The Consistent Travelling Salesman Problem in Healthcare Scheduling

AUTHORS: Mafalda Ponte | SUPERVISORS: Luís Gouveia, Ana Paias

R&D UNIT: CMAFCIO CONTACT: mafaldaponte@gmail.com

The Problem

Consider a set of nodes and a set of routes. Each route represents the schedule for a workday for a healthcare professional. Node *1* represents inactivity, and the other nodes represent tasks that must be performed by one or several healthcare professionals. The relative position a node occupies in a route represents the allocation of the respective task to a time slot in the schedule. If a task is assigned to several healthcare prefessionals, all of them should perform it in the same time slot. If the schedules do not have the same number of tasks, smaller schedules are allowed to start later and/or end earlier. We know, *a priori*:

☐ Which tasks are assigned to each healthcare professional.
☐ The cost of performing a task *i* right after another task *j*.

We wish to determine a set of routes, all starting and finishing at node *1*, such as all tasks appear in the routes they must be in, while respecting consistency constraints, at minimum total cost.

An Example

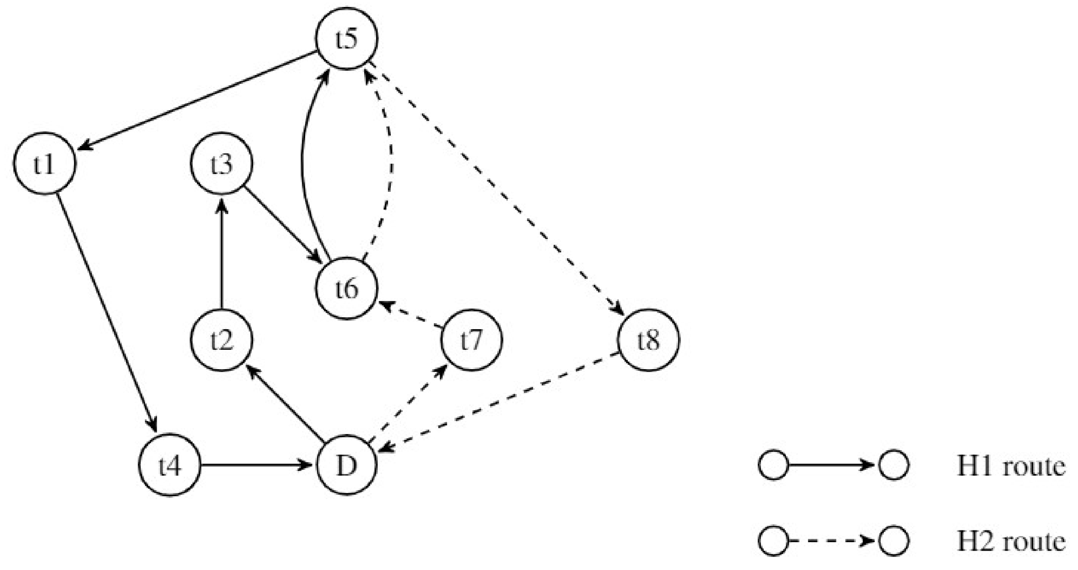
Suppose that we have two healthcare professionals, *H1* and *H2*. Professional *H1* must perform tasks *{t1, t2, t3, t4, t5, t6}*, while professional *H2* must perform tasks *{t5, t6, t7, t8}*.

	Slot 1	Slot 2	Slot 3	Slot 4	Slot 5	Slot 6
H1	t2	t3	t6	t5	t1	t4
H2	t7	t6	t5	t8	-	-

