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Supporting US Arms Control Treaty Negotiations

In late 1989, the Strategic Arms Reduction Treaty (START) negotiations were approaching the final stages. Many of the significant treaty limits had been agreed to by the US and the USSR. After years of negotiations, the two nuclear superpowers had reached agreement on the number of strategic delivery vehicles and nuclear weapons. Each nation's reductions were to occur over seven years. However, the time-phased reduction limits (commonly referred to as drawdown limits) under START had not been negotiated. The Soviet Union requested a US position on the Soviet's proposed drawdown limits. This *OR Practice* paper describes the analysis provided the US negotiating team. D.W. Owens, G.S. Parnell and R.L. Bivins developed a linear programming model to assess drawdown limit alternatives. For the US, the preferred drawdown limit alternatives were independent of the force structures considered, primarily because constraints on US destruction rates drove the drawdown. For the USSR, significant differences occurred between each drawdown limit alternative, especially concerning multiple warhead systems like the SS-18. The results of this study were used to determine the US START negotiation positions and assess the final START agreement.

Maximizing Production Line Efficiency

Production line systems play a fundamental role in modern industry. Considering that the annual expenditures for operating production lines throughout the world total many billions of dollars, even a slight improvement in the efficiency of a production line could amount to a substantial saving over the lifetime of the line. In "On the Simultaneous Optimization of Server and Work Allocations in Production Line Systems with Variable Processing Times," F.S. Hillier and K.C. So address a basic production line design problem of maximizing the throughput of the line by simultaneously allocating servers and work to the respective stations. This study has two important findings regarding the optimal server and work allocation (the "L Phenomenon") and the substantial benefits gained by adding extra servers to the initial one-per-station servers (the "multiple-server phenomenon"). Both findings have important implications for the design of some production line systems in ways that will greatly improve their efficiency.

A Flexible Model for Utilizing Expert Opinions

Experts often provide estimates or probability distributions of uncertain quantities in risk analyses, and typically there is a need to combine those assessments. The available analytic approaches for such combination require complex models of the experts' information, and usually these models must be constructed on the basis of subjective assessments. Moreover, many of the standard models are based on the multinormal distribution. In "Copula Models for Aggregating Expert Opinions," M. Jouini and R. Clemen use copulas—joint distributions with uniform marginals—to develop a new approach to modeling the experts' information. This new approach permits the modeler to judge performance (calibration and precision) of an individual expert separately from the judgment of dependence among the experts, and to do so while employing arbitrary marginal distributions. Thus, the approach provides a more flexible modeling environment while reducing the subjective assessment task.

Inferring System's True State from Quality of Output

"Partially Observable Markov Decision Problem" (POMDP) deals with scenarios where the system's true state is unknown. A decision whether or not to renew the system is based upon a "control limit" (CLT): the posterior probability that the system is in the "good" state, given information such as the quality of the output. The study was motivated by the need for analytical insight: using POMDP involves a functional equation. An analytical solution for this equation is as yet unknown. The new results presented in "A Two-State Partially Observable Markov Decision Process with Uniformly Distributed Observations" included an analytical solution (to compute the CLT) for a special case where observations are uniformly distributed, and interesting properties about nonmonotonicity of finite-horizon CLTs. The results presented by A. Grosfeld-Nir increase our understanding of POMDP, provide insight about sensitivity toward parameters, can serve as an approximation for more complicated circumstances, and furnish a test case for algorithms.

How to Control Production Inputs When Yields Are Random?

Controlling inputs to a production system when yields are random has been a research subject with great interest. Yield losses occur due to production imperfections in processing products, or in the assembly operations where multiple inputs are integrated into a final output. Most of the past research on input controls for production systems with random yields concentrates either on pure processing operations or pure assembly operations. Most real life situations have both types of operations, and this is the focus of "Input Control for Serial Production Lines Consisting of Processing and Assembly Operations with Random Yields" by H. Lee.

