NSF Symposium on
Supply Chain Management in Process Industries

Speaker Abstracts

KEYNOTE

UDAY KARMARKAR

Brief Description of the Talk "STRATEGIC ISSUES IN PROCESS INDUSTRIES: SUPPLY CHAIN DESIGN, LOCATION, CAPACITY AND PLANNING": Many process industries are seeing changes in their supply chains, driven by issues such as environmental factors, competition, changing trade conditions, and demand increases from developing economies. The consequences include entry, exit and consolidation of industries, as well as rationalization and redesign of existing supply chains. In the shorter term, there are issues related to allocation of capacity, and planning under uncertainty. We describe case examples of such questions and summarize our current efforts to formulate and address these problems.

SESSION I: OPTIMIZATION

NICK SAHINIDIS

Brief Description of the Talk "GLOBAL OPTIMIZATION IN SUPPLY CHAIN MANAGEMENT": Accurate models for the design and management of the chemical supply chain must account for economies-of-scale of capacity expansion decisions, uncertainties in supplies and demands, and nonlinearities of reaction and mixing of chemical systems. The talk addresses the development and application of deterministic global optimization algorithms for these problems.

MARTIN GRUNOW

Brief Description of the Talk "MILP APPROACHES TO SUPPLY NETWORK PLANNING IN THE CHEMICAL AND PHARMACEUTICAL INDUSTRIES": The advent of Advanced Planning Systems evoked large interest in Supply Chain Management. Supply Network Planning modules included in these software packages were particularly well received due to the perceived large payback. In the European process industry, however, the number of successful implementations is still very limited. The key drawback of the standard Advanced Planning Systems is that they are based on a single "generic" model of the production and distribution network. Still, the requirements are extremely diverse, even within the process industry as we illustrate with the help of three characteristic cases. We outline alternative modelling approaches to supply network planning appropriate for the production of grades, of special chemicals, and of pharmaceuticals.

LISA MILLER

Brief Description of the Talk "INTEGRATED PLANNING AND SCHEDULING FOR THE PROCESS INDUSTRY: A CUTTING-PLANES APPROACH": We consider the planning and scheduling of production in a multi-task/multi-stage batch manufacturing process typical of industries such as chemical manufacturing, food processing, and oil refining. We formulate the problem as a mixed integer linear program. We show that the formulation leads to an NP-hard problem with a large integrality gap. We introduce the notion of echelon inventory and use it to construct a family of valid inequalities. We show that the formulation with the additional constraints leads to a significantly tighter linear programming relaxation and too much reduced solution times for the mixed integer linear program.

DIMITRIOS VARVAREZOS

Brief Description of the Talk "OPTIMAL SOLUTION RANGE ANALYSIS IN PRODUCTION PLANNING: REFINERY FEEDSTOCK SELECTION": This paper presents a new way to expand and analyze the optimal solution of a planning model. Feedstock selection in a refinery is a complex process, accomplished in many steps that typically involve numerous optimization executions that aim at providing a "value" for each potential crude feedstock to the refinery for a given operational period. Traditionally, the optimal crude slate as determined by the planning system is a point solution that does not provide detailed information regarding potential (finite) changes in the optimal crude selection without degradation of the overall plant economics. In this work we define the optimal selection range for each feedstock as the result of a Pareto-type analysis including all feedstocks. Two flexibility indices are defined for each crude feed providing a quantitative flexibility metric in the context of optimal economics. The proposed approach provides a useful and practical way to quantitatively evaluate each potential crude feed. This is expressed in terms of an optimal range as defined by the ability of a feedstock to replace and be replaced in the optimal solution without significant economic change. In addition, this analysis provides a map of the optimal surface in terms of near-optimal points around the base solution.

