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Optimizing Digital Circuits

The complexity of digital integrated circuits (ICs) has been increasing exponentially since around 1960, with the number of components or devices in a single IC more than doubling every 18 months. Some current ICs contain over 100 million devices and a similar number of wires connecting them. The design of such complex ICs relies heavily on electronic design automation (EDA) and computer-aided design (CAD) technologies, which, in turn, rely on various optimization algorithms. In "Digital Circuit Optimization via Geometric Programming," S. P. Boyd, S.-J. Kim, D. D. Patil, and M. A. Horowitz show that a variety of problems arising in digital circuit optimization can be formulated in a special form, which can be exploited to obtain efficient solution methods. The authors argue that the special form, geometric programming (GP), can be considered a unifying standard form for a variety of circuit optimization problems, the same way linear programming (LP) serves as a unifying standard form for a variety of resource allocation problems.

A Bird's-Eye View of Queuing Networks

The Internet, its pieces, and other communication networks are typical examples of queuing networks—systems where work (or information) is held and processed at various stations. Jobs can enter the system in different possible locations, follow different routes, and exit at different possible locations as well. Very large sizes of files being transferred over the networks make communication networks cause unexpected and, sometimes, hard to explain phenomena: burstiness of the traffic, severe delays, and interesting scaling properties that are often associated with the notion of "fractals." In "Limit Behavior of Fluid Queues and Networks," B. D'Auria and G. Samorodnitsky attempt to shed new light on these problems by looking at the "big picture": What a network looks like at large time and space scales. It turns out that from this "bird's-eye" point of view networks have an interesting inhomogeneous structure, with different parts of the network behaving markedly differently, depending on the topology of the system. Conversely, looking at the network from this angle provides a way to see better certain features of the network, such as the sources of the most intensive flows of jobs together with their routing paths.

A Framework for Selecting a Portfolio of R&D Projects

In high technology companies, the selection and management of research and development (R&D) projects is an important task that can have a significant impact on the future performance of the company. This task is, however, particularly challenging because R&D projects involve significant risks and the selection of the R&D portfolio can be limited by several resource constraints. In "Contingent Portfolio Programming for the Management of Risky Projects," J. Gustafsson and A. Salo present a framework for modeling a portfolio of R&D projects, where risks can be managed using both diversification and staged decision making, and which accounts for the company's resource constraints. An important feature of the framework is that, when the company's risk measure satisfies a linearity property, it leads to linear programming models, which can readily be solved for portfolio selection problems of realistic size.

Detecting Geometric Shapes

Detecting geometric shapes is of interest to several disciplines. For example, a manufacturer needs to determine how well a plate is circular from a few observations of the edge of the plate and an archaeologist wants to detect the circular shape of a stadium out of a few measurements of the edge of the stadium. Other applications exist in location analysis and psychometrics sometimes using noncircular shapes as rectangles and squares. A complication arises when the points to be fitted stem from imperfect shapes, potentially rotated, and of different size. In "Majorization Algorithms for Inspecting Circles, Ellipses, Squares, Rectangles, and Rhombi," K. Van Deun and P. J. F. Groenen propose a flexible algorithm that is computationally inexpensive, applies to several geometric shapes of varying sizes, and allows for rotations of the shapes. Their algorithm can also be used for geometric shapes in three dimensions.

A Call-Routing Problem with Service Failure

Traditional queueing models represent call centers as queueing systems with heterogeneous servers that differ only in their speed. The resultant call routing policies prefer faster servers to slower ones. In practice, however, call center service representatives differ in their speed as well as their quality of service. Routing based on speed alone results in quick services, but the customer may have a higher probability of having to call back for the same problem. These callbacks increase the load on the system, eventually causing the average total time in the system to increase. In "Managing Response Time in a Call-Routing Problem with Service Failure," F. de Véricourt and Y.-P. Zhou propose to incorporate call resolution probability into the call routing model and use the MDP framework to analyze the optimal routing policy. In particular, they provide sufficient conditions under which it is optimal to use the call resolution rate, which is the product of call speed and call resolution probability, as the routing index (the so-called "$p\mu$" index). They also propose efficient heuristics based on the "$p\mu$" index that can be easily implemented.

Solving Large General Routing Problems: The TSP-Opt Methods Adapted to General Routing

Routing problems appear in a wide variety of planning situations such as manufacturing, facilities planning and design, warehouse management and retrieval, transportation and logistics. One can expect that soon every car will be equipped with sophisticated routing software. Perhaps no routing topic has been studied more than the traveling salesperson problem (TSP). The improvements made to solve—at least heuristically—large and even very large TSPs are quite phenomenal. Yet, some straightforward extensions of TSP, such as the general routing problem, have received much less attention. In the general routing problem (GRP) a number of specified nodes and arcs of a road network are visited at minimum cost. In "Exploring Variants of 2-Opt and 3-Opt for the General Routing Problem," L. Muyldermans, P. Beullens, D. Cattrysse, and D. Van Oudheusden show how certain very successful solution techniques for TSP (2- and 3-opt) can be adapted to the GRP. These techniques, in combination with the guided local search metaheuristic, deal satisfactorily with much larger instances than ever before. This algorithmic approach represents a valuable step towards the fast solution of very large, real-life routing problems.

Finding a Friend in Manhattan

Two friends want to find each other in Manhattan when it is crowded. They want to meet at some unspecified intersection, as quickly as possible. So they each move from one of these to another, hoping to be at the same one simultaneously. This is a two-dimensional version of the "rendezvous search problem" that was first posed by Steve Alpern in 1976. The original problem did not receive much attention until about 15 years ago, from which time it has become the subject of much investigation. The two-dimensional version was first studied by E. Anderson and S. Fekete in a recent article in this journal. In "Rendezvous on a Planar Lattice," S. Alpern and V. Baston extend their work by showing how the two friends should move about to best achieve a meeting, given their initial assumptions about their relative locations.

Column Generation for Huge Integer Programs

Wherever the need for optimal or near-optimal solutions to industrial applications lead to large-scale mathematical programs, column generation is just one step around the corner. In application areas such as the airline business, column generation can be considered an industrial standard. With the success of the method, the body of relevant literature is continously growing. This is true in terms of applications, and more recently this is true also in terms of theoretical and computational improvements. It is time for an evaluation of what is presently available and understood and where there remain challenges for tomorrow. In "Selected Topics in Column Generation," M. E. Lübbecke and J. Desrosiers survey the latest development in the area and provide a unified entry point to more than 100 references. Their paper stresses the importance of the "dual point of view," which most recently inspired researchers to develop computational strategies that enable the solution of ever larger and complex problems.