

Herbert Kopfer and Melanie Bloos:
*Transport Collaboration Mechanisms for
Autonomous Carriers*

What aspects have to be considered in collaborative vehicle routing and scheduling and how can different mechanisms be evaluated?

Agenda

1. Motivation to collaboration
2. Collaborative vehicle routing and scheduling
3. Evaluation criteria for the efficiency of coordination mechanisms
4. Summary

Collaborative vehicle routing and scheduling

Partial **exchange** of transport requests
between **autonomous** carriers
using a **market**
thereby **reducing cost** and **leveling capacity**
for **each** hauler.

Motivation: 'alliances' to transport

Driver	Threats	Chances
Market	Competition <ul style="list-style-type: none">• EU enlargement• Cabotage rights	Extension of <ul style="list-style-type: none">• geographical area• customer base
Product	'Stricter' demands by customers (eg. time windows)	Better delivery service as competitive advantage
Knowledge	'Being stuck', eg. usage of old technology	Increased learning New technologies
Transaction Risk	Non-reliable subcontractors Contractual penalties	Trust by repeated businesses Long-term agreements

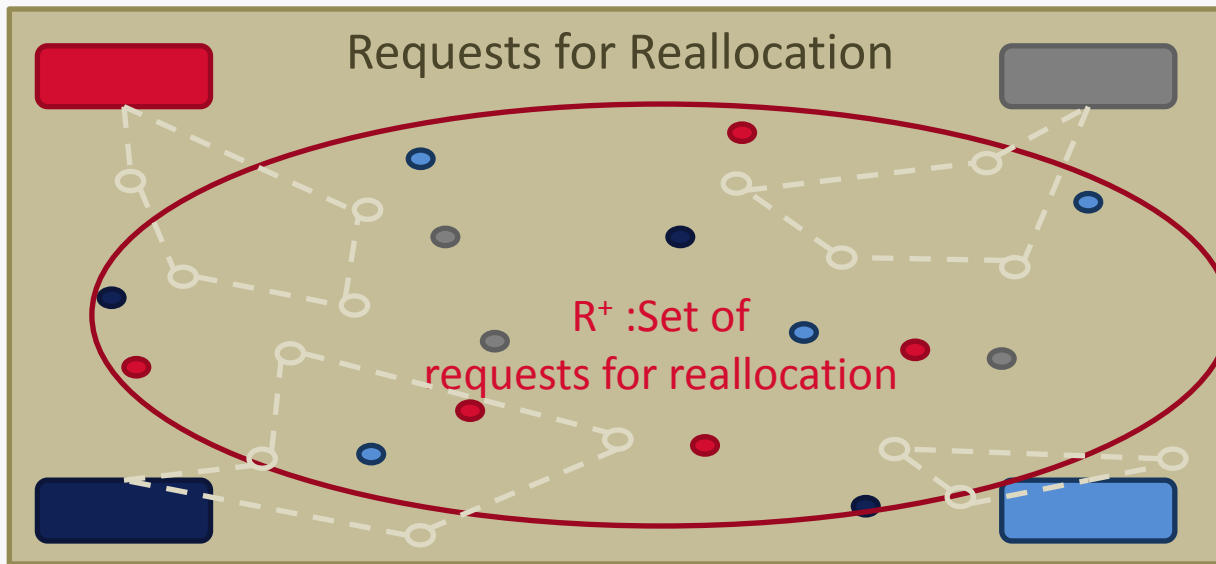
Observed trends:

- Fusion of several SME: IDS Scheer, Timocom
- Electronic freight exchange systems: eg. Teleroute

Comparison to electronic spot markets

	Electronic freight exchange	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 partners
Transactions	One to one (negotiation or fixed price)	Closed system, well known transfer scheme
Organizational Embedding	Between different organizations, vertically or horizontally embedded into transportation market	Between different organizations, horizontal cooperation in transportation market

Collaborative planning



Problems:

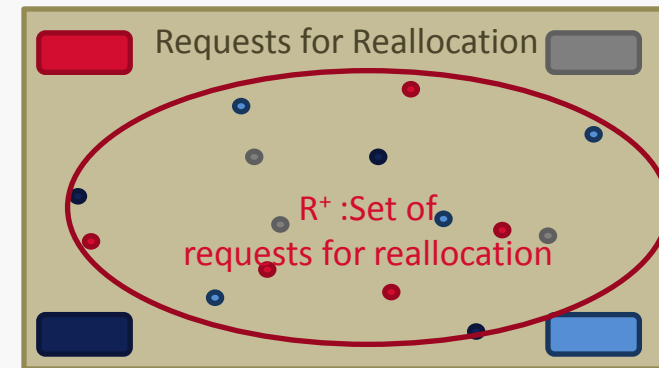
1. Selection of requests for exchange
2. Number and evaluation of bundles $X_k; k = 1 \dots 2^{|R^+|}$
3. Reallocation: efficiency in terms of overall objective
4. Resulting payments: transfer scheme

Exemplary literature on collaborative vehicle routing and scheduling

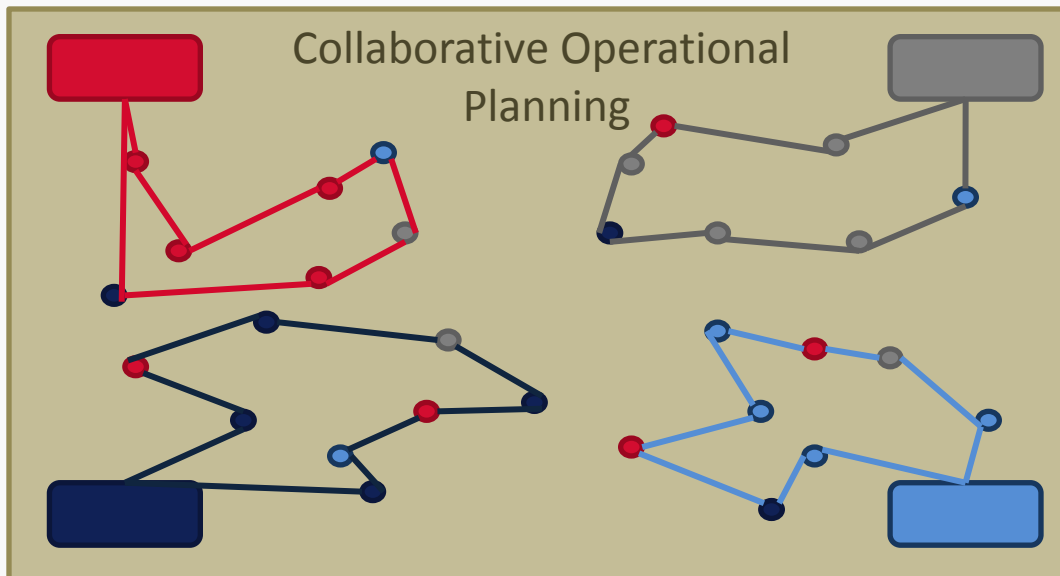
Author(s)	Year	Bundles	Reallocation	Payments
Gomber, Schmidt, Weinhardt	1997	-	Comparison, for LTL: (Comb.) Matrix Auction	-
Schönberger	2005	Routes	Combinatorial Auction, Perfect Information	-
Krajewska & Kopfer	2006	No limitation, bundles not binding	Combinatorial Auction, limited information	Profit Sharing
Berger & Bierwirth	2007	-	Central Multi-Depot VRP Problem	Compensation prices
Gujo, Schwind, Vykoukal	2007	According to location & time windows; only complete bundles	Combinatorial Auction; Perfect Information	-

Number and evaluation of bundles

- Request value = return trip (?)
- Bundle value: \leq sum of return trips
- Bundles generate higher value
- Desirable: only complete bundles sold
- Complexity of real cost functions, travel distance only as approximation



Order reallocation in transport collaboration



Each request creates additional cost p

Submitted requests come with transfer payment t

Utility created by exchange is difference between t and p

Rational preferences, Profit maximization

Evaluation criteria for coordination mechanisms (1/3)

