Math. Forschungsinstitut Oberwolfach
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MATHEMATISCHES FORSCHUNGSINSTITUT OBERWOLFACH

Tagungsbericht 7/1987

Operations Research

16.2. bis 21.2.1987

Zum zweitenmal nach 1984 fand diese Konferenz über Operations Research unter der Leitung von Herrn K. Neumann (Karlsruhe) und Herrn D. Pallaschke (Karlsruhe) statt.

In diesem Jahr waren 50 Teilnehmer aus 10 Ländern eingeladen, ihre neuesten Ergebnisse aus ihren jeweiligen Forschungsbereichen zu präsentieren und einer kritischen Diskussion zu unterwerfen.

Auf diese Weise konnten die Hauptziele der Organisatoren der Tagung erreicht werden:

Die Erfahrungen innerhalb und zwischen den einzelnen Bereichen des Operations Research auszutauschen;

neuere Entwicklungsrichtungen aufzuzeigen und das gegenseitige Verständnis für die verschiedenen Forschungsschwerpunkte innerhalb des Operations Research zu stärken.

Auf dieser Konferenz wurden Themen und neue Ideen aus den verschiedensten Bereichen des Operations Research diskutiert. Im einzelnen waren dies:

- Mathematical Programming
- Graph Theory
- Nondifferentiable Optimization
- Queueing Theory
- Network Theory
- Control Theory
- Expert Systems in Operations Research
- Stochastic Programming
- Applications of OR in Economy.

Wie immer sorgtendie herzliche Atmosphäre und die vorzügliche Ausstattung des Mathematischen Forschungsinstituts für den harmonischen Rahmen, der für das Zustandekommen von fruchtvollen, persönlichen Fachgesprächen notwendig ist.

Die Vorträge, die Diskussionsbeiträge und die persönlichen Kontakte zwischen den Teilnehmern der Konferenz lassen daher einen stimulierenden Effekt auf die zukünftige Forschung innerhalb des Operations Research erwarten.

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Alle Teilnehmer schätzten und erkannten den angenehmen Aufenthalt in Oberwolfach dankbar an.
Im besonderen sei hier der Dank an den Direktor des Instituts, Prof. Dr. Barner, erwähnt.

Um die Ergebnisse der Konferenz auch einem größeren Publikum zugänglich zu machen, wird voraussichtlich im Sommer 1987 ein Proceedingsband beim Springer-Verlag, Heidelberg erscheinen.

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Vortragsauszüge

A. BACHEM:

A Hahn-Banach-Type Theorem For Discrete Structures

Using the notion of convexity in oriented matroids (due to Las Vergnas) we prove a separation theorem for acyclic oriented matroids satisfying a generalized euclidean intersection property. We show how this generalized euclidean intersection property relates to Levi's intersection property and to euclidean oriented matroid. Moreover we prove that none of these properties can be characterized by excluding finitely many minors. We show that all intersection properties are equivalent for matroids of rank 4 or less and give an example of a rank 5 oriented matroid with minimal number of vertices which distinguish euclidean and generalized euclidean matroids.

J. BLAZIEWICZ:

Scheduling Theory ("New Models in Scheduling Theory")

In the talk we present new models arising in scheduling theory. They are defined by one or more assumptions imposed on classical scheduling problems. All these models follow practical applications of the scheduling theory. We consider respectively, scheduling under resource constraints, new models of task processing, multiprocessor task scheduling, scheduling with simultaneous transportation of the required resources. For all the models task assumptions and the results obtained are presented. Directions for further research are also pointed out.

