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1 introduction 2 problem formulation 2 1 notations and representations 2 2 restrictive assumptions 2 3 optimality criteria 2 3 1 regular measures 2 3 1 1 criteria based on completion times 2 3 1 2 criteria based on due dates 2 3 1 3 criteria based on inventory cost and utilization 2 3 2 relations between criteria 2 3 3 analysis of scheduling costs 2 4 classification of problems 3 methods of solution 3 1 complete enumeration 3 2 combinatorial analysis 3 3 mixed integer and non linear programming 3 3 1 bowman 1959 3 3 2 pritsker et al 1969 this work reviews the most important results regarding the use of the α point in scheduling theory it provides a number of different lp relaxations for scheduling problems and seeks to explain their polyhedral consequences it also explains the concept of the α point and how the conversion algorithm works pointing out the relations to the sum of the weighted completion times lastly the book explores the latest techniques used for many scheduling problems with different constraints such as release dates precedences and parallel machines this reference book is intended for advanced undergraduate and postgraduate students who are interested in scheduling theory it is also inspiring for researchers wanting to learn about sophisticated techniques and open problems of the field this book is a printed edition of the special issue algorithms for scheduling problems that was published in algorithms this work reviews the most important results regarding the use of the point in scheduling theory it provides a number of different lp relaxations for scheduling problems and seeks to explain their polyhedral consequences it also explains the concept of the point and how the conversion algorithm works pointing out the relations to the sum of the weighted completion times lastly the book explores the latest techniques used for many scheduling problems with different constraints such as release dates precedences and parallel machines this reference book is intended for advanced undergraduate and postgraduate students who are interested in scheduling theory it is also inspiring for researchers wanting to learn about sophisticated techniques and open problems of the field this is a comprehensive study of various time dependent scheduling problems in single parallel and dedicated machine environments in addition to complexity issues and exact or heuristic algorithms which are typically presented in scheduling books the author also includes more advanced topics such as matrix methods in time dependent scheduling time dependent scheduling with two criteria and time dependent two agent scheduling the reader should be familiar with the basic notions of calculus discrete mathematics and combinatorial optimization theory while the book offers introductory material on theory of algorithms np complete problems and the basics of scheduling theory the author includes numerous examples figures and tables he presents different classes of algorithms using pseudocode he completes all chapters with extensive bibliographies and he closes the book with comprehensive symbol and subject indexes the previous edition of the book focused on computational complexity of time dependent scheduling problems in this edition the author concentrates on models of time dependent job processing times and algorithms for solving time dependent scheduling problems the book is suitable for researchers working on scheduling problem complexity optimization heuristics and local search algorithms machine scheduling problems are counted among the most classic topics in the field of discrete applied mathematics and operations research and have therefore been intensively studied during the last five decades one basic problem is the non preemptively scheduling of a set of independent jobs on identical parallel machines which is dealt with in this thesis three different but related objective functions are considered that indirectly aim at practice oriented balanced schedules despite the multitude of contributions to scheduling problems in literature this thesis brings up interesting questions that have hardly or not yet been investigated thereby detailed and in depth analyses of heuristic solution procedures as well as

