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April 2000

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Designing Perfect Distribution Channels

Software helps determine optimal plan

By Michael Watson and Jim Morton

In today's competitive market, a company's distribution network must meet service goals at the lowest possible cost. In some instances, a company may be able to save millions of dollars in logistics costs and simultaneously improve service levels by redesigning its network. To achieve this, an ideal network must have the optimum number, size and location of warehouses.

To design the best network, one must consider all relevant costs and service-level constraints. Relevant costs include inbound and outbound transportation, fixed and variable warehouse costs, inventory carrying and producing or sourcing from different locations. Complex trade-offs make these costs difficult to analyze. For example, as the number of warehouse locations increase, transportation cost will decrease, but inventory cost will increase. Moreover, costs are often dependent on the location and capacity of plants or vendors, as well as the location and demand characteristics of customers.

Fortunately, commercially available software can make network redesign a manageable task. Several companies make network design software that can model your supply chain and compute the optimum network configuration. Among other things, this software allows you to input facility locations, product information and relevant cost data as mentioned above. To use these models successfully, you must consider all factors that drive your supply chain.

Using software to design networks

The following case study uses network design software to optimize network performance. LogicNet, PC-based software from LogicTools, Inc., is used for the analysis. The case study examines how logistics costs and service criteria impact design of an optimal network. In addition, the example shows how to design a network that meets a desired customer service level by integrating carrier time-in-transit data into the logistics model.

In this case study, "BuyPC.com" is a fictitious company that sells computers via the Internet. BuyPC.com emphasizes next-day delivery of its products so its distribution network must feature high availability and one-day transit time. It ships customer orders using a small package carrier. A network of 15 warehouses located throughout the US provides next-day ground service to most customers. A factory in Asia ships replenishment stock to the port of Los Angeles. From there, products are shipped in truckload quantities to the warehouses.

Figure 1: Product flow and ground service levels for current network.

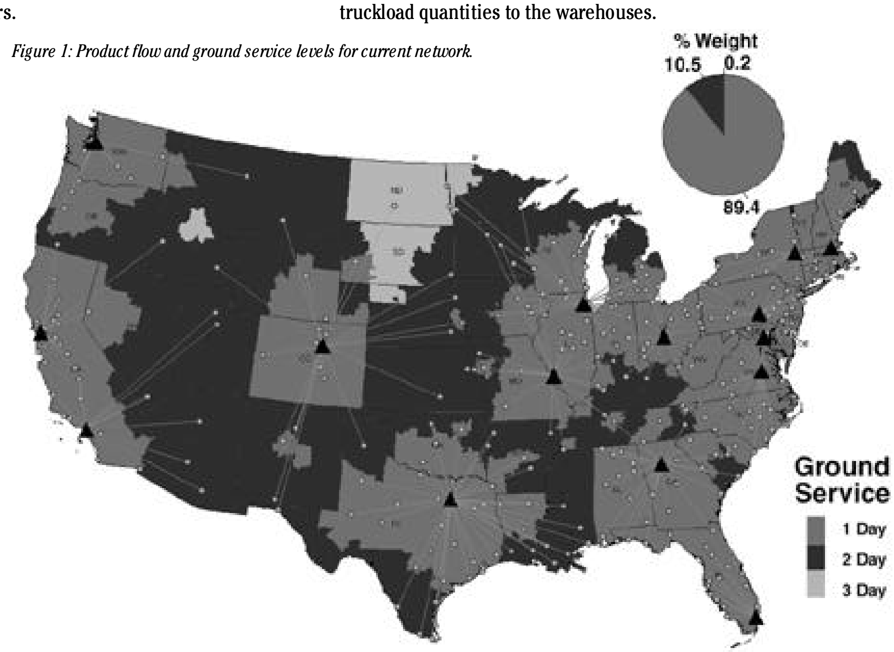


Figure 2: Logistics costs versus number of warehouses for an optimum network.

