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

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Figure 1: Dial A Ride Problem (DARP)
Context and motivation

"As is" model

- Requests are centralized in a portal
- Linear/ Mixed integer program models
  - NP-Hard problem, lack of scalability 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
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
Auction criteria

Insertion-heuristic-based auctions

\[ Bid^d_v (T_{\text{start}}, \text{cost}) \]

- \( T_{\text{start}} \) : potential pick_up time
- \( \text{cost} \) : 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:** $V_1$ finds new candidate for improvement $d(D \rightarrow C)$
Pull Auction

A vehicle $V_1$ may select one potential improvement candidate (request $d$) a time (1-opt) and inter an auction with $d$’s serving vehicle $V_2$

\[
pull\_cost = V_1\text{’s marginal cost to insert } d
\]

\[
pull\_gain = V_2\text{’s marginal cost to abandon } d
\]

\[
if (pull\_gain > pull\_cost) \text{ : } V_1\text{ and } V_2 \text{ update their schedules}
\]

**Figure 3:** $V_1$’s potential improved schedule by inserting $d(D \rightarrow C)$
Evaluation criteria

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

\[
\text{profit} = \text{totalPriceIncome} - \text{totalMovingCost}
\]

where

\[
\text{totalPriceIncome} = \sum_{d \in D_s} T + p \times \text{distance}_d
\]

\[
\text{totalMovingCost} = \sum_{v \in V} \text{cpd}_v \times \text{totalMovingDistance}_v
\]
Experimental settings

- **City map**: A graph structure $G = \langle N, E \rangle$ 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 $[t_{w_{min}}, t_{w_{max}}]$.

- **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.
A discrete time transport simulator is used, included in *Plateforme Territoire*¹

¹https://territoire.emse.fr/
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
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 transport scheduling algorithms:

- Compare to centralized dispatching → evaluate the solution optimality
- Compare with decentralized solutions (mainly DCOP) → evaluate the communication behavior (message count and size)
Thank you!
References


