Multi-Hop Courier-Parcel Delivery through Spatial Segmentation of Labor

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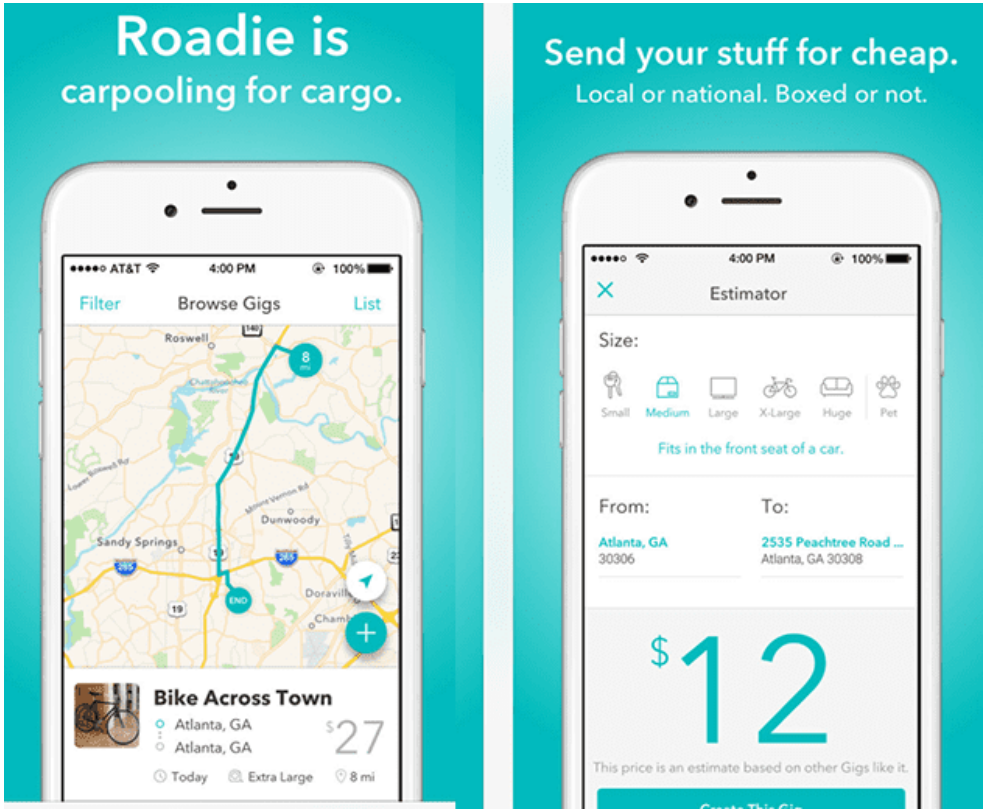
On-demand courier-parcel delivery

