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Distributed Framework for designing improved supply chain management system

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***Abstract*— Based on a literature survey, we aim to answer our main question: "How should we plan and execute logistics in supply chains that aim to meet today's requirements, and how can we support such planning and execution using IT?" Today's requirements in supply chains include inter-organizational collaboration and more responsive and tailored supply to meet specific demand. Enterprise systems fall short in meeting these requirements The focus of planning and execution systems should move towards an inter-enterprise and event-driven mode. Inter-organizational systems may support planning going from supporting information exchange and henceforth enable synchronized planning within the organizations towards the capability to do network planning based on available information throughout the network. We provide a framework for planning systems, constituting a rich landscape of possible configurations, where the centralized and fully decentralized approaches are two extremes.**

***Keywords*— SCM, CBR, Demand Forecasting, MAS.**

I. INTRODUCTION

A supply chain can be defined as a network of autonomous or semiautonomous business entities collectively responsible for procurement, manufacturing and distribution activities associated with one or more families of related products Different entities in a supply chain operate subject to different sets of constraints and objectives. However, these entities are highly interdependent when it comes to improving performance of the supply chain in terms of objectives such as on-time delivery, quality assurance, and cost minimization. As a result, performance of any entity in a supply chain depends on the performance of others, and their willingness and ability to coordinate activities within the supply chain. A global economy and increase in customer expectations regarding cost and service have influenced manufacturers to strive to improve processes within their supply chains, often referred to as supply chain reengineering (Swaminathan, 1996).

Figure 1 SCM

For example, Hewlett Packard's Vancouver division reduced inventory costs by approximately 18% for HP Deskjet printers through delayed product differentiation (Billington, 1994). Similarly, National Semiconductor has managed to reduce delivery time, increase sales, and reduce distribution cost through effective supply chain reengineering (Henkoff, 1994). Supply chain reengineering efforts have the potential to impact performance in a big way. Often they are undertaken with only a probabilistic view of the future, and it is essential to perform a detailed risk analysis before adopting a new process.

In addition, many times these reengineering efforts are made under politically and emotionally charged circumstances. As a result, decision support tools that can analyze various alternatives can be very useful in impartially quantifying gains and helping the organization make the right decision (Feigin, An, Connors, & Crawford, 1996). In most organizations, reengineering decisions are generally based on either qualitative analysis (such as benchmarking) or customized simulation analysis.

This is because complex interactions between different entities and the multitiered structure of supply chains make it difficult to utilize closed form analytical solutions.

Benchmarking solutions provide insights into current trends but are not prescriptive. This leaves simulation as the only viable platform for detailed analysis for alternative solutions. However, there are two major problems associated with building customized simulation models: (1) they take a long time to develop and, (2) they are very specific and have limited reuse. Our aim in this paper is to provide a flexible and reusable modeling and simulation framework that enables rapid development of customized decision support tools for supply chain management.

II. SCM CHALLENGES

The old thinking is that if a company had control within its "four walls," operations were smooth, costs were controlled,

and customers were happy. Brick by brick these walls came down - due to numerous external factors that extended the impact on the business and the impact of internal decisions. Now, increased competition, global markets, rapidly changing customer demands and world economical factors have activated a wrecking ball of external business forces.

Companies who focus all of their attention only within their now imaginary walls are wondering why they are having capacity issues, inventory surplus, transportation problems, difficulty with aftermarket sales and more. The reason is that value chains are now made up of large networks, and the focus has to extend to all contributors in that value chain regarding not only the physical flow of materials, but the virtual flow of information.

Customer value is the product of the cumulative effort of the multitude of players within the supply chain. Every weak link in that chain diminishes customer value. The most successful global companies today construct business strategies that**include all members of the supply chain** throughout the entire product lifecycle – from choosing suppliers to aftermarket services as well as optimizing their suppliers' performance for increased quality and efficiency.

Our Supplier Performance Improvement service is used to move cost from fixed to variable, reduce overtime, eliminate waste, reduce rework/scrap and produce throughput. We focus on partnering with suppliers on behalf of the manufacturer to enable the following **Operational and Financial benefits:**

Improved Operations Metrics:

- Reduced Parts Per Million (PPM)
- Improved Delivery Performance
- On-time New Product Introduction
- Functional Quality Management System
- Capacity Improvement
- Yield Improvement
- First Time Quality
- Overall Equipment Effectiveness (OEE)

Improved Financial Metrics:

- Improved Return on Net Assets
- Improved Contribution Margins
- Increased Revenues
- Reduced Cost of Goods Manufactured

III. RELATED WORK

H. L. Lee and C. Billington state that there are organizational barriers between the facilities of the supply chain [9]. Thus**,** information flows can be restricted such that complete centralized control of material flows in a supply chain may not be feasible or desirable [9]. In addition, organizational barriers are not the problems for material flows only, it also applies to optimization, coordination and efficient of the supply chain. **As** most of the companies want to decentralize operational control of their business units or functions geographically, there will be different cultures, objectives and constraints in different organizations. Therefore, it is hard to perform analysis and coordination based on the status of the entire system. There is a need for a distributed information system, which can accelerate the information flow of the supply chain. Agent and the Internet technologies can be one of the solutions.

