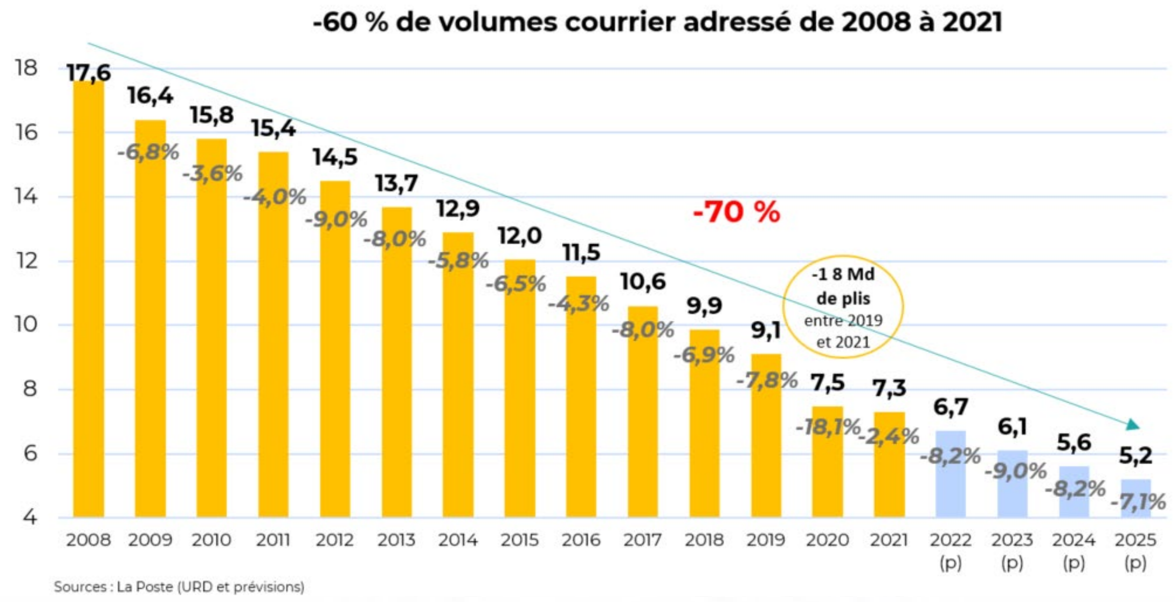
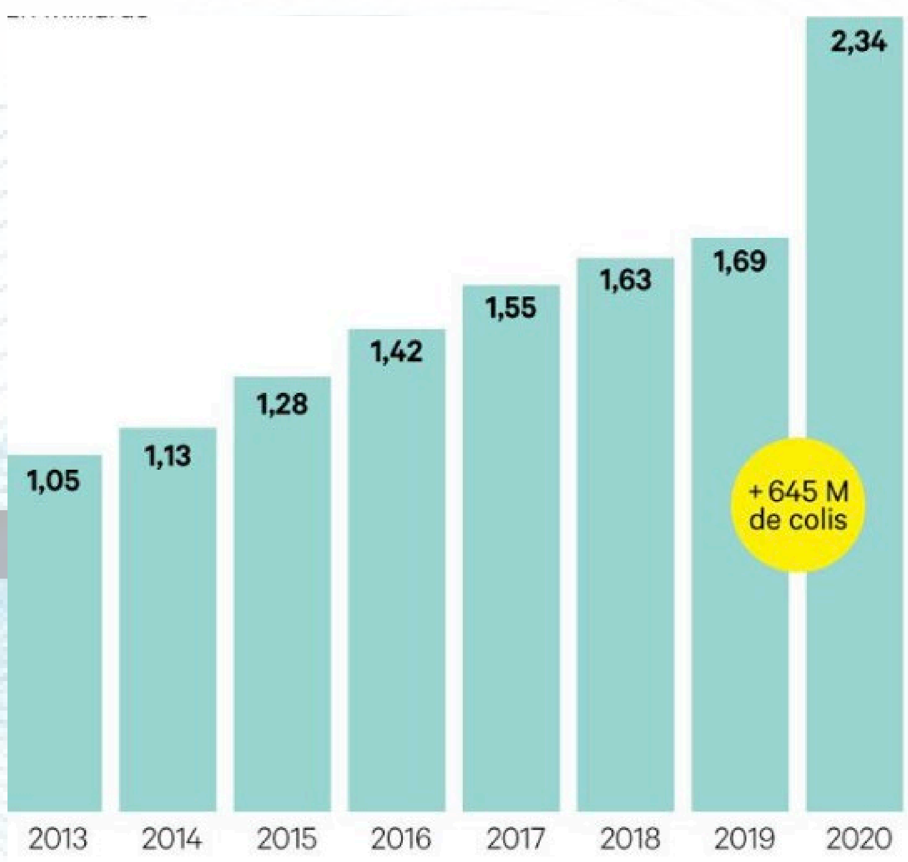
Hyperconnected Urban Parcel Network Design with Tight Delivery Service Requirements

