

DM86 Local Search Methods – Weekly Notes

Week 9, Spring 2006

Lecture March 30

We continued to discuss about Manufacturing (or Machine) Scheduling. We pointed out the differences between the three classes of problems, Single Machine, Flow Shop and Group Shop. We reviewed the objectives of interest in these problems.

On the Single Machine we extended the list of Construction Heuristics, also called “dispatching rules”. A list is given as appendix in the slides.

On the Permutation Flow Shop problem (PFSP) we went through the details of the NEH insertion heuristic and described the procedure to perform it in $O(n^2m)$. These description is given in Section 4 of the paper by Taillard listed below. We then defined the procedure to compute the critical path. Related to the critical path is the concept of blocks and block internal operations. We described the exact and heuristic neighborhood restriction based on critical path operations given by Novicki and Smutnicki. This part is available from the text book however the original paper from Novicki and Smutnicki in Sections 1,2,3,4 and up to page 164 is a suggested reading. Finally we sketched the Tabu Search algorithm which together with the ILS of the previous lecture is particularly efficient.

On the Group Shop Problem we distinguished the two relevant particular cases: Open Shop and Job Shop and gave the Disjunctive graph formalization of the problem. Then we sketched two construction heuristics: the candidate list dispatching rule heuristic and the NEH insertion heuristic. Next we defined the solution representation typically used and extended the neighborhood restriction rules seen on the PFSP to the GSP case. Finally, we mentioned about the underlying principle of Beam-ACO.

In conclusion of the lecture we described the four ways of generating problem instances for testing algorithms.

In the next lecture we will deal with Vehicle Routing Applications. This topic is not treated in the text book. A short extract from the book of Toth and Vigo was provided that introduces the topic and classifies Vehicle Routing Problems (a copy of it can be obtained from the lecturer office). Further material will be provided at the next lecture or can be visioned from the papers of Bräysy (see literature below).

Literature

E. Taillard. Some efficient heuristic methods for the flow shop sequencing problem. *Journal of Operational Research*. 1990. 47(1), 65-74.

E. Nowicki and C. Smutnicki. A fast tabu search algorithm for the permutation flow-shop problem. *European Journal of Operational Research*, 1996, 91(1), 160-175

P. Toth and D. Vigo. *The Vehicle Routing Problem*. SIAM Monographs on Discrete Mathematics and Applications. 2002.

O. Bräysy. *Vehicle Routing Problem with Time Windows, Part I: Route Construction and Local Search Algorithms*. *Transportation Science*, 2005, vol. 39, issue 1, p 104.

Exercises

Exercise 1

Given a PFPS instance of 5 jobs and 3 machines with processing time matrix:

Jobs	J_1	J_2	J_3	J_4	J_5
p_{i1}	3	3	4	2	3
p_{i2}	2	1	3	3	1
p_{i3}	4	2	1	2	3

Specify the permutation which represents a candidate solution by using a reversal canonical permutation (eg, $n, n-1, \dots, 1$). Represent graphically this solution by means of the Gantt chart and the matrix graph used at the lecture. Compute the makespan by using the recursive procedures. From these procedures you obtain also the earliest start times and the latest start time of every job. Use these data to derive the critical path and to define the blocks and the internal blocks.

Exercise 2

Given a GSP instance composed by 3 machines, 3 jobs with operations $J_1 = \{o_{11}, o_{12}, o_{13}\}$, $J_2 = \{o_{21}, o_{22}, o_{23}\}$, $J_3 = \{o_{31}, o_{32}\}$, the following precedence constraints $G_1 : \{o_{11}, o_{12}\} \prec \{o_{13}\}$, $G_2 : \{o_{21}\} \prec \{o_{22}, o_{23}\}$, $G_3 : \{o_{31}, o_{32}\}$ and the processing time matrix:

p_{ij}	$i = 1$	$i = 2$	$i = 3$
$j = 1$	3	2	4
$j = 2$	4	3	2
$j = 3$	1	5	—

Specify a permutation which represents a candidate solution for this instance. Obtain a feasible permutation of integers for this instance by applying the candidate list dispatching rule heuristic (use active schedules rule). Represent graphically this solution by means of the Gantt chart and the matrix graph used at the lecture. Compute the makespan by using the recursive procedures. From these procedures obtain also the earliest start times and the latest start time of every job. Use these data to derive the critical path and to define the blocks and the internal blocks.

Exercise 3

Watch the following short promotional movie of ILOG (duration about 20 min, size 136 MB) to learn about real life applications of Scheduling in airports.