R. E. BURKARD:

Global ε-Approximations of Parametric Network Flow Problems
(Co-Authors: H. Hamacher and G. Rote)

We consider a network with supplies and capacities dependent on a single parameter t, $0 \leq t \leq T$. The value function z(t) of the corresponding min cost network flow problem is piecewise linear and convex. According to Zadeh z(t) has exponentially many breakpoints. Therefore the straightforward solution of the parametric problem starting from t=0 is an exponential task. We show that z(t) can be approximated by two piecewise linear convex functions z_1 and z_n such that

$$z_1(t) \leq z(t) \leq z_n(t) \quad \forall t \in [0,T] \text{ and } \|z_n - z_1\|_\infty \leq \varepsilon .$$

Using a bisection algorithm for the approximation of an arbitrary convex function z it can be shown that the number M of evaluations of z and subgradients z' to obtain lower and upper approximation functions z_1 and z_n is bounded by

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$$M \leq \max(2, \lceil \sqrt{1/\varepsilon} \cdot \sqrt{9/8 \cdot T \cdot (z'(T) - z'(O))} \rceil)$$

where z'(O) and z'(T) are (finite) subgradients of z(t) for t=O and T, resp. Thus, the parametric network flow problem can be solved up to an arbitrary small $\varepsilon > 0$ by a pseudo-polynomial algorithm.

W. EICHHORN:

Optimization and Estimation in Price Measurement

Let x^t, p^t be quantity and price vectors, resp., at time t=O,1. The statistical theory of the price index calls every function

$$P: \mathbb{R}^{4n}_{++} \rightarrow \mathbb{R}_+, \quad (x^o, p^o, x^1, p^1) \rightarrow P(x^o, p^o, x^1, p^1)$$

satisfying a system of (certain monotonicity, homogeneity, dimensionality and normalizing) axioms a price index. An advantage of this theory is the fact that only directly observable variables are handled. But there is also a drawback: the dependency of the quantities on the prices is not sufficiently dealt with. The economic theory of the price index does not have this disadvantage. In this theory the definition

$$(1) \qquad \mathcal{P}(p^o, p^1, U, u^*) = \frac{\min_x \{xp^1 \mid U(x) \geq u^*\}}{\min_x \{xp^o \mid U(x) \geq u^*\}}$$

plays an important rule. Since one does not know the utility function U of a household (exactly), one is interested in lower and upper bounds for the so-called Konüs index (1) with different utility levels u*. These bounds should possible be functions only of x^o, p^o, x^1, p^1, where x^o, x^1 are assumed to be solutions of $\min_x \{xp^o \mid U(x) \geq u^*\}$ and $\min_x \{xp^1 \mid U(x) \geq u^{**}\}$, respectively. In this connection, some results from the PhD thesis of U. Niemeyer, Karlsruhe, were presented.

G. FEICHTINGER:

Production-Pollution Trade Off: An Example in Nonlinear Optimal Control

The concept of a representative firm's 'normal' pollution level as weighted average of past 'actual' pollution levels is introduced:

$$R(t) = m\int_{-\infty}^{t} \exp\{-m(t-s)\} P(s)ds.$$

The impact of an incentive scheme is analysed, in which the representative firm pays a penalty (or receives a subsidy) when it deviates above (or below) its normal pollution level. The conclusion is, a cyclical production and pollution problem may be optimal under certain conditions.

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M. GRÖTSCHEL:

Finding Optimum Clusters

A number of real world clustering problems can be formulated in the following way. Given a complete graph $G=(V,E)$ with edge weights $c_e \in \mathbb{R}$ for all $e \in E$, partition V into disjoint node sets $V_1,\ldots,V_k$ (for some $k \geq 1$) such that $\sum_{i=1}^{k} \sum_{e \in E(V_i)} c_e$ is as small as possible.
This problem is $\mathcal{NP}$-complete. We will report in this talk about a polyhedral approach to this problem and about a cutting plane algorithm that is based on the facet description of the corresponding polytope. This cutting plane algorithm has been implemented and shows very good (empirical) behaviour. Solutions of some large-scale problems from practice will also be discussed. This work is joint with Yoshiko Wakabayashi (São Paulo).

H. W. HAMACHER:

Convex Time-Cost Tradeoff Problems

The convex component functions h_j of a separable convex program $CP(h)=\min_{x \in P} H(x)=\sum_{j=1}^{m} h_j(x_j)$ can be approximated by upper and lower ε-approximations h_j^n and h_j^l using the sandwitch algorithm of Burkard et al. Since these approximations are piecewise linear, $CP(h^n)$ and $CP(h^l)$ can in many cases be computed efficiently. The optimal objective values of these programs provide lower and upper ε-approximations of the objective value of $CP(h)$.
After discussing this general result we look at its consequences in convex time-cost tradeoff problems.

