Workload equity in vehicle routing with a medium-term perspective

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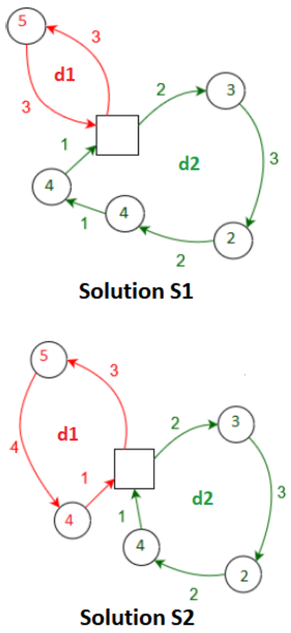
SIS SCIENCES INGÉNIERIE SANTÉ UNIVERSITÉ DE LYON — ÉCOLE DOCTORALE 488

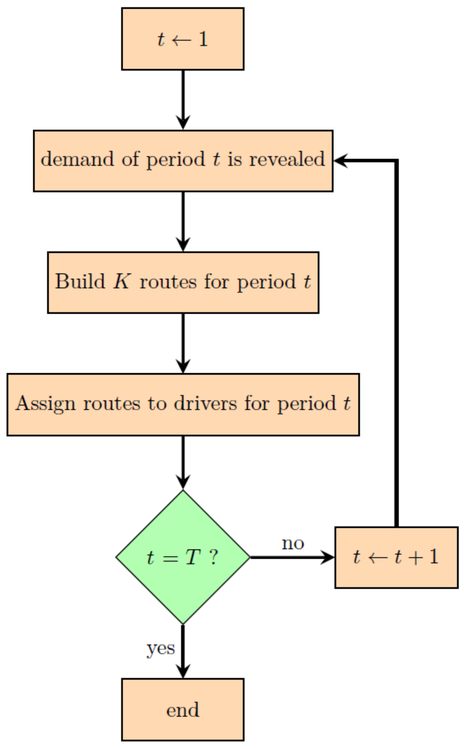
Context and problem description

- Gain of interest of equity in the Vehicle Routing Problem (VRP) literature [1]
- Common way of addressing equity in the routing context : balance vehicle routes when computing the routing plan on a daily basis
- Weaknesses of this approach :
  - Routing cost largely impacted
  - Perception that drivers may have of inequity is on a medium-term perspective (instead of a daily basis)
- Test-bed problem selected in the field of healthcare logistics:
  - Patients need to be transported either from home to hospital or from hospital to home
  - A set of K drivers is available to provide transportation services on a time horizon of several days [1,…,T]
  - Patients requests are revealed day by day and each day, two decisions are made, routing and assignment of routes to drivers
  - Metric to balance fairly: route painfulness, a constant-sum metric (the sum of workload assigned to drivers remains constant for any solution)
- Objectives:
  - Propose different solution frameworks to ensure equity globally on the time horizon
  - Evaluate how addressing equity with this medium-term perspective allows limiting its impact on routing costs through extensive numerical experiments on a benchmark of realistic instances



Two solutions for a daily routing problem

- **Solution S1**: routing cost = 15; drivers d1 and d2 serve 1 and 4 customers with costs 6 and 9 (**efficient solution**)
- **Solution S2**: routing cost = 16; drivers d1 and d2 serve 2 and 3 customers with costs 8 and 8 (**equitable solution**)



Decision process

Solution frameworks

- We propose 5 solution frameworks which consist in sequentially solve daily routing problems and assign the built routes to drivers
- The same assignment strategy is used for all frameworks and is proven to be optimal with regards to the accumulative routes assigned to drivers up to the current day
- Frameworks only differ in the way equity is considered when solving the daily routing problems. Different equity constraints are considered in the routing problem
- The daily routing problem is formulated as a set partitioning problem and solved with a branch-and-price algorithm [2]. It is adapted to suit every solution frameworks

Numerical results and perspectives

- 30 realistic instances of 5, 10 and 20 days generated and tested with the 5 solution frameworks
- Solution frameworks are compared based on different measures among equity and routing cost
- Results highlight the weaknesses and strengths of each solution frameworks. Particularly, they show the small impact on the routing cost of the new solution frameworks (against the commonly used one) with effective equity measures
- Perspectives :
  - Investigate variable-sum metrics such as route cost
  - Consider a driver-dependant equity metric (e.g. drivers with different perceptions of patient painfulness)
  - Consider several transportation companies and propose equity between them in terms of profit

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References

[1] *Matl, P., Hartl, R.F., Vidal, T., 2018. Workload equity in vehicle routing problems: A survey and analysis. ransportation Science 52, 239–260*

[2] *Agius, M., Absi, N., Feillet, D., Garaix, T., 2022. A branch-and-price algorithm for a routing problem with inbound and outbound requests. Computers & Operations Research , 105896*

13 octobre 2022 Colloque IMT « Les sciences de l'information au service des nouvelles mobilités »