer is one of the alternative solutions considered by each haulier. The offer can be evaluated by the haulier regarding mainly qualitative decision criteria related to the cooperative framework but also regarding improvements of the planning and cost situation for different scenarios that include different degrees of participation of the cooperation partners. The participation can vary from one planning period to the next since it always involves the autonomously made operational decision on how many transportation requests to offer to cooperation partners and on how many to acquire from them.

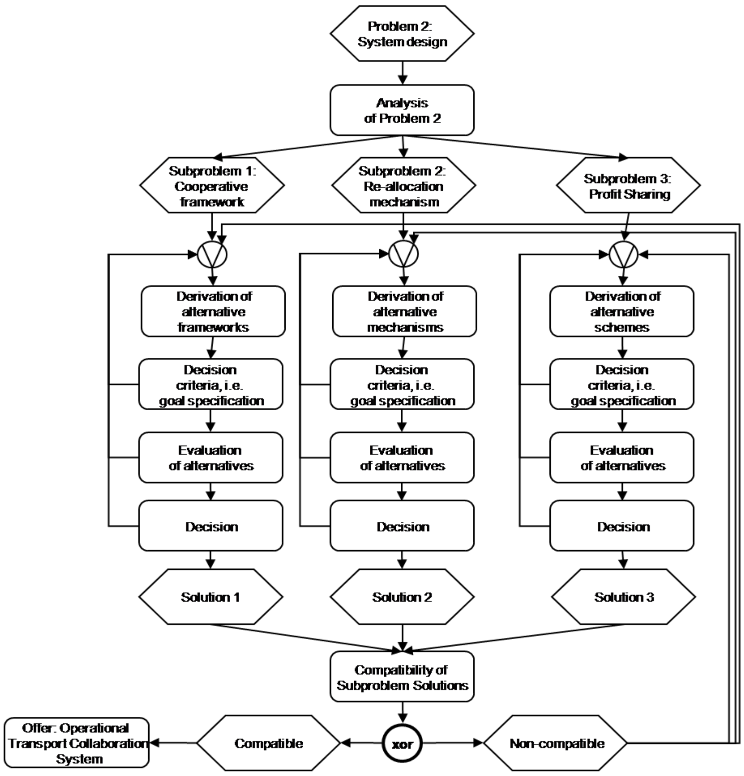

Fig.2: Decision on the design of the operational transport collaboration system

4. Conclusions

The formation process of operational transport collaboration systems has been scribed as two distinct decision making problems – one for the haulier considering participation and one for the party offering the system. Although the decision making problems are distinct they are also interlinked, since the goal formulation and derived decision criteria of the haulier determine the acceptance and as such the success of the offered system. For both decision making problems not only quantitative goals such as expected cost reduction or generated revenue are vant but also qualitative goals like mutual trust. Therefore, a framework for the heuristic decision making procedure has been suggested and aspects related to the procedure have been discussed for both problems. The procedure is capable of considering multiple quantitative as well as qualitative goals. Additionally, the procedure defers the specification of the decision criteria to the latest possible moment which improves its performance in dynamic environments. The sion here is limited to very general goals with no decision criteria specified since those depend on the situation of the decision maker and her degree of risk aversion.

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