A. HORDYK:

Constrained Admission Control to a Queueing System

This talk reports on joint research with Floske Spieksma.
Consider an exponential queue with arrival and service rates depending on the number of jobs present in the system. The system can be controlled by restricting arrivals. A good policy should provide a proper balance between throughput and congues-tion.
A mathematical model for computing such a policy is a Markov decision chain with reward and a constrained cost function. We give general conditions on the reward and cost function which guarantee the existence of an optimal threshold policy. An optimal policy of this type can be computed recursively.

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R. HORST:

On an Outer Approximation Concept

An outer approximation concept for global optimization is presented that admits unbounded feasible regions and non-affine cuts. A related theorem on the convergence is deduced that allows to derive
(i) several practicable and useful constraint dropping strategies,
(ii) a mechanism for deleting constraints in nonlinear optimization problems having a large number of constraints,
(iii) a large new class of catting plane algorithms.
The results stem from joint work with Hoang Tuy and Nguyen V. Thoai.

P. S. KENDEROV:

On a Class of "Max Min" Problems

Let X and Y be compact spaces. For $f \in C(X \times Y)$ consider the "max min" problem $(P_f) \max_{x \in X} \min_{y \in Y} f(x,y)$.
For a large class of spaces $\mathcal{L}$, including - in increasing generality - all metrizable, Eberlein, Talagrand, Gul'no, Radon-Nikodym compacta, the following result is proved
Theorem (N. Ribarska and P. S. Kenderov). If X and Y are from the class $\mathcal{L}$, then the set $\{f \in C(X \times Y) : (P_f)$ has unique solution$\}$ contains a dense and G_δ suspace of $C(X \times Y)$ when $C(X \times Y)$ is endowed with the uniform distance norm.

H. KÖNIG:

Recent Progress Around the Hahn-Banach Theorem

In 1978 Rodé (Arch. Math. 32 (1978), 474-481) published an abstract sandwich version of the Hahn-Banach theorem which seems to contain all the familiar forms of the theorem. Its formulation requires very little structure, but the proof given by Rodé is much more complicated than it has to be expected in such a situation and has resisted all efforts for simplification ever since. Now the present author recently found a simple proof of Rodé's theorem which is outlined in the talk; it will be published in Aequationes Math. Finally an application due to Kuhn (General Inequalities 4, Oberwolfach 1983) is described which in a sense requires the full power of Rodé's theorem.

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A. B. KURZHANSKI:

Duality Concepts in Feedback Control

A duality theory is presented which links the solutions to feedback control problems under state constraints with those obtained for adaptive estimation of the state space variables of linear systems under set-membership uncertainty in the inputs and measurement errors. The result is a reflection in "system-theoretic" terms of some duality relations in subdifferential calculus of nonlinear analysis. The emphasis in the result is on the duality of feedback solutions in contrast with the conventional "static" duality for open-loop control problems of control and observation.

C. LEMARECHAL:

A Case Study in Glass Industry

A glass furnace has several outputs (multi-machine problem) from which come drops of glass at a high frequency. Several products (multi-item problem) can be made then, via the appropriate device: window panes, windschields, bottles... The demand is sold at a low frequency so there is a stock and the problem is to optimize the rate of production (economic lot-size problem).
The resulting optimization problem lends itself to decomposition, and this gives raise to a nondifferentiable convex problem with few variables. This problem can be solved efficiently.

K. MARTI:

Effiziente Lösungen stochastischer Programme

Betrachtet werden stochastische Optimierungsprobleme der Art

$$\min Eu(A(\omega)x-b(\omega)) \text{ bez. } x\in D \qquad (1)$$

unter der Annahme, daß die Zufallsmatrix $(A(\omega),b(\omega))$ eine diskrete Verteilung hat. Da in der Praxis die konvexe Verlustfunktion u häufig nicht eindeutig festgelegt werden kann, wird als Ersatz für eine Optimallösung x^* von (1) die Menge E_D der effizienten Lösungen von (1) eingeführt. Ausgehend von einem Verfahren zur Berechnung von Abstiegsrichtungen der Zielfunktion F von (1), das sich auf ein System linearer Relationen stützt, werden verschiedene Methoden zur Berechnung von E_D sowie zur Berechnung von Inklusionen $\underline{E}\subset E_D\subset \bar{E}$ angegeben.