Context





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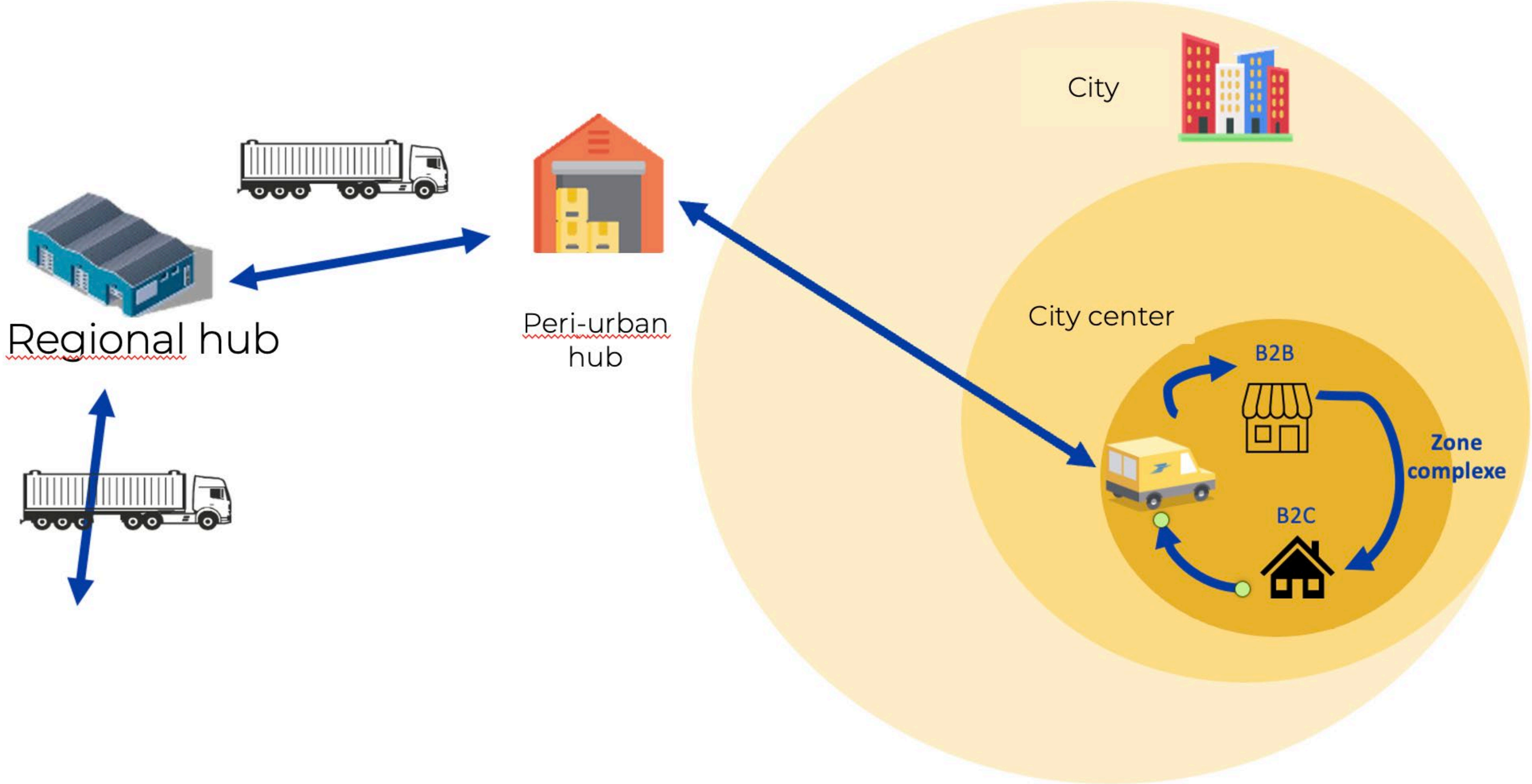
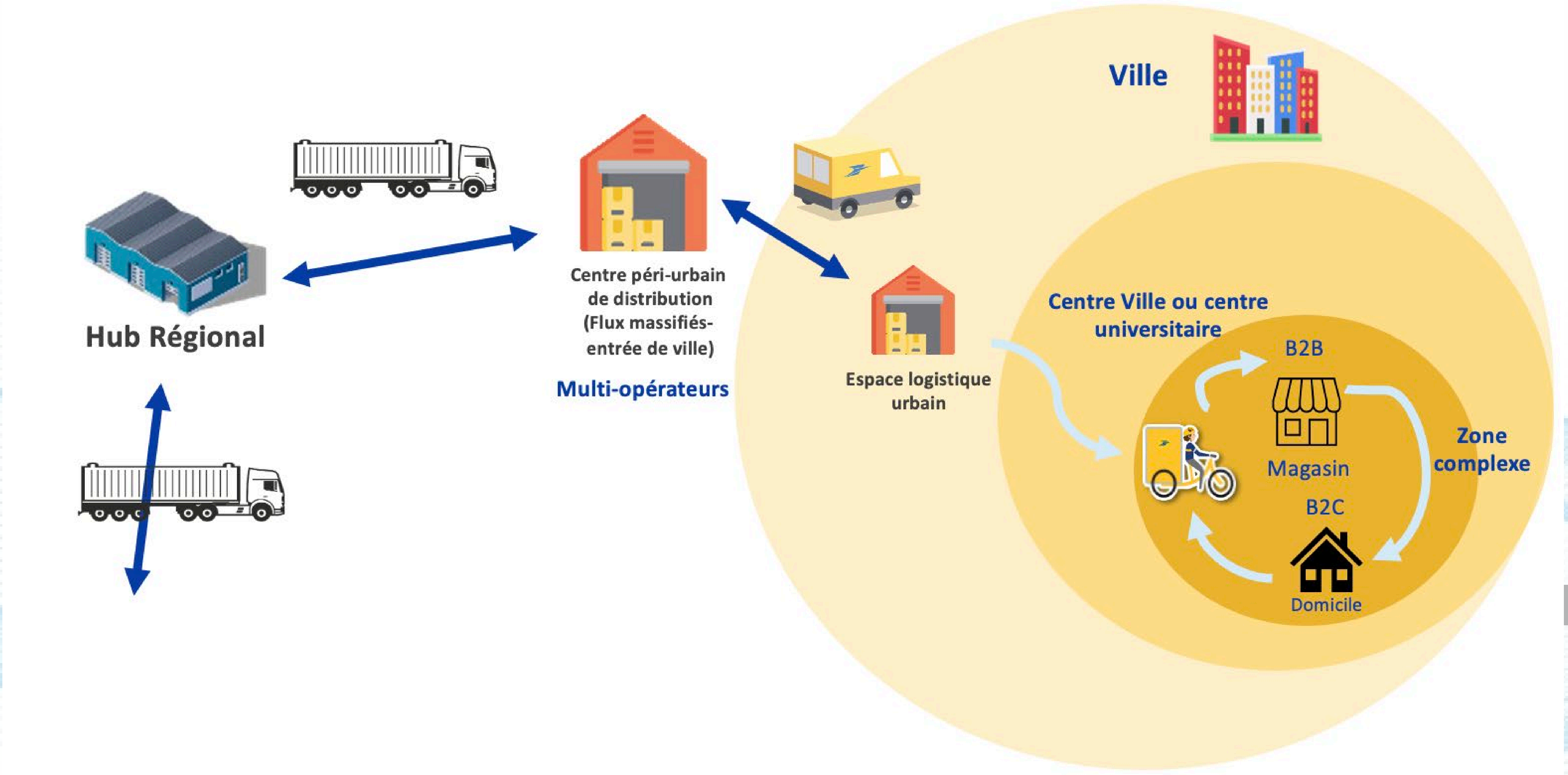
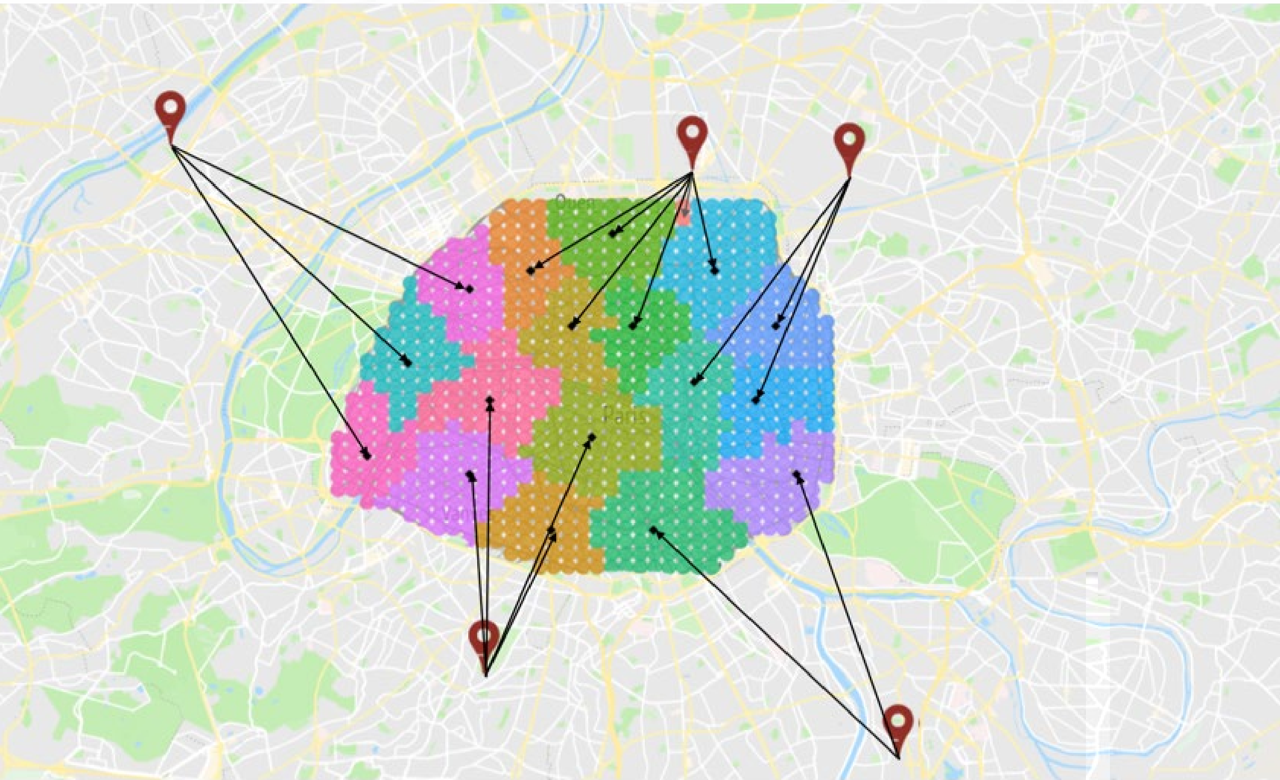
Historical delivery network



Current delivery network



Emerging quick markets



BFMTV

L'hypercroissance du E-commerce : un challenge pour les ...

Le développement du « Ship from store » complexifie les plans de transport avec l'utilisation de plusieurs prestataires du dernier kilomètre. La ...

Il y a 1 jour

PR Newswire

Same Day Delivery Market Size to hit $ 16739 Million by 2027 ...

The same day delivery is very fast process so to avoid mix-ups if product ordered before noon are delivered on same day otherwise next morning ...

Il y a 3 semaines

E-marketing

Ship-from-store : ba&sh multiplie ses ventes en ligne par 3,5 ...

Ship-from-store : ba&sh multiplie ses ventes en ligne par 3,5 le premier jour des soldes. Publié par Clément Fages le 1 mars 2021 I Mis à jour le 5 mars 2021 à ...

