Approche décentralisée d'insertion avec amélioration continue de la qualité de la solution pour un système TAD

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Sep. 10, 2020
RO-IA 2020

INSPIRING INNOVATION
SINCE 1816

On-Demand Transport

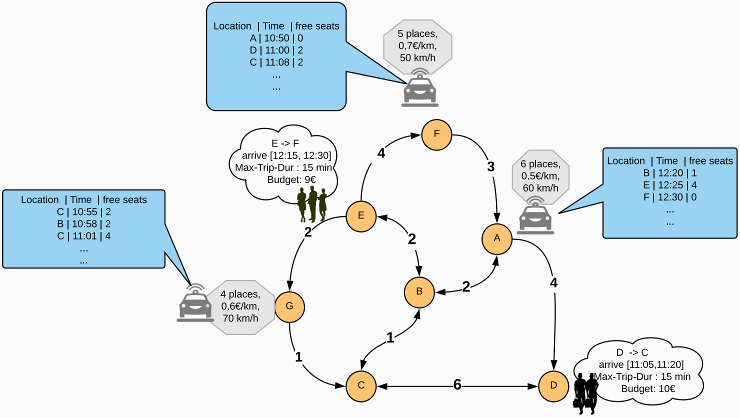

Figure 1: Dial A Ride Problem (DARP)

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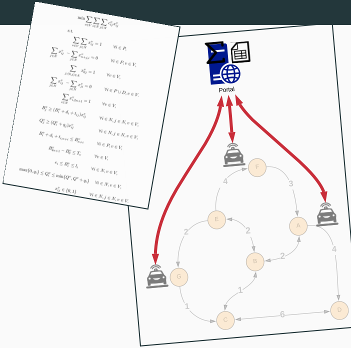


"As is" model

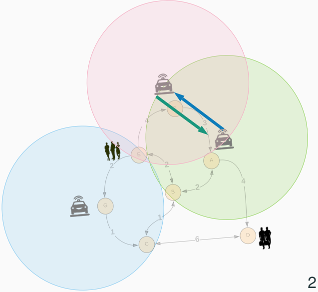
- Requests are centralized in a portal
- Linear/ Mixed integer program models

  ⇒ NP-Hard problem, lack of scalablity for (environment, demand and supply) dynamics
- Continuous access to the portal

  ⇒ expensive with a critical bottleneck

"To be" model

- peer-to-peer (P2P) communication
- Decentralized decisions with coordination
- Equivalent performances with dynamic settings



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Dynamic extension of classical DARP

Objective: Decentralized solution ⇒ Multi-agent

- Each vehicle is an autonomous agent: local goals (solve sub-problems)
- Global solution: aggregation of local solutions (never been calculated)
- Peer to Peer communication: scalable communication model is required

Proposal: From individual decisions to global optimization

- Combinatorial auctions to allocate resources ⇒ feasible global solution
- Demand exchange strategies⇒ optimize global solution
- Connection graph:
  - Global infrastructure: ⇒ complete graph
  - Scalable message passing management: ⇒ incomplete connected graph
  - Peer-to-Peer with connection range: ⇒ disconnected graph

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Auction criteria

Insertion-heuristic-based auctions

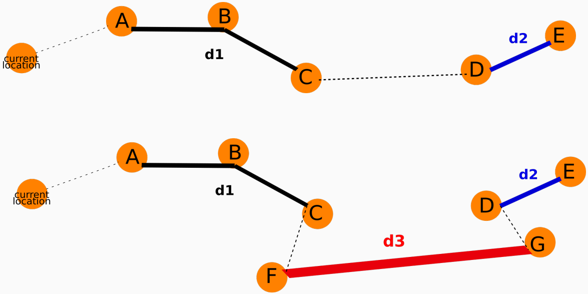
$$Bid_v^d(T_{start}, cost)$$

- T_{start} : potential pick_up time
- $cost$: the marginal cost of inserting d in the schedule of v

$$d3(F \rightarrow G)$$

Current path:

Potential path:



Improvement candidates

Each vehicle looks for requests that are scheduled by others and could be inserted in its schedule with lower cost.

