Logic-based Benders Decomposition for an Inventory-Location Problem with Service Constraints

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Abstract

We study an integrated inventory-location problem with service requirements faced by an aerospace company in designing its service parts logistics network. Customer demand is Poisson distributed and the service levels are time-based leading to highly non-linear, stochastic service constraints and a nonlinear, mixed-integer optimization problem. Unlike previous work in the literature, which propose approximations for the nonlinear constraints, we present an exact solution methodology using logic-based Benders decomposition. We decompose the problem to separate the location decisions in the master problem from the inventory decisions in the subproblem. We propose a new family of valid cuts and prove that the algorithm is guaranteed to converge to optimality. This is the first attempt to solve this type of problem exactly. Then, we present a new restrict-and-decompose scheme to further decompose the Benders master problem by part. We test on industry instances as well as random instances. Using the exact algorithm and restrict-and-decompose scheme we are able to solve industry instances with up to 60 parts within reasonable time, while the maximum number of parts attempted in the literature is 5.

Keywords: Integer programming, Inventory control, Location, Mathematical programming, Operational/OR, Optimization

1. Introduction

The sale of after-market service parts is a significant source of revenue in the aerospace industry, but it is a complex industry with many unique challenges. Customers who operate aircraft around the world discover failed parts during routine maintenance and may require replacement parts immediately. An aircraft on ground event is estimated [1] to cost between U.S.$5,000 and U.S.$150,000 per hour, depending on the operator and model of aircraft. It is therefore common practice in the aerospace after-market industry to have service agreements that require delivery of failed parts within a specified time window to ensure timely return to service of an aircraft on ground.

[4]Supported by NSERC CRD Grant RPGIN-298767-2007