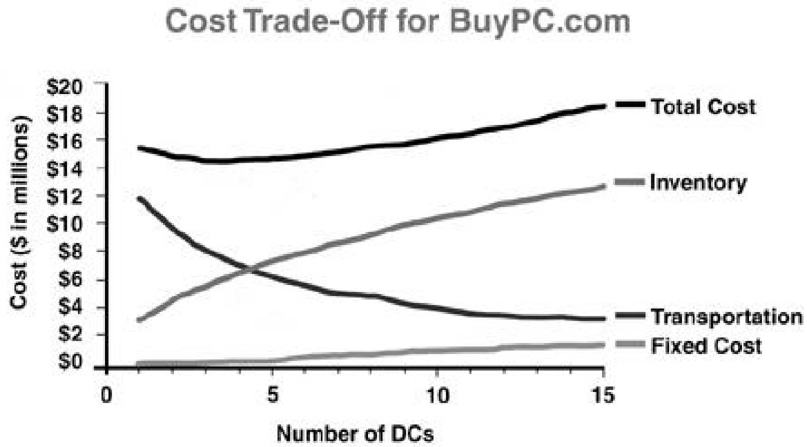


Figure 1 illustrates product flow and service levels within the existing network. In this example, map colors are based on UPS time-in-transit for ground service, with the assumption that each customer is served from the warehouse location that provides fastest service. The pie chart reflects the percent of orders that can be delivered relative to ground transit time. BuyPC.com ships about 90% of customer orders (customers within red areas) inexpensively via ground service. The company upgrades the remaining 10% of orders (customers within blue or orange areas) to one-day air service in order to meet the next-day delivery commitment.

Table 1 summarizes annual logistics costs. Transportation costs are $3.8 million. Average total inventory is approximately $50

Table 1: *Summary of current logistics costs.*

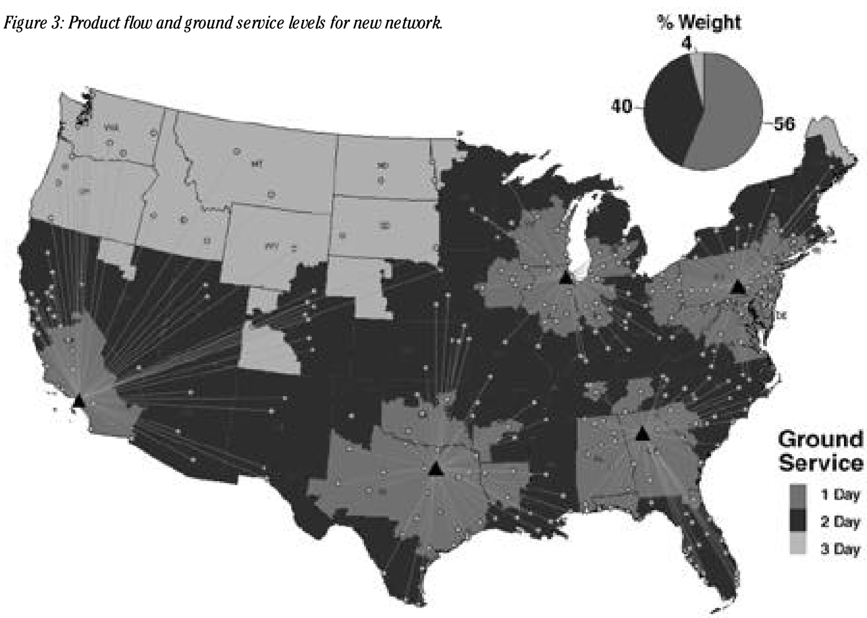
Port to Warehouse Shipping Cost	$850,984
Warehouse to Customer Shipping Cost	$2,929,853
Inventory Carrying Cost	$13,291,150
Warehouse Fixed Cost	$1,875,000
TOTAL COST	**$18,946,987**

million, sufficient to ensure high product availability. Management estimates the inventory carrying cost (ICC) is 25% of the value of the inventory. This estimate includes the cost of capital, depreciation, obsolescence, damage and also shrinkage. Therefore, annual inventory carrying costs are about $13 million. Warehouse fixed costs, including leases, utilities, security and also staffing, are about $1.8 million. Total logistics cost is $18.9 million.

Management wants to reduce total logistics cost by reducing the number of warehouses. Consolidating the network should reduce inventory, ICC expense and brick and mortar expense. Unfortunately, having fewer sites will also increase transportation cost because more orders will be fulfilled via one-day air service. So, what network configuration will achieve the ideal balance between warehouse cost and transportation cost? A single warehouse? Ten warehouses? Where should the warehouses be located? And what financial impact is expected?

