Otto-von-Guericke-Universität Magdeburg
Fakultät für Wirtschaftswissenschaft
Lehrstuhl für Betriebswirtschaftslehre VIII
- Management Science -
Prof. Dr. Gerhard Wäscher

6th PhD-Workshop

on

"Cutting, Packing and Related Topics"

Lauterbad, Germany

September 13-17, 2005

Program Overview

Tuesday, Sept. 13, 2005

15:00 -	Arrival of Participants
19:00	Dinner
20:30	Welcome (Gerhard Wäscher)

Wednesday, Sept. 14, 2005

08:00-09:00	Breakfast
09:00-12:00	Session 1 (3 papers)
12:00-12:30	Gerhard Wäscher: OR-related Research and Teaching at the Department of Management Science, Otto-von-Guericke-Universität Magdeburg
13:00-14:00	Lunch
14:00-17:00	Session 2 (3 papers)
17:00-17:30	Eberhard Bischoff: OR-related Research and Teaching at the School of Business and Economics, University of Wales Swansea
19:00	Dinner

Thursday, Sept. 15, 2005 (Day Out)

08:30-09:30	Breakfast
09:30	Hike to Alpirsbach
	Lunch on the way
15:20	Visit of the Monastery at Alpirsbach
17:00	Visit of the Brewery at Alpirsbach
19:30	Dinner either at Alpirsbach or Freudenstadt

Friday, Sept. 16, 2005

08:00-09:00	Breakfast
09:00-12:00	Session 3 (3 papers)
12:00-12:30	José Valério de Carvalho: OR-related Research and Teaching at the Dept Producao e Sistemas, Universidade do Minho, Braga
13:00-14:00	Lunch
14:00-18:00	Session 4 (4 papers)
18:00-18:30	José Fernando Oliveira: OR-related Research and Teaching at the Faculty of Engineering, University of Porto
19:00	Dinner

Saturday, Sept. 17, 2005

08:00-09:00	Breakfast
09:00-09:30	Horacio Hideki Yanasse: OR-related Research and Teaching at the National Space Research Center, São José dos Campos
09:30-10:00	Marcos Arenales: OR-related Research and Teaching at the Instituto de Ciências Matemáticas e de Computação São Carlos, Universidade de São Paulo
10:00-12:00	Discussion: Perspectives of Future Cooperation in the Area of Cutting and Packing
12:00	Good Byes
12:30	End of Workshop

Scientific Program Schedule

Wednesday, Sept. 14, 2005

9h00-12h00 Session 1

- Branch-and-price-and-cut: application in the cutting stock problem
  J. M. Valério de Carvalho
- Exact algorithms for one-dimensional cutting stock problems: recent developments
  Cláudio Alves
- The 1D Residual Bin Packing Problem – A Problem Generator and some basic heuristics
  Heike Haussner

14h00-17h00 Session 2

- Multiple periods cutting stock problems
  Kelly Cristina Poldi and Marcos Nereu Arenales
- Algorithm based on graphs for the non-guillotinable two-dimensional packing problem
  Eduarda Pinto Ferreira, José Fernando Oliveira
- Using AND/OR-Graphs to Solve Two-Dimensional Cutting Problems with One Defect
  Vera Neidlein

Friday, Sept. 16, 2005

9h00-12h00 Session 3

- An improved TOPOS constructive algorithm for nesting problems
  J.A. Bennell, X. Song
- A comparison between different approaches to the large-scale regular packing of irregular shapes in a limited sheet
  M. Teresa Costa, A. Miguel Gomes, José F. Oliveira
- LocalCompact II - a Neighbourhood Structure for Nesting Problems
  A. Miguel Gomes, José F. Oliveira

14h00-18h00 Session 4

- Predicting the solution of a random search procedure: Some experiments with a container loading algorithm
  Eberhard Bischoff
- Metaheuristic approaches to vehicle routing and container loading problems
  Ana Moura
- Neighbourhood structures for the hierarchical planning of the glass container industry
  Almado Lobo
- Data Envelopment Analysis (DEA) for Benchmarking the Performance of Distribution Centres
  Alexander Förster

Abstracts

Session 1

1.1 Branch-and-price-and-cut: application in the cutting stock problem

Author: J. M. Valério de Carvalho

Theory
- Original formulations
- Dantzig-Wolfe decomposition
- Reformulated models
- Advantages of using reformulations

Branching schemes
- robust branch-and-price
- branching based on original variables
- branching based on reformulated variables

Stabilization and acceleration of column generation processes
- Stabilization functions (Chen et al., du Merle et al., Ben-Amor et al.)
- Relation with bundle methods
- Degeneracy and perturbation
- Dual cuts