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R. H. MÖHRING:

Scheduling Project Networks With Resource Constraints And Time Windows

Project networks with time windows are generalizations of the well-known CPM and MPM networks that allow for the introduction of arbitrary minimal and maximal time lags between the starting and completion times of any pair of activities.
We consider the problem to schedule such networks subject to arbitrary (even time-dependent) resource constraints in order to minimize an arbitrary regular performance measure (i.e. a non-decreasing function of the completion times). This problem arises in many standard industrial construction or production processes.
The treatment is done by a structural approach that involves a generalization of both the disjunctive graph method in job shop scheduling and the order-theoretic methods for ordinary project scheduling. Besides theoretical insights into the problem structure, this approach also leads to rather powerful branch-and-bound algorithms.

M. MORLOCK:

Structures of Heuristics

Influenced by the progress in the field of artificial intelligence and especially rule based expert systems heuristics recently are becoming more importance as an appropriate tool for solving a lot of OR-problems which are of practical interest. Furthermore by the simple structure of these algorithms problem solving procedures and solutions can be constructed in an interactive and clear way thus supporting the acceptance of the derived solutions.
Outgoing from some principles of common sense to solve problems in everyday life close relations to basic search procedures in heuristics are outlined and transfered to a concept of a meta-heuristic in which a bundle of heuristics is used at the same time to adjoin their advantages and eliminate their disadvantages using not only heuristic information of the problem to solve, but also of the heuristics and their respective structure in combination thus - implemented in the framework of an expert system - serving both as a brain amplifier and learning system.

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K. NEUMANN:

Stochastic Single-Machine Scheduling With OR Network Precedence Constraints

OR networks are cyclic GERT project networks all of whose nodes have an OR entrance and a deterministic or stochastic exit. The assumption that, figuratively speaking, different walks emanating from a deterministic node of an OR network do not need beyond that node ensures that an OR network has some (generalized) tree structure. The tree-structure property can be exploited to generalize Smith's ratio rule from deterministic scheduling to solve the stochastic single-machine scheduling problem for minimizing the sum of expected weighted completion times subject to precedence constraints given by an OR network in polynomial time. We consider two different cases: First, activities in cycles are counted for the objective function as often as they are carried out, and second, a passage through a strong component C is viewed as a whole and each activity of C is taken into account only once.

J. VAN NUNEN:

Has the Centre to be in the Middle

The problem that is addressed stems from a location allocation problem at Shell. It concerned the distribution of iron gas bottles from a filling plant via (26) warehouses to about (4000) subdepots. The problem can be formulated as a mixed integer linear program. When we solved the problem it appeared that the majority of the warehouse locations were almost at the border of the area they had to serve. So the question arised whether we could get insight in this phenomenon. It appeared that if the transportation costs of bulle transport from plant to warehouse compared with the distribution costs from warehouse to subdepot are $1:\mu$, then the warehouse will be close at the border of their area for $\mu \leq 2$. For $\mu \to \infty$ the warehouse will approach the middle of his area. Several cases are analysed to support the idea that the title of the talk contains a practically relevant question.

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D. PALLASCHKE:

Second Order Derivatives For Quasi-Differentiable Functions
(jointly with Peter Recht and Ryszard Urbański)

Let $U \subseteq \mathbb{R}^n$ be an open set, $x_o \in U$ and $f: U \to \mathbb{R}$ a locally Lipschitz function. Moreover let $\mathcal{D}(\mathbb{R}^n) := \{p-q \mid p,q: \mathbb{R}^n \to \mathbb{R} \text{ sublinear}\}$. Then f is quasi-differentiable at $x_o \in U$ iff there exists a $T \in \mathcal{D}(\mathbb{R}^n)$, such that $\bigwedge_{\varepsilon>0} \bigvee_{\delta>0} \bigwedge_{\substack{h\in\mathbb{R}^n \\ x_o+h\in U \\ \|h\|\leq\delta}} |f(x_o+h)-f(x_o)-T(h)| \leq \varepsilon \|h\|$.

