Transshipment Network Design

According to the 15th Annual State of Logistics Report (Council of Logistics Management, 2004), logistic costs in the United States are rising, from $910 billion in 2002 to $936 billion in 2003. Inventory costs account for a third of this total. The report identifies “the ability to respond faster to changing customer needs” and “the flexibility to adjust manufacturing and delivery cycles” as keys to success in this competitive environment. Even industries with stable demand patterns spend millions of dollars each year coping with uncertainty in customer demand and operating costs. Uncertainty can lead to major supply chain inefficiencies, causing lost revenue, poor service, high inventory levels and unrealized profits.

A promising strategy that can provide crucial operational flexibility to mitigate the effect of demand uncertainty is inventory transshipment. Many clothing and footwear retailers, such as Macy’s and Footlocker, already request articles from other retail locations when a specific product (because of size or design) is unavailable. Consumer electronic stores have also employed such a practice with cameras, video recorders and televisions. Typically retailers will hold high levels of inventory in order to avoid stock-outs, with the flexibility transshipments bring, retailers are able meet uncertain demand with lower inventory levels.

A complete transshipment network, where every retailer is able to transship to every other retailer, provides the most flexibility and thus the most savings. However complete networks use the most transshipment links. Since establishing transshipment links between retailers may be costly, complex or infeasible – industrial engineers have begun to study transshipment models with partial network connectivity. The focus of much of the research has been on group configurations, where retailers are divided into groups and transshipments are allowed within these groups. Studies have shown that savings from such transshipment networks are substantial.

Our work expands the research on partial connectivity by studying other configurations. Specifically we consider chain and star configurations which use the same number of links as a group configuration of size 3. Our results show that savings from chain transshipment networks under all cost and demand scenarios are equal to or greater than savings from group transshipment networks of size 3. This is mainly due to the fact that in a chain configuration retailers are drawing inventory from diverse sources, while in the group configuration a retailer’s transshipment partners are more correlated.

Additionally we see that when demand variability is high and transshipment costs are low then a star transshipment network will experience higher savings than a chain transshipment network. This difference becomes more significant when the cost of stock-out and holding inventory is high.