Description of CLSPL Test Instances

Christopher Sürie

Technische Universität Darmstadt
Institut für Betriebswirtschaftslehre
Fachgebiet Fertigungs- und Materialwirtschaft
Hochschulstraße 1
D-64289 Darmstadt
E-Mail: suerie@bwl.tu-darmstadt.de

State: April, 19th, 2002

1. Overview

The test instances provided here serve as a basis for computational tests on lot-sizing problems of the CLSPL type without backlogging (Capacitated Lot-Sizing Problem with Linked Lot-Sizes, see Section 2 for a model formulation).
The solutions made available via this website are not all proven to be optimal, because of the problem size and the solution approach used. However, they are the best solutions known to the author.
There are three data sets available, together with the best known objective function value and a lower bound.

1) The first data set – data – is the same used by Trigeiro et al. (1989), but has a different data format than the original files available at ftp://ftp.eng.auburn.edu/pub/gaoyubo/clspst
2) The second data set – datam – originates from the phase III problems of Trigeiro et al. (1989), but the data is aggregated according to the following procedure: For test instances with 10 items, items 1-4 and 5-8 are aggregated to form two new items, such that together with the unchanged items 9 and 10 this subset now has four items. For test instances with 20 items, items 1-8 and 9-16 are aggregated to form a new class with six items, whereas for test instances with 30 items, items 1-10, 11-20, 21-23 and 24-26 are aggregated, resulting in a total of eight items. The aggregation is defined such, that the sum of demands (setup costs, setup times) is taken as the demand (setup cost, setup time) of the new item, whereas the average is taken for production coefficients and holding cost coefficients.
3) The third data set – datab – contains 60 MLCLSP instances taken from class B+ of Stadtler, H. 2002. Multi-Level Lot-Sizing with Setup Times and Multiple Constrained Resources: Internally Rolling Schedules with Lot-Sizing Windows, *Oper. Res.* to appear, which can be found at http://www.bwl.tu-darmstadt.de/bwl1/FORSCH/lotsize/TI_Description.htm)

2. Model formulation

The dynamic capacitated lot-sizing problem with linked lot-sizes aims at minimizing variable production costs over a finite planning interval. The variable production costs considered comprise inventory holding and setup costs. The planning interval is divided into several periods t and limited by the planning horizon T.

For each period in the planning interval the end item demand is assumed to be known and has to be fulfilled without backlogging. Inventory holding costs are calculated based on the end-of-period inventory. Setup costs and setup times accrue for an item in each period of production.

Resources have limited capacities per period and may be extended by overtime.
Model formulation (see e.g. Haase (1994):

$$Min. \quad \sum_{j=1}^{J}\sum_{t=1}^{T} h_j \cdot I_{jt} + \sum_{j=1}^{J}\sum_{t=1}^{T} sc_j \cdot (Y_{jt} - W_{jt}) + \sum_{m=1}^{M}\sum_{t=1}^{T} oc_{mt} \cdot O_{mt} \tag{1.1}$$

subject to

$$I_{jt-1} + X_{jt} = P_{jt} + \sum_{k \in S_j} r_{jk}^{d} \cdot X_{kt} + I_{jt} \qquad \forall\, j=1, ..., J,\ t=1, ..., T \tag{1.2}$$

$$\sum_{j \in R_m} a_{mj} \cdot X_{jt} + \sum_{j \in R_m} st_{jm} \cdot (Y_{jt} - W_{jt}) \le C_{mt} + O_{mt} \qquad \forall\, m=1, ..., M,\ t=1,...,T \tag{1.3}$$

$$X_{jt} \le B_{jt} \cdot Y_{jt} \qquad \forall\, j=1,...,J,\ t=1, ..., T \tag{1.4}$$

$$\sum_{j \in R_m} W_{jt} \le 1 \qquad \forall\, m=1, ..., M,\ t=2..T \tag{1.5}$$

$$W_{jt} \le Y_{jt-1} \qquad \forall\, j=1..J,\ t=2..T \tag{1.6}$$

$$W_{jt} \le Y_{jt} \qquad \forall\, j=1..J,\ t=2..T \tag{1.7}$$

$$1 - \sum_{j \in R_m} Y_{jt} + J \cdot Q_{mt} \ge 0 \qquad \forall\, m=1, ..., M,\ t=2..T\text{-}1 \tag{1.8}$$

$$W_{jt+1} + W_{jt} + Q_{mt} \le 2 \qquad \forall\, m=1, ..., M,\ j \in R_m,\ t=2..T\text{-}1 \tag{1.9}$$

$$\left.\begin{array}{ll} I_{jt} \ge 0 & \forall\, j=1, ..., J,\ t=1, ..., T \\ O_{mt} \ge 0 & \forall\, m=1, ..., M,\ t=1, ..., T \\ 0 \le Q_{mt} \le 1 & \forall\, m=1, ..., M,\ t=2..T\text{-}1 \\ X_{jt} \ge 0 & \forall\, j=1, ..., J,\ t=1, ..., T \\ Y_{jt} \in \{0,1\} & \forall\, j=1, ..., J,\ t=1, ..., T \\ W_{jt} \in \{0;1\} & \forall\, j=1..J,\ t=2..T \end{array}\right\} \tag{1.10}$$