We write $df|_{x_o} = T$.

Let $\mathcal{D}_2(\mathbb{R}^n) := \{p-q \mid p,q: \mathbb{R}^n \to \mathcal{D}(\mathbb{R}^n) \text{ sublinear}\}$ and let $g \in \mathbb{R}^n$. We say that $x \to df|_x$ is directional differentiable with respect to g if there exist subsets $\tilde{\underline{\partial}} f|_{x_o} \subseteq \underline{\partial} f|_{x_o}$ and $\tilde{\overline{\partial}} f|_{x_o} \subseteq \overline{\partial} f|_{x_o}$ such that

$$\frac{d}{dg}\Big|_{x_o}(df) = \lim_{\substack{\alpha\to 0 \\ \alpha>0}} \frac{df|_{x_o+\alpha y} - \tilde{d}f|_{x_o}}{\alpha}$$

exists in $\mathcal{D}(\mathbb{R}^n)$ where $\tilde{d}f|_{x_o}(g) = \sup_{v\in\tilde{\underline{\partial}} f|_{x_o}} \langle v,g\rangle + \inf_{v\in\tilde{\overline{\partial}} f|_{x_o}} \langle v,g\rangle$.

If $g \to \frac{d}{dg}\Big|_x df \in \mathcal{D}_2(\mathbb{R}^n)$, then we denote this map by $d^2 f|_{x_o}$.

Linearity and basic properties of the second order derivation is proved.

D. PRZEWORSKA-ROLEWICZ:

Smooth Solutions of Equations in a Right Invertible Operator With Scalar Coefficients

Let X be a linear space over an algebraically closed field $\mathcal{F}$ (for instance, $\mathcal{F} = \mathbb{C}$) of scalars. Let D be a right invertible operator with the domain and range in X and let $\ker D \neq \{0\}$. A linear subset U of X is said to be D-closed if $DU \subset U$, $RU \subset U$ for a right inverse R and if every equation with scalar coefficients $P(D)x = y \in U$ has all solutions in U. The set $D_\infty = \bigcap_{i=0}^{\infty} \operatorname{dom} D^i$ (where $\operatorname{dom} D^0 = X$) is D-closed.
If X is a Banach space and F is an initial operator for D corresponding to a quasinilpotent right inverse R (i.e. a projection onto $\ker D$ such that $FR=0$) then the following sets are D-closed:

(i) $A_R(D) = \{x\in D_\infty : x = \sum_{k=0}^{\infty} R^k F D^k x\} = \{x \in D_\infty : \lim_{n\to\infty} R^n D^n x = 0\}$ - analytic elements.

(ii) $A_R(D) \oplus Q_R$, where $Q_R = \bigcap_{i=0}^{\infty} R^i X = \{x\in D_\infty : R^n D^n x = x \text{ for all } n \in \mathbb{N}\} = \{x \in D_\infty : FD^k x = 0 \text{ for } k=0,1,\ldots\}$;

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(iii) $PA_R(D)=\{x\in D_\infty:\lim_{n\to\infty} R^n FD^n x=0\}$-paraanalytic elements.

By definition $A_R(D) \oplus Q_R \subset PA_R(D)$ and $PA_R(D)\neq D_\infty$. There are elements of $PA_R(D)$ which do not belong to $A_R(D) \oplus Q_R$. Examples are given by J. Rogulski.

W. R. PULLEYBLANK:

Network Reliability and Matroid Steiner Problems

A matroid Steiner problem is obtained by selecting a suitable subfamily $\hat{\mathcal{C}}$e of the cocircuits, and then defining a Steiner "tree" to be a minimal set having nonempty intersection with all members of $\hat{\mathcal{C}}$e. The family of all sets whose complements contain Steiner trees forms and independence system which we call the Steiner complex. We show that this complex can be partitioned into as many intervals as there are bases in the underlying matroid. We also describe a generalization of the Tutte polynomial for matroids to an extended Tutte polynomial for Steiner complexes. This provides an alternative method for evaluating the independence or reliability polynomials. We also discuss reliability applications.

