ABSTRACT

Conflicts in the supply chain system put a firm's supply chain at risk and thereby, increase its level of vulnerability. Conflicts are performances of mutually dependent parties in response to potential or actual obstructions that hinder one or more of the parties achieving their goals. The conflicts can disrupt the operation of a supply chain and affect performance measures such as on time delivery and quality. Because of the potential for conflict in supply chains, practitioners have spent significant effort and money to implement safety mechanisms such as accelerating orders, frequent checking of order status and buffer inventories. However, extensive safety measures can cause increased inventories throughout the supply chain leading to obsolescence and increased costs. Therefore, a methodology to detect, analyse and resolve conflicts in a supply chain before they occur (or at least before the effects of a conflict can propagate far-reaching areas of the supply chain) would be of benefit to practitioners. However, this is a difficult task due to the size, complexity, distributed nature, lack of information and lack of goal sharing in supply chains.

Even though the need of conflict detection is noted in the previous research, effective methods to realize detection are still to be developed. Different conflict models have been proposed considering the isolated activities or different functions of the supply chain, but they appear to be fragmented efforts. To develop a better model for understanding the conflict issues in a supply chain, a systematic approach is required to throw light on the importance of supply chain conflicts. The objectives of this thesis are (1) to report and review various perspectives on conflict issues in the supply chain; (2) to understand and appreciate various mechanisms

available for conflict detection and prevention and to identify the gaps existing in the literature; (3) to provide an approach by means of the development of a Colored Petri Net (CPN) model to detect and analyse conflicts in an integrated supply chain system; (4) to analyse various supply chain conflicts using *CPN Tools*, which is a tool for editing, simulation and performance analysis of CPN models and (5) to propose suitable coordination mechanisms to manage the conflicts in the supply chain.

This research proposes a unique and integrated approach for the detection of conflicts in a supply chain. The approach involves linking different levels of the supply chain and detecting conflicts occurring when the single entities, each optimized for its own operations, are combined together in a supply chain. Specifically, a methodology was proposed for synthesizing individual Petri net models combined with matrix equations in order to detect and manage conflicts in a supply chain. These conflicts may stem from differing goals, planning and resources. The methodology offers the user the ability to investigate the potential for conflicts in the system and manage the system to avoid such conflicts before they occur. The application of the tool was performed on the supply chain of a company that designs and manufactures a chassis for an aircraft communication system. The proposed approach holds promise for both the short term and long term for effective supply chain management and design. This would enable the supply chain to put sufficient protection (e.g. buffers) in strategic locations relative to the potential conflict or contingency plans in place to handle the conflict when it occurs.

The development of a Colored Petri Net (CPN) model, with the help of *CPN Tools,* was used for the analysis of conflicts in an integrated supply chain system. The use of Petri nets allows for a high-level

customizable interface for the supply chain manager. The conflict analysis was established with the help of a case study of the supply chain for the manufacture and sale of textile machinery parts. The system consists of two suppliers, the manufacturer, vendors and the customer. Various causes of conflicts analysed in the supply chain are (1) scarcity of right quality material, (2) the non-availability of parts at a specified time from the vendors and (3) the rejection of finished parts after inspection. The manufacturer experienced issues with material suppliers of raw materials as well as the outside vendors who perform various precise machining operations.

The CPN model was used for various experiments to study the system behaviour and particularly, the impact of conflicts in the supply chain. For random time durations of delivery of finished spare parts to the customer, the relative errors between the schedules of manufacturer and the customer were evaluated. The variations in the quantity delivered to the customer due to various conflicts in the supply chain were measured and tabulated. It was observed that the major reasons for conflicts are the parts rejected at various inspection stages in the supply chain. This approach also allows the manufacturer to quantify the impact of conflicts so that suitable precautionary measures can be adopted in the design phase. A variety of manufacturer's problems were considered, where the delivery time of a product is the maximum of the suppliers' delivery times for the parts needed for that product. It was shown that an optimal schedule for the manufacturer's problem can be far from the optimal schedule for the suppliers' problem, and vice versa.

Finally, the coordinated optimal policies for two supply chain situations are studied: (1) a supply chain consisting of a manufacturer and one buyer and (2) a three stage supply chain consisting of an original

equipment manufacturer, a contract manufacturer and a distributor. For a given sales price, determined by the market and charged by the manufacturer, the buyer has control over the order quantity. The buyer's decision is to choose an order quantity that maximises the buyer's expected profit. While the buyer's optimal order quantity maximises the buyer's expected profit, it does not necessarily maximise the manufacturer's expected profit. To induce the customer to order an optimal order quantity that is different from his optimal order quantity, the manufacturer may have to provide some pricing incentive to the buyer. The manufacturer may desire to develop a quantity discount policy to coordinate with the buyer on the ordering decisions.

The impacts of coordination were analysed by comparing the system profits for the model explained in the case study, without coordination in the presence of conflicts and the profit values obtained for the supply chain with coordination. Expected joint profits were calculated for the simulated random demands for the model and the results demonstrated that the expected system profit increases are affected heavily by the reduction of ordering and production set up costs and by the reduction of overstock costs because of coordination.

However, supply chains are complex dynamic systems with intricate interrelations and cumbersome functions. Therefore, additional modelling work is required to capture all characteristics of conflicts in real supply chains. An important research topic is to implement various cooperation mechanisms in the chain to reduce conflicts. Studies that examine the benefits of cooperation should also consider the value of organizational integration. Another research issue is the optimization of the supply chain system by minimizing the effect of conflicts.