Strengthening reformulated models with valid inequalities
- compatibility with subproblem
- superadditive and non-decreasing valid inequalities
- dual feasible functions

1.2 Exact algorithms for one-dimensional cutting stock problems: recent developments

Author: Cláudio Alves

In this communication, we will present different integer programming models and exact solution methods for hard cutting and packing problems, based on the so-called branch-and-price-and-cut algorithm. We consider in particular the combinatorial problems of this family that are defined over a single dimension. Three variants of the standard one-dimensional Cutting Stock Problem are considered. We analyse the case for which more than a single large object is available, and an optimal cutting or packing has to be found so as to minimize the total length or capacity used. A related problem, which consists in selecting the best assortment of large objects subject to cardinality constraints, is also reported. The problem of maximizing the homogeneity of the plans, and hence reducing the number of setups involved with its execution, is addressed. We propose to improve an existing column generation model, and describe how to derive new valid cutting planes for it using an original approach. Finally, we describe an exact solution algorithm for the Ordered Cutting Stock Problem. Three integer programming models are discussed, along with two families of cutting planes and their respective separation algorithms.
Different strategies are also presented to improve the convergence of the column generation algorithm, when applied to one-dimensional cutting and packing problems. New dual cutting planes are presented, and we describe how existing ones can be extended to the whole branch-and-bound search tree, for a given branching scheme. Two alternative methods based on model aggregation are also explored.Various computational experiments are reported. For this purpose, we used problem instances from the literature, and randomly generated instances.

1.3 The 1D Residual Bin Packing Problem - A Problem Generator and Some Basic Heuristics

Author: Heike Haußner

One-dimensional Bin packing problems are considered, where the bins (input length) as well as the pieces, which are to be packed (output length), have different lengths. The objective is to minimize the total length of the used bins (1-dimensional RBPP). We developed a problem generator for this particular problem, which includes the input lengths as well as the desired output lengths. Both are linked by parameters that can be chosen in advance. By reason that the considered problem differs from the well-known classic one-dimensional Bin Packing Problem only in the assortment of bins, basic algorithms are developed, which derive from FFD and BFD heuristics and their variants. Using the problem generator, problem instances were generated to test these basic heuristics for the problem and some results are presented.

Session 2

2.1 Multiple periods cutting stock problems

Authors: Kelly Cristina Poldi, Marcos Nereu Arenales

2.2 Algorithm based on graphs for the non-guillotinable two-dimensional packing problem

Authors: Eduarda Pinto Ferreira, José Fernando Oliveira

The problem of cutting a rectangle into smaller rectangular pieces of given sizes is known as the two-dimensional packing problem. We are going to present an approach to this problem, which uses a graph-theoretic characterization of a feasible two-dimensional orthogonal packing problem. This characterization allows for the construction of sub optimal solutions for this type of two-dimensional packing problems with n>1000 pieces. Finally, we present computational results of the implemented algorithm.

2.3 Using AND/OR-Graphs to Solve Two-Dimensional Cutting Problems with One Defect

Author: Vera Neidlein

Many methods have been developed to solve two-dimensional cutting problems, one of which is the AND/OR-graph approach by Morabito and Arenales. Here we extend this approach to cutting problems with one rectangular defect. In particular, we show how the defect influences the shape of the plates throughout the cutting process as well as the upper and lower bounds that are required for the AND/OR-graph approach.

Session 3

3.1 An improved TOPOS constructive algorithm for nesting problems

Authors: J. A. Bennell, X. Song

The paper tackles nesting problems also know as irregular shape cutting stock problems. A constructive approach based on the TOPOS algorithm is presented and improved via a more powerful nofit polygon generator that can efficiently represent holes in the partial solution. As a result the solution quality is less dependent on the order in which the pieces are placed and new “best fit” criteria can be utilised.

3.2 A comparison between different approaches to the large-scale regular packing of irregular shapes in a limited sheet

Authors: M. Teresa Costa, A. Miguel Gomes, José F. Oliveira

The nesting problem is a two-dimensional cutting and packing problem where the small pieces to cut have irregular shapes. Nesting has been widely studied, as it is a common problem in several industrial production processes (textile, garment, footwear, metalware, etc.). A special case is the nesting of congruent copies of one Single irregular shape, which will fill, as much as possible, a limited stock sheet. Usually, the shape is very small when compared with the sheet's size.
A possible approach to this problem is the regular placement of the shapes, in a lattice way, usually called the Densest Lattice Packing (DLP). Theoretical results have been published in the literature, however, mostly considering unlimited sheets and/or convex shapes. Also simplifications of a mathematical model are described and solved to optimality. Heuristic algorithms have also been proposed, mainly concerning real industrial irregular shapes.
In this work, we propose three different approaches to tackle the DLP problem with a limited stock sheet. As no orientation constraints were considered, the first attempt was based on changing the rotation angle α, so that a list of the most promising rotation angles, which we have considered all the rotations that make some edge of the shape’s convex hull to be parallel to some edge of the stock sheet, is created and exhaustively analysed. The second one uses a list of equally spaced rotation angles, which allows the computational time to be easily controlled by the rotation angle step. The last one is based on the metaheuristic Iterated Local Search (ILS). The results obtained were compared with literature, some of them maintaining and other being improved.