Il y a 1 mois

Voxlog

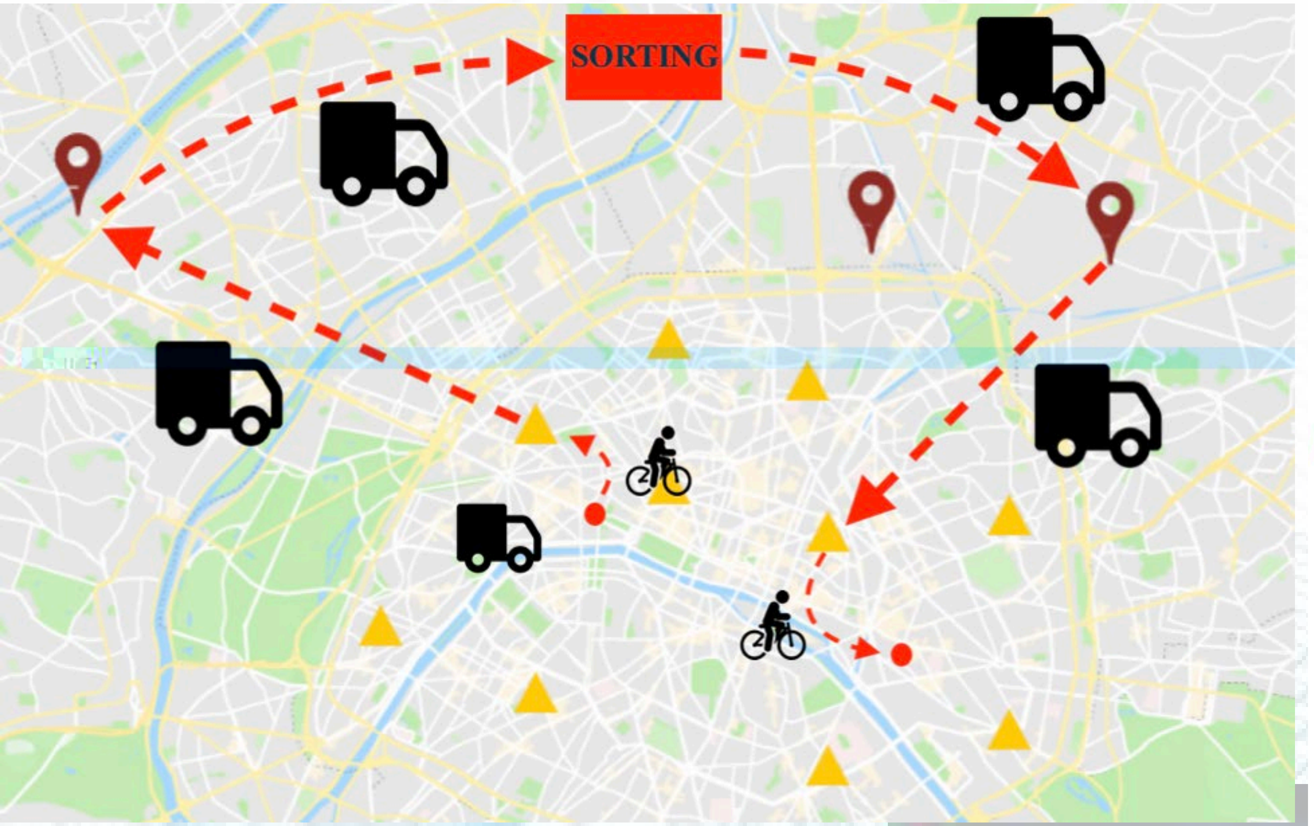
Electro Dépôt déploie le ship-from-store avec Woop

Depuis la mi-novembre, l'enseigne de multimédia et d'électroménager a pu déployer une solution de livraison ship-from-store depuis ses 81 ...

20 janv. 2021

X

Emerging quick markets



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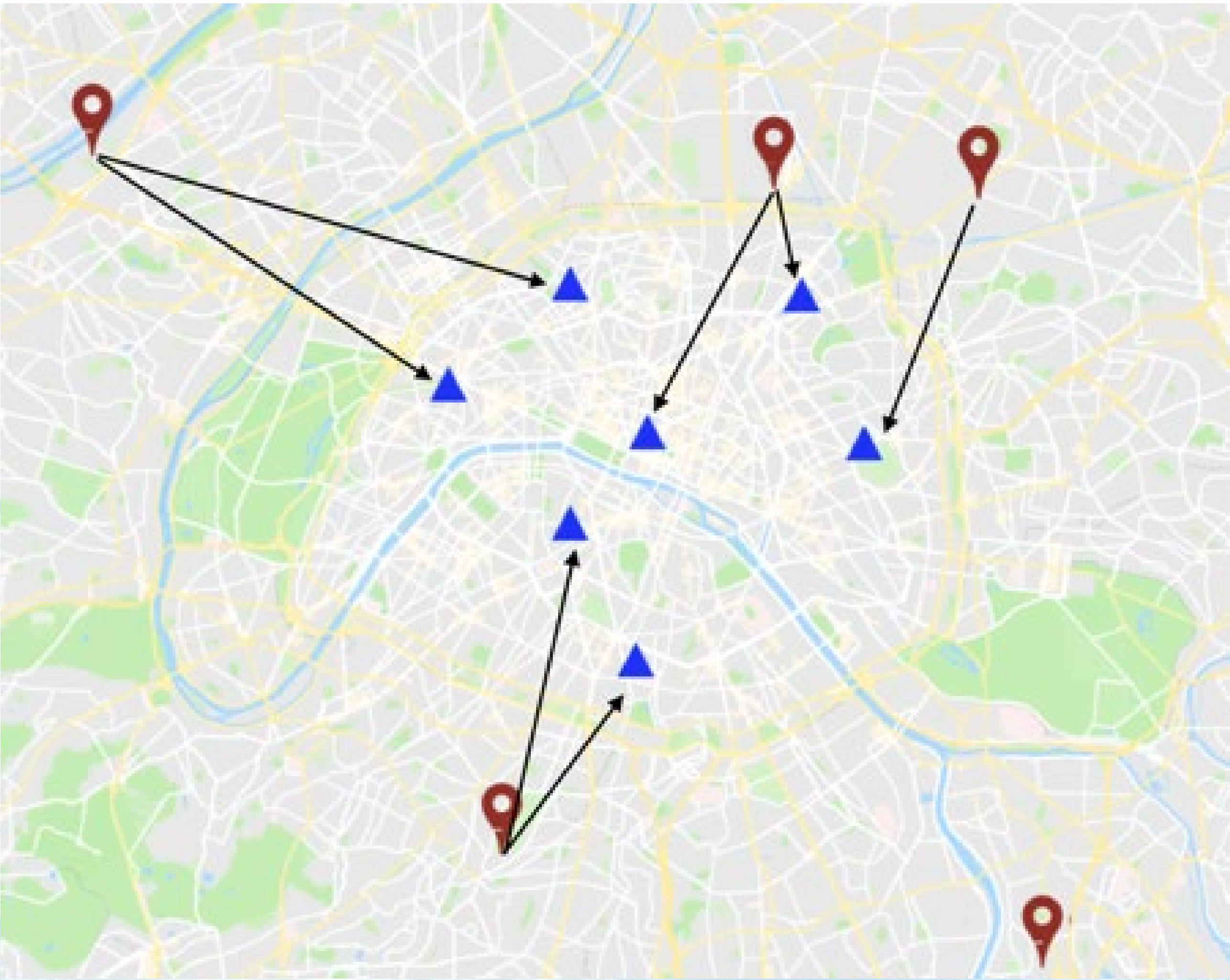
La Poste’s Group organization

