

DMP204
SCHEDULING,
TIMETABLING AND ROUTING

Lecture 28
Rich Vehicle Routing Problems

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1. A Uniform Model

2. Other Variants of VRP

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Outline

A Uniform Model
Other Variants of VRP

1. A Uniform Model

2. Other Variants of VRP

Efficient Local Search

A Uniform Model
Other Variants of VRP

Blackboard [Irnich 2008].

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1. A Uniform Model
2. Other Variants of VRP

VRP with Backhauls

Further Input from CVRP:

- a partition of customers:
 $L = \{1, \dots, n\}$ Linehaul customers (deliveries)
 $B = \{n + 1, \dots, n + m\}$ Backhaul customers (collections)
- precedence constraint:
 in a route, customers from L must be served before customers from B

Task: Find a collection of K simple circuits with minimum costs, such that:

- each circuit visit the depot vertex
- each customer vertex is visited by exactly one circuit; and
- the sum of the demands of the vertices visited by a circuit does not exceed the vehicle capacity Q .
- in any circuit all the linehaul customers precede the backhaul customers, if any.

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Rich VRP

Definition

Rich Models are non idealized models that represent the application at hand in an adequate way by including all important optimization criteria, constraints and preferences [Hasle et al., 2006]

Solution

- Exact methods are often impractical:
 - instances are too large
 - decision support systems require short response times
- Metaheuristics based on local search components are mostly used

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VRP with Pickup and Delivery

Further Input from CVRP:

- each customer i is associated with quantities d_i and p_i to be delivered and picked up, resp.
- for each customer i , O_i denotes the vertex that is the origin of the delivery demand and D_i denotes the vertex that is the destination of the pickup demand

Task:

Find a collection of K simple circuits with minimum costs, such that:

- each circuit visit the depot vertex
- each customer vertex is visited by exactly one circuit; and
- the current load of the vehicle along the circuit must be non-negative and may never exceed Q
- for each customer i , the customer O_i when different from the depot, must be served in the same circuit and before customer i
- for each customer i , the customer D_i when different from the depot, must be served in the same circuit and after customer i

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Further Input from CVRP:

- multiple depots to which customers can be assigned
- a fleet of vehicles at each depot

Task:

Find a collection of K simple circuits for each depot with minimum costs, such that:

- each circuit visit the depot vertex
- each customer vertex is visited by exactly one circuit; and
- the current load of the vehicle along the circuit must be non-negative and may never exceed Q
- vehicles start and return to the depots they belong

Vertex set $V = \{1, 2, \dots, n\}$ and $V_0 = \{n+1, \dots, n+m\}$

Route i defined by $R_i = \{1, 1, \dots, 1\}$

Three phase approach:

1. Generate feasible alternatives for each customer.

Example, $M = 3$ days $\{d1, d2, d3\}$ then the possible combinations are: $0 \rightarrow 000$; $1 \rightarrow 001$; $2 \rightarrow 010$; $3 \rightarrow 011$; $4 \rightarrow 100$; $5 \rightarrow 101$; $6 \rightarrow 110$; $7 \rightarrow 111$.

| Customer | Diary Demand | De- | Number of Visits | Number of Combina-tions | Possible Combina-tions |
|----------|--------------|-----|------------------|-------------------------|------------------------|
| 1 | 30 | | 1 | 3 | 1,2,4 |
| 2 | 20 | | 2 | 3 | 3,4,6 |
| 3 | 20 | | 2 | 3 | 3,4,6 |
| 4 | 30 | | 2 | 3 | 1,2,4 |
| 5 | 10 | | 3 | 1 | 7 |

2. Select one of the alternatives for each customer, so that the daily constraints are satisfied. Thus, select the customers to be visited in each day.
3. Solve the vehicle routing problem for each day.

Further Input from CVRP:

- planning period of M days

Task:

Find a collection of K simple circuits with minimum costs, such that:

- each circuit visit the depot vertex
- each customer vertex is visited by exactly one circuit; and
- the current load of the vehicle along the circuit must be non-negative and may never exceed Q
- A vehicle may not return to the depot in the same day it departs.
- Over the M -day period, each customer must be visited l times, where $1 \leq l \leq M$.

Constraint Relaxation: it is allowed to serve the same customer by different vehicles. (necessary if $d_i > Q$)

Task:

Find a collection of K simple circuits with minimum costs, such that:

- each circuit visit the depot vertex
- the current load of the vehicle along the circuit must be non-negative and may never exceed Q

Note: a SDVRP can be transformed into a VRP by splitting each customer order into a number of smaller indivisible orders [Burrows 1988].

Input:

- a facility, a set of customers and a planning horizon T
- r_i product consumption rate of customer i (volume per day)
- C_i maximum local inventory of the product for customer i
- a fleet of M homogeneous vehicles with capacity Q

Task:

Find a collection of K **daily circuits to run over the planning horizon** with minimum costs and such that:

- each circuit visit the depot vertex
- **no customer goes in stock-out during the planning horizon**
- the current load of the vehicle along the circuit must be non-negative and may never exceed Q

VRP with Satellite Facilities (VRPSF)

Possible use of **satellite facilities** to replenish vehicles during a route.

Open VRP (OVRP)

The vehicles do not need to return at the depot, hence routes are not circuits but paths

Dial-a-ride VRP (DARP)

- It generalizes the VRPTW and VRP with Pick-up and Delivery by incorporating time windows and maximum ride time constraints
- It has a human perspective
- Vehicle capacity is normally constraining in the DARP whereas it is often redundant in PDVRP applications (collection and delivery of letters and small parcels)