Hinkkanen has suggested the distributed decision support systems for real time supply chain management using agent technology [4]. He suggests that agent can be modeled as a human and accommodate as many situation as possible. Thus, the supply chain can be driven and managed by agents completely. For optimization of resources allocation, he uses auction market model, which have resource agents and request agents to bid and ask simultaneously. The optimization is focused on the resources allocation within a manufacturing plant but it does not consider the delivery of resources within a supply chain. In this paper, we focus on the optimization of the delivery system of the supply chain and the proposed model can also handle the resource allocation problem.

On the other hand, Beck and Fox develop a mediated approach to coordinate the supply chain instead of a negotiation approach. It consists of a schema for constraint relaxation algorithms on Partial Constraint Satisfaction Problems (PCSPs) [2]. **An** experiment is run and the results show poor performances for a negotiation-based algorithm, while a mediated algorithm using heuristic search decision on the aggregate constraint graph out-performed the human expert. Therefore, using a mediated agent to do optimization is better than every agent carries a bundle of communication information for negotiation. However, constraint relaxation is expensive in term of computing complexity and the performance is mostly depended on the heuristic accuracy. In this paper, genetic algorithm will be used to do the optimization.

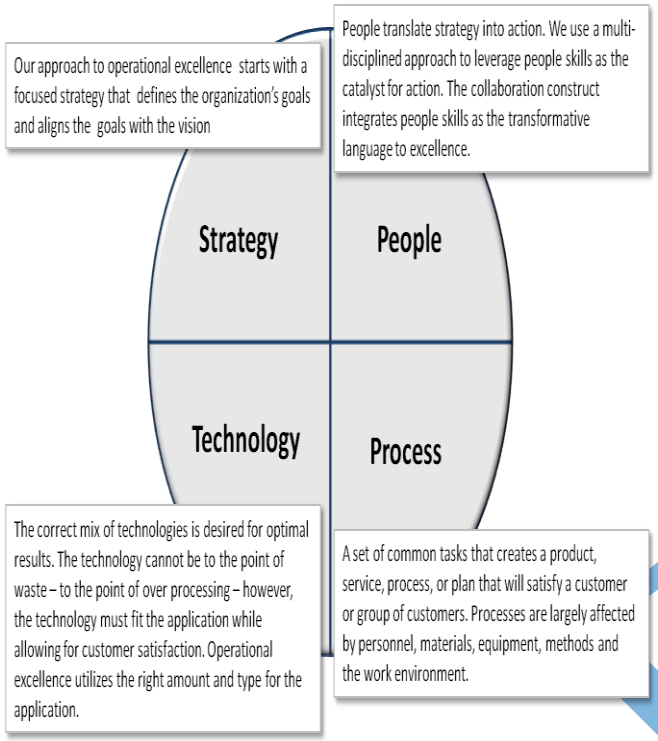
Barbuceanu and Fox integrate an agent-based system with rule based mechanism to the supply chain industry [11. To find the best rules that account the uncertainty of the environment in supply chain, an associated probability is assigned to each rule and state. By employing the Markov Decision Process to simulate the uncertainty, the optimal actions are determined to execute in order to maximize the expected accumulated rewards of the rules and states. Even though best rules can be selected to deal with different situations, a large amount of rules are required to handle all the situations. In addition, due to the rule chaining complexity, rule based system may not able to obtain the most optimal solution.

Kalakota has designed an agent-based real-time system to coordinate the supply chain and model it **as** a multi-commodity network flow problem (MCNFP) with side constraints [SI. He employs the Primal (Benders-type) Decomposition approach to decompose the whole problem into a sub network problem in each time period naturally. When all the sub network problems are solved, the overall problem is solved accordingly. Since the supply chain is highly complicated, the decomposition does not decrease the complexity of the sub-problems significantly. As a result, the computation time is very expensive.

IV. IMPROVING PERFOMANCE OF SCM SYSTEM

There are 4 key ingredients that - with the right mix - can drive **sustained operational excellence** and optimize the supply base. Those 4 ingredients - Strategy, People, Process

and Technology encompass our philosophy of Supplier Performance Improvement Business Transformation.



