COLLABORATIVE RESOURCE CONSTRAINED SCHEDULING: A COAL INDUSTRY EXAMPLE

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Introduction

Coal mining and transportation is a vital and economically important industry in Australia and India. We present a collaborative resource constrained scheduling problem motivated from the mining industry.

- This project is supported by CSIRO, Australia[1] which has worked with the coal mining industry in Australia to solve large and complex scheduling problems.
- Often, large scheduling problems must be broken up into smaller, manageable sub-problems that can be solved. This approach however, while solvable, leads to loss of information and exactness.

Problem Description

- 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.

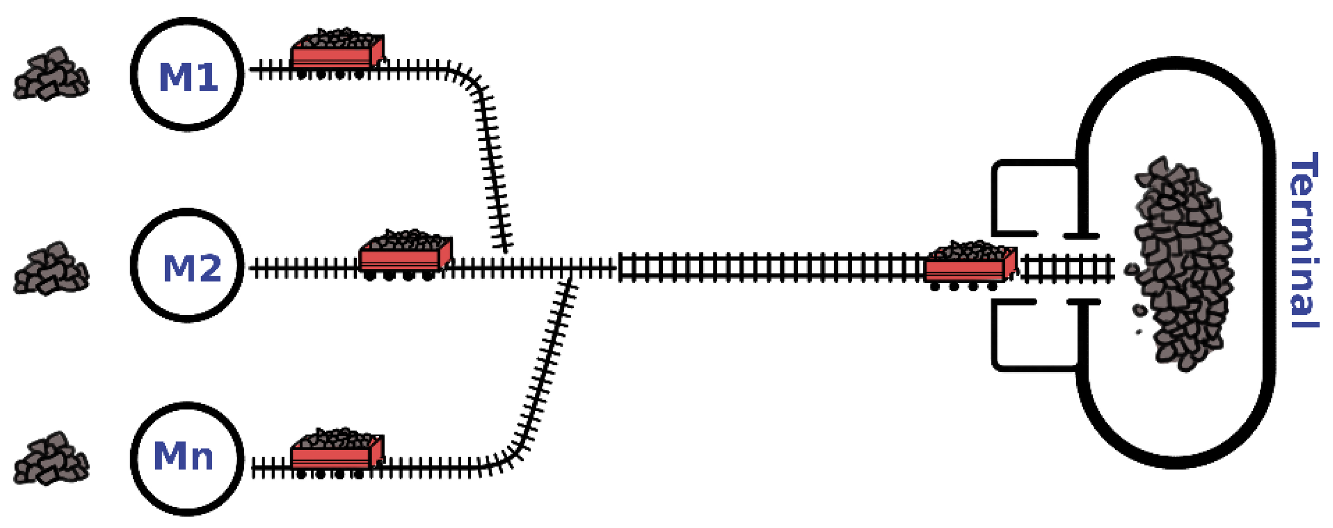

Figure: Schematic diagram of coal mines and terminal network

Decentralised Decision Making Model

Objectives:

(Mine) Minimise the total weighted 'tardiness' (lateness) of jobs associated with the mine.

(Rail) Minimise losses due to unmet contractual obligations.

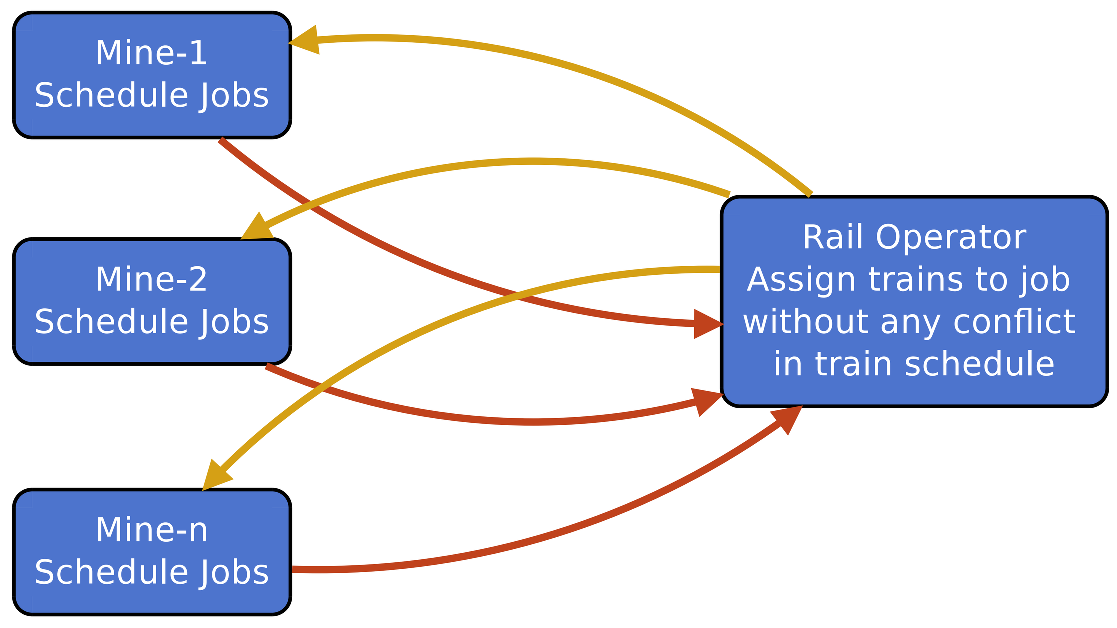

Figure: Information exchange in decentralised model

Advantages Split into multiple solvable models, useful even when partial information is shared, problem size is smaller, less complexity, partial sensitivity analysis is possible.

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

[1] Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia, *www.csiro.au*.

Centralised (Integrated) Decision Making Model

Objective: Minimise the total weighted 'tardiness' of all jobs.

Integrated Model

1. Schedule all jobs and assign a unique set of trains for each job without any conflicts in train schedule at mines.
2. Minimise losses due to unmet contractual obligations.

Advantages It gives the global optimal solution, if it is solvable. Single model makes the decisions simultaneously. Conflicting objectives can be incorporated as multi-objectives.

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.

Complexity The integrated model is *NP-hard* even with a single mine. Hence the complete model is also *NP-hard*.

Problem size

Mines	Jobs	Trains	Interval	Variables	Constraints
3	15	5	30	2700	4020
10	100	40	70	287000	309450

Solution Approaches

The integrated and decentralised models are formulated as mixed integer programming (MIP) problems.

- Centralised Model:
  - Attaining a global optimal solution is *NP-Hard*. We aim to develop algorithms to find near optimal solutions within reasonable computational time.
  - Heuristics based on Lagrangian relaxation and Bender's decomposition will be used to split and solve the model for individual mines.
- Decentralised Model: An iterative scheme with feedback would be developed to solve the decentralised model.
- All models and algorithms will be implemented in CPLEX© 12.1[2].

Summary and Future Work

- Mathematical formulation and solution approaches have been developed. This needs to be tested and validated using a large set of randomly generated data.
- These data are as close to real-world as possible, since these are motivated by past CSIRO projects.
- Computational results which shows the practical significance of the decentralised model on large sized problems will be summarised.
- Information sharing and other coordination mechanisms will be explored.
- Although this model is motivated by a mining example, we intend to tackle a few other complex centralised-decentralised applications (airlines, manufacturing) in the future.

[2] IBM ILOG Optimization Suite, copyright to IBM Corporation, *www.ibm.com*.

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