relationships between different heuristics play an important role moreover the present work contributes to optimal scheduling by containing a complete characterization of the set of potentially optimal makespan schedules in a two machine environment finally attractive ideas and suggestions for future research top off this thesis two algorithms have been formulated for scheduling n jobs through a single facility to minimize the number of late jobs when set up times are sequence dependent the first is a simple matrix algorithm which solves the problem when jobs must be processes in first come first served fcfs order the second is a branch and bound technique which arrives at an optimal solution with no restrictions on the sequence used both algorithms are demonstrated by examples author the work is about fundamental parallel machine scheduling problems which occur in manufacturing systems where a set of jobs with individual processing times has to be assigned to a set of machines with respect to several workload objective functions like makespan minimization machine covering or workload balancing in the first chapter of the work an up to date survey on the most relevant literature for these problems is given since the last review dealing with these problems has been published almost 20 years ago we also give an insight into the relevant literature contributed by the artificial intelligence community where the problem is known as number partitioning the core of the work is a universally valid characterization of optimal makespan and machine covering solutions where schedules are evaluated independently from the processing times of the jobs based on these novel structural insights we derive several strong dominance criteria implemented in a branch and bound algorithm these criteria have proved to be effective in limiting the solution space particularly in the case of small ratios of the number of jobs to the number of machines further we provide a counter example to a central result by ho et al 2009 who proved that a schedule which minimizes the normalized sum of squared workload deviations is necessarily a makespan optimal one we explain why their proof is incorrect and present computational results revealing the difference between workload balancing and makespan minimization the last chapter of the work is about the minimum cardinality bin covering problem which is a dual problem of machine covering with respect to bounding techniques we discuss reduction criteria derive several lower bound arguments and propose construction heuristics as well as a subset sum based improvement algorithm moreover we present a tailored branch and bound method which is able to solve instances with up to 20 bins this thesis proposes and evaluates some online algorithms for machine scheduling problems deterministic scheduling models have been extensively studied in the literature one of the basic assumptions of these models is that all the information is known in advance however this assumption is usually not realistic this observation promotes the emergence of online scheduling in online scheduling problems an online algorithm has to make decisions without future information competitive analysis is a method invented for analyzing online algorithms in which the performance of an online algorithm which must satisfy an unpredictable sequence of requests completing each request without being able to see the future is compared with the performance of an a posteriori optimal solution where the sequence of requests is known in the framework of competitive analysis the performance of an online algorithm is measured by its competitive ratio we mainly deal with two online paradigms the one where jobs arrive over list and the one where jobs arrive over time based on these two paradigms we consider different models single machine two identical parallel machines two uniform parallel machines batch processing machine and open shop for each of the problems we prove a lower bound of competitive ratios and propose online algorithms then we further measure the worst case performance of these algorithms for some problems we can show that the algorithms we proposed are optimal in the sense that their competitive ratios match the lower bounds the usps is the second largest employer in the u s with over 800 000 personnel more than 1 3 of them work at approximately 275 mail processing centers p dcs nationwide these facilities run 24 hours a day 7 days a week and contain a wide variety of equipment for accepting processing and transporting the mail this dissertation focuses on developing a comprehensive framework on how to manage the use of this equipment with minimum labor cost the equipment scheduling problem is modeled as a large scale mixed integer program with multi criteria one of the main contributions in the model is the inclusion of a surrogate for labor costs in the form of workers shifts that match daily operations

the problem is solved sequentially using a three phase methodology related to goal programming in conjunction with a post processor to assign operations to machines two specialized algorithms have been investigated to solve the mixed integer program in the third phase the first is a piece by piece lp based heuristic and the second is a benders decomposition the heuristic uses the lp fractional solution as a target and attempts to find integer solutions that are as close to it as possible the process consists of solving the lp relaxation and two additional integer programs and is similar to a piece by piece decomposition used in nonlinear programming while a branch and bound algorithm is computationally expensive and the classic benders algorithm failed to give feasible solutions the lp based heuristic yields near optimal almost feasible solutions orders of magnitude faster in post processing a multi period machine assignment problem is solved this problem is modeled as a bi criterion 0 1 integer program and a two stage heuristic is developed in a comparative study high quality solutions were routinely provided by the heuristic in negligible time when compared to a branch and bound algorithm for most hard problem instances the branch and bound algorithm was not able to even find continuous solutions within acceptable time limits the methodology developed in this dissertation is demonstrated with data provided by the dallas p dc the results indicate that annual savings on the order of 1 6 million per facility can be achieved the system will be implemented nationwide in the next three years we consider a single machine scheduling problem with deadlines and we want to characterise the set of optimal solutions without enumerating them we assume that jobs are numbered in edd order and that this sequence is feasible the key idea is to use the lattice of permutations and to associate to the supremum permutation the edd sequence in order to characterize a lot of solutions we search for a feasible sequence as far as possible to the supremum the distance is the level of the sequence in the lattice which has to be minimum this new objective function is investigated some polynomially particular cases are identified but the complexity of the general case problem remains open some resolution methods polynomial and exponential are proposed and evaluated the level of the sequence being related to the positions of jobs in the sequence new objective functions related to the jobs positions are identified and studied the problem of minimizing the total weighted positions of jobs is proved to be strongly np hard some particular cases are investigated resolution methods are also proposed and evaluated scheduling theory has received a growing interest since its origins in the second half of the 20th century developed initially for the study of scheduling problems with a single objective the theory has been recently extended to problems involving multiple criteria however this extension has still left a gap between the classical multi criteria approaches and some real life problems in which not all jobs contribute to the evaluation of each criterion in this book we close this gap by presenting and developing multi agent scheduling models in which subsets of jobs sharing the same resources are evaluated by different criteria several scenarios are introduced depending on the definition and the intersection structure of the job subsets complexity results approximation schemes heuristics and exact algorithms are discussed for single machine and parallel machine scheduling environments definitions and algorithms are illustrated with the help of examples and figures abstract a parallel machine scheduling problem is considered in which each job has a processing time and a delivery time the objective is to find a schedule which minimizes the time by which all jobs are delivered for the single machine this problem is easily solved in polynomial time for m or machines it becomes np hard several heuristics using list scheduling as a subroutine are proposed and analysed the best one of our heuristics has a worst case performance guarantee of 2 2 m 1 for the on line case we give a heuristic with the best possible worst case performance of two