SESSION II: COPING WITH UNCERTAINTY

JOHN BIRGE

Brief Description of the Talk "REAL OPTIONS IN PROCESS INDUSTRY SUPPLY CHAIN MANAGEMENT": Supply chain issues in the process industries typically involve considerations of significant fixed costs for expensive facilities, highly variable pricing of raw materials, varying product prices, and geographical variations in revenue and cost. These factors combine to make flexibility in capacity, location, and contract terms important management considerations. These factors combine to give substantial option value to supply chain decisions. This talk will describe real option approaches to evaluate these options and potential research directions for these analyses.

SUVRAJEET SEN

Brief Description of the Talk "WHAT DOES STOCHASTIC PROGRAMMING OFFER DECISION MAKERS IN PROCESS INDUSTRIES?":

SHABBIR AHMED

Brief Description of the Talk "SUPPLY CHAIN NETWORK DESIGN UNDER UNCERTAINTY": This talk will present a stochastic programming approach for designing supply chain networks under uncertainty. Existing approaches for these problems are either restricted to deterministic environments or can only address a modest number of scenarios for the uncertain problem parameters. Our solution methodology integrates a sampling strategy, with an accelerated Benders decomposition algorithm to quickly compute high quality solutions to large-scale stochastic supply chain design problems with a huge number of scenarios. Computational results involving real supply chain networks will be presented to highlight the efficiency of the proposed strategy. Extensions of the approach to handle risk will also be discussed.

N. VISWANADHAM

Brief Description of the Talk "AN ANALYTICAL FRAMEWORK FOR THE MANAGEMENT OF RISK IN SUPPLY CHAIN NETWORKS": In this presentation, we develop a framework to classify supply chain risk management problems and approaches for the solution of these problems. We argue that risk management problems need to be handled at three levels strategic, operational and tactical. In addition, risk within the supply chain might manifest itself in the form of deviations, disruptions and disasters. To handle unforeseen events in the supply chain there are two obvious approaches: (1) to design chains with built in risk-tolerance and (2) to contain the damage once the undesirable event has occurred. Both of these approaches require a clear understanding of undesirable events that may take place in the supply chain and also the associated consequences and impacts from these events. We can then focus our efforts on mapping out the propagation of events in the supply chain due to supplier non-performance, and employ our insight to develop two mathematical programming based preventive models for strategic level deviation and disruption management. The first model, a simple integer quadratic optimization model, adapted from the Markowitz model, determines optimal partner selection with the objective of minimizing both the operational cost and the variability of total operational cost. The second model, a simple mixed integer programming optimization model, adapted from the credit risk minimization model, determines optimal partner selection such that the supply shortfall is minimized even in the face of supplier disruptions. Hence, both of these models offer possible approaches to robust supply chain design.

SESSION III: OPTIMIZATION IN INDUSTRY

MIKE PINEDO

Brief Description of the Talk "PLANNING AND SCHEDULING IN SUPPLY CHAINS: AN OVERVIEW OF ISSUES IN PRACTICE": This paper gives an overview of the theory and practice of planning and scheduling in supply chains. It first gives an overview of the various planning and scheduling models that have been studied in the literature, including lot sizing models and machine scheduling models. It subsequently categorizes the various industrial sectors in which planning and scheduling in the supply chains are important; these industries include continuous manufacturing (process industries) as well as discrete manufacturing. We then describe how planning and scheduling models can be used in the design and the development of decision support systems for planning and scheduling in supply chains in the various industries and conclude with a detailed discussion of an implementation of such a system at the Carlsberg A/S beerbrewer in Denmark.

