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Sharing and Coordination to reduce Transportation-raised Pollution

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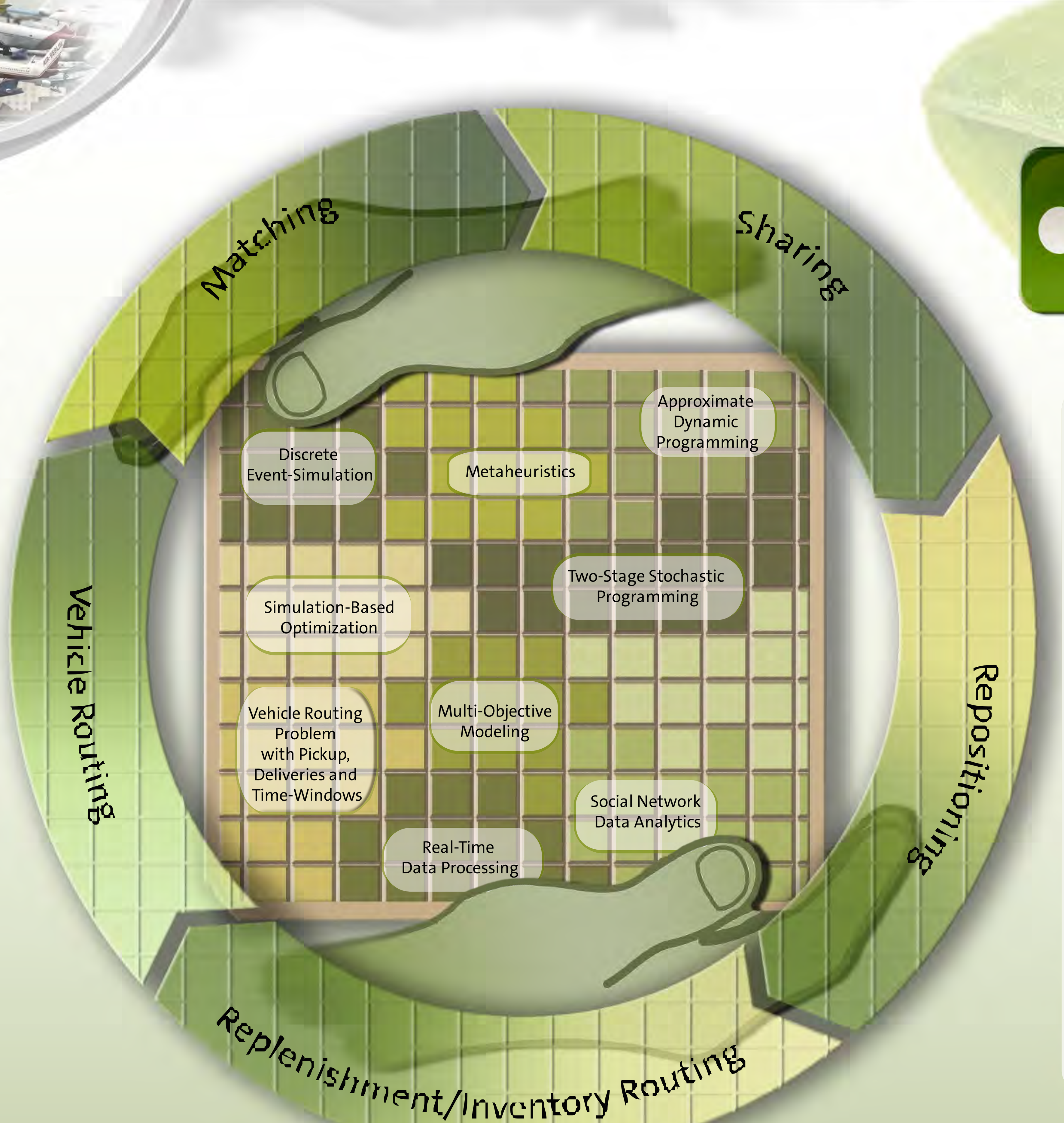
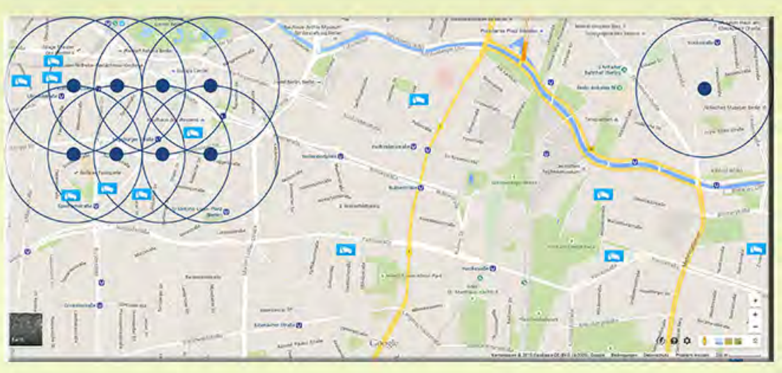
Efficient use of resources on planet earth is one of the major challenges in sustainable development of mankind. In the urban environment, transportation needs form a significant obstacle on the way to more sustainable communities. Growth in trade, mobility desires of individuals, and the ongoing trend of living in cities has dramatically increased this problem in cities all over the world. The negative impact of transport activities is manifold and not limited to the generation of emissions, noise, congestion, or fuel consumption. The European Environment Agency (EEA), e.g., assumes that 400.000 premature deaths each year are caused by air pollution – only in Europe. Nevertheless, transport resources are often used very inefficiently. This is mainly caused by a lack of sharing, collaboration or coordination of community members using these resources. For instance, recently shared mobility systems, as car sharing systems, have been introduced. These systems make use of modern information technology and systems to organize sharing among their users, but still need to be enhanced in order to effectively serve sustainability objectives. On the other hand, there are further urban transport applications that would widely profit from sharing among their users, but still lack necessary information systems to enable sharing. With this project we address both cases and develop effective decision support solutions for mobility sharing with the objective of a sustainable urban transport. We conduct empirical studies in order to understand the needs of members in the different transport communities. On this foundation we design individual planning approaches that use sharing ideas to promote problem-specific suitability objectives. We evaluate the developed approaches with real-world data and actively communicate our results to international stakeholders and related communities. To this end, we have focused on four international cases as illustrated below.