Vehicle Routing Under Uncertainty

The vehicle routing problem lies at the heart of distribution management and has attracted the attention of several researchers over the last three decades. In several contexts, like in less-than-truckload operations, some of the elements of the problem are stochastic. In "A Tabu Search Heuristic for the Vehicle Routing Problem with Stochastic Customers and Demands," M. Gendreau, G. Laporte and R. Séguin consider capacity constrained problems where both customer presence and their demands are stochastic. Such problems are very difficult to solve, and only relatively small instances can be optimized. The authors have developed a tabu search heuristic that embeds a fair amount of problem-specific knowledge in order to speed up computations and enrich the search. In particular, the objective function is approximated, in order to avoid computing it at each iteration, and infeasible solutions are allowed to occur during the search. The methodology developed here can probably be applied or extended to other types of stochastic problems.

Overlay Optimization

To meet customers' needs
for different costs and speeds,
install base facilities
and add functionalities.
What's the min-cost solution
for this critical decision?

The problem's hard to solve,
so worst-case we resolve
for heuristics and LPs
of trees on trees.
Either upgrade the base,
or extend the overlays.
As one bound increases,
the other decreases.
Find the intersection
and a little reflection
gives the worst-case ratios
for various scenarios.

Using this approach, in "Heuristics, LPs and Trees on Trees: Network Design Analyses," A. Balakrishnan, T. Magnanti, and P. Mirchandani introduce and analyze a new class of overlay optimization models for choosing, at minimum total cost, a set of base activities and overlay activities that model enhanced services to certain key customers. The paper studies the worst-case performance of a composite heuristic and a linear programming relaxation for this problem. The authors develop worst-case bounds for the well-known uncapacitated, fixed-charge network design problem.

Minimizing Burn-in Costs

In many industrial situations, quality control often requires testing of goods after production. It is the purpose of this burn-in process to screen out defective products before they are shipped to customers or put into field operation. One of the major problems associated with burn-in is to decide exactly how long the burn-in should continue, balancing appropriate needs of reliability and the cost due to burn-in. In "Minimizing Some Cost Functions Related to Both Burn-In and Field Use," several models are proposed to describe the total cost. By assuming the failure rate of the products exhibit a bathtub shape, J. Mi shows in this paper that the optimal burn-in time, minimizing the mean cost, never exceeds the first change point of the failure rate.

Probabilistic Analysis, Randomized Algorithms and Deterministic Problems

In the last two decades, probabilistic analysis has been used to characterize the average performance of heuristics for many difficult problems. Typically, it is carried out to explain the observed behavior of a specific algorithm. Similarly, randomized algorithms have developed for various problems and in some cases have been shown to have attractive theoretical properties. Since in both cases the analysis is often quite complex, practical issues are ignored and consequently for the most part these tools are of interest mainly to theoreticians. In "Probabilistic Analysis and Practical Algorithms for the Vehicle Routing Problem with Time Windows," J. Bramel and D. Simchi-Levi use a randomized algorithm, along with probabilistic analysis, to develop a completely new deterministic algorithm. This algorithm performs very well on various sets of standard test problems.

Machine Scheduling Problems with No-wait in Process

A variety of production problems, arising particularly in modern manufacturing plants, can be considered as no-wait scheduling problems. Here all the operations of a job must follow one another without interruption. In the review paper, "A Survey of Machine Scheduling Problems with Blocking and No-wait in Process," N.G. Hall and C. Sriskandarajah describe several applications in which such an environment arises. They present a comprehensive categorization of those problems, according to their difficulty of solution. The known methods for fast solution are described in detail, as are a variety of heuristic approaches for harder problems in this class. The literature on stochastic scheduling in the no-wait environment is also examined. Insights about where future applications will arise and about possible extensions of the existing methodology are provided.

Weighted Markov Decision Processes

The results on the structure of nearly optimal policies in weighted Markov decision processes, which are stronger than the results of this type published by Filar, Krass and Sinha in *Operations Research* in 1992, could be directly derived from a paper published by Feinberg in 1982.