3.3 LocalCompact II - a Neighbourhood Structure for Nesting Problems

Authors: A. Miguel Gomes, José F. Oliveira

This talk describes a neighbourhood structure for Nesting Problems. Two types of movements are allowed: the swap movement (pieces exchanging) and the insertion movement (hole lling). Special rules are used to select the adequate type of movement to apply to pieces.

Session 4

4.1 Predicting the solution of a random search procedure: Some experiments with a container loading algorithm

Authors: Eberhard Bischoff

4.2 Metaheuristic approaches to vehicle routing and container loading problems

Authors: Ana Moura

Distribution problems in the real world raise some practical considerations usually not considered in theoretical studies, at least in a realistic way. One of these considerations is connected with the vehicle capacity, not only in terms of cubic meters but also in terms of the cargo physical arrangements. In a distribution scene, the vehicle routing and the container loading problems are inherently related to each other. Let us consider the following scenario: a group of customers with well defined geographical locations and one vehicle to visit them. It is necessary to define the order by which the clients are visited. The respective requests (different quantities of boxes) must be loaded into the vehicle. Time windows must also be taken into consideration. Both the order by which the clients are visited and the way how cargo is arranged inside the vehicle are important issues for the feasibility and quality of a distribution solution. So, in this case, two combinatorial optimization problems meet: the vehicle routing problem with time windows (VRPTW) and the container loading problem (CLP). For the routing problem, the goal to achieve is to minimize the number of vehicles and the related total travel distance. For the loading problem is to maximize the vehicles volume utilization.
This work presents an integration of these two problems. The resulting problem is named by us Vehicle Routing and Loading Problem (VRLP). Two different methods were developed in order to solve de integrated problem. The first one treats the problem in a sequential way and the second one in a hierarchical way. Using the sequential approach three heuristics were developed one based in Monte Carlo procedure, a compound heuristic and the last one using the GRASP heuristic. With the hierarchical approach, the VRLP is solved with a GRASP heuristic. This heuristic is composed of two constructive heuristics (each one solving each of the two independent problems in a hierarchical way) that generate a first solution. Then a routes reduction and a local search procedure are applied to this first solution in order to improve the results.
Some test problems were developed in order to test the quality and efficiency of the approaches. Those problems are based in the well-known Solomon and Bischoff and Ratcliff test problems with the same basic characteristics. In general two problem classes I1 and I2, was developed each one with twenty four and twenty two instances respectively. Each class has instances with few demands per client (forty two boxes per demand in average) and instances with many demands per client (sixty two boxes per demand in average).
The results of the four different integrated approaches are presented. And compared with some results achieved using separated approaches developed to VRPTW and CLP problems. The results are analyzed and some conclusions are taken.

4.3 Neighbourhood structures for the hierarchical planning of the glass container industry

Authors: Bernardo Almada Lobo

This presentation deals with the production planning and scheduling problem of the glass container industry. This is a multi-facility production system, where each facility has a set of furnaces that continuously melt glass of a certain colour. The glass paste is afterwards cut into gobs and distributed to a set of parallel and unrelated moulding machines. The furnace colour represents the main constraint due to the high setup times involved in a colour change and to the fact that machines linked to the same furnace have to process products with the same colour. The complexity of the production system and the presence of different decision-making levels lead to a hierarchical approach, which decomposes the planning problem into two sub-problems, namely long-term and short-term planning. In the first one the lot sizes are defined and colour and production process campaigns are scheduled. In the second one the products within each campaign are scheduled.
This work focuses on the long-term level for which several local search neighbourhood structures, that try to take advantage of the particularities of this production process, are presented. These structures are implemented on GRASP metaheuristic and tested for a real instance of a pilot glass company.

4.4 Data Envelopment Analysis (DEA) for Benchmarking the Performance of Distribution Centres

Authors: Alexander Förster

The paper investigates the use of data envelopment analysis (DEA) for the benchmarking of distribution centres (DCs). DEA is a linear programming based technique for measuring the relative efficiency of organisational units. Based on real data from a wholesaler an input-oriented DEA model was developed. Efficient DCs are ranked using different ranking methods and the results are analyzed and compared. Also a regional comparison and an efficiency analysis over time was done.

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