Machine Scheduling Problems

2012-12-06

1 introduction 2 problem formulation 2 1 notations and representations 2 2 restrictive assumptions 2 3 optimality criteria 2 3 1 regular measures 2 3 1 1 criteria based on completion times 2 3 1 2 criteria based on due dates 2 3 1 3 criteria based on inventory cost and utilization 2 3 2 relations between criteria 2 3 3 analysis of scheduling costs 2 4 classification of problems 3 methods of solution 3 1 complete enumeration 3 2 combinatorial analysis 3 3 mixed integer and non linear programming 3 3 1 bowman 1959 3 3 2 pritsker et al 1969

Machine Scheduling to Minimize Weighted Completion Times

2018-04-30

this work reviews the most important results regarding the use of the α point in scheduling theory it provides a number of different lp relaxations for scheduling problems and seeks to explain their polyhedral consequences it also explains the concept of the α point and how the conversion algorithm works pointing out the relations to the sum of the weighted completion times lastly the book explores the latest techniques used for many scheduling problems with different constraints such as release dates precedences and parallel machines this reference book is intended for advanced undergraduate and postgraduate students who are interested in scheduling theory it is also inspiring for researchers wanting to learn about sophisticated techniques and open problems of the field

Algorithms for Scheduling Problems

2018-08-24

this book is a printed edition of the special issue algorithms for scheduling problems that was published in algorithms

Machine Scheduling to Minimize Weighted Completion Times

2018

this work reviews the most important results regarding the use of the point in scheduling theory it provides a number of different lp relaxations for scheduling problems and seeks to explain their polyhedral consequences it also explains the concept of the point and how the conversion algorithm works pointing out the relations to the sum of the weighted completion times lastly the book explores the latest techniques used for many scheduling problems with different constraints such as release dates precedences and parallel machines this reference book is intended for advanced

undergraduate and postgraduate students who are interested in scheduling theory it is also inspiring for researchers wanting to learn about sophisticated techniques and open problems of the field

Games and Mechansim Design in Machine Scheduling

2006

this is a comprehensive study of various time dependent scheduling problems in single parallel and dedicated machine environments in addition to complexity issues and exact or heuristic algorithms which are typically presented in scheduling books the author also includes more advanced topics such as matrix methods in time dependent scheduling time dependent scheduling with two criteria and time dependent two agent scheduling the reader should be familiar with the basic notions of calculus discrete mathematics and combinatorial optimization theory while the book offers introductory material on theory of algorithms np complete problems and the basics of scheduling theory the author includes numerous examples figures and tables he presents different classes of algorithms using pseudocode he completes all chapters with extensive bibliographies and he closes the book with comprehensive symbol and subject indexes the previous edition of the book focused on computational complexity of time dependent scheduling problems in this edition the author concentrates on models of time dependent job processing times and algorithms for solving time dependent scheduling problems the book is suitable for researchers working on scheduling problem complexity optimization heuristics and local search algorithms

SCHEDULE

1986

machine scheduling problems are counted among the most classic topics in the field of discrete applied mathematics and operations research and have therefore been intensively studied during the last five decades one basic problem is the non preemptively scheduling of a set of independent jobs on identical parallel machines which is dealt with in this thesis three different but related objective functions are considered that indirectly aim at practice oriented balanced schedules despite the multitude of contributions to scheduling problems in literature this thesis brings up interesting questions that have hardly or not yet been investigated thereby detailed and in depth analyses of heuristic solution procedures as well as dominance relationships between different heuristics play an important role moreover the present work contributes to optimal scheduling by containing a complete characterization of the set of potentially optimal makespan schedules in a two machine environment finally attractive ideas and suggestions for future research top off this thesis