Historical role

La Poste’s Group organization

La Poste has several twin companies, with their own already established networks



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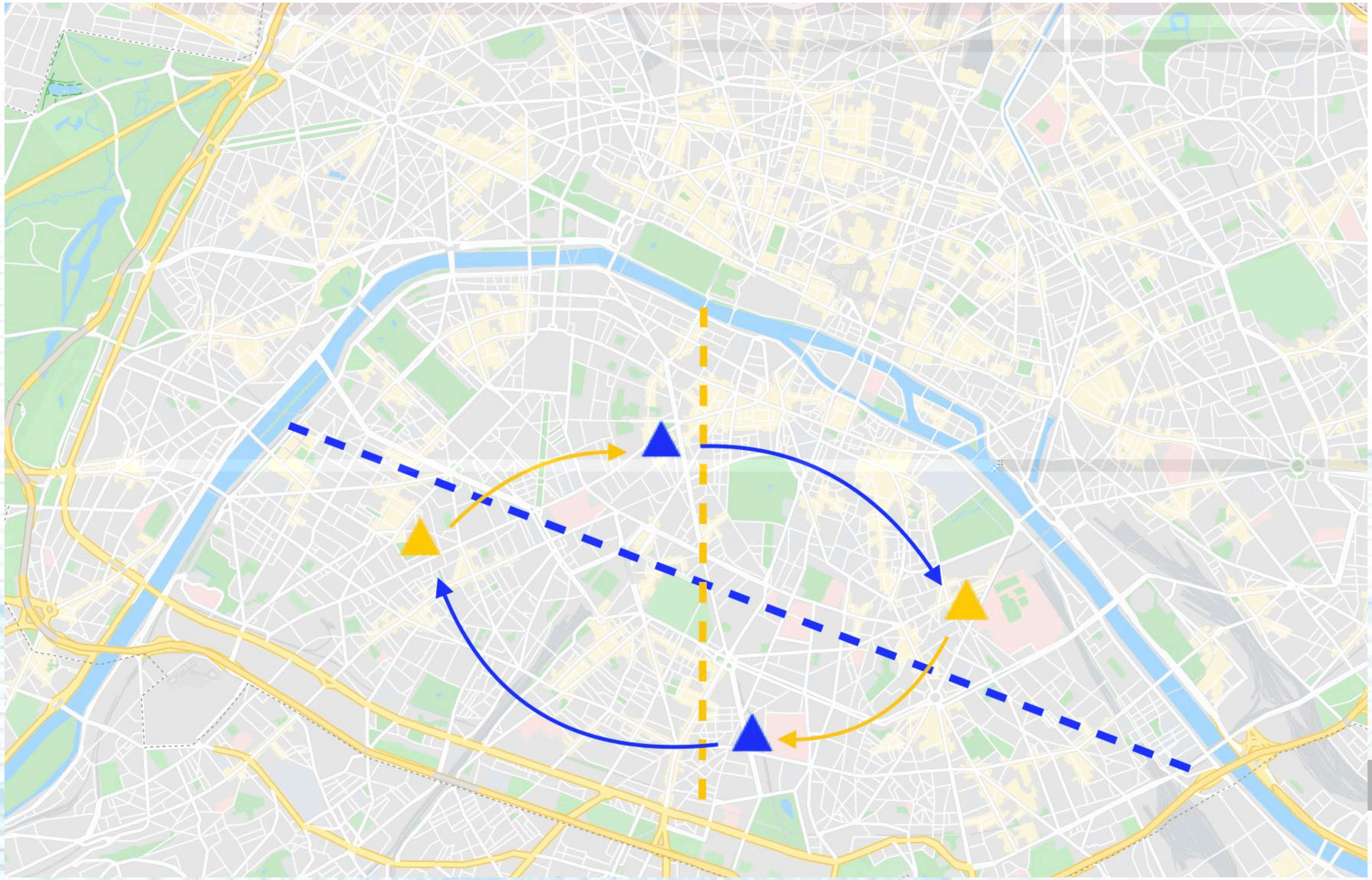
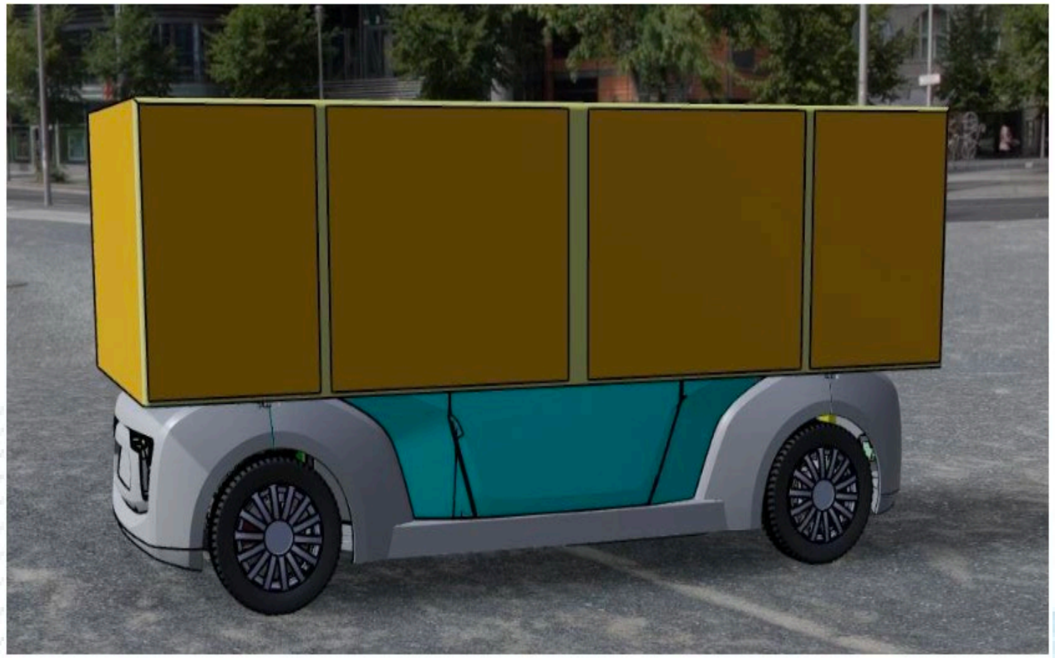
Natural overlapping