Vehicle Sharing (Hamburg)

Algorithms, information systems, and Apps that let you find a shared vehicle when you need to find it (and another user to share a ride when you want to).

Current market figures from Europe seem to indicate that recently-introduced free-floating car sharing (FFCS) can be a breakthrough for the car sharing idea, taking the step from a niche service to a mass means of transportation and a serious alternative to a self-owned car. The convenience to rent and park vehicles almost at any place within cities seems to convince new user groups, making it an attractive product–service system (PSS) for the automobile industry. Recent studies assume that one car sharing car can replace up to eight conventional cars. Empirical research has shown that in order to use this potential and to convince more and more users of car sharing as a substitute to their self-owned car, constant availability of shared vehicles is crucial. Literature shows that PSS initiatives in the automobile sector often do not unify identified key elements to meet sustainability challenges of the industry. FFCS with appropriate decision support for vehicle relocations addresses major sustainability objectives for PSS defined by Mont (2002), such as, e.g., alternative product use, resource productivity, and functional efficiency. Like other vehicle sharing systems, FFCS systems face significant regional demand fluctuations. Thus, providers might have to reposition empty vehicles to not loose potential customers. However, this aspect has been hardly examined in research and practice regarding FFCS. This study aims to investigate cost and carbon-efficient relocation strategies for FFCS in the case of car2go. For this purpose a demand analysis for car2go was conducted, an integrated decision support approach was developed, and relocation strategies were evaluated with respect to both objectives based on a discrete-event simulation model using real-time data from car2go. The results show that the proposed approach is effective and has a significant potential to reduce costs and related emissions.



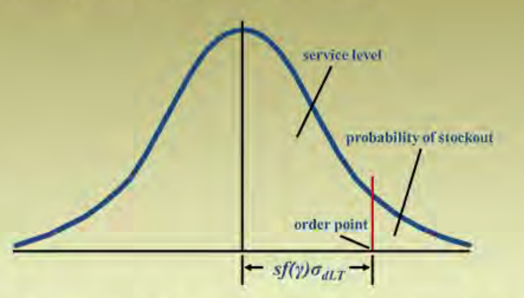
Container Trucks (Valparaíso)

Matching systems that enable truckers to share capacity and orders.