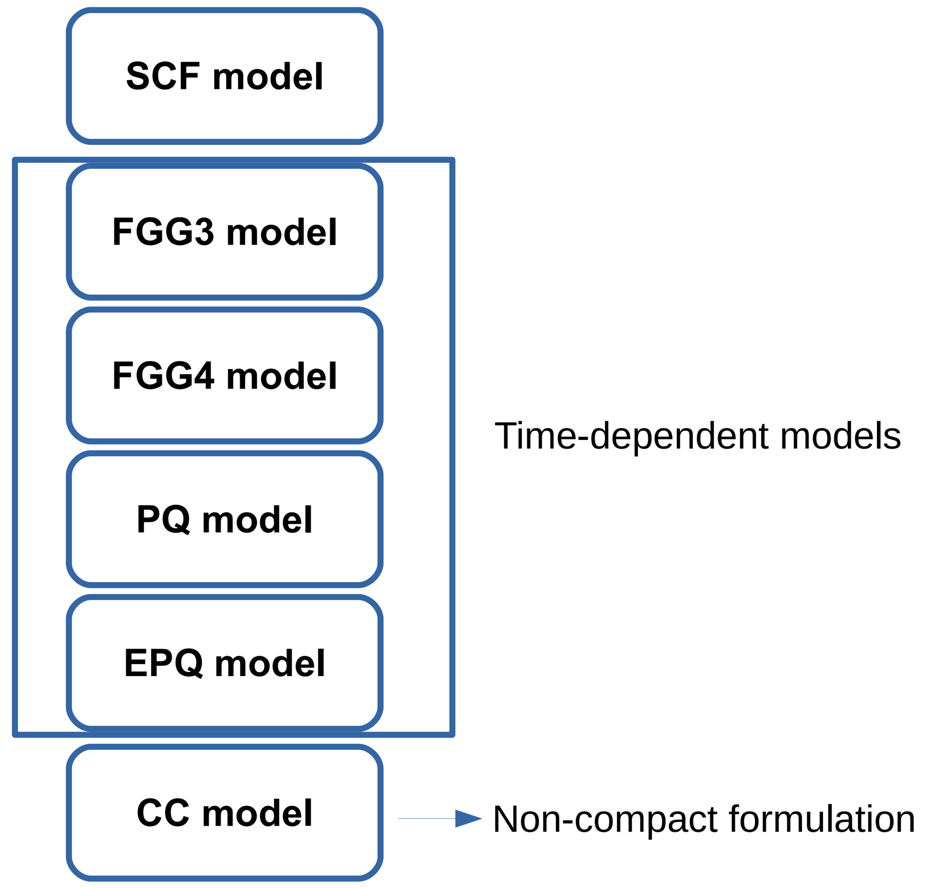
In the first table both schedules start in the same time slot. This solution is not feasible, because tasks *t5* and *t6*, which are common to both healthcare professionals, are not assigned to the same time slot.

	Slot 1	Slot 2	Slot 3	Slot 4	Slot 5	Slot 6
H1	t2	t3	t6	t5	t1	t4
H2	-	t7	t6	t5	t8	-

In the second table the tasks are performed in the same order as in the first. Because now *H2* is allowed to start schedule in slot *2*, the solution becomes feasible.
The solutions from both tables can be represented by the same set of routes, as shown in the figure:

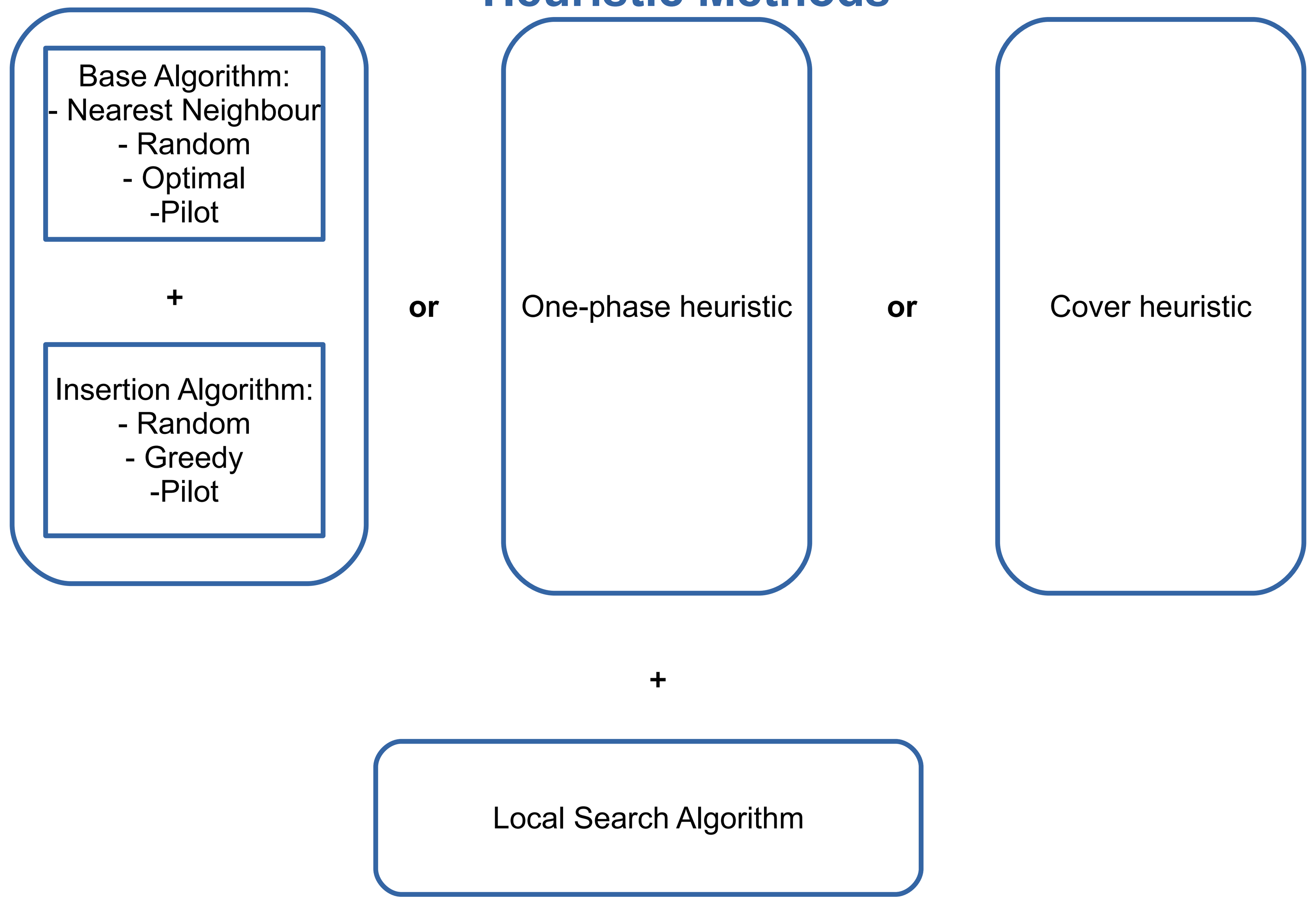


Exact Methods – Routing Models



Exact Methods – Consistency Constraints
☐ Using flow variables.
☐ Using time-dependent variables.
☐ Using position variables.

Heuristic Methods



Computational results and conclusions

☐ Instances were generated randomly taking into account characteristics of the schedules for healthcare professionals.
☐ Each instance considers two routes – one for the doctor and the other for the nurse.
☐ The best lp gaps were attained with models PQ, EPQ and CC, which are also the ones that require more time to solve the linear relaxation.
☐ In terms of integer time, models PQ and EPQ are the ones to obtain smaller times, especially with consistency constraints using time-dependent variables.
☐ Good feasible solutions are obtained with the heuristics. The best feasible solutions before local search are obtained when applying the Optimal Base with any of the insertion algorithms, although this heuristic is also the most time consuming. The cover heuristic, on the other hand, is the only heuristic that can be applied to instances with more than 2 routes.

Future work

☐ Relaxing the consistency constraints in the heuristics, admitting that there is an upper limit for the difference between relative positions, which is not necessarily 0.
☐ Allowing for the existence of more than 2 routes.
☐ Admitting that we may know how many services are required by each client, but not on which routes.
☐ Considering the need for inconsistency, instead of consistency.
☐ Considering the need for temporal consistency, rather than positional consistency.

References

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Acknowledgements

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