ALGORITHMS FOR SINGLE MACHINE SCHEDULING PROBLEMS MINIMIZING TARDINESS AND EARLINESS

1986

two algorithms have been formulated for scheduling n jobs through a single facility to minimize the number of late jobs when set up times are sequence dependent the first is a simple matrix algorithm which solves the problem when jobs must be processes in first come first served fcfs order the second is a branch and bound technique which arrives at an optimal solution with no restrictions on the sequence used both algorithms are demonstrated by examples author

Machine scheduling problems

1993

the work is about fundamental parallel machine scheduling problems which occur in manufacturing systems where a set of jobs with individual processing times has to be assigned to a set of machines with respect to several workload objective functions like makespan minimization machine covering or workload balancing in the first chapter of the work an up to date survey on the most relevant literature for these problems is given since the last review dealing with these problems has been published almost 20 years ago we also give an insight into the relevant literature contributed by the artificial intelligence community where the problem is known as number partitioning the core of the work is a universally valid characterization of optimal makespan and machine covering solutions where schedules are evaluated independently from the processing times of the jobs based on these novel structural insights we derive several strong dominance criteria implemented in a branch and bound algorithm these criteria have proved to be effective in limiting the solution space particularly in the case of small ratios of the number of jobs to the number of machines further we provide a counter example to a central result by ho et al 2009 who proved that a schedule which minimizes the normalized sum of squared workload deviations is necessarily a makespan optimal one we explain why their proof is incorrect and present computational results revealing the difference between workload balancing and makespan minimization the last chapter of the work is about the minimum cardinality bin covering problem which is a dual problem of machine covering with respect to bounding techniques we discuss reduction criteria derive several lower bound arguments and propose construction heuristics as well as a subset sum based improvement algorithm moreover we present a tailored branch and bound method which is able to solve instances with up to 20 bins

Games and Mechanism Design in Machine Scheduling

2006

this thesis proposes and evaluates some online algorithms for machine scheduling problems deterministic scheduling models have been extensively studied in the literature one of the basic assumptions of these models is that all the information is known in advance however this assumption is usually not realistic this observation promotes the emergence of online scheduling in online scheduling problems an online algorithm has to make decisions without future information competitive analysis is a method invented for analyzing online algorithms in which the performance of an online algorithm which must satisfy an unpredictable sequence of requests completing each request without being able to see the future is compared with the performance of an a posteriori optimal solution where the sequence of requests is known in the framework of competitive analysis the performance of an online algorithm is measured by its competitive ratio we mainly deal with two online paradigms the one where jobs arrive over list and the one where jobs arrive over time based on these two paradigms we consider different models single machine two identical parallel machines two uniform parallel machines batch processing machine and open shop for each of the problems we prove a lower bound of competitive ratios and propose online algorithms then we further measure the worst case performance of these algorithms for some problems we can show that the algorithms we proposed are optimal in the sense that their competitive ratios match the lower bounds

The Machine Scheduling Problem

1973

the usps is the second largest employer in the u s with over 800 000 personnel more than 1 3 of them work at approximately 275 mail processing centers p dcs nationwide these facilities run 24 hours a day 7 days a week and contain a wide variety of equipment for accepting processing and transporting the mail this dissertation focuses on developing a comprehensive framework on how to manage the use of this equipment with minimum labor cost the equipment scheduling problem is modeled as a large scale mixed integer program with multi criteria one of the main contributions in the model is the inclusion of a surrogate for labor costs in the form of worker shifts that match daily operations the problem is solved sequentially using a three phase methodology related to goal programming in conjunction with a post processor to assign operations to machines two specialized algorithms have been investigated to solve the mixed integer program in the third phase the first is a piece by piece lp based heuristic and the second is a benders decomposition the heuristic uses the lp fractional solution as a target and attempts to find integer solutions that are as close to it as possible the process consists of solving the lp relaxation and two additional integer programs and is similar to a piece by piece decomposition used in nonlinear programming while a branch and bound algorithm is computationally expensive and the classic benders algorithm failed to give feasible solutions the lp based heuristic yields near optimal almost feasible solutions orders of magnitude faster in post processing a multi period machine assignment problem is solved this problem is modeled as a bi criterion 0 1 integer program and a two stage heuristic is developed in a comparative study high quality solutions were routinely provided by the heuristic in negligible time when compared to a branch and bound algorithm for most hard problem instances the branch and bound algorithm was not able to even find continuous solutions within acceptable time limits the methodology developed in this dissertation is demonstrated with data provided by the dallas p dc the results indicate that annual savings on the order of 1 6 million per facility can be achieved the system will be implemented nationwide in the next three years