Port-related emissions are a growing problem for urban areas often located directly next to ports highly frequented by trucks and vessels. Empty trips make a significant percentage of truck trips and are responsible for a significant share of port emissions. Truck appointment systems (TAS) allow scheduling of truck arrivals and enable collaboration among truckers. Nevertheless, TASs leveraging the potential to reduce avoidable emissions raised by empty trips have hardly been studied. With this study we aim to demonstrate how a TAS following this idea may be designed and evaluate the approach. We thus review requirements for a collaborative TAS and develop a discrete-event simulation model to assess coordinated truck appointments in a practical case of drayage. The results indicate that the approach effectively reduces port-related truck emissions, but might create congestion in the port. The considered case refers to drayage processes, but may also be transferred to the hinterland. The developed simulation model assumes a generic truck appointment process and may also serve to analyze diverse cases.

Empty Container Management (South America)

An empty container strategy that makes use of empty slots on vessels to avoid unnecessary trips.



Inventory control of empty containers in hinterland transportation systems has a significant impact on the efficiency and sustainability of hinterland container transport. In hinterland container transportation, containers are transported between terminal and th- customers' location by trucks, trains, and barges. To exactly forecast the demand of empty containers is a challenging task, and we therefore need to build an efficient approach to reposition the empty containers. In this project, we propose an efficient inventory strategy to control empty containers. To satisfy the demand of empty containers, we reposition empty containers from other hubs based on various inventory policies. We also consider leasing of empty containers. For the leased containers, we may return the number of empty containers leased to the leasing company after a specified time. To evaluate inventory policies, simulation is used in order to estimate the expected costs and emissions. We use the simulation-based optimization to set parameters of the inventory policies.

Push-Back Vehicles (Oslo)

Decision support that lets airport planners release airplanes at the right time to minimize their emissions on the ground.

Airport emissions have recently received plenty of attention by regulators, airport operators, and researchers developing approaches for environmental sustainability. Empirical research has shown that airside or ground operations form a significant percentage of overall airport-related emissions (British Airports Authority, 2011; Ekici et al., 2013; Winther et al., 2015). Among those operations taxiing is one of the most emission-intensive processes, closely related to the initiating pushback process – that in many cases determines the taxiing duration (Simaiakis and Balakrishnan, 2010). Thus, various approaches to reduce taxiing emissions have been introduced recently (Simaiakis and Balakrishnan, 2009; Wollenheit and Mühlhausen, 2013). These studies focused on the development of alternative engines or pushback rates to control the taxiing duration, but did not consider planning approaches to grant the availability of pushback vehicles in a holistic planning model for airside operations. Possible approaches to tackle this problem are simulation and optimization models for an effective management of pushbacks as a resource at the airport. Promising relocation models (Herrmann et al., 2014) and adaptions of the vehicle routing problem (Schwarze and Voß, 2015, 2012) have been proposed for related problems in different domains. Airside operations at major airports involve a complex interplay of many operations and parties (Smith et al., 2014) and thus need to be planned and optimized in a coordinated fashion. Yet, existing approaches have not been applied in a comprehensive planning environment for airside operations. They rather understand pushback availability as an input for taxiing planning (Simaiakis and Balakrishnan, 2009). We propose to plan taxiing in order to minimize waiting times and emissions and to schedule pushbacks on that basis. For this approach pushback vehicles need to be relocated according to the position of aircraft scheduled for taxiing. In this work we develop an algorithm-based relocation approach for pushback vehicles that enables an effective minimization of waiting times and emissions during the taxiing process. These algorithms are applied in a realistic simulation environment for airside operations and evaluated for the real-world case of Oslo Airport, Norway.

Selected related articles:

Sascha Herrmann, Frederik Schulte, and Stefan Voß. Increasing acceptance of free-floating car-sharing systems using smart relocation strategies:a survey-based study of car2go hamburg. In Computational Logistics, pages 151-162. Springer International Publishing, 2014.

Frederik Schulte and Stefan Voß. Decision support for environmental-friendly vehicle relocations in free-floating car sharing systems: The case of car2go. Procedia CIRP, 30:275-280, 2015.

Frederik Schulte, Kevin Tierney, and Stefan Voß. An approximate dynamic programming approach to manage vehicle sharing systems. (Working Paper)

Frederik Schulte, Rosa G. González Ramírez, and Stefan Voß. Reducing port-related truck emissions: Coordinated truck appointments to reduce empty truck trips. In Computational Logistics. Springer International Publishing, 2015.

Frederik Schulte, Branko Bubalo, Douglas Smith, and Stefan Voß. Optimized Push-backs to reduce Aircraft Emissions in Taxiing. (Working Paper)

Frederik Schulte, Norberto Sainz, and Stefan Voß. A Bi-Objective Simulation Optimization Approach for Empty Container Replenishment considering GHG Emissions. (working Paper)

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