Logistics problems such as this one are complex because there are so many possible combinations of the underlying variables. It is virtually impossible to find the optimal solution without the aid of network design software. Optimization-based software models use a mixed-integer programming (MIP) algorithm that intelligently sorts the myriad of possible combinations to find the minimum-cost network. However, in our example, BuyPC.com must minimize total cost and satisfy the service constraint — one-day delivery to all customers. Consequently, it is necessary to set up the model such that it meets both goals simultaneously.

Figure 3: Product flow and ground service levels for new network.



Setting rates

Among other things, LogicNet requires carrier rates for every possible warehouse-to-customer lane. For the model to consider both cost and service levels, the rate assigned to each lane must reflect the carrier service level required for one-day delivery. For example, consider Chicago as a warehouse location. Using ground service, Chicago can reach Milwaukee customers in one day. Consequently, the rate for the Chicago to Milwaukee lane is set to the ground service rate. However, Chicago requires two days to reach Atlanta customers via ground service. The warehouse must upgrade these customers to one-day air service to meet the service goal. The rate for the Chicago to Atlanta lane is set to the one-day air rate. Each lane is assigned an appropriate rate in this manner.

BuyPC.com needs a rate structure that guarantees next-day service. Using the above approach, one can design mixed-mode networks to meet different customer service levels. For example, an optimum two-day network consists of a blend of ground service and two-day air service. An optimum three-day network consists of a blend of ground service and a guaranteed three-day service. In each case, the rate assigned to a lane reflects the carrier service level required to meet the desired customer service level. Integrating carrier time-in-transit information using the rate structure enables the software to examine the complex trade-off between the number and location of distribution centers and the proper mix of ground and premium services.

Optimizing the distribution network

Once all data has been entered into the model, the optimizer is run. In general, LogicNet determines the best set of warehouse locations from a list of potential locations. BuyPC.com wants to consolidate its network by selectively eliminating warehouse locations. Consequently, LogicNet will consider only existing warehouse locations as potential locations in the redesigned network.

Figure 2 depicts optimization results for BuyPC.com. This graph shows how total logistics cost varies with the number of warehouse locations. It clearly illustrates the trade-off between warehouse-related costs and transportation cost. Having just one or two warehouses results in excessive transportation cost. Too many orders are shipped using one-day air service. Conversely, having much more than five warehouses results in excessive inventory and brick-and-mortar costs. A five-warehouse network represents a good compromise and minimizes total logistics cost.

Figure 3 shows the optimum five-warehouse network, including product flow and ground service time-in-transit. This new network costs $15 million annually, a savings of $4 million (about 20%) from the original network. Table 2 shows the source of the savings. With fewer warehouse locations, transportation cost increases by $2.9 million. However, warehouse fixed costs and inventory carrying costs decrease by a combined $6.9 million. Clearly, the savings in warehouse costs more than compensates for the increase in transportation costs. BuyPC.com will now ship about 44% of orders using air service.

Table 2: *Summary of revised logistics costs.*

Plant to Warehouse Shipping Cost	$783,328
Warehouse to Customer Shipping Cost	$5,899,685
Warehouse to Customer Variable/Holding Cost	$7,679,331
Warehouse Fixed Cost	$625,000
TOTAL COST	**$14,987,344**

Decreasing ground transportation costs

Note that the Los Angeles warehouse has a particularly large service area. Los Angeles serves some customers, including locations in the Dakotas, which are actually closer to the Chicago warehouse. This may not make sense unless one considers inbound transportation costs. Intuitively, it is more costly to ship a one-day air package to Sioux Falls from Los Angeles than from Chicago. However, the inbound line haul cost to Los Angeles is much less expensive than the line haul cost to Chicago. With regards to total transportation cost, Los Angeles is the better choice for serving customers such as those in Sioux Falls.

Putting it all together

Network design software is a valuable tool in the design of optimal distribution networks. In our example, BuyPC.com can redesign its network, substantially reducing logistics costs while maintaining a one-day service level. Software models allow you to incorporate all costs relevant to your supply chain. Typically, these models seek to minimize total logistics cost. However, by integrating carrier time-in-transit data with carrier rates, a model can minimize cost while meeting a desired service level, such as next-day delivery. Properly configured, the model is able to find the ideal number and location of warehouses and determine the proper mix of ground and premium services.

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