Indices and index sets:

j	Items or operations (e.g. end products, intermediate products, raw materials), j=1, ..., J
m	Resources (e.g. personnel, machines, production lines), m=1, ..., M
t	Periods, t=1, ..., T
R_m	Set of products producible on resource m
S_j	Set of immediate successors of item j in the bill of material

Data:

a_{mj} Capacity needed on a resource m for one unit of item j

B_{jt} Large number, not limiting feasible lot-sizes of item j in period t

C_{mt} Available capacity of resource m in period t

h_j Holding cost for one unit of item j in a period

oc_{mt} Overtime cost for one unit of resource m in period t

P_{jt} Primary, gross demand for item j in period t

r^d_{jk} Number of units of item j required to produce one unit of the immediate successor item k

sc_j Setup cost for a lot of item j

st_{jm} Setup time for item j on resource m

Variables:

I_{jt} Inventory of item j at the end of period t

O_{mt} Amount of overtime on resource m used in period t

Q_{mt} Single-item production indicator (=0, if there is production of at most 1 item on resource m in period t

W_{jt} Binary link variable (=1, if production of item j is linked from period t-1 to t, 0 otherwise)

X_{jt} Production quantity of item j in period t (lot-size)

Y_{jt} Binary setup variable (=1, if item j is setup in period t, 0 otherwise)

The objective function (1.1) aims at minimizing the sum of inventory holding, setup and overtime costs. All other production costs are assumed to be fixed and independent of time, consequently no direct production costs are attributed to a lot-size X_{jt}.

Multi-level inventory balance constraints (1.2) make sure that no backlogging will occur. For multi-level production a lot-size of item k will result in a dependent demand for its immediate predecessor items j. Required capacities for lot-size production must not exceed available normal capacities (possibly extended by overtime; 1.3). Capacity requirements result from both production time per item times the amounts produced as well as setup times incurred with each lot. Setup constraints (1.4) enforce binary variables Y_{jt} to unity, in case a lot of item j is produced in a period t.

Constraints (1.5) secure that at most one setup state per machine can be preserved. Constraints (1.6) and (1.7) link the link variables to the setup variables, whereas constraints (1.8) and (1.9) control that the setups are calculated correctly if the same setup is preserved on two consecutive bucket boundaries. All variables are restricted to non-negative or binary values, respectively (1.10).

3. Data format

The data format used here is closely related to the one used at http://www.bwl.tu-darmstadt.de/bwl1/FORSCH/lotsize/TI_Description.htm. Each data set consists of 11 files.

Filename	Content	Structure
DIREKT-B.PRN	Demand coefficients	Each Row: j, k, r_{jk}^{d} (or empty: single-level problems)
INDEX.PRN	Index data	1 Row: J, T, M
KAPAZ.PRN	Capacities	M Rows, T Columns (per period)
LAGKOST.PRN	Holding cost coefficient	1 Row, J Columns (per product)
L0.PRN	Beginning inventories	1 Row, J Columns (per product)
LT.PRN	Ending inventories	1 Row, J Columns (per product)
P-BEDARF.PRN	Demand series	J Rows (products), T Columns (periods)
PRODKOEF.PRN	Production coefficients	Each Row: m, j, a_{mj}
RUESTK.PRN	Setup cost coefficient	J Rows (per product), 1 Column
RUESTZ.PRN	Setup time profiles	Each Row: m, j, st_{jm}
UEBER-KS.PRN	Overtime cost coefficients	M Rows (per machine), 1 Column

4. Solutions

The best solutions known and lower bounds are available as spreadsheets (MS-EXCEL).

5. References

Haase, K. (1994): Lotsizing and Scheduling for Production Planning, Berlin et al., 1994

Stadtler, H. (2002): Multi-Level Lot-Sizing with Setup Times and Multiple Constrained Resources: Internally Rolling Schedules with Lot-Sizing Windows, *Oper. Res.*, to appear

Trigeiro, W.W., L.J. Thomas, J.O. McClain (1989): Capacitated lotsizing with setup times, *Management Sci*. **35** 353-366