



University of Antwerp
Operations Research Group

ANT/OR

Horizontal co-operation in a clustered distribution environment

exchanging zones for increased efficiency

Christof Defryn Kenneth Sörensen

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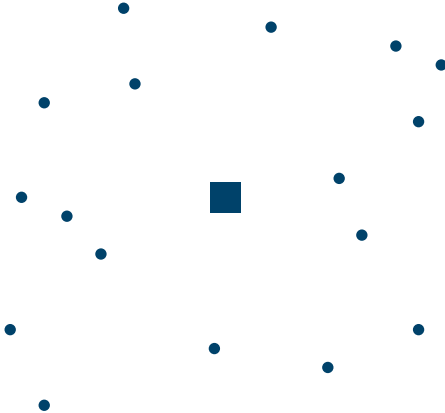
ORBEL 30 28-29th January 2016 – Louvain-la-neuve

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The concept of client clustering

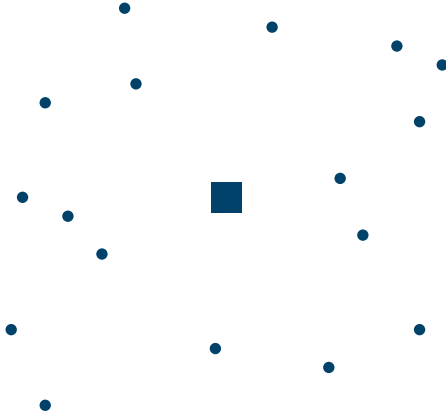


Optimisation context

- ▶ Large-scale VRP
- ▶ Short-term planning
- ▶ Dynamic



The concept of **client clustering**



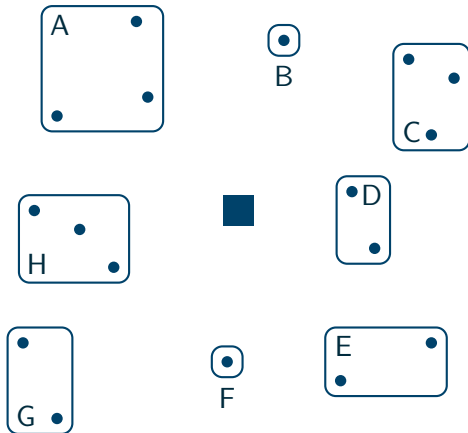
Optimisation context

- ▶ Large-scale VRP
- ▶ Short-term planning
- ▶ Dynamic

*How to deal with such a
nasty beast?*



The concept of **client clustering**



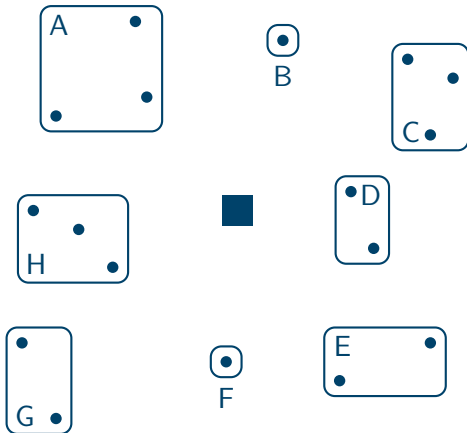
**Divide distribution area
in **zones****

- ▶ One vehicle serves multiple zones
- ▶ *Sorting* is decoupled from *routing*
- ▶ Reduction of problem complexity

Janssens et al. (2015)



The clustered vehicle routing problem

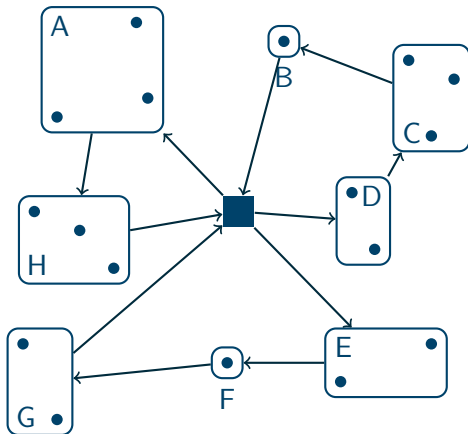


Strong cluster constraints

- ▶ Serve all clients with a given fleet of vehicles
- ▶ Visit clients of each zone sequentially in the same path



The clustered vehicle routing problem



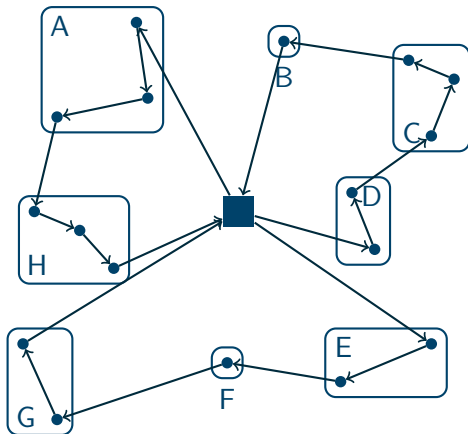
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A vehicle trip is represented by a sequence of zones