1. Social Welfare

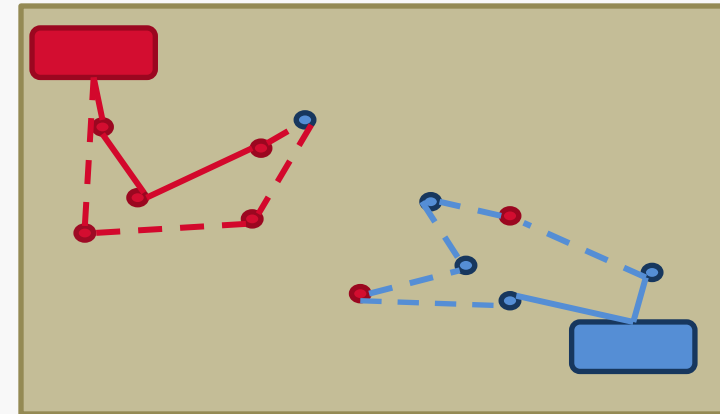
Maximize total utility!

2. Individual Rationality

For each participant: Utility in collaboration ≥ 0 leads to participation

Mechanism: all carriers participate

3. Pareto Efficiency



Evaluation criteria for coordination mechanisms (2/3)

4. Stability

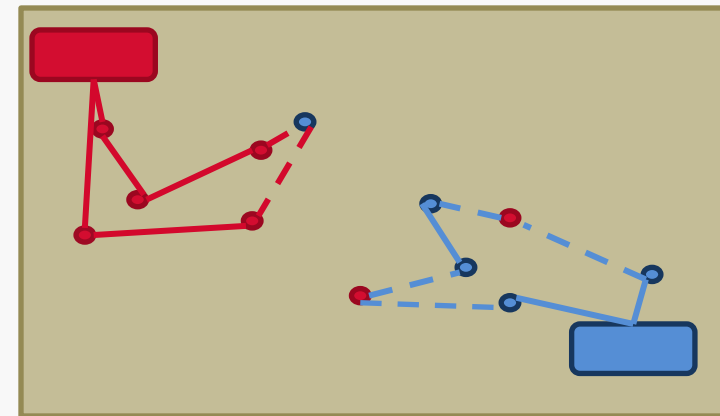
Incentive compatibility:

- no strategic behaviour
- truthful reporting

Coalitions

5. Symmetry

No a priori preference for individual carrier with same evaluation

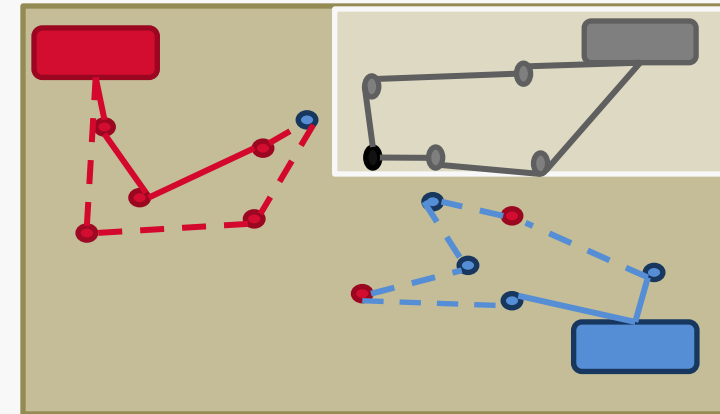


Evaluation criteria for coordination mechanisms (3/3)

6. Computational Effort

Evaluation of 2^N bundles

Repetition → Re-evaluation



7. Distribution and Communication Effort

Bidding

Decentralized transportation planning systems

Profit sharing

- Collaboration advantage indices (Krajewska & Kopfer 2006)
 - Additional profit created centrally, redistribution by “Collaboration Advantage Indices“
 - Assumption of truthful bidding of cost
 - Transfers for participation create additional profit
- Effects only in combination with reallocation mechanism
- Manipulates perception of individuals

Summary

What aspects have to be considered in collaborative vehicle routing and scheduling and how can different mechanisms be evaluated?

- Evaluation of request bundles necessary
- Desired properties of exchange mechanism derived from Game Theory/ Mechanism Design
- Combination of mechanism and profit sharing scheme in order to achieve those properties

Thank you for your attention.

Herbert Kopfer & Melanie Bloos