MARCO DURAN

Brief Description of the Talk "RESEARCH ON LOGISTICS AND OPTIMIZATION OF THE OIL INDUSTRY'S DOWNSTREAM SUPPLY CHAIN CASE: WORLD-WIDE CRUDE SUPPLY": The world wide crude transportation is the central operation that links the upstream and downstream functions and plays a crucial role in the global supply chain management in the oil industry. In this work, we develop a decision support system to investigate and improve the combined inventory and transportation system in the world wide crude supply problem. The decision support system is based on the integration of discrete event simulation and stochastic optimal control of the inventory/transportation system. A unifying simulation framework that integrates the simulation model and controller is constructed to simulate the controlled inventory/transportation system. It provides the decision makers valuable insight into the behavior the dynamic and stochastic system and a powerful tool to evaluate strategies for the design and operation of the system. We formulate the optimal design/control problem rigorously as a Markov decision process that incorporates uncertainties such as travel time and crude demand. Due to the overwhelming computational requirement of the rigorous methods, approximate methods based on dynamic programming are needed to determine the near-optimal control policy that minimizes the expected total cost. We propose an approximation architecture that involves two stages: decomposition of the system into individual subsystems and parametric function approximator for the cost-to-go functions. The solution algorithm is being implemented to evaluate the effectiveness and efficiency of the approximation architecture.

NICO VANDAELE

Brief Description of the Talk "MODELING BLOCKING SYSTEMS WITH ZERO BUFFERS IN SEMI-PROCESS INDUSTRIES: THE BREWING CASE": Blocking systems with zero buffers are

typical in (semi)process industries. They have not only the characteristics of limited buffer systems, but if buffer sizes are zero, the equipment is often used as temporary storage. This causes the effective utilization to be higher than the natural (productive) utilization. As in (semi-)process industries the capital intensity is high, the correct load for a given capacity is crucial. For given demand volumes (and mix), the objective is to operate the equipment in such a way that productivity is maximized without (too much) blocking. This problem is very complex especially in stochastic setting. Methodologically, we can conclude that analytical models to model these systems are not wide spread. There exists a great similarity between blocking systems without buffer and Kanban systems. For Kanban systems, analytical models to calculate the performance are available. The purpose of this paper is to apply an analytical model of a Kanban system to a blocking system without buffer. Based on simulation results, the performance of the Kanban analytical model applied to the blocking system is studied. We illustrate this with exemplary material from the brewing industry.

NICOLAS MIÈGEVILLE

Brief Description of the Talk "A PLANNING SUPPORT SYSTEM FOR THE FLOAT GLASS MANUFACTURING INDUSTRY": We describe a decision tool for production planning of a single Float Glass Plant. Starting from the industrial float process, we propose a framework to structure the planning process in a hierarchical way by ordering decisions according to their relative importance. We base our model on the multi attribute product structure present in this particular industry. At each level of hierarchy, we provide a mixed integer model to capture the costs and constraints of both production and inventory systems. The underlying model is a lot-sizing and scheduling model with sequence-dependent setups. We propose a reformulation of a classical lot sizing models and adapt it to the particular structure of our problem. We use a commercial solver (CPLEX) to solve the problem for several real examples from one industrial company. In spite of the complexity of the model, we show that the resulting decision tool can be useful for both tactical and operational decisions. We outline how the tool can be extended to problems with multiple plants.

SESSION IV: SUPPLY CHAIN MANAGEMENT I

JAN FRANSOO

Brief Description of the Talk "REGRESSION MODELS FOR CAPACITY PLANNING IN MULTIPURPOSE BATCH CHEMICAL PLANTS": The complexity and uncertainty characteristics of multipurpose batch plants preclude the use of traditional capacity planning methods such a queuing and scheduling models. We develop an approach based on linear regression modelling that enables us to give lead times estimates for complex synthesis processes.

DIWAKAR GUPTA

Brief Description of the Talk "MANUFACTURING CAPACITY REVENUE MANAGEMENT IN PROCESS INDUSTRIES": Manufacturers in process industries typically produce to order on account of the custom nature (large variety) of end products. However, the presence of both contractual and transactional customers have created situations in which different price- and delivery-time sensitivity of buyers can be exploited to extract more of the consumer surplus by using a delivery-time based discriminatory pricing strategy. Such practices are broadly called revenue management (RM). While RM has made significant contributions to the profitability of service enterprises, its use in manufacturing is only now beginning. This is, in part, due to the fact that by varying lead times and prices, the manufacturing companies also create new challenges for production and inventory control. The talk will describe these challenges and some modeling efforts aimed at resolving them.