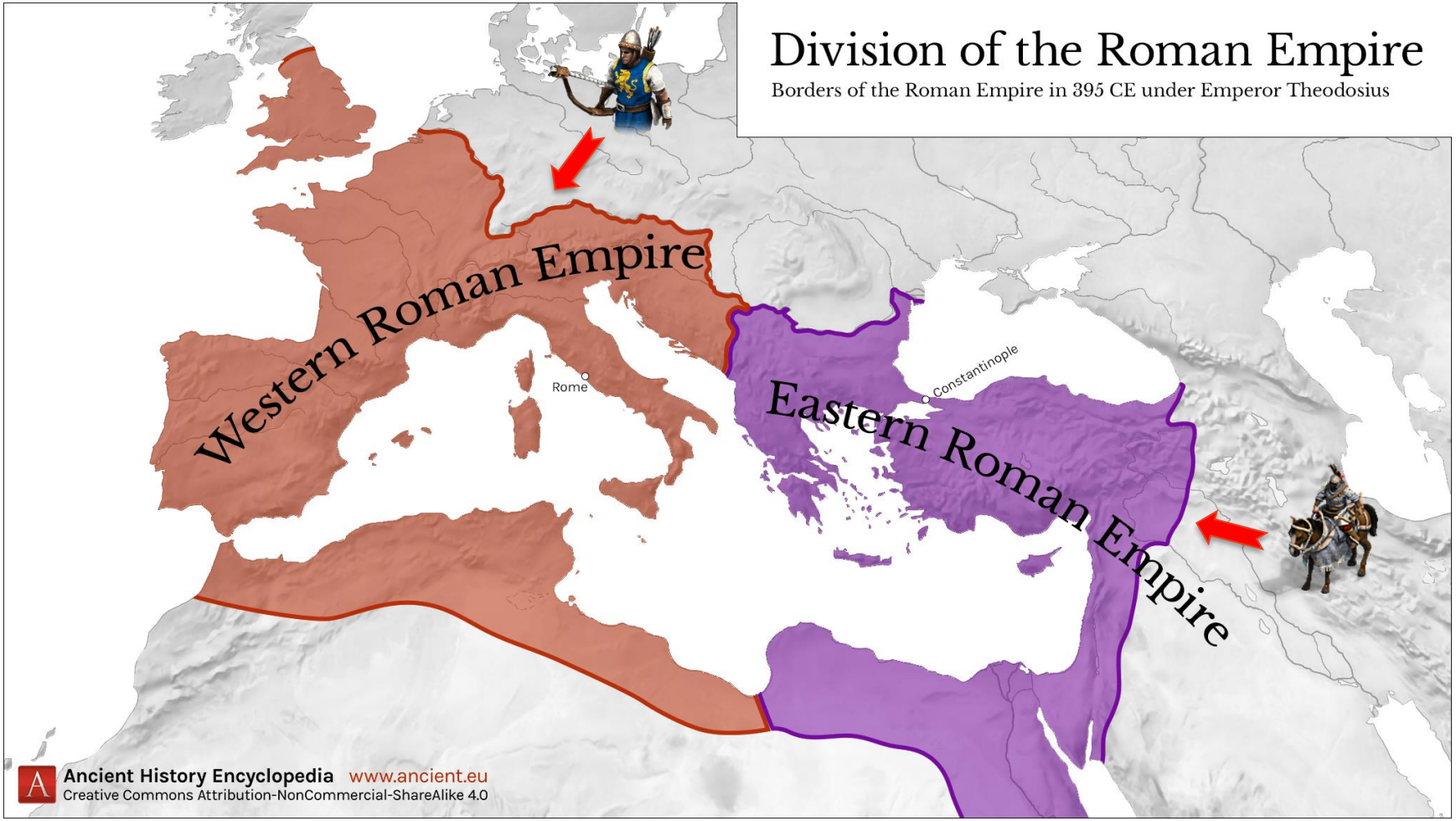


FLEX

Australia Post

https://easternpeak.com/blog/guide-to-building-an-on-demand-parcel-delivery-app/

What is the spatial division?

