XXIII International Conference MHCL 2019 – Extended Review Abstract

A heuristic approach for operating the marine container drayage using dummy node concept

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Abstract

CO_2 occupies over 90% of artificially emitted the Greenhouse Gas (GHG). It has the most hazardous impact on the environment. CO_2 is mainly emitted by the factory, road traffic and thermal power plant and so on. As related in road traffic, we focus on freight transportation. In Japan, as shown in Figure 1, in the inbound operation, after the full container arrives at a specific consignee point, we need the time spent for making an empty container, which can be supplied to other customers by cleaning and checking it after devanning operation. On the contrary, a shipper gets an empty container from the terminal or the other customers, and the container is loaded for outbound trip. As well, it is needed that the time for vanning container and so on.

Under such a situation, “Round use of containers” [9] is promoted by Ministry of Economy, Trade and Industry in Japan as one of the projects. To be concrete, inbound/outbound container movements are combined with empty containers’ movement at the inland depot, and the objective is to reduce the throughput of empty containers in an internal area. We focus on a vehicle routing for container transport on this project, there are three conditions for containers: inbound trip, outbound trip and empty condition, and there are two situations for vehicles: trailer truck (with full or empty container loaded), empty truck (as tractor only). The change of situation at each one customer is dealt with two different points: (a) a delivery point and a point with an empty container supplied at a consignee, (b) a point with an empty container demanded and a pickup point at a shipper. By the conventional operation, one truck is assigned to points before and after the situation change at one customer. We propose the operation that one or more trucks can be assigned to points before and after the situation changes at one customer.

Therefore, in this study, we consider the vehicle routing problem taking container conditions and vehicle situations into account without the inland depot but with the precedence constraints between two situations at a customer. Additionally, we propose the heuristic approach based on Ant Colony Optimization for the large scale problem can be solved.

This problem is closely related to the vehicle routing problem with back hauls, that finds an optimal set of paths visiting delivery points and pick-up points after leaving a particular depot in each route, any load is carried on the return trip after delivery operation. There are so many studies related vehicle routing problem. Jula *et al*. [5] treat that the multi-traveling salesman problem with time windows for container’s movement. In their study, a lot of container movements are performed by multiple trailers, each of undertakes a series of two types of container movements: one from an intermodal facility such as port, etc. to a customer and the other vice versa. As each delivery has a pick-up interrelated, a pick-up & delivery pair is regarded as a corresponding node. That study is

similar to our study, in that each trailer has the time limit for working, and it must return to the depot as its time limit is not exceeded.

Imai *et al*. [4] consider the problem of vehicle routing that arises in pickup & delivery full container loaded from/to an intermodal terminal. As most shippers and consignees are located close to in a distribution area near a terminal in Japan, they assume that the requests to a container, such as the time of shipment and the container suitability to goods like type and size, are satisfied. The objective is, that an empty container movement is reduced by a merged route consisted of both delivery and pick-up trips. Then the related cost of the vehicle fleet is minimized. In their study, they consider the full/empty container movement, however, an empty truck movement is not considered. Additionally, as they described, a trailer-truck consists of a tractor and a trailer, normally they can be uncoupled. In Japan, the shuttle service is operated between the intermodal terminal and customers once or twice a day. Thus a tractor uncouples a trailer as a chassis with a container on it, and it leaves it at a customer site, so that the truck can be assigned to the next shipment. Therefore, our study considers the tractor assignment to trailer with full and empty containers.

Cheung *et al*. [3] consider the cross-border drayage problem and show how the regulatry policy impacts the system. In Hong Kong, the container drayage has very low productivity in terms of drivers' time, trip time and tractor time. In a trip, a full container is taken in one direction, and the relevant container returns as an empty in another direction. Therefore they use the approach as a policy evaluator to quantify the benefit of relaxing the 1st policy which the driver, tractor, chassis and container have to be operated simultaneously, and the 2nd policy which a tractor can be operated by one particular driver only. It is shown that their proposed approach provides the good solutions. Breakers *et al*. [2] study a full truckload vehicle routing for transporting loaded and empty containers in drayage operation. This study is so closely related to our study, which considers customer locations, including empty supply and demand locations. However, a full container pickup location as a shipper is not considered. That study considers that the empty containers can be stored at several vehicle depots. However, in Japan, those containers are stored at a container terminal. Thus in our study, the vehicle depot is the same as a relevant container terminal.

Nossack and Pesch [8] consider a truck scheduling problem that arises in intermodal container transportation, where containers need to be transported between shippers/consignees and container terminals and vice versa. They address the problem setting with multiple terminals and multiple depots. It is assumed that as the transportation requests have inbound ones and outbound ones, and the container loading states have full and empty. They propose the heuristic approach for this problem that aims at minimizing the total truck operating time with time windows.