SEZA ORCUN

Brief Description of the Talk "IMPACT OF RESOURCE ALLOCATION DECISIONS IN SUPPLY CHAIN NETWORKS": The different protocols by which components of the supply chain interact with each other, such as collaborative planning, information sharing and contractual arrangements, are clearly important drivers of supply chain performance. Hence there is a strong need for modeling tools that allow decision makers to rapidly develop aggregate models of supply chains, including both material and information flow, that they can use to gain insights and assess alternative configurations. This work presents a prototype implementation of such a system along with computational results illustrating the impacts of resource allocation decisions via application of the system to a simple manufacturing supply chain as our first case study. Our second case study focuses on the research and development pipeline management. It studies, by utilizing SimOpt (simulation based optimization) technique, the implications of resource allocation decisions with results in a sample Pharmaceutical R&D Pipeline Portfolio, which can be viewed as a new product development supply chain.

SESSION V: SUPPLY CHAIN MANAGEMENT II

PHILIP JONES

Brief Description of the Talk "CONTINGENCY PLANNING IN HYBRID SEED CORN PREPARATION": There are currently several types of chemical coatings applied to hybrid seed corn to combat a variety of diseases and insects. Since a farmer can specify the type of coating he wants, the seed producer faces the option of either pre-treating all seed before demand is known, or pre-treating only some seed before demand is known. There are several quality grades of seed within a given hybrid, and once treated, some grades of seed can be upgraded and /or downgraded to meet actual demand. We

report on a model designed to help a seed producer decide how much of each grade of seed to pre-treat.

MATTHEW REALFF

Brief Description of the Talk "DYNAMIC PROGRAMMING IN A HEURISTICALLY CONFINED STATE SPACE: STOCHASTIC SUPPLY CHAIN MANAGEMENT": Product demand variability can be identified as one of the key sources of uncertainty in any supply chain. Failure to account for significant product demand fluctuations in the mid term (1-2 years) by deterministic planning models may either lead to excessively high production costs (translating to high inventory charges) or unsatisfied customer demand and loss of market share. We model uncertainty through Markov chains, and employ an approach based on stochastic dynamic programming (DP) which can generate a dynamic operating policy in every period by incorporating available information about the uncertainty. However, DP is computationally intensive due to the large size of the state and action space for realistic problems. To circumvent the "curse of dimensionality" of DP, an evolutionary solution approach*, dynamic programming in a heuristically confined state space* is developed for the problem. The first step of the proposed approach is a stochastic simulation of the given supply chain system with many suboptimal policies (heuristics) for a large number of scenarios generated by an underlying Markov chain model. The heuristics are local in nature and applied at each inventory node of the supply chain. The simulation data contains rich information for the system and the data is presented as trajectories of states and the objective function values, 'profit-to-go', computed for each of those state by using a dynamic programming technique. Finally, an online decision policy is obtained by maximizing the objective function value at each stage. The usefulness of the approach is demonstrated with an industrial SCM problem with multi-products and multi-production facilities.

JAMES RAPPOLD

Brief Description of the Talk "THE VALUE OF STABLE PRODUCTION CYCLES AND ADVANCED DEMAND INFORMATION IN THE PRESENCE OF SIGNIFICANT CHANGEOVERS AND DEMAND UNCERTAINTY": Our observations from working with executives from different process manufacturing firms suggest a broad disconnect between strategic and tactical supply chain decisions. We have observed such situations in chemical, petroleum, paper and other process manufacturing operations in which production is capital intensive, products are narrowly focused, and setup times are significant Our objective in this research is to construct a set of models and computationally efficient solution approaches that may be easily used to assess the tactical and operational consequences of strategic decisions in a capacitated supply chain system. We analyze a multi-item production and inventory system in which demand is highly uncertain and there are significant changeover times, or setups, between items. The items are produced in a predetermined sequence determined based on engineering and

equipment considerations, such as sequence-dependent setup times, that is typically established to minimize the total setup time spent on the equipment.