Shipping Stem Generation for the Hunter Valley Coal Chain

Natashia Boland and Hamish Waterer
School of Mathematical and Physical Sciences
University of Newcastle, Australia
hamish.waterer@newcastle.edu.au

Martin Savelsbergh
CSIRO Mathematics, Informatics, and Statistics
Australia

Extended Abstract

The Hunter Valley Coal Chain (HVCC) refers to the inland portion of the coal export supply chain in the Hunter Valley, New South Wales, Australia. The HVCC essentially follows the path of the Hunter River traveling south-east from the mining areas in the Hunter Valley to Newcastle. The Port of Newcastle is the world's largest coal export port. In 2008 port throughput was around 92 million tonnes, or more than 10 percent of the world's total trade in coal.

Most of the coal mines in the Hunter Valley are open pit mines. The coal is mined and stored either at a railway siding located at the mine or at a coal loading facility (used by several mines). The coal is then transported to one of the terminals at the Port of Newcastle, almost exclusively by rail. (Some coal is transported to the port by truck.) The coal is dumped and stacked at a terminal to form stockpiles. Coal brands are a blended product, with coal from different mines having different specifications "mixed" in a stockpile to meet the specifications of the customer. Blends and hence stockpiles are most often make-to-order, however the use of dedicated stockpiles for high volume products is increasing. Once the vessel for which the coal is destined arrives at a berth at the terminal, the coal is loaded onto the vessel. The vessel then transports the coal to its destination.

In 2003, the Hunter Valley Coal Chain Logistics Team (HVCCLT) was established to improve the movement of coal from Hunter Valley mines to the port's coal loaders and then to markets across the globe. HVCCLT pools the resources of port operators, railway operators, and railway infrastructure managers into one logistics team. In 2009, when the HVCC went through a major restructuring, the Hunter Valley Coal Chain Coordinator Limited (HVCCC) was incorporated as a new legal entity and formally replaced the HVCCLT (See `http://www.hvccc.com.au/` and Vandervoort [3] for more information on the HVCCC). The HVCCC's mission is to plan and coordinate the cooperative daily operation and long term capacity alignment of the HVCC. Its strategic objectives include, among others:

- To plan and schedule the movement of coal through the HVCC in accordance with the agreed collective needs and contractual obligations of producers and service providers;
- To ensure minimum logistics cost and maximum throughput through the provision of appropriate analysis and advice on capacity constraints (whether physical, operational or commercial) affecting the efficient operation of the HVCC; and
- To advocate positions to other stakeholders and governments on issues relevant to efficient operation, in order to maximize opportunities for improved coordination and/or further expansion of the coal chain.

An important decision support tool employed by HVCCC is a detailed simulation of the HVCC (Welgama and Oyston [4]). The tool is used, among others, for the analysis of the impact of forecast mine production on operations and the analysis of the impact of possible infrastructure expansions on throughput. As the HVCC can be viewed as operating as a pull-system, in which the arrival of a vessel at the port triggers the production, transportation, storage, and ultimately the loading of coal onto the vessel, the forecast mine production needs to be mapped into a stream of vessel arrivals at the port. Such a stream of vessel arrivals is referred to as a shipping stem. Each vessel arrival, referred to as a trip, is characterized by an arrival time, the terminal at which the vessel is to be loaded, a cargo-profile, which specifies the various brands of coal and their tonnage that make up the vessel's cargo, the associated brand-recipes, which specify the various coal components, and thus the mines, that make up a brand (or blend) and their tonnage.

Our work is concerned with this conversion of forecast mine production into a shipping stem, which we refer to as *stem generation*. Generating a shipping stem that matches forecast mine production and that resembles an historic shipping stem is challenging in itself, but the process is complicated by the fact that new mines are brought on line, existing mines are (temporarily) shut down, new brands and new brand-recipes are introduced, and new terminals may start their operations. This information, in particular regarding new brands, recipes, and the nature of demand expected for these, is largely unknown by HVCCC at the time the stem needs to be generated. The blend specifications are regarded as highly sensitive commercial information by the producers, and forward planning needs to be done without it.

Shipping stems are currently produced manually, which is extremely time-consuming; creating a single shipping stem can take up to three weeks. We have developed a multi-phase approach for generating shipping stems that relies on quadratic and integer programming and sampling and produces a shipping stem in a matter of hours. It allows for the generation of multiple shipping stems for the same forecast mine production. The generated shipping stems have been validated by the HVCCC and our shipping stem generator is now an integral part of their analysis framework.

Accommodating future growth is one of the most pressing challenges, if not the most pressing challenge, facing the HVCC. Demand for coal is expected to more than double in the next decade. Thus, strategic capacity planning is a core activity for the HVCCC (Singh et al. [2], Boland and Savelsbergh [1]). Using optimization and simulation models as part of this strategic planning effort provides valuable insights that cannot be obtained, or are extremely hard to obtain, otherwise. However, developing and deploying quantitative models in such situations is non-trivial. Deciding the appropriate level of detail to include in the models is crucial, but often more an art than a science. And so is deciding the scenarios that need to be analyzed and understood. As these scenarios may be quite different from the present environment, obtaining or generating appropriate data for these scenarios can be an ordeal. But even the best strategic planning models are of little use, or, even worse, may inadvertently suggest wrong decisions, if they are populated with inaccurate data.

This is exactly the situation that HVCCC finds itself in. Given the anticipated substantial increase in demand for coal over the next decades, the HVCC needs to significantly increase its annual throughput. Increasing the annual throughput can be accomplished in two ways: (1) by expanding the infrastructure, and (2) by improving the operational efficiency. Understanding the impact of infrastructure expansions, changes in operational procedures, and demand characteristics on the achievable annual throughput is essential.

To be able to assess the achievable annual throughput with confidence, the HVCC needs to be modeled at a fairly detailed level, i.e., at a daily operational level. This implies that yearly mine production forecasts need to be converted to daily demands on the HVCC, i.e., a shipping stem. The importance of generating shipping stems that are representative of what the future may bring cannot be overemphasized. Furthermore, generating such shipping stems is not simply a matter of scaling, of “more of the same”. The shipping stems have to reflect that the HVCC is changing, e.g., that new terminals will commence operations and that new mines will start producing and shipping coal.

Our work completely focuses on generating shipping stems, i.e., generating input data, and the challenges associated with doing so. Even though we consider a specific setting, namely the HVCC, similar challenges occur in strategic planning efforts in other industries in which blended products are shipped, such as wheat, fertilizer, gas and petroleum, and our approach may provide ideas and insights that are valuable for others facing similar situations.

References

[1] N.L. Boland and M.W.P. Savelsbergh. Optimizing the Hunter Valley Coal Chain. In *Managing Supply Disruptions*. H. Gurnani, A. Mehrotra, and S. Ray (eds.) Springer-Verlag London Ltd. To appear.

[2] G. Singh, D. Sier, A.T. Ernst, P. Welgama, R. Oyston, and T. Giles. “Long Term Capacity Planning for the Hunter Valley Coal Chain: Models and Algorithms”, *20th National ASOR Conference*, Gold Coast, Australia, September 27th–30th, 2009.

[3] J. Vandervoort. "Hunter Valley Coal Chain Coordinator", *CEDA Annual Conference*, Newcastle, Australia, September 9th, 2010, available at `http://www.hvccc.com.au/Communications/MiscellaneousPresentations.aspx`.

[4] P.S. Welgama and R. Oyston. "Study of options to increase the throughput of the Hunter Valley coal chain", *Proceedings of MODSIM 2003*, Townsville, July 2003, pp. 1841–1846.