DECOMPOSITION TECHNIQUES FOR PARKING VEHICLES IN DEPOTS

Thé-Van Luong, Éric D. Taillard

HEIG-Vd, Univ. of Applied Sci. Western Switzerland
**PROBLEM DESCRIPTION**

Find a position of each vehicle in the depots of a public transportation company

Vehicles are placed on lanes

Knowing the departure hour of each vehicle, be sure that each vehicle can leave the depot easily

**Looks like a bin-packing**

The total length of vehicles parked on a lane must not be higher than the length of the lane

But...
And few lanes may block all the depot

And...
SPECIALIZED EQUIPMENT FOR LANES

Tramway

Tram-car can be placed only on rail

Trolley buses

Must have electrical wire overhead

Buses

Can be parked everywhere

And...
FAVOUR NATURAL MOVES IN THE DEPOT

The departure hour of each vehicle is precisely known and must be respected

The return hour may fluctuate due to traffic conditions

Moving a vehicle not placed at the right place in the depot may be very complicated

There are vehicles that must stay in the depot for maintenance
PARKING THE VEHICLE AT THE RIGHT PLACE WHEN RETURNING TO THE DEPOT

**Add a set of constraints:**

Each lane must contain only a single type of vehicle

Not so easy to respect:
- Exception for lanes blocking the depot
- Sum of lanes length almost equal to the total vehicle lengths: about 8km

When arriving in the morning, the 400 drivers must find a vehicle of right type
- Difficult if vehicle of a given type are spread over the depot

**Add another set of constraints:**

All vehicles of the same type must be placed on contiguous lanes
- Not always possible

**Objective functions**

Maximize the number of free lanes
- Minimize the distance of blocks of vehicles of a given type that are not contiguous
- Minimize the sum of unused space in occupied lanes
**Pre-processing**

Fill the lanes blocking the depot with the vehicles having earliest service time

**A solution is always produced**

Partially, in the worst case
FIRST DECOMPOSITION LEVEL

Make blocks of vehicles of a given type

Do not consider the departure hour of each vehicle (assigned in a second phase)

Consider the higher number of vehicles that must go outside the depots during a week
  e.g. Monday morning

The other parking plans can be based on the blocks found for the busiest one

Vehicles not in service can be placed on « free » lanes

Solution method

Exact backtracking method

Variables: all possible positions for each block

Depth first search by fixing variables with fewer possible values first

Keep 10 solutions that maximize the number of free lanes (1. objective) and
minimize sum of unused space on lanes

If no feasible solution found: Create additional blocks by splitting largest blocks of vehicles

In any case: stop after a given CPU time
SECOND PHASE: VEHICLE ASSIGNMENT

First phase
Create blocks of lanes with same vehicle type

Second phase
Assign departure hour to each vehicle

Additional constraints
Minimal time interval for 2 vehicles leaving on the same lane
  Avoid delay if a vehicle have a problem
Maximal time interval for 2 vehicles leaving the same lane
  Avoid to have lanes not empty while additional vehicles for rush hours return to the depot

And...
TOPOLOGICAL CONSTRAINTS

Tramway lanes are uni- or bi-directional

The trolley bus in the middle and in front of a group of 3 lanes must leave first
Mega-buses cannot be placed on every lanes

And...
ADDITIONAL CHARACTERISTICS

Different equipment for the same vehicle type

- Video camera (required if the vehicle is in service after 22h)
- Ticket distributor (required for few lines)

Different schedule (timetable) types

- Additional service for rush hour
- Return before 20h for cleaning

Objective function

- First hierarchical objective:
  - Group vehicles by additional characteristics inside a block of the same type
- Second objective:
  - Deviation from ideal departure time interval
SOLUTION METHODS FOR ASSIGNMENT

Enumeration with backtracking
- Takes topological constraints into account
- Depth first search always find a solution, if any
- Stopped if computational time too high

Tabu search
- Only invoked in case of backtrack abortion
- In practice, for improving over second hierarchical objective

Neighbourhood:
- Exchange 2 schedules
- Only feasible solutions considered

Tabu list
- Prevent to exchange the same schedules for a fixed number of iterations
- Guarantee that 2 executions lead to the same solution
Cluster in the depot vehicles servicing the international district
NUMERICAL RESULTS

None ! But...

Problem size

5 depots
155 lanes from 18m to 134m
6 different types of trolley buses (12m, 18m, 25m)
5 different types of buses (12m, 18m, 25m)
4 different types of tram-car (up to 53m)

11 parking plans for a week :
  Monday, Tuesday, Thursday (morning, noon, evening)
  Wednesday noon
  Friday evening
1750 schedules to handle for a week
450 schedules on morning for the working days
Building parking plans from scratch
Few times a year, build ideal parking plans:
   Each time the national railway timetables changes
   At the beginning of vacation periods (reduced service)

Everyday use
Modify ideal parking plans:
   Timetable modifications due to works on streets
   Additional services (sportive manifestations, school, ...)
Start as far as possible in the building process
Company satisfaction

Add additional constraints

Groups of 3 adjacent lanes must be freed before 8 in the morning
Create angle parking for the private vehicles of the employees