A metaheuristic for solving large instances of the School Bus Routing Problem

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EURO XXII
Prague – July 10, 2007
Motivations

Request of the Flemish region (Belgium)
- Being transported to school is a right
- Public transportation is organised by the Flemish transportation company
- Routes of buses are annually revised

Interesting features
- Students can walk to a nearby bus stop
- Potential bus stop locations are known

⇒ School Bus Routing problem
The School Bus Routing problem

- a school
The School Bus Routing problem

- a school
- a set of students
The School Bus Routing problem

- a school
- a set of students
- a set of potential bus stops
The School Bus Routing problem

- a school
- a set of students
- a set of potential bus stops
- a maximum walking distance (students → stops)
A possible solution
A possible solution

- students are assigned to bus stops
A possible solution

- students are assigned to bus stops
- two potential bus stops are not visited
A possible solution

- students are assigned to bus stops
- two potential bus stops are not visited
- two bus tours are created
Difference with Basic VRP

Decisions

- How many routes?
- Allocate stops to route
- Order stops within a route
- Allocate items to stops

Objective: Minimize total distance

Restrictions

- Vehicle capacity restrictions
- Unit-stop restrictions
- etc.

Introduction

Aims

Integration in commercial software

Small experiment

Conclusion and future work
Aims of the study

Company related requests
► help the Flemish region in this decision problem
► reducing their costs / keep a high service level

Research related aims
► solve this two-level problem at once
► implement dedicated heuristics and metaheuristics
► take advantages from similar problems and vice versa

Aim of this presentation
► Integration in commercial software application
► Usefulness of multi-neighbourhood metaheuristics
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Schittekat et al.

Introduction

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Figure: real-life routing application
Student allocation problem

- Special case of the Transportation problem
- Students → supply points
  Routes → demand points

\[
\begin{align*}
\min & \sum_{i \in S} \sum_{j \in R} c_{ij} x_{ij} \\
\sum_{j \in R} x_{ij} &= 1 \quad \forall i \in S \\
\sum_{i \in S} x_{ij} &\leq K \quad \forall j \in R \\
x_{ij} &\in 0,1
\end{align*}
\]
Dedicated neighbourhood

Figure: Part of solution unimprovable by a remove-insert move
Dedicated neighbourhood

**Figure:** 2-opt neighbourhood is able to overcome this problem

Kenneth Sørensen, Marc Sevaux, and Patrick Schittekat, Variable neighbourhood search in commercial VRP packages: evolving towards self-adaptive methods, submitted as book chapter on Adaptive Metaheuristics edited by Carlos Cotta
Overview

- Metaheuristics and Exact methods
- Iterated fashion → multiple solutions
- Construction phase (GRASP, stochastic)
  - Clark-Wright savings heuristic
  - $s_{ij} = c_{i0} + c_{0j} - c_{ij}$
  - Three selection types
- Improvement phase (VNS, deterministic)
  - Change two stops within one route
  - Change two stops between routes
  - Replace one stop
  - Add unvisited stops/remove visited stops
Comparison with/without dedicated local search

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</table>

Table: Comparison
Conclusion and Future Work

Conclusion
- Embedded an exact algorithm in an metaheuristic
- Emphasized the importance of dedicated neighbourhoods

Future work
- Speeding up student allocation
- Include different schools
- Include other objectives
- Find strong lower bounds
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