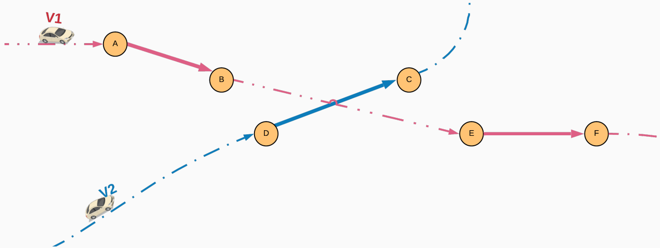


Figure 2: $V1$ finds new candidate for improvement $d(D \to C)$

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Pull Auction

A vehicle $V1$ may select one potential improvement candidate (request d) a time (1-opt) and inter an auction with d's serving vehicle $V2$

$$pull\_cost = V1\text{'s marginal cost to insert } d$$

$$pull\_gain = V2\text{'s marginal cost to abandon } d$$

$$if(pull\_gain > pull\_cost) : V1 \text{and} V2 \text{ update their schedules}$$

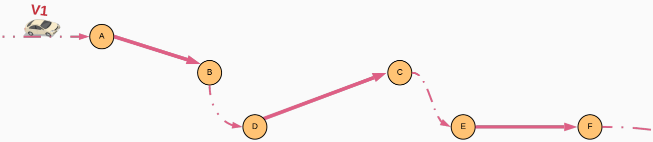

Figure 3: $V1$'s potential improved schedule by inserting $d(D \to C)$

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Evaluation criteria

- **Quality of service (QoS)**: The number of satisfied requests
- **Quality of Business (QoB)**: the simulated profit of the solution

$$profit = totalPriceIncome - totalMovingCost$$

where

$$totalPriceIncome = \sum_{d \in D_s} T + p * distance_d$$

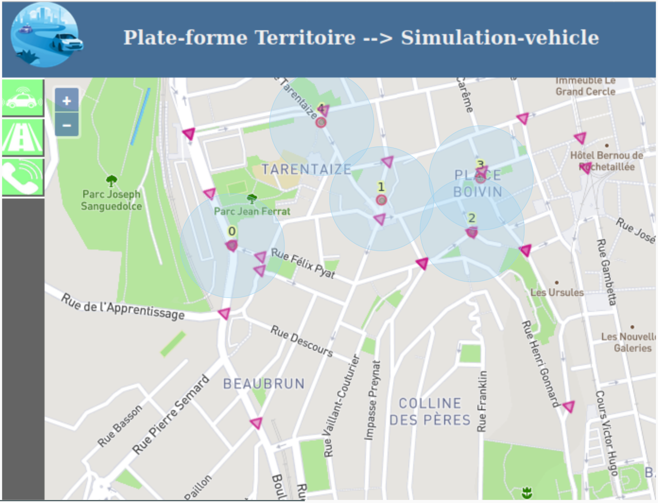
$$totalMovingCost = \sum_{v \in V} cpd_v * totalMovingDistance_v$$

Experimental settings

- **City map**: A graph structure $G =< N, E >$ of Saint Etienne extracted from OpenStreetMap (OSM). Distance between two consecutive points is 40 meters
- **Demand emission sources**: a set $S \subset N : |S| = 20$, having a set of edges $E_S \subset E$, such that $|E_S| = 75$
- **Demand generation** At each simulation cycle, 0 or 1 request is generated randomly Each request has a source and a destination point generated randomly from the source set, and associated with a time window $[tw_{min}, tw_{max}]$
- **Supply**: A fleet V of n vehicles is distributed randomly through S at the beginning of execution
  Each vehicle $v \in V$ moves from one point to another on the same edge during each simulation cycle
- **Communication mean**: Dedicated Short Range Communication (DSRC) with a realistic communication range of 250m

Simulator

A discrete time transport simulator is used, included in *Plateforme Territoire*[1]



[1] https://territoire.emse.fr/

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Results

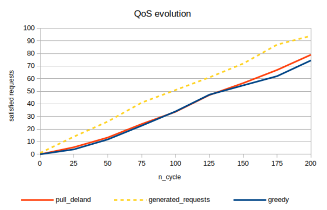

Figure 4: Quality of service for a fleet of 16 vehicles

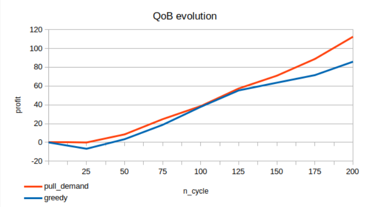

Figure 5: Quality of business for a fleet of 16 vehicles

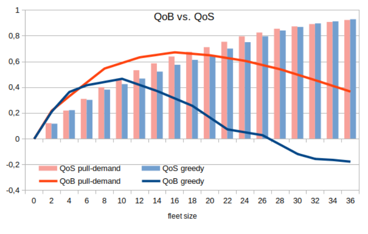

Figure 6: Quality of business vs. quality of service evolution

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Summary

Our contribution

- A multi-agent model of ODT system
- Auction based coordination mechanism → fast feasible agreements
- Auction based rescheduling protocol → run-time optimization
- Comparison with greedy approach → preliminary feasibility evaluation

On-going and future work

Implement a testbed for on-demand trasport scheduling algorithms:

- Compare to centralized dispatching
  → evaluate the solution optimality
- Compare with decentralized solutions (mainly DCOP)
  → evaluate the commuincation behavior (message count and size)

Thanks

Thank you!

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