The Supplier Performance Improvement practice benefits are possible through our proven methodologies and hands-on services performed and perfected with suppliers like you for over 20 years.

- **Supplier Assessments** – A targeted assessment method tailored to assess a supplier's technology, diversification, and performance metrics or to assess the organization against the benchmarked leaders in the industry
- **Supplier Strategic Improvement Planning** – Details the supplier's core competencies, business and financial health, customer alignment and business vision. Defines the organizations' strategy/direction and is the roadmap for strategic decisions, allocation of resources and execution of business planning
- **Problem Solving** – Distinctive, strategic problem solving approach; structured yet flexible enough for complex problems and unique client needs
- **New Product Introduction** – Process validation, Part move execution, Advanced Product Quality Planning (APQP), Production Part Approval Process (PPAP)
- **Production & Operations Improvement** - Facility moves, First time quality improvement, Parts per Million (PPM) Reduction, Scrap reduction
- **Production System Improvement** - New plant start-ups, Work Cell developments, Value Stream Transformations, Lean Manufacturing Implementation
- **Lean Operations Implementation** – Eliminates waste in administrative and service areas using lean techniques to increase efficiency and throughput
- **Variation Reduction & Process Capability Improvement** - Focused on processes (welding, painting, etc.), Improve Process Capability (Cpk), Measurement System Capability
- **Quality Management System Development** - Process/ Quality Audits, Quality Manuals – Document Control, SPC Program, Implementing layered audits, Preventive Maintenance Program

V. DEMAND MANAGEMENT

One of the biggest challenges for any organization is to understand the consumer demand for the goods and services that it offers in the marketplace. However, the story does not just end with understanding demand patterns. The actual magic, should a company be able to effectively harness it, lies in "managing" that demand.

Often, management will deplete its trained resources in a downturn due to less demand. When organizations do this, they will not be prepared for any upturn when demand increases. The business is sourced to the organization that had developed the ecosystem for recovery – opportunity lost. Through demand management, CGN Global works with companies of all types to better predict customer needs, creating an agile organization – transformed to not only handle ups and downs, but embrace the volatility and turn it into a competitive advantage

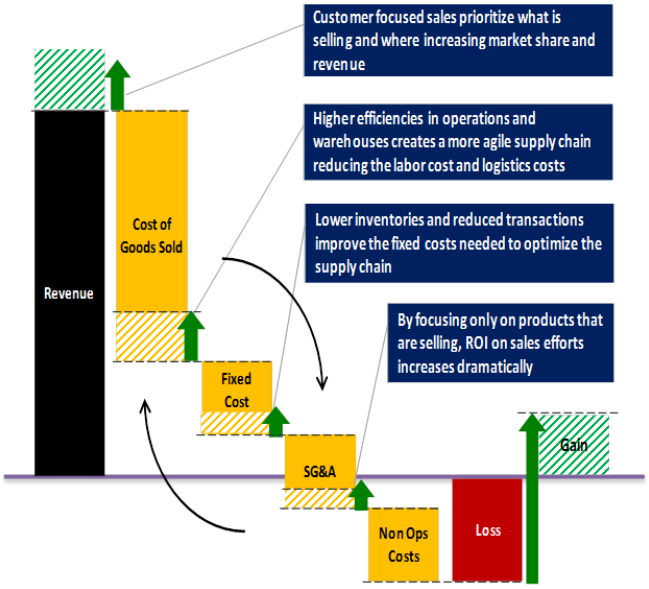


Figure 2 Demand

The partners with organizations in all industries to create a demand driven network which is capable of generating superior economic results driving a true advantage over competitors in the marketplace.

The key to making the transition includes:

- **Complete transparency** across all players in the value network
- Dynamic **inventory management** across selling channels
- Dynamic **management of pricing and capacity** to respond to customer trends
- Clear view of **"Active" and "Passive" capacity** and associated switching costs
- Integrated global view of **risk and opportunity**

A more evolved approach of dealing with demand challenges is to actively **shape** incoming demand and manage it. While different organizations deal with the challenge differently, almost all of them include a key understanding of **"What is the customer actually paying for"?**

Some examples of demand shaping include:

