Research Project Proposed for a PhD Student

Optimization of Multi-echelon Inventory Systems in E-commerce Supply Chains

Haoxun Chen

Full Professor, Supervisor of the PhD student

Industrial Systems Optimization Laboratory, Charles Delaunay Institute

University of Technology of Troyes, France

haoxun.chen@utt.fr

In recent years, e-commerce companies such as Alibaba, JD, and Amazon have been promoting the new retail that integrates on-line E-commerce sites, off-line retail stores, and logistics. One key for the success of this new generation of retail is effective supply chain management to ensure that goods ordered on-line can be delivered from suppliers or retail stores to customers quickly and on-time at lower costs. To achieve this goal, effective inventory management across the entire supply chain of an e-commerce company is critical for it to reduce inventory costs while assuring a high service level to customers.

The following figure 1 illustrates a possible configuration of an e-commerce supply chain. In this configuration, multiple distribution centers (warehouses) are involved, including central distribution center (CDC), regional distribution centers (RDC), and front distribution centers (FDC). The CDC replenishes its inventories of various goods from suppliers, each RDC replenishes its inventories from the CDC, and each FDC replenishes its inventories from its corresponding upstream RDC.

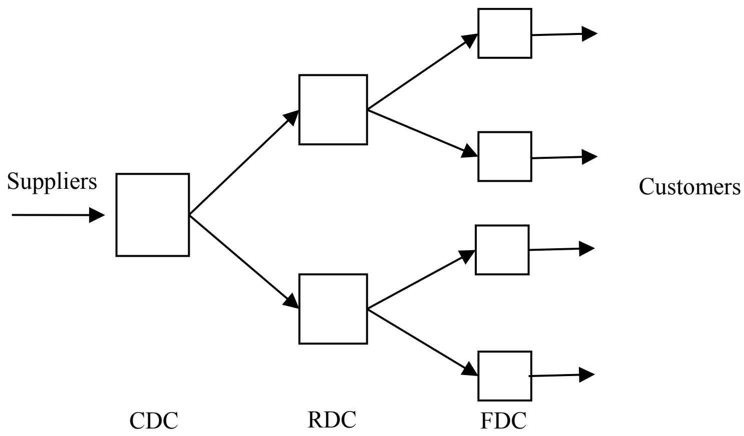

Figure 1: Supply Chain of an E-commerce Company

The inventory management problem of such a supply chain is to determine its inventory policy for each stock to minimize its total cost including order costs, holding costs, and backorder costs. In some cases, except for the cost minimization, a given service level to customers is imposed on the system, where the service level of a stock is usually defined as its probability of non-stock-out. In addition to customer demand and lead time uncertainties, the main challenge for managing such a supply chain is that it is a multi-echelon inventory system with multiple interdependent stocks.

An inventory policy of a stock determines when it places an order to its supplier to replenish its inventory and how many units it should order in each replenishment. Inventory policies used in practice for controlling the inventory of a stock include the base stock (order-up to level) policy, the batch ordering (R, Q) policy, and the (s, S) policy. Which policy is more appropriate for the control of a stock depends on its cost structure. For a multi-echelon inventory system, if the type of inventory policy used for the control of each stock is determined, the remaining problem is to optimize the parameters of the inventory policies used for controlling all stocks in the system. This problem is quite difficult to solve since the stocks in such system are interdependent.

In the literature, there are many papers studying the inventory management of a single stock or more generally multi-echelon systems. However, most studies on distribution systems were focused on so called one warehouse multi-retailer system, much simpler than the supply chain in Figure 1, and even for such two-echelon system, its optimal policy is not known generally and most heuristic policies for the system are quite complicated and difficult to be computed. Moreover, very few papers studied distribution systems with uncertain lead times. However, the lead time uncertainty has a great impact on the performance of an inventory system. So there is a big gap between the theory of inventory management and its practical needs. Currently, we try to bridge the gap by cooperating with Alibaba Group on inventory management under its AIR program (Alibaba Innovative Research program).

In this research project, the PhD student will study multi-echelon inventory systems in E-commerce supply chains especially multi-level distribution systems composed of central distribution centers, regional distribution centers, and front distribution centers. The objective of the project is to develop effective methods for optimizing inventory replenishment and rationing policies in such systems under various criterions and constraints imposed by real applications. To achieve this goal, stochastic programming models and stochastic optimization methods will be developed and implemented in computer programs and tested on real instances to evaluate their performances.

References

[1] Edward A. Silver, David F. Pyke, Rein Peterson, Inventory Management and Production Planning and Scheduling, Wiley, 3rd edition, 1998.

[2] Zipkin, Paul Herbert, Foundations of Inventory Management, McGraw-Hill, Boston, 2000.

[3] E.B. Diks, A.G. de Kok, Optimal control of a divergent multi-echelon inventory system, European Journal of Operational Research 111 (1998) 75-97.

[4] M.C. van der Heijden, Supply rationing in multi-echelon divergent systems, European Journal of Operational Research 101 (1997) 532-549.

[5] Stephen C. Graves, Sean P. Willems, Optimizing Strategic Safety Stock Placement in Supply Chains, Manufacturing & Service Operations Management, Vol. 2, No. 1, 2000, pp. 68–83.

[6] Marti, Kurt, Stochastic Optimization Methods: Applications in Engineering and Operations Research, Springer, New York, 2015.

[7] Peng Li, Haoxun Chen, Ada Che, Optimal batch ordering policies for assembly systems with guaranteed service, International Journal of Production Research, Vol.51, No. 20, 2013, pp.6275-6293.

[8] Haoxun Chen, Peng Li, Optimization of (R, Q) policies for serial inventory systems using the guaranteed service approach, Computers and Industrial Engineering, 80 (2015) 261–273.

[9] Peng Li and Haoxun Chen, Optimization of (R, Q) Policies for Two-Level Distribution Inventory Systems with Operating Flexibility, Proceedings of 2015 IEEE 12th International Conference on Networking, Sensing and Control, Taipei, Taiwan, April 9-11, 2015.