The clustered vehicle routing problem



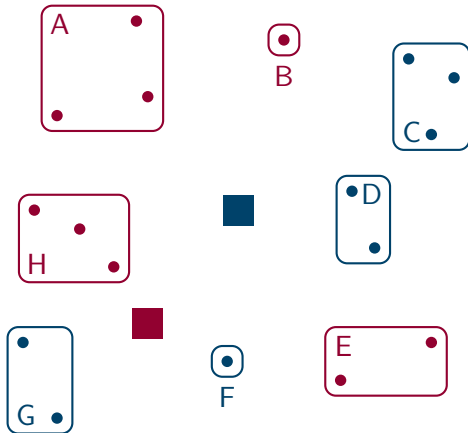
Strong cluster constraints

- ▶ Serve all clients with a given fleet of vehicles
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A vehicle trip is represented by a sequence of zones



Introducing a collaborative environment



In a world with multiple courier companies...

- ▶ ... setting up a horizontal collaboration might be beneficial
- ▶ A single courier company then becomes a **partner** in the **coalition**



Solving a collaborative routing problem

Operational plan + fair cost allocation mechanism

- ▶ **Method of aggregation** (solve problem at coalition level)
 - ▶ All resources are shared (*vehicles, warehouse capacity, . . .*)
 - ▶ All clients and their orders can be exchanged among partner



- ▶ The size of the problem grows significantly, together with its **complexity**
- ▶ Coalition efficiency $\stackrel{?}{=} \text{Individual partner efficiency}$



Solving a collaborative routing problem

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A two-level solution approach

Master problem

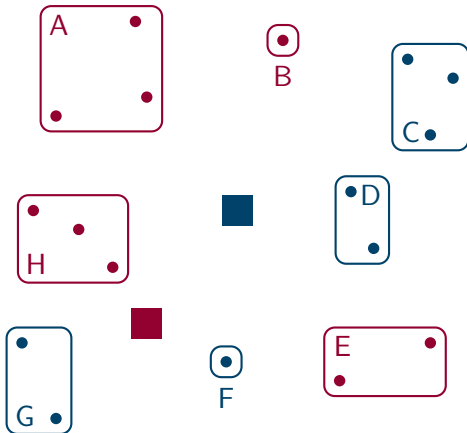
- ▶ Coalition efficiency
- ▶ **Suggesting** *good moves*
 - ▶ Exchange/interaction between partners
→ **collaboration**
 - ▶ Most profitable for the coalition (*e.g. reduction of total logistic cost*)

Slave problems

- ▶ Individual partner efficiency
- ▶ Can be different for each partner
- ▶ **Evaluating** the move
 - ▶ *"At what cost will I accept the move?"*
 - ▶ *"What am I willing to pay for this move?"*



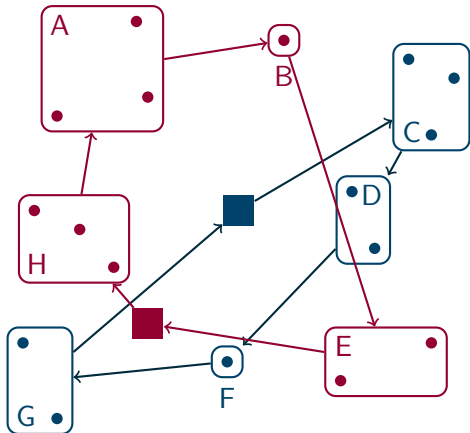
Hands-on example



- **Initial Solution:**
Stand-alone scenario



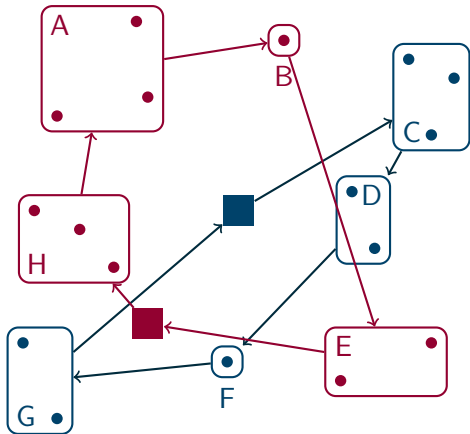
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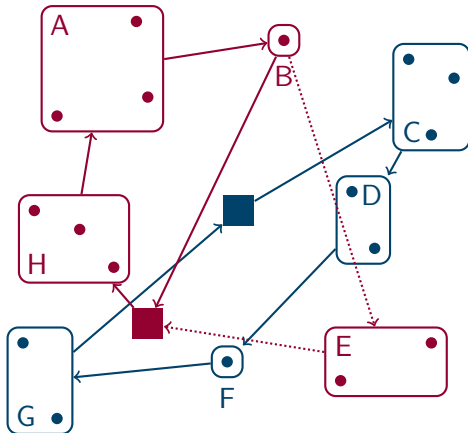
Hands-on example