- **Uniqueness** – The best form of demand shaping is when the customer will wait for a product/service to become available no matter the cost or time. Such exclusivity is usually associated with an IP protected or highly regulated environment. In such a situation, the manufacturer can dictate terms to the market till the exclusivity lasts (which is unequivocally not forever).
- **Promotions** – Effective organizations use the right promotion for the right customer – product/service combination to drive superior returns on their promotion dollar. More importantly, these organizations are able to accurately predict the sales lift from individual promotional actions to arrive at a more reliable input to the sales and operations planning process.
- **Delayed Differentiation** – Many organizations deal with demand variability through their product/service architecture where a common base can be appended with specific modules much closer to the point of sale minimizing the lead time and variability felt by the whole network. E.g. printers.
- **Lane Strategy** – Organizations that view availability as a key differentiator in the customer buying behavior will make available vanilla configurations of their products/services at a preference over more customized offerings thereby incentivizing the customer to choose those configurations that work best for the manufacturer. E.g. cars.
- **Innovation** – While many people don't value the impact of their R&D budget on managing demand, it is perhaps the most important disruptor an organization's demand planning than any other individual action. An in-depth understanding of managing product/service cycles can be a make or break decision in managing customer demand in the market place at an enterprise level.

  The right steps depend on your current situation, the competitive landscape and most of all the customer demand. Finding the balance means finding a niche and exploiting it. In order to do this, organizations need to have the knowledge and visibility throughout the entire enterprise and product lifecycle to truly understand the operational and financial impact of shaping and managing demand.

VI. BALANCING SUPPLY AND DEMAND

When demand is booming and production volumes are at a high, excess product is being built, moved and stored to make sure customer demands will be met. When the economy slows and the orders suddenly get turned off, the reaction time of complex supply chains – due to all the source points and manufacturing points spread out across the globe creating long lead times – has a very damaging effect to the bottom line.

Material is already under process at factories, in transit on ships and trucks, in storage in warehouses and distribution centers throughout the pipeline. So when demand abruptly slows, all players throughout the supply chain are left with excess inventory that gluts the pipeline. This is usually the point when managers start worrying about what to do with all the excess. A day late and a lot of dollars short.

Ironically, the answer in addressing the inventory management problem is not in attacking the inventory itself. That will provide only a short term reprieve. The answer lies in addressing the root causes for the inventory issues such as:

- Demand variability
- Extended response times
- Transportation structure and processes
- Lack of visibility in the supply chain
- Lack of collaboration between partners
- Quality levels and reliability of service from suppliers

All of these root causes drive variability into the system. It is this variability that managers are planning against by carrying more than necessary inventory in the pipeline. Leading organizations have managed to establish means of reducing this variability across the supply chain through superior inventory management.

CGN partners with organizations of all types to transform the way they manage their transportation function. We help organizations sustainably reduce inventory through properly managing capacity and demand, while becoming more agile and adaptive to changing customer needs and unforeseen challenges. This results in lower costs, higher profitability, and better customer satisfaction due to the ability to give the customer what they want, when they want it with the utmost efficiency.

Your organization is unique, so should be your solution. We apply our vast subject-matter and inventory expertise to uncover the true issues behind your inventory problem, apply the right tools and methodologies to effectively solve the issues, and work with management and employees to transfer our knowledge to you in order to sustain the gains and create a culture of continuous improvement.

Generally, this is a high-level view of the stages of CGN's Inventory Management solution:

Find waste and areas for improvement

- Identifying waste in the process from order to delivery that creates no value for the customer
- Identify areas for improvement throughout the process
- Develop an action plan to analyze, fix and sustain proper inventory management

Fixing the problems

- Uncover root causes for the key issues and set target inventory levels
- Select the right tools and methodologies for effective implementation and sustainment
- Implement improvements to reduce excess inventory

Sustaining the changes

- Knowledge transfer to workforce through education and training on new tools and processes

- Create a culture of continuous improvement to sustain progress through a strong learning plan

VII. CONCLUSION & FUTURE SCOPE

In this paper, a constraint model is proposed with agent technology to coordinate the supply chain. It can adapt the changes of environment dynamically and can model different management behaviors of different managers. In addition, agents can communicate through the Internet and perform real time optimization. Specifically, the problem of product distribution for delivery is demonstrated with experiment.

With agent, constraint and their ability to provide information, optimization can have more parameters, for example, the number reorders in the problem of product distribution for delivery. On top of the agent architecture and constraint model, value-added services agent can be added implemented to handle more sub problems in the supply chain. Therefore, constraint model and agent technologies are suitable for tackling the supply chain problems. Finally, we will try to integrate all the agents in a standardized infrastructure and handle the whole supply chain through the Internet smoothly.

For future research, we will try to model more supply chain problems by using constraints and agents. In addition, we will try to find suitable optimization techniques to different problems. Finally, all problems are integrated together and try to solve the global optimization for the whole supply chain.

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