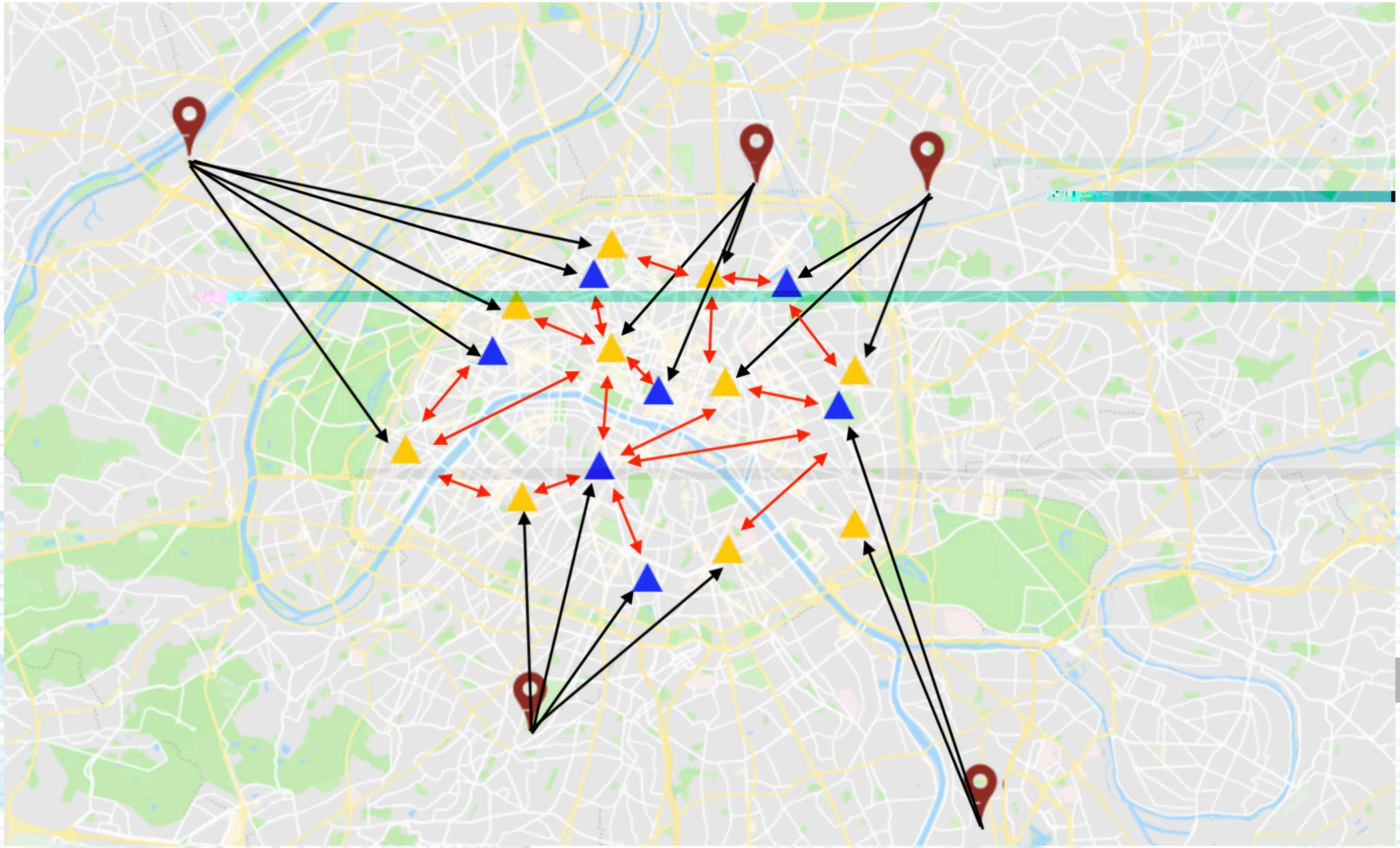
chronopost

colissimo

The introduction of new delivery methods allows a higher agility



Introduction of interconnected networks



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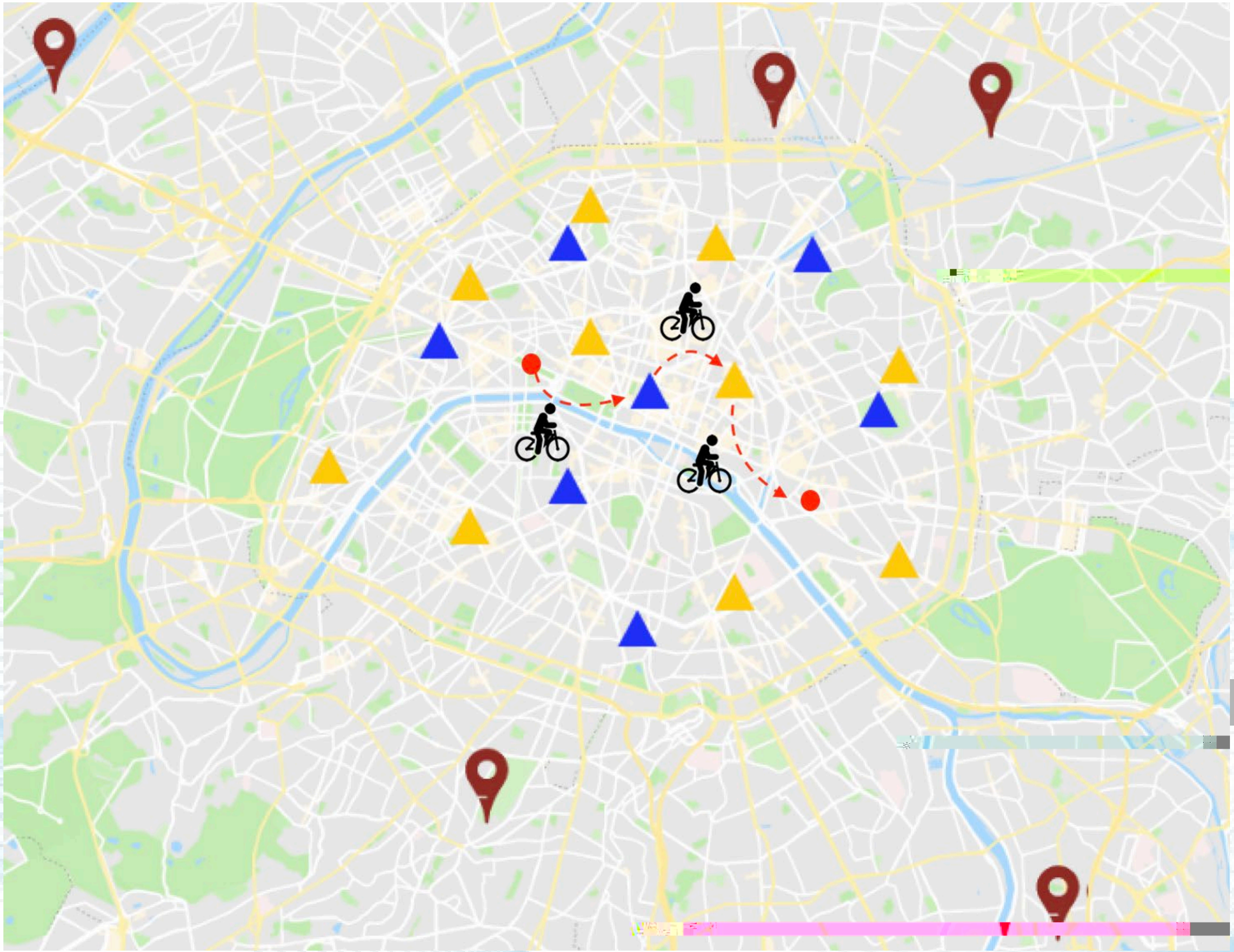

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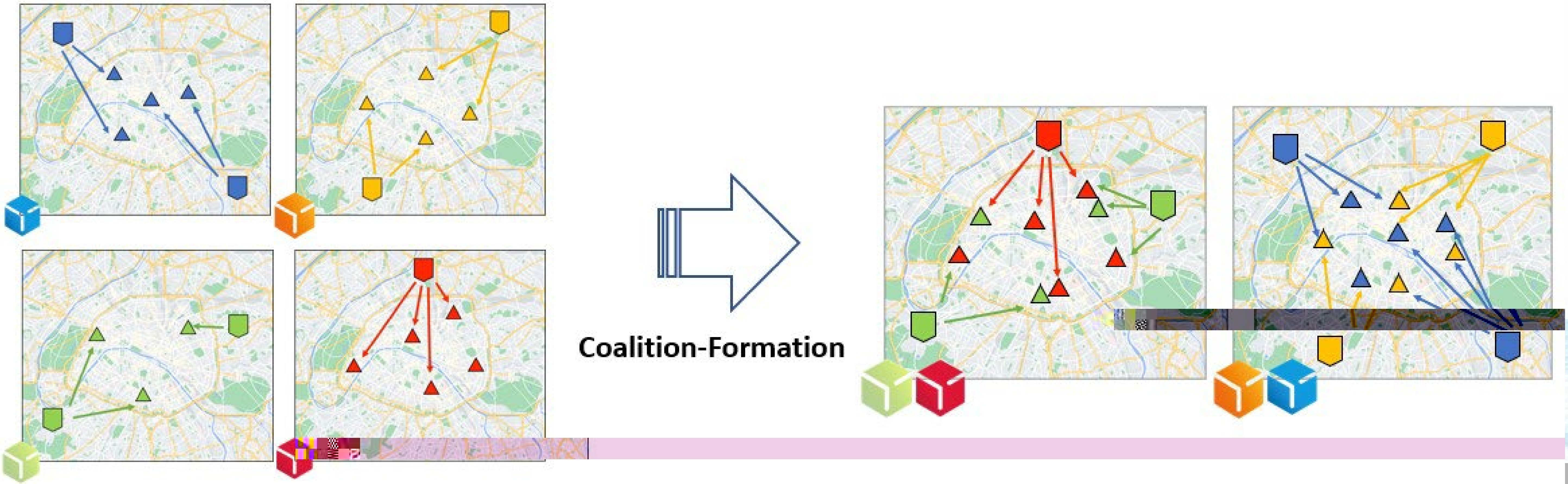
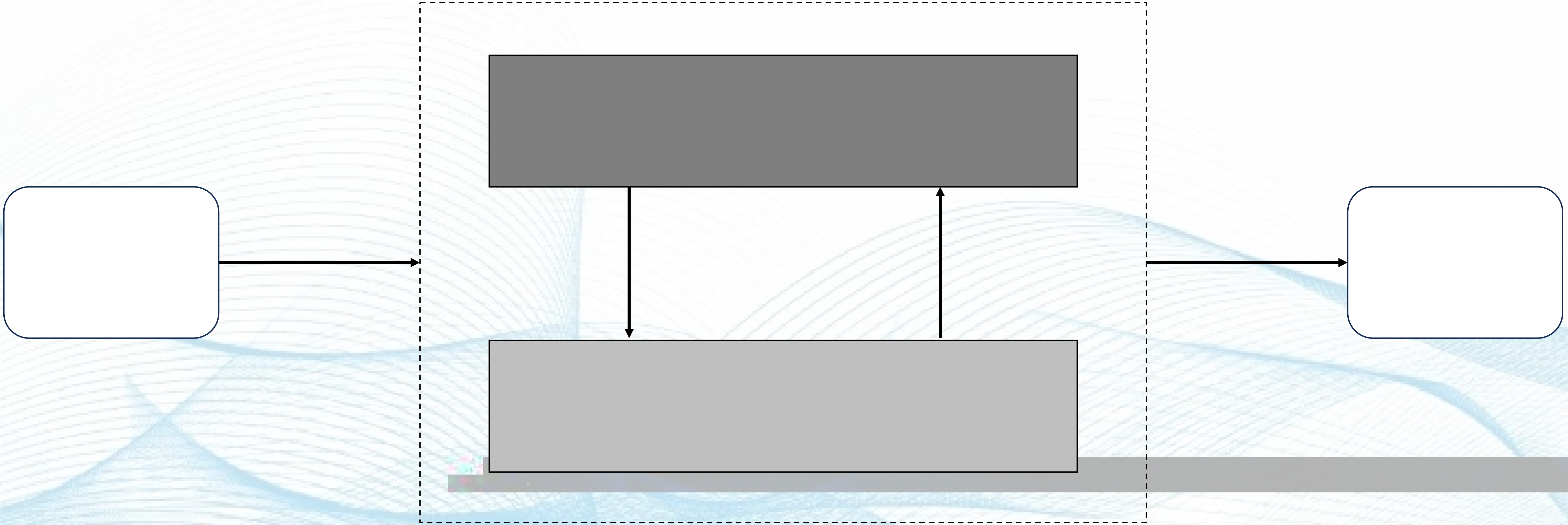
Idea of coalition formation



Set of delivery actors with
their own dedicated parcel
delivery networks

Set of coalitions of actors
with shared parcel delivery
networks

Coalitional Decision-Making Framework

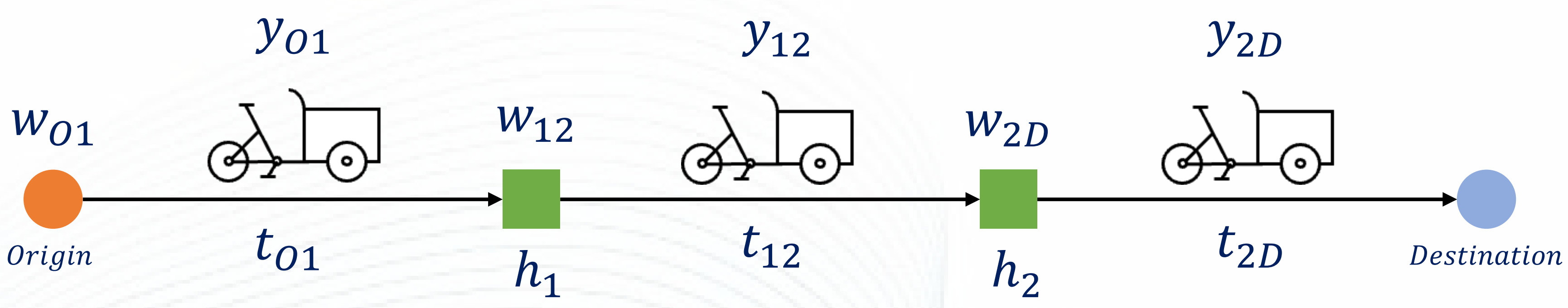


Coalitional Network Design

- **Aim:**
  -

- **Model and Decisions:**
  -
  -
    - →
    - →

Modelling Delivery Service Requirements



- τ_k: k
- t_a: a
- h_i: i
- y_a: a
- w_a: a

Assumptions

-
-

$\Rightarrow$ a $w_a \sim$ $(0, \frac{1}{y_a})$ $\frac{1}{2} \cdot \frac{1}{y_a}$

$$\sum_{a \in p} t_a + \sum_{i \in p} h_i + \sum_{a \in p} \mathbb{E}[w_a] \leq \tau_k \quad \Rightarrow \sum_{a \in p} \frac{1}{2} \cdot \frac{1}{y_a} \leq \widehat{\omega}_{kp} = \tau_k - \left(\sum_{a \in p} t_a + \sum_{i \in p} h_i \right)$$

p k

Coalitional Network Design Model with TDSR

➤

- $\mathcal{S}$:
- $\mathcal{N}^s$: $s \in \mathcal{S}$
- $\mathcal{A}^s$: $s \in \mathcal{S}$
- $\mathcal{K}^s$:
  $s \in \mathcal{S}$
- $\mathcal{P}_k^s$
  $k \in \mathcal{K}$ $s \in \mathcal{S}$