Bektas *et al*. [1] consider the pollution-routing problem, an extension of the classical Vehicle Routing Problem with the objective function that accounts for the amount of greenhouse emissions, fuel, travel times and the related costs. However, they consider only the transport with container loaded, without the empty container's transport and empty truck's movement.

Nishimura and Hayashida [6] assume that each truck can serve a single load at a time, and a driver can assign to customers in the network during a single working time limit. Each location is regarded as any one in a delivery point, a point with an empty container supplied, a point with an empty container demanded, and a pick-up point. They consider the tractor assignment to trailer with full and empty containers in order to minimize CO_2 emissions. Comparing with the conventional operation, our proposed model can reduce CO_2 emissions.

Nishimura *et al*. [7] proposed the MIP model for marine container drayage. The change of situation at each one customer is dealt with two different points, such as (a) a delivery point and a point with an empty container supplied at a consignee, (b) a point with an empty container demanded and a pick-up point at a shipper. It is given that the handling time between different points at one customer with considering the precedence constraints. From computational results in small size problem by CPLEX, it is clear that the CO_2 emissions reduction depends on handling time length.

Therefore, we assume that each truck can serve a single load at a time, and a driver can assign to customers in the network during a single working time limit. This study considers the conventional operation and location type expressed by ACO as shown in Figure 2. In the ACO based heuristic, dummy nodes located at terminal-0, consignee or shipper are needed in order to find the feasible solution for large size problem in Nishimura *et al*. [7]. From the computational results, there are around 20 % reductions of CO_2 emissions in the proposed approach.

Keywords: Freight transportation, Container drayage, Global warming countermeasure.

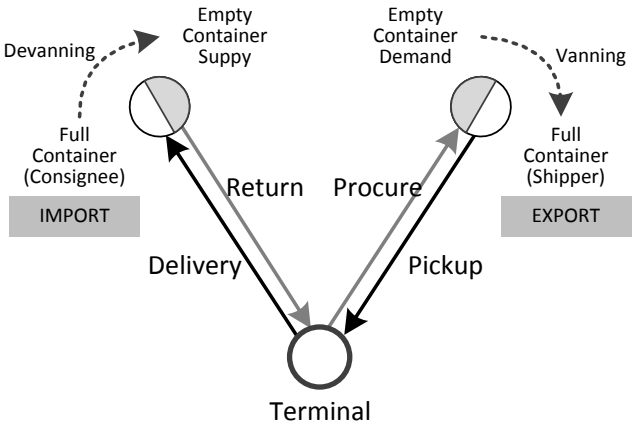

Figure 1. Conventional operation for marine container drayage in Japan

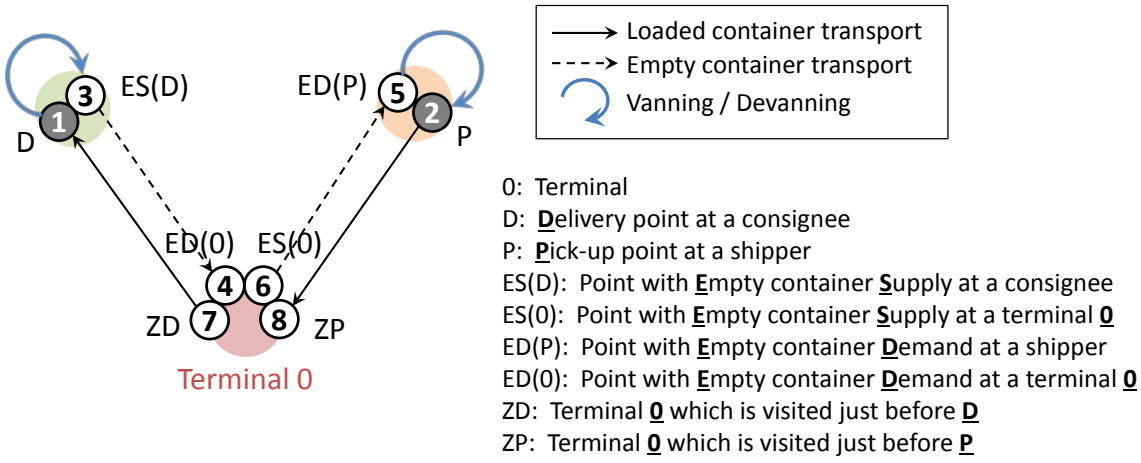

Figure 2. Conventional operation expressed by ACO based heuristic approach

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