F. J. RADERMACHER:

Characterization of the Critical Posets in Two-Machine Unit Time Scheduling

Scheduling of partially ordered unit time jobs on m machines, aiming at minimal schedule length, is known as one of the notorious combinatorial optimization problems, for which the complexity status still is unresolved. Available results give polynomial time algorithms for special classes of partial orders and for the case m=2. From a systematicial point of view, insight into the minimal (critical) posets with a certain optimal schedule lenght could be pivotal for finding polynomial time algorithms in general. The paper includes some comments on this approach, the complete characterization of the minimal posets in case m=2 and some remarks on minimal posets in case m>2.

A. M. G. RINNOYKAN:

Heuristic Methods Under Uncertainty

The quality of heuristic methods as measured by their behaviour under uncertainty in the problem data can be evaluated in many

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ways. We compare four different approaches by applying them to the parallel makespan scheduling problem and the (multi) knapsack problem.

S. ROLEWICZ:

On Δ-Uniform Convexity And Drop Property

Let $(X, \|\ \|)$ be a real Banach space. Let B denote the closed unit ball in X. We say that the norm $\|\ \|$ has drop property f for any closed set C disjoint with B. There is a point $x \in C$ such that $C \cap \operatorname{conv}(\{x\} \cup B) = \{x\}$.
It was proved by the speaker and V. Montesinos that the norm $\|\ \|$ has drop property if and only if the following condition holds
(α) for any linear continuous functional f of norm 1

$$(*) \qquad \lim_{\delta \to 0} \alpha(S(f,\delta)) = 0,$$

where $S(f,\delta) = \{x \in B : f(x) \geq 1-\delta\}$ and α denotes the index of noncompactness of Kuratowski. In the talk it was shown that the uniform condition (α), i.e. uniform, with respect to f limit (*) it is nothing else as so called Δ-uniform convexity introduced by Goebel and Sekowski in investigations of non-expansive mappings.

M. SCHÄL:

On the Two Optimality Equations in Dynamic Programming

We consider a Markov decision process with the average reward criterion. At each step n a decision function $f_n \in \mathbb{F}$ is chosen. With each $f \in \mathbb{F}$ there is associated a one-step reward vector r_f and a transition matrix $\mathbb{P}_f$. If g^* is the optimal average reward vector, then the first optimality equation is

$$(1) \qquad g^* = \max_{f \in \mathbb{F}} \mathbb{P}_f\, g^*, \text{ let } \mathbb{F}^0 = \{f \in \mathbb{F};\ g^* = \mathbb{P}_f\, g^*\}.$$

For the second optimality equation two versions are used:

$$(2) \qquad g^* + v = \max_{f \in \mathbb{F}} [r_f + \mathbb{P}_f v] \text{ for some vector } v,$$

$$(2)^0 \qquad g^* + v^0 = \max_{f \in \mathbb{F}^0} [r_f + \mathbb{P}_f v^0] \text{ for some vector } v^0.$$

By (1) and $(2)^0$ one can construct an optimal stationary plan. By (1) and (2) one can show that each plan which is optimal within the set of stationary plans is also strongly optimal in the class of all non-stationary plans. Here it is shown that (2) holds under the same natural compactness and continuity assumptions which are known for the validity of $(2)^0$.

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S. SCHAIBLE:

Multi-Ratio Fractional Programs

Fractional programs involving several ratios in the objective function are analyzed. First, for max-min fractional programs duality results as well as an algorithm are presented. In the second part of the talk we consider multiobjective fractional programs. For two and three criteria (ratios) the connectedness of the set of pareto-optimal solutions is analyzed. This is done for the more general case of quasiconcave objective functions.

R. SCHASSBERGER:

Some New Results for the M|G|1 Queue Under Time-Sharing Disciplins

The time sharing disciplines considered in this talk for the M|G|1 queue are SSPT (shortest spent processing time) and SRPT (shortest remaining processing time). For both of these the state of the queue can be considered a measure on the Borel sets of the positive real line, where, for instance in the case of SSPT, the interval (a,b) has measure n if there are n customers present with spent service times between a and b. The state process is then a measure-valued Markov process, and the objective of the talk is a presentation of the Laplace functionals of the limiting random measures for both disciplines, as time goes to infinity.