➤ $s \in \mathcal{S}$

- $x_h^s \in \{0,1\}$:
- $y_a^s \in \mathbb{Z}_{\geq 0}$: a
- $z_{kp}^s \in \{0,1\}$: k

$$\min \quad \sum_{h \in \mathcal{N}^s} f_h \cdot x_h^s + \sum_{a \in \mathcal{A}^s} g_a \cdot y_a^s$$

$$\text{s.t} \quad \sum_{p \in \mathcal{P}_k^s} z_{kp}^s = 1, \qquad \forall k \in \mathcal{K}^s$$

$$\sum_{k \in \mathcal{K}^s} \sum_{p \in \{p \in \mathcal{P}_k^s : a \in p\}} q_k \cdot z_{kp}^s \leq v \cdot y_a^s, \qquad \forall a \in \mathcal{A}^s$$

$$\sum_{a \in p} \frac{1}{2} \cdot \frac{1}{y_a^s} \leq \hat{\omega}_{kp} + M \cdot \left(1 - z_{kp}^s\right), \qquad \forall k \in \mathcal{K}^s, p \in \mathcal{P}_k^s$$

$$Q_i^{min} \cdot x_i^s \leq \sum_{a \in \delta^+(i)} y_a^s \leq Q_i^{max} \cdot x_i^s, \qquad \forall i \in \mathcal{N}^s$$

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Case Study

Table 1: Summary of parcel delivery actors

Delivery actor	# of Micro-hubs	Market Share	# of OD Commodities
1	19	60%	35591
2	3	10%	6162
3	8	30%	18105

- B
- B

Case Study: Cost-Sharing Methods

Input:

S:

I:

I^s: $s \in S$

M: Set of cost-sharing methods

$= \{\text{Shapley, PF, Eg}\}$

K_i i

q_{ik}: i

$C_{i,s}^{m}$: i s

$m \in M$

Cost-Sharing Methods:

- B $C_{i,s}^{Shapley} = \sum_{\bar{I} \subseteq I^s : i \in \bar{I}} \frac{(|I^s| - |\bar{I}|)! \cdot (|\bar{I}| - 1)!}{|I^s|!} \cdot (C_{\bar{I}} - C_{\bar{I} \setminus \mathrm{i}})$
- B $C_{i,s}^{PF} = \frac{C_s \cdot \sum_{k \in K_i} q_{ik}}{\sum_{i' \in I^s} \sum_{k \in K_{i'}} q_{ik}}$
- B $C_{i,s}^{Eg} = \frac{C_s}{|I^s|}$

Case Study: Global Network Design Performance

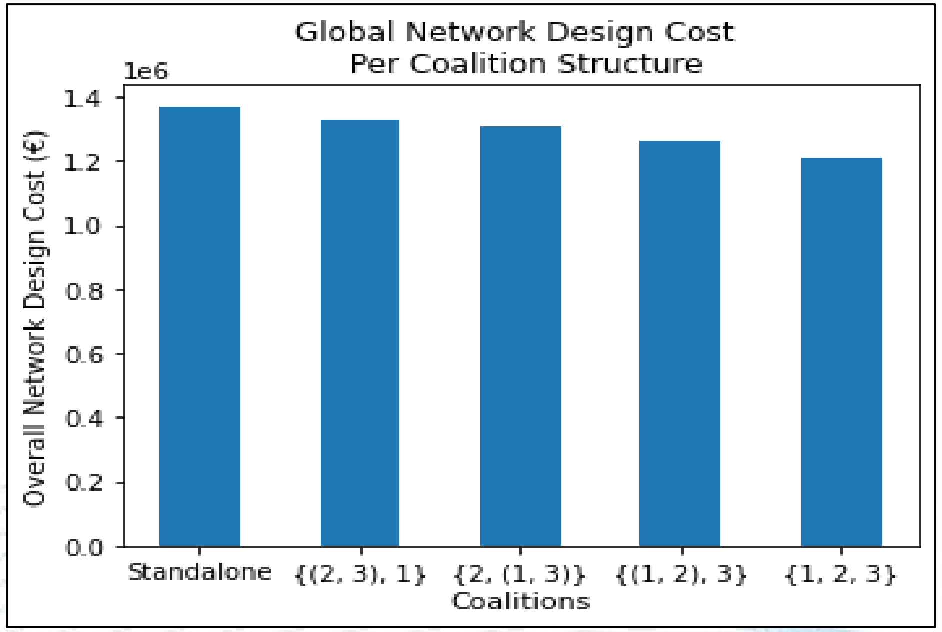
Table 1: Summary of Network Design of individual actors

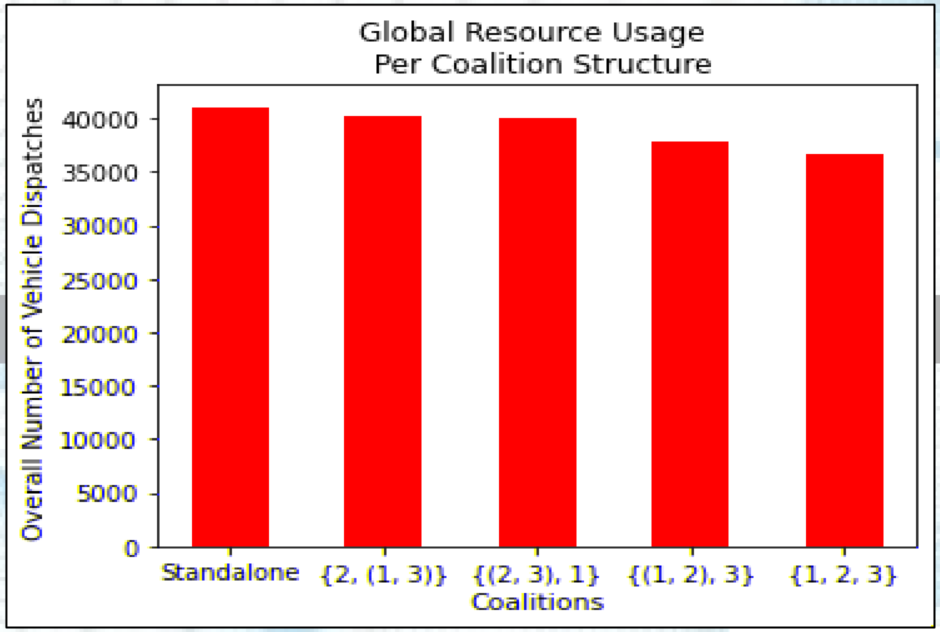
Actor	#. of open MHs	No. O-D Commodities	Cost (€)

Table 2: Summary of possible coalitions

Coalition	# of potential MHs	# of open MHs	# of O-D Commodities	Description
				B
				B
				B