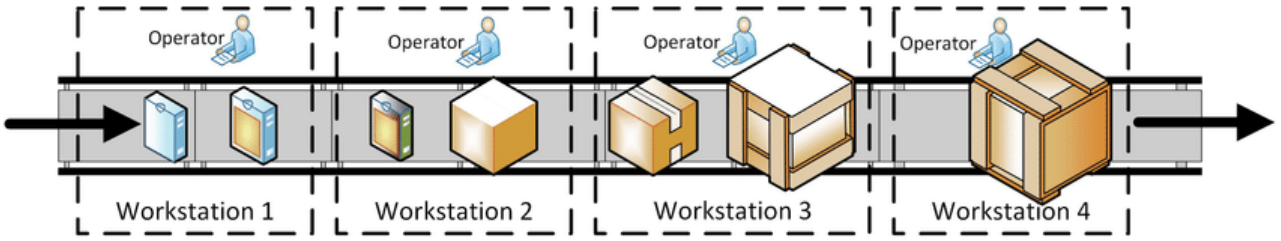


Graph source

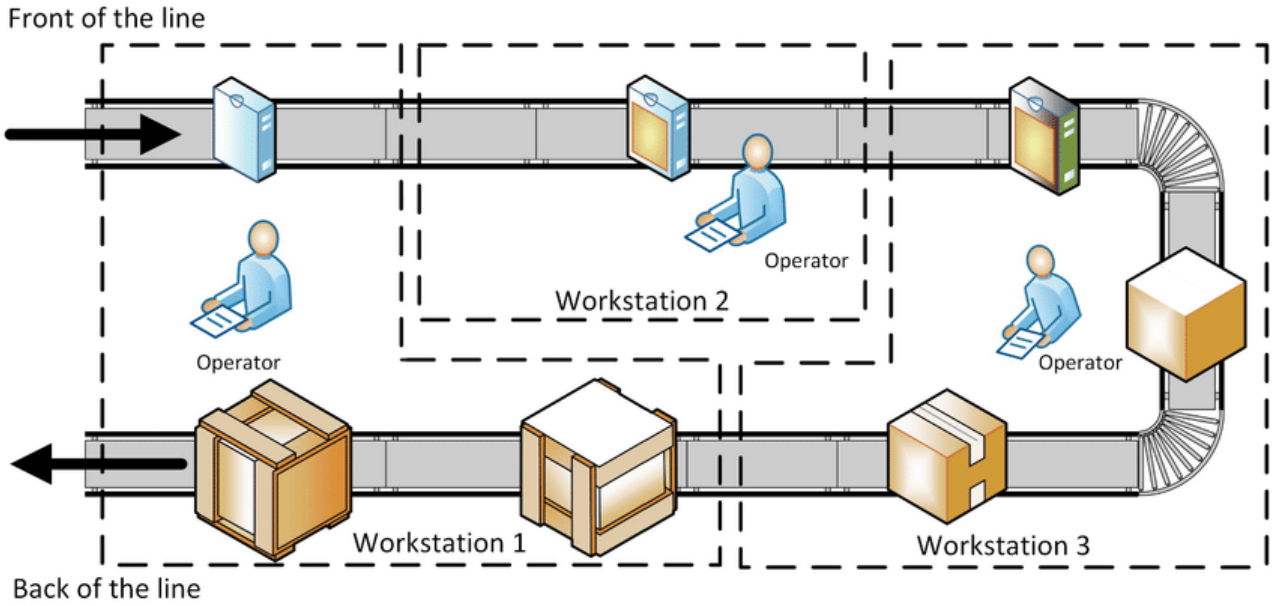
The map is collected from https://www.worldhistory.org/image/11818/western--eastern-roman-empire-395-ce/

Icons of soldiers and cavalry come from Video Game "Age of Empires II".

What is the spatial division?



(a) Straight assembly line



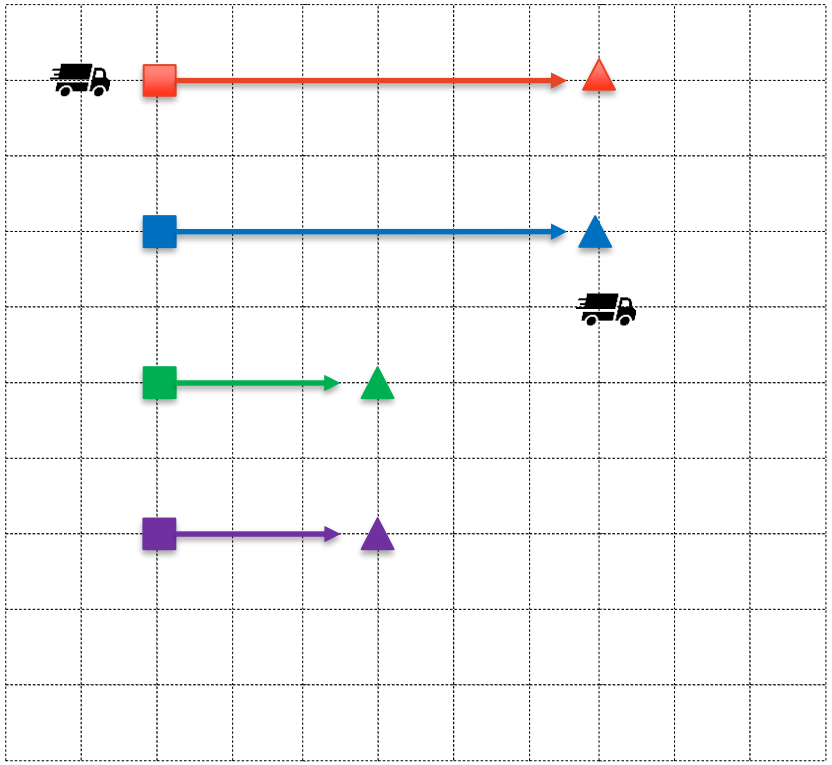
(b) U-shaped assembly line

Graph source

https://www.researchgate.net/figure/Assembly-line-types-in-terms-of-the-layout_fig1_352202986

Why is spatial division implemented in deliveries?

