CALIBER TECHNOLOGY: DESIGN OF A LESS-THAN-TRUCKLOAD NETWORK

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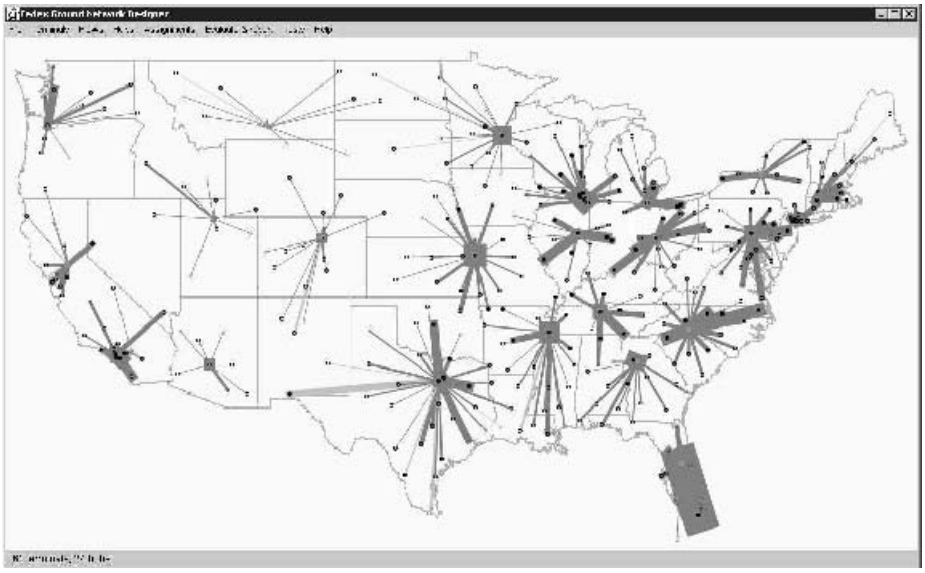

FIGURE 1. Hub-and-spoke network. Each terminal is connected to its parent hub by a line of thickness proportional to the number of packages expected to be shipped on that lane.

1. INTRODUCTION

Caliber Technology provides technical support to the family of Caliber companies. Caliber approached The Logistics Institute for help in building a network design tool. It was decided to test this tool at RPS, a package carrier, in redesigning their hub-and-spoke network. (The Caliber companies, including RPS, were subsequently acquired by FDX Corporation; RPS now operates as FedEx Ground.)

Sending a full-truckload freight shipment directly from origin to destination is efficient. However direct shipments are inefficient when they comprise a small fraction of a truck. This is the typical case in the parcel delivery industry, where shipments are usually less than 50 pounds, while a truck may have a capacity of 10,000 pounds. Less-than-truckload (LTL) carriers can realize economies of scale by consolidating shipments. Most LTL carriers have developed hub-and-spoke systems for consolidating and distributing freight shipments. Figure 1 shows a typical hub-and-spoke network in the United States.

Hub-and-spoke systems work in the following way: The shipment is picked up from the shipper and brought to an origin terminal, the entry point of the hub-and-spoke system. From the terminal, the freight is sent to a parent hub, where it is sorted and combined with other

shipments, and sent on to the parent hub of the destination terminal, where it may be sorted again. From the second hub, it is sent to the destination terminal, which is the exit point of the hub-and-spoke system. A local delivery truck takes the shipment from the destination terminal to its final destination.

The flow of shipments is often more complicated in practice. In an attempt to reduce sorting costs, load planners sometimes take this skeletal hub-and-spoke infrastructure and modify it to maximize their truck utilization, while satisfying service constraints. Unfortunately, a load planner has a local perspective and potentially conflicting operating policies. For example, a load planner at the origin terminal may want to delay shipments so that he can collect sufficient freight to fill a truck and send it directly to the second hub, bypassing the first hub (this is known as "direct load"). However, the load planner at the first hub may want to use that freight to fill a truck to send directly to the destination terminal, bypassing the second hub. Thus a decision made by a load planner may have a cascading effect on load building throughout the network. Consequently, decentralized load planning may result in expensive global solutions. Our goal was to build a tool that would help Caliber Technology in designing a global network to reduce operating costs.

2. Outcomes

We have built a visual, user-friendly tool, NetworkDesigner©, that generates the hub-and-spoke distribution system, based on supplied data (see Figure 1). The front-end of NetworkDesigner is a Java-based graphical user interface (GUI). The back-end is a Java-based heuristic that assigns terminals to hubs. A hub-and-spoke network can be generated in a few minutes or less, depending on the size of the problem. NetworkDesigner generates reports according to the requirements of FedEx Ground. It also accounts for all the shipments and the various costs, and it gives a detailed break-down of the estimated total operational costs — sorting costs, linehaul costs, etc.

Some of the questions that can be addressed using NetworkDesigner are:

- How will assigning a particular terminal to a hub affect freight flows?
- How will re-allocating hub capacities affect the hub-and-spoke network?

- If a hub is over-capacity, should capacity be added to an existing hub, or should planners consider locating a new hub "nearby" ?
- How sensitive are the cost parameters?

NetworkDesigner generates robust solutions that compare favorably with solutions generated by a commercial model being used by FedEx Ground.

3. Other Work

One of the issues that remained was centralizing load planning operations. We developed mathematical models as mixed integer programs (MIPs) to capture all possible shipment routes. This led to a very accurate model, but one that was beyond the capabilities of standard MIP solvers.

Instead of compromising the accuracy of the model, we sought more rigorous theoretical and computational tools. We were able to decompose the problem into smaller networks, each network solvable by a commercial MIP solver. The solutions from these sub-networks were then combined to generate a solution for the original problem. However, the computational time to solve the MIPs sequentially was over two days. To preserve the usefulness of NetworkDesigner, we decided that solution time had to be reduced, allowing an analyst to perform a "what-if" analysis in a reasonable amount of time. To reduce computational time, custom heuristics based on the problem structure were implemented within the commercial MIP solver. We also extended this work to a parallel computing environment.

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