Figure 3: Global Network Design Performance





Case Study: Impact of Cost-Sharing Methods

Figure 4: Allocated cost to actors per cost-sharing method

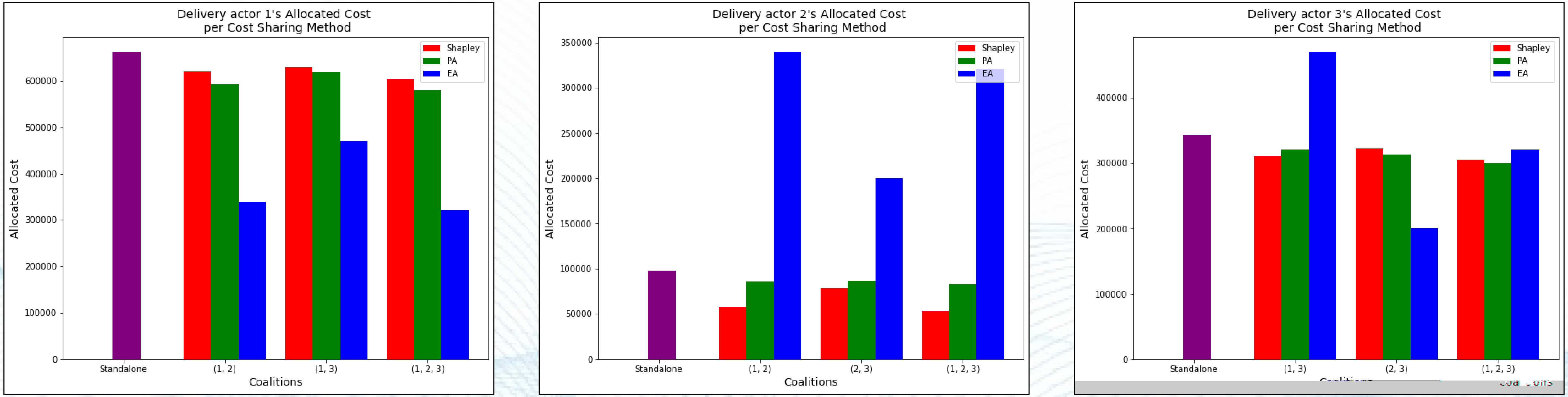


Table 3: Summary of coalitional decisions per cost-sharing method

Total No. Coalitions	**Shapley**			**Proportional (PA)**			**Egalitarian (EA)**		
	B			B			B		

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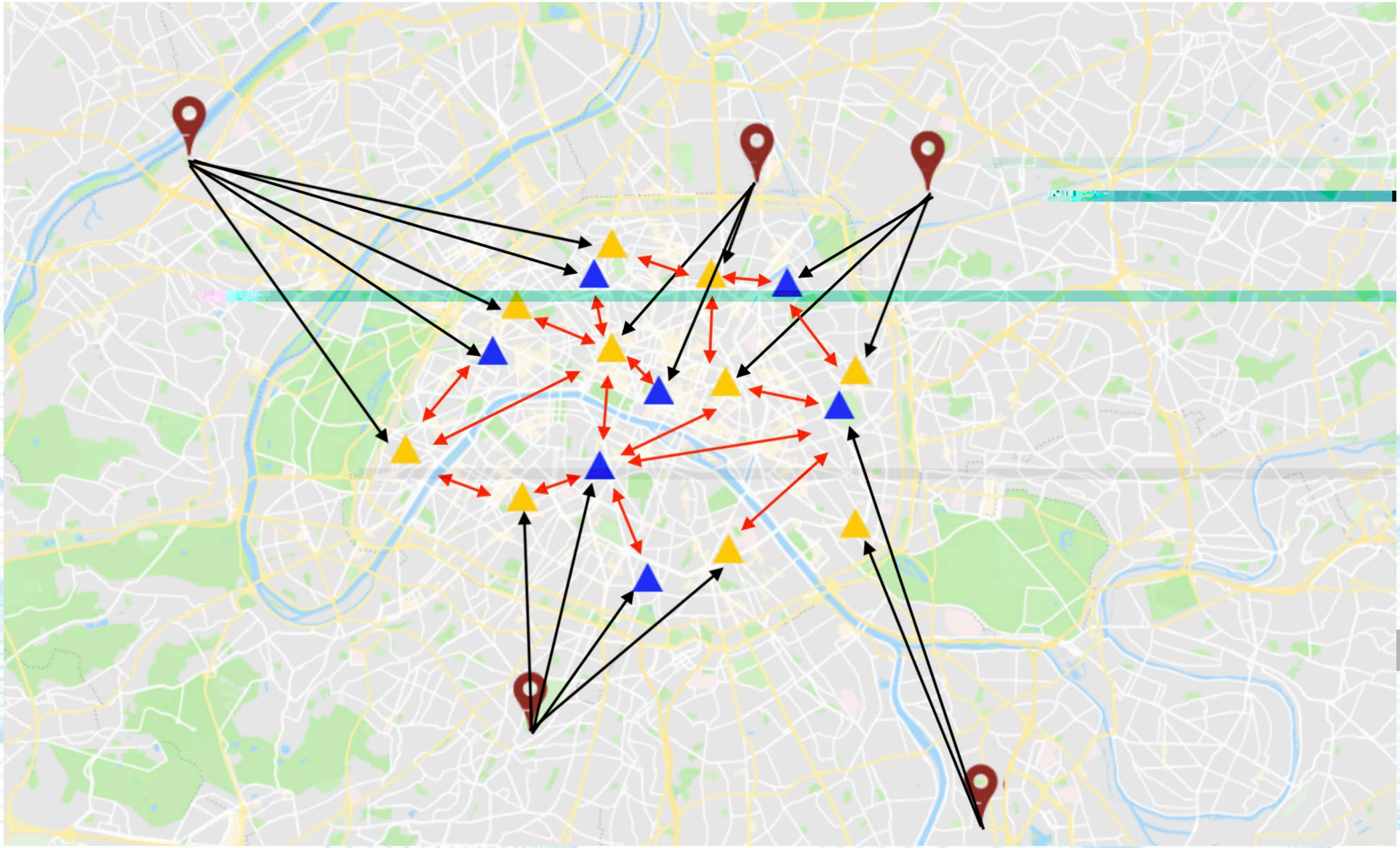
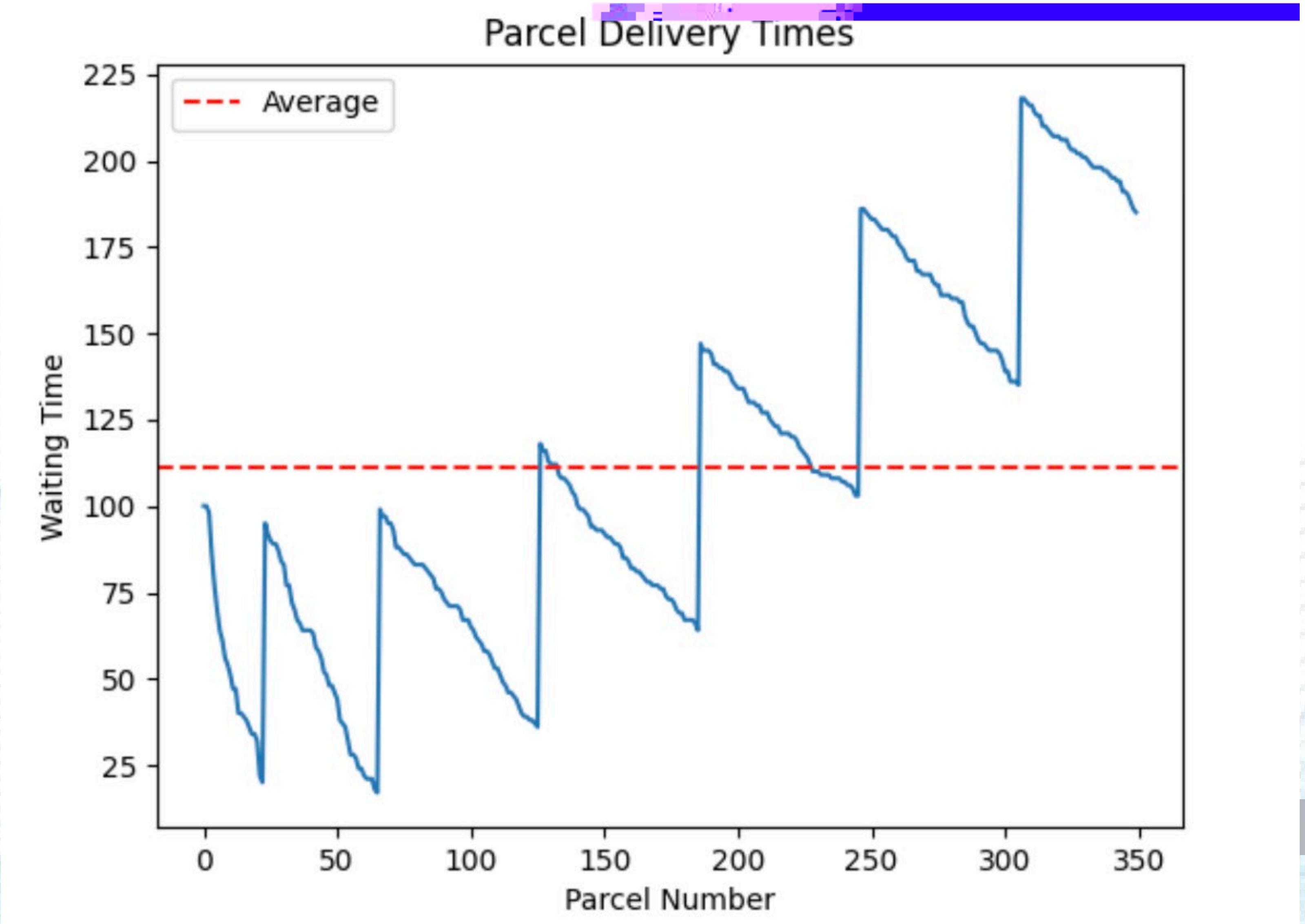
Type of connected networks



Simulation for Robust O-D Service Guarantees



Future work

Summary

Thank you!