- **Localized Knowledge**
- **Efficiency**
- **Cost**



Couriers

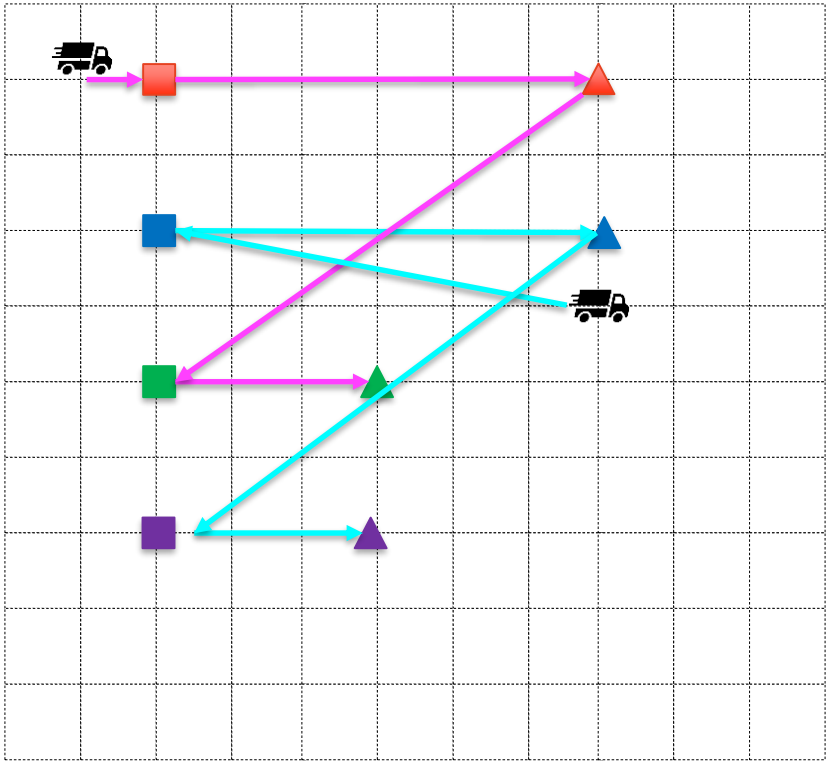
Parcel requests

Pick-up location

Drop-off location

arrive in sequence.

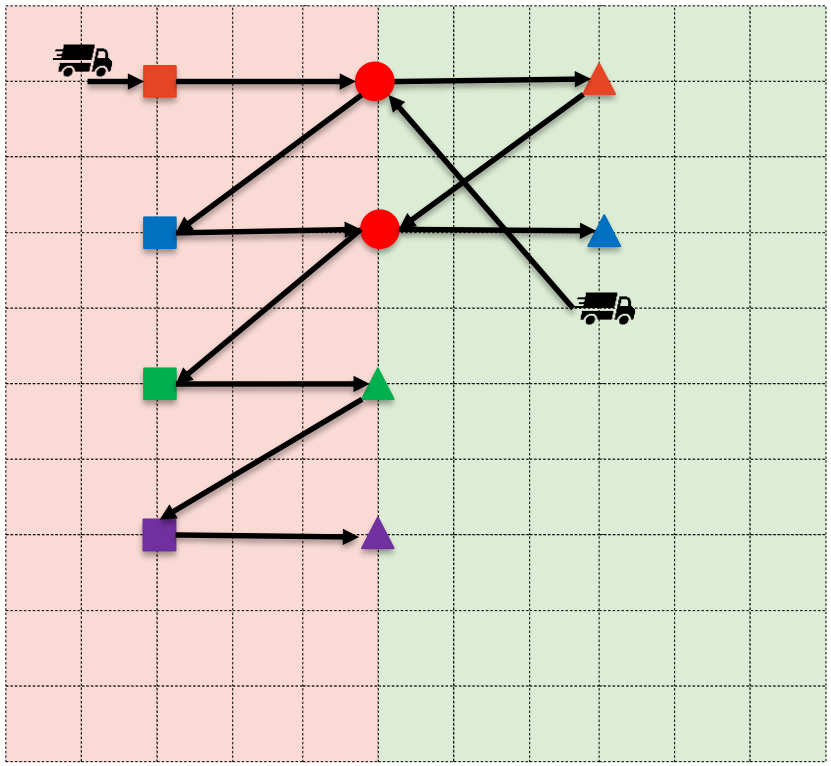
arrive in sequence. Dispatching rule: FCFS



No spatial division and single-hop

Total distance:

$$L_1 = 1 + 6 + \sqrt{52} + 3 \approx 17.21$$
$$L_2 = \sqrt{37} + 6 + \sqrt{52} + 3 \approx 22.29$$
$$L_1 + L_2 = 39.50$$



