Real-time vehicle scheduling of a FTL transportation system

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Outline

Cement industry in Canada

- 13 million of tonnes of cement.
- 1.6 billion $ of production. [a]
- Wide variety of products: cement, concrete (UNISOLANT, UNIGEL, UNIPLAN, AGRIMIX, UNIFLOW)

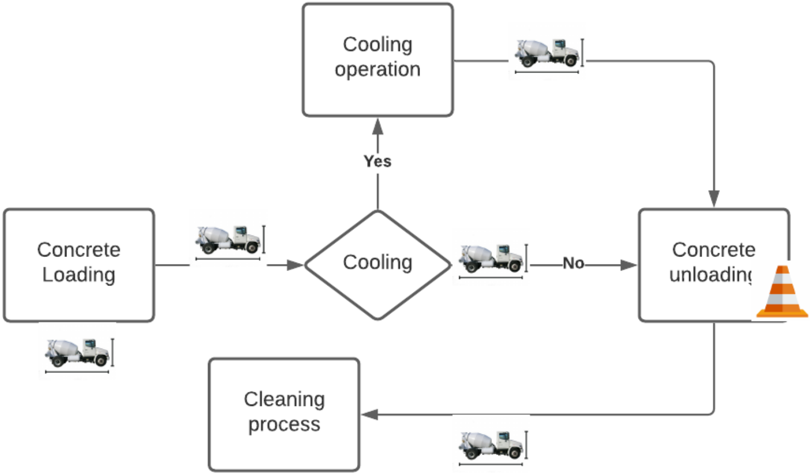
[a] 2014

Issues for concrete deliveries

Unibéton
Ciment Québec

- Hundred thousands deliveries per year.
- Specialized workforce to drive the concrete-mixer. 
- Highly dynamic, perishable and seasonal demand.
- Restrictions on deliverymen weekly work time.
- High operating costs.
- Weather dependent activities.

Flowchart


Cooling operation
Yes
Concrete Loading
Cooling
No
Concrete unloading
Cleaning process

Problem description

Constraints (1)

- Loading operation
  - One vehicle at a time
  - Loading time dependent of the type of concrete
  - Additional cooling operation for some product.
- Transit time dependent of the road traffic.
- Delivery at due time (synchronization with other services at the customer location).
- Demand of a customer may be delivered at different periods in the same day per the customer requirements.
- Concrete must be delivered at most 3 hours after loading.
- Unload concrete-mixer one at a time.
- Deliverymen must work at least 40 hours weekly.
- Deliverymen may have additional constraints related to the maximal daily working time.

Problem description

Constraints (2)

- Concrete-mixer with different sizes.
- Demands are known two or three days before the delivery, therefore the planning of the deliverymen is highly dynamic

Objectives

- Minimize the fleet utilization.
- Plan deliveries of each day according to the available deliverymen and concrete-mixers.
- Plan the deliverymen weekly schedule.

Literature review

Relevant problems

- The single depot vehicle scheduling problem with length of path restrictions. [Raff, 1983]
- The single depot vehicle scheduling problem with multiple vehicle types. [Raff, 1983]
- The Tractor-trailer routing and scheduling with full load. [Raff, 1983]
- Real-time dispatching problem [Brown and Graves, 1981]
- Dynamic vehicle routing problem [Liao, 2004]

Simulation of the current system

- Model the current system
- Simulate the system with a discrete-event simulation software (SIMIO)

Mathematical formulation

- Propose a mathematical model for the problem
- Solve this model with small to medium instances.
- Compare the solution obtained with the current state of the system.
- Adjust the model if required.

Heuristic algorithm

- Design heuristic (metaheuristic) algorithm(s)
- Compare the solution obtained with the current state of the system.
- Adjust the algorithm(s) if required.
- Assess the algorithm(s) performance.

Expected results

Reduction of the concrete-mixers utilization

Objective: Reduce the number of yearly delivery trips.

Dynamic dispatching of the deliverymen

Objective: Implement a software to dispatch in real-time deliveries to workers.

Contribution to the OR literature

Objective: Develop quick and efficient algorithms for real-time vehicle scheduling problems.

Highlights

- Describe a complex problem arising in the concrete transportation
- Present some solution approaches.
- Present expected results
- This problem can be applied to other truck load transportation system such as transportation of vehicles from plants to dealers.

G. G. Brown and G. W. Graves. Real-time dispatch of petroleum tank trucks. *Management Science*, 27(1):19–32, 1981.

T.-Y. Liao. Tabu search algorithm for dynamic vehicle routing problems under real-time information. *Transportation Research Record*, 1882(1):140–149, 2004.

S. Raff. Routing and scheduling of vehicles and crews: The state of the art. *Computers & Operations Research*, 10(2):63–211, 1983.