Robust O-D Service Guarantees

Assumptions

- ➢
- ➢

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$$\sum_{a \in p} t_a + \sum_{i \in p} h_i + \sum_{a \in p} \mathbb{E}[w_a] \leq \tau_k \;\Rightarrow\; \sum_{a \in p} \frac{1}{2} \cdot \frac{1}{y_a} \leq \widehat{\omega}_{kp} = \tau_k - \left(\sum_{a \in p} t_a + \sum_{i \in p} h_i \right)$$

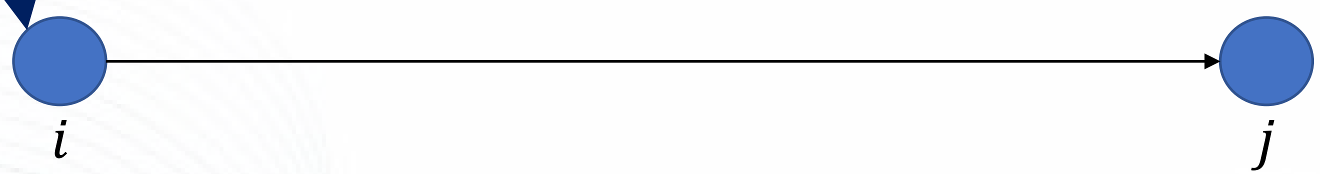
- $\Rightarrow$
  -
  - $\Rightarrow$
-

Robust O-D Service Guarantees

n

- $\{1,2,..n\}$
- B $[0, T]$

$q_d \ \forall d \in$



k v

$k * v \geq \sum_d q_d$

Policy:

- **either at the latest at $\frac{1}{k}$ time or when full**
    - τ_i i
- i^{th} $(\forall i > 1)$ **either at the latest at $\tau_{i-1} + \frac{1}{k}$ or when full**

IPIC 2023

Robust O-D Service Guarantees

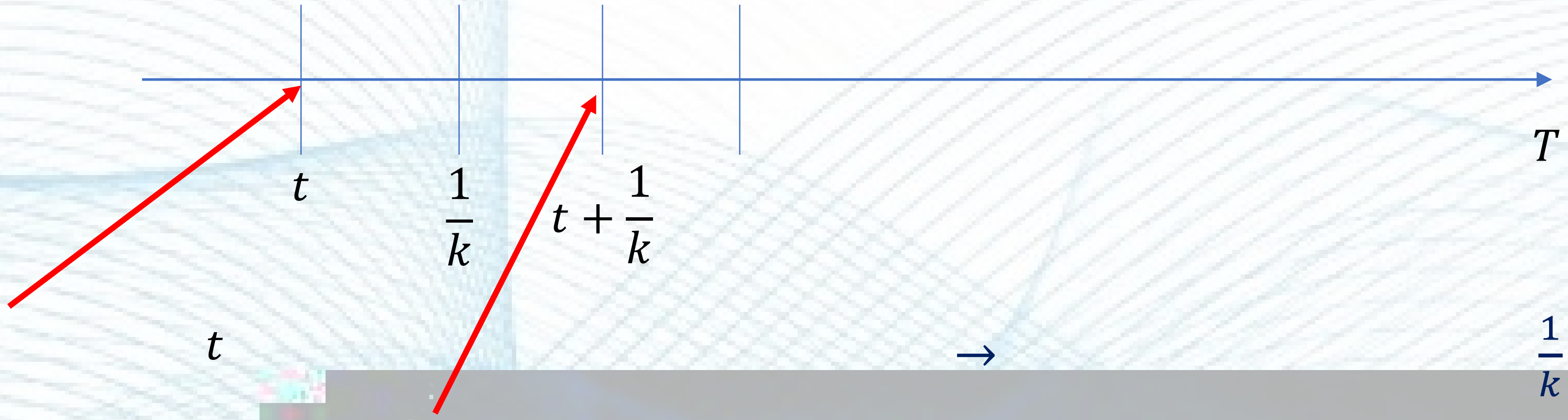
n

- $\{1,2,..n\}$
- B $[0, T]$

$q_d \ \forall d \in$

k v

$k * v \geq \sum_d q_d$



t $\rightarrow$ $\frac{1}{k}$

$\rightarrow$ $\leq \frac{1}{k}$

$t + \frac{1}{k}$

- B
- B

$\frac{1}{k}$

Robust O-D Service Guarantees

➢

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Robust O-D Service Guarantees

what if $k < 2$?

- $k < 2$
- k

$$\min \sum_{h \in \mathcal{N}^s} f_h \cdot x_h^s + \sum_{a \in \mathcal{A}^s} 2 \cdot g_a \cdot y_a^s$$

$$\text{s.t} \quad \sum_{p \in \mathcal{P}_k^s} z_{kp}^s = 1, \qquad \forall k \in \mathcal{K}^s$$

$$\sum_{k \in \mathcal{K}^s} \sum_{p \in \{p \in \mathcal{P}_k^s : a \in p\}} q_k \cdot z_{kp}^s \le v \cdot y_a^s, \qquad \forall a \in \mathcal{A}^s$$

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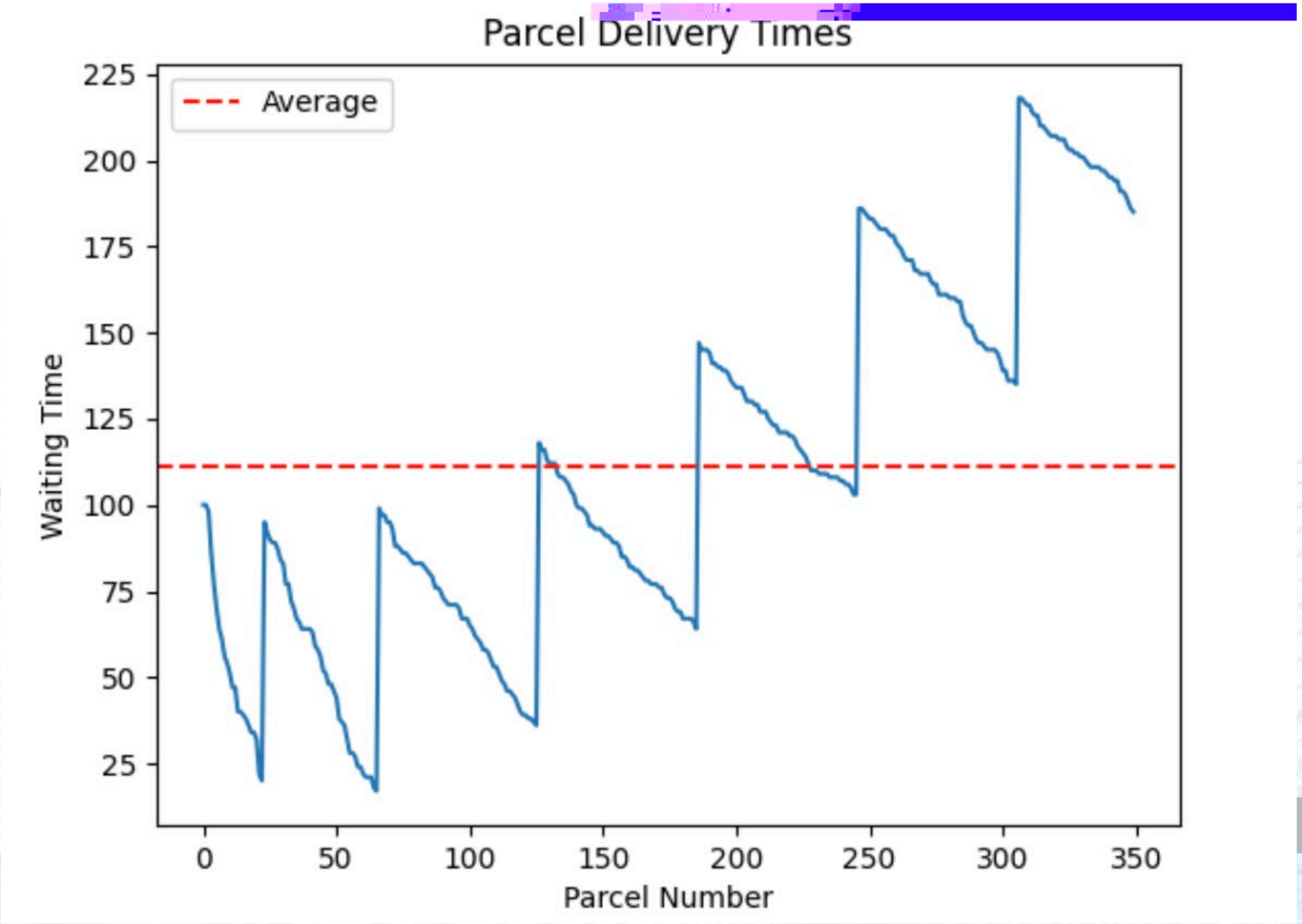

Simulation for Robust O-D Service Guarantees

→

B