K. SCHITTKOWSKI:

Advanced Software Technologies for Solving Mathematical Programming problems

When considering the whole life cycle a practical problem solving process, the effort to calculate a numerical solution of a mathematical model becomes more and more negligible compared with the work to model the problem, to provide input data, to organize data and programs and to interprete the results. By using more advanced programming techniques it is possible to implement intelligent, knowledge-based mathematical programming systems. The result might be an integrated problem solving system that supports model building, algorithmic decisions, data processing and interactive communication with the computer, and that is capable to learn and to guide an user in error situations. As an example, a specific system is introduced that was designed to support the numerical solution of mathematical programming problems (LP,QP, NLP,LS,MCO,NSO,...). It is shown how a rule-based failure analysis might work in a special situation to find out the reason for the error reported by a nonlinear programming algorithm, and to propose remedies for further actions.

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C. SCHNEEWEISS:

Main Aspects of an Export System for Pure Short-Term Inventory Problems

The paper considers periodically reviewed multi-item (single) inventory problems having capacity constraints (handling, budget, warehouse space), deterministic or stochastic demand and delivery times, cost an non-cost criteria, and service level constraints. For these problems the main features of an export system are developed assigning for given datas a specified ordering rule. The main structuring idea is to relax the original problem to a stationary non-constraint DP-problem resulting in an (s,S)-rule. In a second step the richer features of the original problem are then reintroduced starting with the characteristics of the time series involved. Their deterministic forecoasts together with the capacity constraints are used to calculate an adapted D:=S¬s whereas mainly the variances of demand and lead time are responsible of an adaptation of the recorder point s. Various simulation results constitute one expert knowledge which allows to select the appropriate models to calculate s and S for a specific (s,S)-ordering rule.

H. C. TIJMS:

The Interval Availability Distribution for the 1 Out-Of-2 Reliability System With Repair

In this talk we consider a reliability model with one operating unit and one cold standby unit. If the operating unit fails, it is replaced immediately by the failed unit if available. The failed unit enters directly repair. The system goes down when both units are in repair. Both the life time and the repair time have general probability distributions. The literature usually considers the performance measure of the fraction of time the system is down. However, in practice one is typically interested in availability distributions. We shall discuss how accurate approximations can be obtained to the probability distributions of the amount of time the system is down during a time interval of given length. The basic idea is to approximate the process of up- and downtimes by an alternating renewal process in which the on- and off-periods have exponential distributions. This approximate approach is bached up by the basic result that the time until the first occurrence of a rare event in a stochastic process is approximately exponentially distributed.

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W. VOGEL:

Sequential Approximation with Errors

We show that the comparison of the asymptotic behaviour of a certain linear difference-equation with a nonlinear difference-equation may be regarded as a Mercer-Type-Theorem. This comparison is then used to prove the convergence of approximation-procedures, which involve an error-term, especially the convergence of stochastic approximation procedure.

J. WEGLARZ:

Scheduling Under Continuous Models of Jobs: Processing Speed vs. Resource Amount

We consider problems of allocating continuous (i.e. continuously-divisible) resources among jobs described by differential equations relating their processing speeds to resource amounts alloted at every moment. Beginning (equal to zero) and final states of jobs are known. Resources can be renewable, nonrenewable or doubly constrained. Using a geometrical interpretation of the properties of optimal or feasible schedules when schedule length C_{max} or maximum lateness L_{max} have to be minimized or jobs have to be processed by their deadlines. We also formulate vector-optimization problems of finding the best (in a given sense) compromise between resource levels and project performance measures.