Two-area division and multi-hop

Total distance:

$$L_1 = 1 + 3 + \sqrt{13} + 3 + \sqrt{13} + 3 + \sqrt{13} + 3 \approx 23.81$$
$$L_2 = \sqrt{18} + 3 + \sqrt{13} + 6 \approx 13.85$$
$$L_1 + L_2 = 37.66$$

Single-hop vs. Multi-hop

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Single-Hop Parcel Delivery:

Origin

Destination

Origin

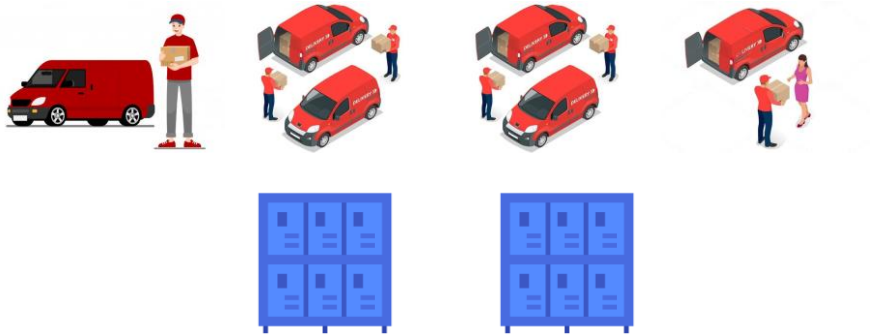
Destination

Multi-Hop Parcel Delivery:

Origin

lotus leaves

Destination

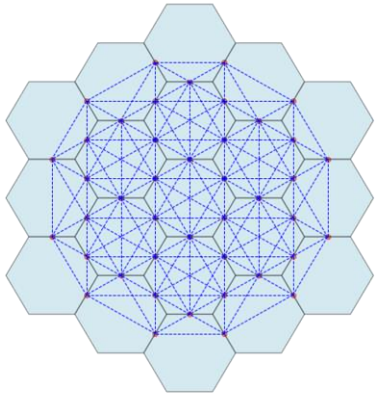


Origin

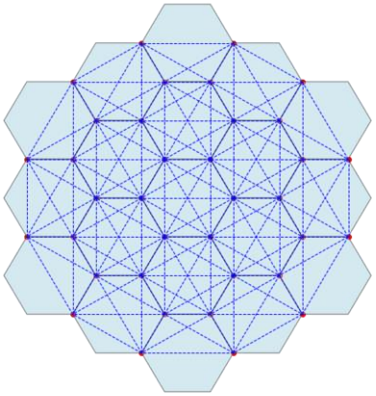
Transfer lockers

Destination

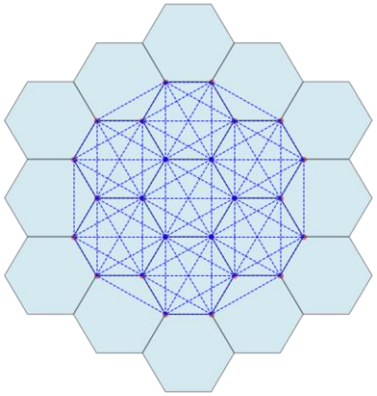
How do we implement network segmentation?



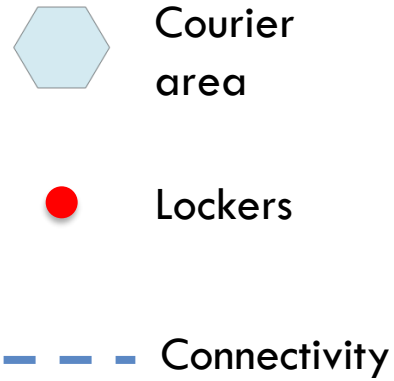
Network 1
Number of Lockers: 42
Number of Edges: 159



Network 2
Number of Lockers: 36
Number of Edges: 159



Network 3
Number of Lockers: 24
Number of Edges: 99



How do we assign parcel requests to couriers?

