My research problem

Enterprise-wide problems are often difficult to solve with a single decision making model due to its large and complex structure. In most cases, inherent structure of the problem allows us to group decision variables for each sub-decision maker. There will be few interlinking constraints connecting these sub-problems.

Aim of my research is to come up with alternative and better approaches, methods and algorithms for solving such enterprise-wide decision problems.

Background problem - Coal supply chains

▶ Several independent mines are connected to a common terminal by a single rail operator.
▶ Each mine has to complete a set of delivery ‘jobs’ before their due dates.
▶ A job is a portion of the cargo that needs to be moved by a certain train type from a mine to the terminal.
▶ Each job requires a certain train type that is provided by the rail operator from a limited pool of trains.

General planning-scheduling problem

▶ It is a resource constrained planning and scheduling problem which involves n independent producers and an interlinking resource manager.
▶ Generic representation can be formulated as,

$$\min \sum_i C_i x_i \quad \text{(Total cost)} \quad (1)$$

subject to

$$A x_i \leq B_i \quad \forall i \quad \text{(production planning)} \quad (2)$$

$$\sum_j R_{ij} x_i \leq K_j \quad \forall j \quad \text{(Resource constraint)} \quad (3)$$

Coordination models and solution approaches

We have already developed the following models.

▶ Integrated model (IM) is the single model which incorporates the decisions of all subunits. This is the traditional way to solve the coordination problems.

Disadvantages: Complete information should be shared, model will be large and complex, partial execution is not possible, known solution approaches could not be applied directly.

▶ Decentralised Models based on decomposition

- LR - An iterative scheme based on Lagrangian relaxation is developed and strengthened with Volume algorithm and Wedelin algorithm.
- CG - An iterative scheme based on Dantzig-Wolfe decomposition and column generation is also developed and strengthened with stabilisation techniques.
- Current research includes exploring mechanism design, truly 2-party-decomposition models etc.

Disadvantages: Information flow between multiple models, mostly provides sub-optimal solutions, conflict in objectives.

Decomposition

We decompose the problem into two parts:

Production planning Each decision maker plans their production based on their priorities and objective and places a set of requests to the resource manager for certain number of resources.

Resource scheduling After receiving the requests from the producers, the resource manager prepares a schedule based on resource availability. This problem is equivalent to a job scheduling problem.

Computational experiments

Problem Instances

▶ 240 randomly generated instances in eight series (30 × 8)
▶ Each series represents 5, 6, 7, 8, 9, 10, 12 or 15 mines.
▶ Four train classes with 3000, 5400, 7200 and 8400 tonnes
▶ In each instance, the number of orders for a producer, the order quantity and order due-dates are generated randomly.
▶ The average demand for each producer is 25000 tonnes.

Computational experiments - results

(a) Lower bound - LBR
(b) Upper bound - UBR
(c) Relative gap
(d) Run time

Summary

▶ Decentralised modelling algorithms have significant advantages over IM on all performance measures.
▶ The trend is identical for LBR and UBR of both schemes.
▶ On an average, LBR for CG is higher than that of LR by 1-2%. However in the case of UBR, it varies upto 8%.
▶ The UBR is close to zero for the series with 5 or 6 producers. All models, IM, LR and CG, were able converge to a close to optimal solution.

Relative Gap

<table>
<thead>
<tr>
<th></th>
<th>IM</th>
<th>LR</th>
<th>CG</th>
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</thead>
<tbody>
<tr>
<td>&lt; 5%</td>
<td>17/240</td>
<td>134/240</td>
<td>216/240</td>
</tr>
<tr>
<td>&lt; 10%</td>
<td>24/240</td>
<td>198/240</td>
<td>232/240</td>
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Run time of CG is better than the run time of LR and IM.

Publications