A Mixed-Integer Linear Programming model for container assignment optimization on an intermodal network.

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1 Motivation

The greatest part of commercial traffic across the world is carried out by maritime transports and, every year, dozens of millions of containers are moved. Given the huge number of maritime services characterized by different frequencies, travel times and capacity, identify the best path from each origin-destination couple is not a trivial issue to be solved by hand. Furthermore, the optimal flow assignment for the global travel time minimization on the network often does not correspond to find the shortest path from each origin to each destination (which is a problem broadly addressed in the literature) because also delays caused by ports overloading must be taken into account; in fact, containers management operational times are directly dependent on the incoming flow at the port and, for this reason, major ports should be not overloaded, but, instead, ports with a very low traffic may be much more involved in the freight transportation system. Nowadays incoming traffic passes, in its greatest part, through a restricted number of gateways causing a systematic delay in loading/unloading operations. Furthermore, in some cases, the inland component of the expedition is not considered a relevant element in the maritime component path choice. This imply long inland paths which may have a negative effect on the road traffic congestion increasing the probability of accidents if carried out by road, and may yield to frequent delays in goods delivery operations, especially in case of adverse weather conditions, if carried out by rail. Although literature on freight transportation is huge, containers assignment on an intermodal network is still an open issue. In fact, works addressing container assignment are in general more focused on the maritime network neglecting the inland component of the transportation chain.

2 Aim of the paper

In this paper it is proposed a Mixed-Integer Linear Programming model for container assignment optimization on an intermodal network, act to minimize the sum of the total travel times for containers traveling from different origins to different destinations on the network. In this model we address both the maritime and the inland component. Furthermore, we take into account port characteristics as accessibility, loading/unloading times dependent on the port and duty check times depending on port, origin and final destinations of the expedition. Dwell times at ports for a given service are considered as variables of the problem correlated to the ratio between incoming flow at the port and frequency of the service, extending the frequency based approach introduced in [1]. In this way, we can take into account that overloading some gateway ports would imply a delay in the containers management operation. In fact, the solution provided by the model does not assign all the traffic on the shortest path but identifies several attractive paths on which the flow is split. The model aims to minimize the total travel time on the network computed as the sum of the travel times of each container for going from its origin to its destination. Since maritime travel times are generally much larger than road ones, a scaling factor is introduced to make them comparable among each others, otherwise the maritime leg of the chain would play the main role in the path decision process almost discarding the inland component. Port attributes (loading/unloading and duty check times) may be also seen, in a more abstract way, as the port reliability perception that shippers have. In fact, some large shipping companies are used to collaborate with large hubs discarding small and emerging ports, while other companies have established advantageous economic agreements with certain ports, and they use exclusively them as gateway ports. These perception attributes may be used as parameters for the model calibration on real data. In fact, calibrating the model in order to be able to represent the current real container assignment distribution on the services and ports usage rate, we would create a powerful tool to analyze possible future scenarios obtained using estimations on the future origin-destination demand based on countries business and economic development trends.

3 Conclusions and perspectives

The innovation of the proposed approach is twofold. First of all, we address the container assignment problem in its wholeness, through a realistic representation, instead of considering simplified versions of the problems, representing only parts of the distribution process. Second, we introduce a frequency based assignment criteria, which allow the model to identify more attractive paths connecting each origin-destination pair, and to proportionally split the flow among them in order to find an equilibrium between actual travel times (sailing times) and ports congestion. This model may become a powerful tool both for shipping companies and for ports authorities. In fact, shipping companies may use it to identify the most convenient routes for their expedition and ports authority may analyze how the reduction of loading/unloading and duty check times may increase their port competitiveness. Furthermore it could be of particular interest to shipping lines planning new routes or modifying existing routes and to port planners considering expansion plans. An illustrative example will be presented at the conference, showing how the different port characteristics and the frequency based approach impact on the solution. Moreover, a real application to European incoming traffic will be reported, and the model calibration will be discussed in details.

References

[1] Bell, M.G.H., Liu, X., Angeloudis, P., Fonzone, A. and Hosseinloo, S., "A frequency based maritime container assignment model", *Transportation Research Part B*, 45, 1152-1161, 2011.