An Exact Algorithm for Parallel Machine Scheduling with Conflicts

2015

we consider a single machine scheduling problem with deadlines and we want to characterise the set of optimal solutions without enumerating them we assume that jobs are numbered in edd order and that this sequence is feasible the key idea is to use the lattice of permutations and to associate to the supremum permutation the edd sequence in order to characterize a lot of solutions we search for a feasible sequence as far as possible to the supremum the distance is the level of the sequence in the lattice which has to be minimum this new objective function is investigated some polynomially particular cases are identified but the complexity of the general case problem remains open some resolution methods polynomial and exponential are proposed and evaluated the level of the sequence being related to the positions of jobs in the sequence new objective functions related to the jobs positions are identified and studied the problem of minimizing the total weighted positions of jobs is proved to be strongly np hard some particular cases are investigated resolution methods are also proposed and evaluated

Single Machine Scheduling to Minimize Weighted Earliness Subject to No Tardy Job

1985

scheduling theory has received a growing interest since its origins in the second half of the 20th century developed initially for the study of scheduling problems with a single objective the theory has been recently extended to problems involving multiple criteria however this extension has still left a gap between the classical multi criteria approaches and some real life problems in which not all jobs contribute to the evaluation of each criterion in this book we close this gap by presenting and developing multi agent scheduling models in which subsets of jobs sharing the same resources are evaluated by different criteria several scenarios are introduced depending on the definition and the intersection structure of the job subsets complexity results approximation schemes heuristics and exact algorithms are discussed for single machine and parallel machine scheduling environments definitions and algorithms are illustrated with the help of examples and figures

Complexity of machine scheduling problems

1975

abstract a parallel machine scheduling problem is considered in which each job has a processing time and a delivery time the objective is to find a schedule which minimizes the time by which all jobs are delivered for the single machine this problem is easily solved in polynomial time for m or machines it becomes np hard several heuristics using list scheduling as a subroutine are proposed and analysed the best one of our heuristics has a worst case performance guarantee of 2 2 m 1 for the on line case we give a heuristic with the best possible worst case performance of two

Solution Approaches for the Parallel Identical Machine Scheduling Problem with Sequence Dependent Setups

2002

Approaches to the N-job M-machine Scheduling Problem

1971

Models and Algorithms of Time-Dependent Scheduling

2020-06-13

Analyzing Various Aspects of Scheduling Independent Jobs on Identical Machines

2010

N Job

1972

Identical Parallel Machine Scheduling Problems

2017

Machine scheduling problems

1976

New Directions in Machine Scheduling

2000

A Novel Algorithm for Parallel Machine Scheduling

2000

Single Machine Scheduling with Timelag Constraints

2014

Parallel Machine Scheduling with a Common Server

1994

Design and Evaluation of Algorithms for Online Machine Scheduling Problems

2009

The M-machine Scheduling Problem

1969

Single Machine Scheduling with Controllable, Resource Dependent Processing Times

2009

On Parallel-machine Scheduling with Operator-constrained Setups

1994

Model and Solution Techniques for Machine Scheduling Problems in High Volume Factories

2003

A Study of Models and Algorithms for Machine Scheduling Problems with Setup Times

2000

Uniform Parallel Machine Scheduling with Family Set-up Times

2003

Optimal solutions to restricted n-job 2-machine scheduling problems of minimising makespan

1973

minimizing mean tardiness and earliness in single machine scheduling problems with unequal due-dates

1992

New Single Machine Scheduling Problems with Deadline for the Characterization of Optimal Solutions

2018

Multiagent Scheduling

2014-02-04

Essays on Machine Scheduling Problems

1994

Parallel Machine Scheduling with Resource Constraints

2019

Heuristics for Parallel Machine Scheduling with Delivery Times

1991

Application of the Branch and Bound Principle to Machine Scheduling Problems

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Robust Single Machine Scheduling-Location Problems

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