G. WEISS:

Some Results And Conjectures in Stochastic Scheduling

Jobs $1,\ldots,n$ with processing times $X_1,\ldots,X_n$ are started in that order on two parallel machines and completed at $C_1,\ldots C_n$. When job i starts its processing on one machine let D_{i-1} be the remaining processing time of the job on the other machine, $i=1,\ldots,n$; let D_n be the remaining processing of the last job when the first machine completes all processing. The flowtime $\sum_1^n c_i$, is given by:

$$\sum c_i=\frac{1}{2}\{nx_1+(n-1)x_2+\ldots+x_n\}+\frac{1}{2}\{(X_1-D_o)+(X_2-D_1)+\ldots(X_n-D_n)\},$$

and the D_i form a Markov chain, $D_i=|X_i-D_{i-1}|$, $i=1,\ldots,n$.

If all jobs have the same expected processing time, $E(X_i)=\mu$, and variances σ_i^2, $i=1,\ldots,n$, then:

$$E(\sum C_i)=\frac{n(n+1)}{4}\mu+\frac{n}{4}\mu(1-\frac{\Sigma\sigma_i^2}{n\mu^\lambda})-\frac{D_o^2}{4\mu}+\frac{E(D_n^2|D_o)}{4\mu}.$$

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Since only the last term depends on the schedule, all schedules are approximately optimal in minimising expected makespan.
We conjecture that in general, SEPT (shortest expected processing time first) is almost optimal, i.e.:

(i) $E(\sum C_i \text{ SEPT}) - E(\sum C_i \text{ OPTIMAL}) = O(1)$

(ii) If more than n_o jobs remain it is optimal to start the SEPT job (turnpike).

J. WESSELS:

Design of Production Lines

In the talk the problem is considered of designing an automatic production line based on a flexible transport system. The main features of the system with respect to model analysis are its size and the fact that in part 1 of the system production proceeds in batcher. Furthermore, most of the machines suffer from irregular breakdown which require repair. The analysis is completed by breaking down the model into a sequence of small models which can be treated by a renewal theoretic method of J. Wŷngaard. Wŷngaard's method considers production as a stream of fluid. Remarkably even the batcher can be treated that way if one uses a little trick.

U. ZIMMERMANN:

Some Approximation Problems In Totally Ordered Structures

A share function $f: M \to N$ for t.o. sets M and N is characterized by the fact that all its level sets are either empty or closed intervals, say $x \in [f^-(z), f^+(z)]$ iff $f(x) \leq z$. We consider approximation problems of the type

$$z_* := \min\{ \|a(x) - b(y)\|_\infty \mid 0 \leq x \leq u,\ 0 \leq y \leq d\}$$

where $a_i(x) := \max\{r_{ij}(x_j) \mid 1 \leq j \leq n\}$, $b_i(y) := \max\{s_{i\mu}(y_\mu) \mid 1 \leq \mu \leq r\}$, $1 \leq i \leq m$, and where $r_{ij}, s_{i\mu}$ are monotone share functions. For general nonmonotone share functions the problem is introctable, in particular it contains the satisfyability problem. We reduce the problem to solving a sequence of functional equations

$$t_i = z + \min(a_i(x(t)), b_i(x(t))) \qquad (1 \leq i \leq m)$$

where $x_j(t) := \min(n_j, r^+_{1j}(t_i), \ldots, r^+_{mj}(r_m))$, $1 \leq j \leq n$ and where $y_\mu(t) := \min(d_\mu, s^+_{1\mu}(t_1), \ldots, s^+_{m\mu}(t_m))$, $1 \leq \mu \leq r$. The respective functional equation is solved using the method of successive approximations which is proved to converge under suitable assumptions, e.g. if all share functions are continuous. Then, z_* is found using binary search techniques.

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J. ZOWE:

How to Approximate a Set-Valued Map

The known methods in nonsmooth optimization are taken slow. In order to accelerate them we propose to incorporate second order elements (like the Hessian in the smoothcase). For convex f this means: we have to look for a derivative (or an approximation) of the set-valued map $x \to F(x) := \partial f(x)$. We show that the obvious approach, namely to approximate F by some affine set-valued map, is a too strong concept; semialtinity or even convexity of the graph proves to be more suitable. We give necessary and sufficient conditions in terms of the support functions of F(x) under which such approximations exist; we characterize these approximations and show unicity for the affine and semiaffine case.

Berichterstatter: P. Recht

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