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Invited Review

# A Survey of Variants and Extensions of the Location-Routing Problem

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# A Survey of Variants and Extensions of the Location-Routing Problem

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**Abstract**

This is a review of the literature on variants and extensions of the standard location-routing problem published since the last survey, by Nagy and Salhi, appeared in 2006. We propose a classification of problem variants, provide concise paper excerpts that convey the central ideas of each work, discuss recent developments in the field, and list promising topics for further research.
Keywords: Survey; Location-routing; Problem variants

## 1 Introduction

Location-Routing Problems (LRPs) combine two basic planning tasks in logistics. In LRPs, as their name implies, decisions on the location of arbitrary types of facilities (plants, depots, warehouses, hubs, cross-docks etc.) are jointly taken with decisions on the routing of vehicles. It is well-known that making these types of decisions independently of one another may lead to highly suboptimal planning results (Salhi and Rand 1989), even if the location decisions must be made for the long term (Salhi and Nagy 1999). We define the term *location-routing problem* (LRP) as a mathematical optimization problem where at least the following two types of decisions must be made interdependently:

(i) Which facilities out of a finite or infinite set of potential ones should be used (for a certain purpose)?
(ii) Which vehicle routes should be built, i.e., which customer clusters should be formed and in which sequence should the customers in each cluster be visited by a vehicle from a given fleet (to perform a certain service)?

We further define a *standard* LRP as a deterministic, static, discrete, single-echelon, single-objective problem where each customer (vertex) must be visited exactly once for the delivery of a good from a facility, and where no inventory decisions are relevant. We give a survey of newer works on the standard LRP in a separate paper (Drexl and Schneider 2014). The present paper discusses variants and extensions of the standard LRP, which include problems with stochastic and fuzzy data, multi-period planning horizons, continuous location in the plane, multiple objectives, more complex requests or route structures, such as pickup-and-delivery requests or routes with load transfers, and inventory decisions.

We consider only problems where the selection of the facilities to use is not implicitly determined by the routing decisions, and where routes for vehicles must be determined, not only assignments of customers or flows of goods. In particular, the selection of facilities will not be implicitly determined by the routing decisions if

(i) there are fixed costs for opening and/or variable (volume-dependent) costs for using a facility or
(ii) (exactly or at most) a given number of facilities must be selected out of a larger set or
(iii) the facilities have some kind of capacity limitation.

We use these criteria as a general guideline for limiting the material discussed in this review. Thus, problems not studied here are pure facility location problems (FLPs, Daskin 1995), and (service) network design

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