- ▶ **Initial Solution:**
Stand-alone scenario
- ▶ **Master:**
Cluster with highest marginal cost = E



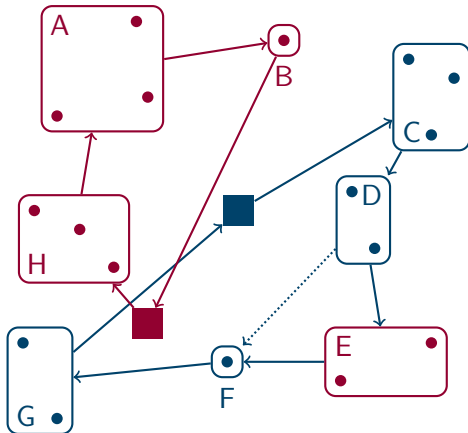
Hands-on example



- ▶ **Initial Solution:**
Stand-alone scenario
- ▶ **Master:**
Cluster with highest marginal cost = E
- ▶ **Slave:**
Red is willing to pay



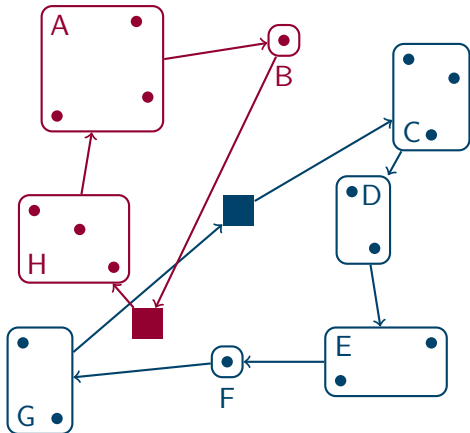
Hands-on example



- ▶ **Initial Solution:**
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- ▶ **Master:**
Cluster with highest marginal cost = E
- ▶ **Slave:**
Red is willing to pay
Blue wants to receive money



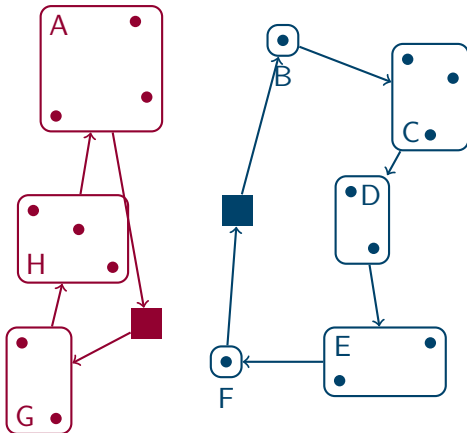
Hands-on example



- ▶ **Initial Solution:**
Stand-alone scenario
- ▶ **Master:**
Cluster with highest marginal cost = E
- ▶ **Slave:**
Red is willing to pay
Blue wants to receive money
- ▶ **Master:**
If match found
 - ▶ Execute move
 - ▶ Money transfer



Iterate until ...



Remarks:

- ▶ What if no match
 - ▶ Master suggests another move
- ▶ Stopping criterion
 - ▶ No more feasible moves available



The result

- ▶ A solution approach for the Collaborative Clustered Vehicle Routing Problem



The result

- ▶ A solution approach for the Collaborative Clustered Vehicle Routing Problem
 - ▶ **Is the solution good?**
 - At least as good as the stand-alone scenario.



- ▶ A solution approach for the **Collaborative Clustered Vehicle Routing Problem**
 - ▶ **Is the solution good?**
 - At least as good as the stand-alone scenario.

- ▶ **Coalition efficiency:**

- **Yes!**

- Decrease in total logistic cost for the coalition, ensured by the suggestions from the Master problem.

- ▶ **Individual partner efficiency:**

- **Yes!**

- Before executing a move, it is evaluated by the involved partners.



The result

- ▶ A solution approach for the Collaborative Clustered Vehicle Routing Problem
- ▶ A **cost allocation mechanism** is included implicitly in the solution procedure



The result

- ▶ A solution approach for the Collaborative Clustered Vehicle Routing Problem
- ▶ A **cost allocation mechanism** is included implicitly in the solution procedure
- ▶ **How good (fair) is this cost allocation?**
 - ▶ No game theoretical concepts or properties can be proven
 - ▶ Based on what the individual partners **want**
 - ▶ We know that all partners **agree**



And for the future?

- ▶ Run tests and simulations for different instances and scenarios
 - ▶ Try to understand the behaviour and impact of the different building blocks in our model
- ▶ Try these ideas and framework on other routing problems that include horizontal co-operation
- ▶ Talk about these ideas, and look for feedback
- ▶ and ...



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DESIGN AND ANALYSIS OF METAHEURISTICS

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