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DECENTRALISED APPROACHES TO OPTIMISE PRODUCTION PLANNING AND RESOURCE SCHEDULING

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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 finite pool of trains.

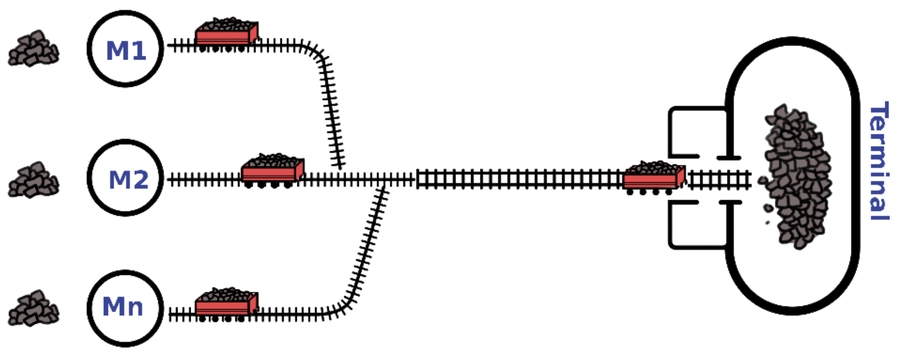


Figure: Schematic diagram of coal mines and terminal network

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,

$$\min \sum_i C_i^T x_i \qquad \text{(Total cost)} \qquad (1)$$

$$\text{subject to} \quad A_i x_i \leq B_i \quad \forall\, i \qquad \text{(production planning)} \qquad (2)$$

$$\sum_i R_{i,j} x_i \leq K_j \quad \forall\, j \qquad \text{(Resource constraint)} \qquad (3)$$

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.

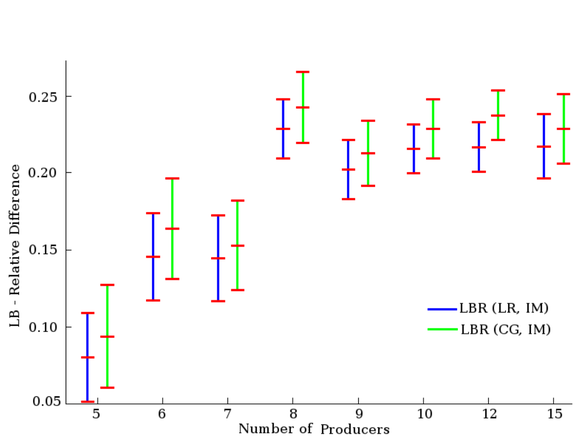
Resource scheduling After receiving the requests from the producers, the resource manager prepares a schedule based on resource availability. This problem is equivalent to a job scheduling problem.

Computational experiments

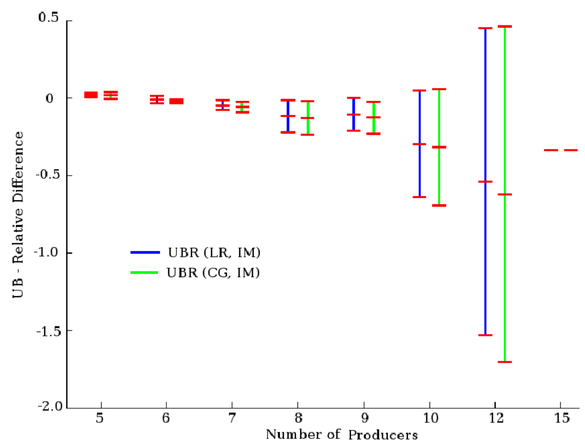
Problem Instances

- 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

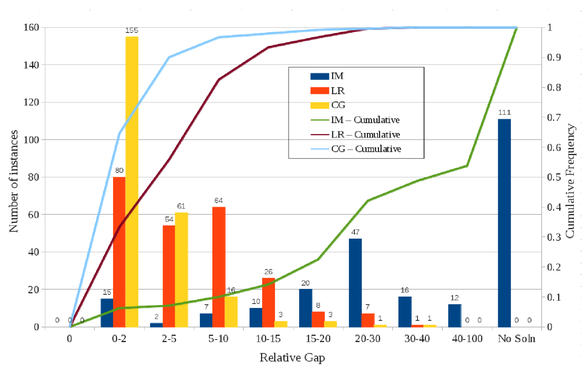


(a) Lower bound - LBR

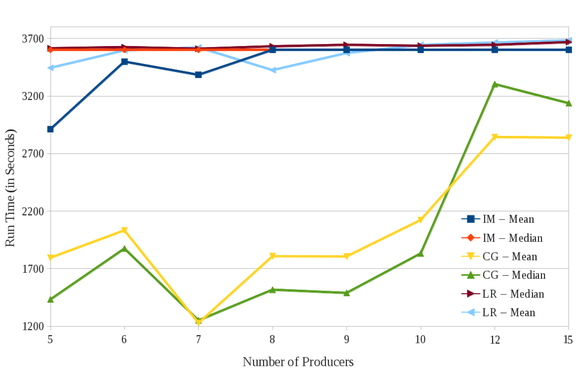


(b) Upper bound -UBR

95% confidence interval for the relative difference



(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	IM	LR	CG
$< 5\%$	17/240	134/240	216/240
$< 10\%$	24/240	198/240	232/240
- Run time of CG is better than the run time of LR and IM.

Publications

1. Distributed Optimisation Method for Multi-resource Constrained Scheduling in Coal Supply Chains, International Journal of Production Research, 2012 (Accepted for publication, DOI:10.1080/00207543.2012.737955).
2. A Resource Constrained Scheduling Problem with Multiple Independent Decision Makers and a Single Linking Constraint: A Coal Supply Chain Example, Submitted to European Journal of Operations Research.

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