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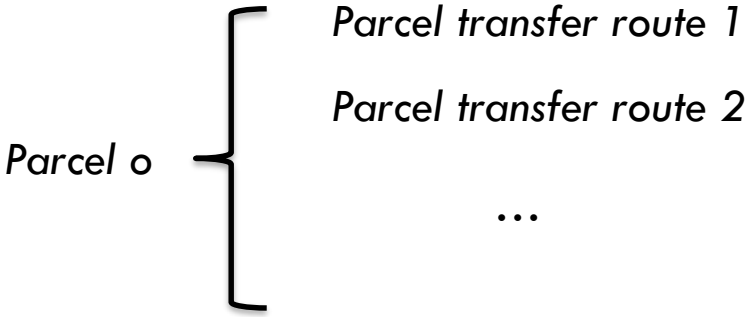
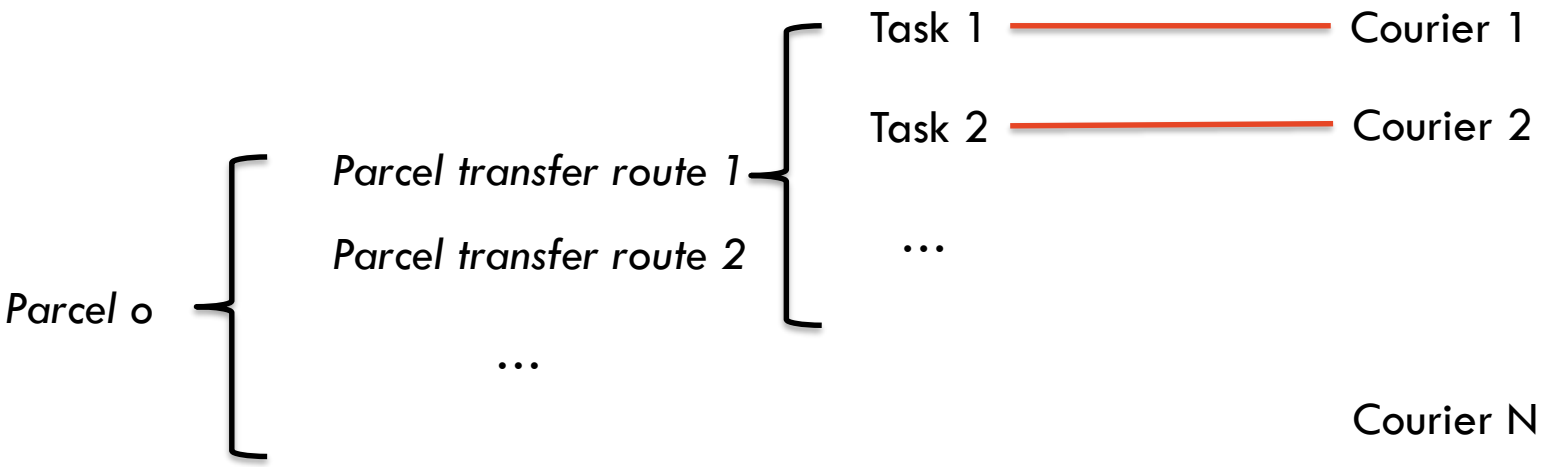
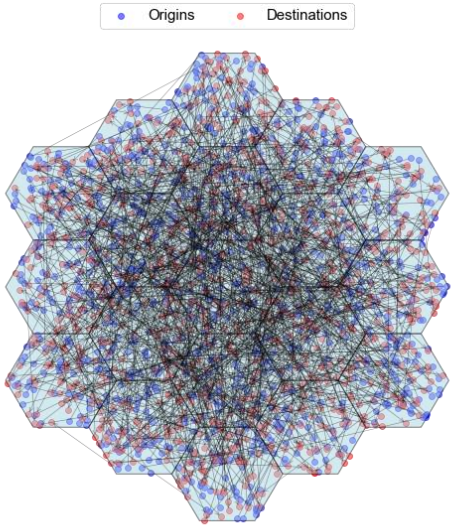
1. Parcel transfer route search

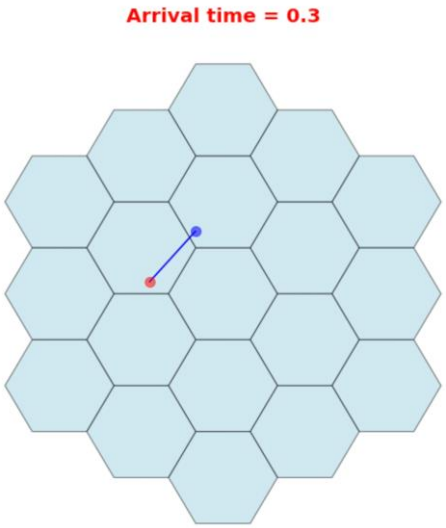


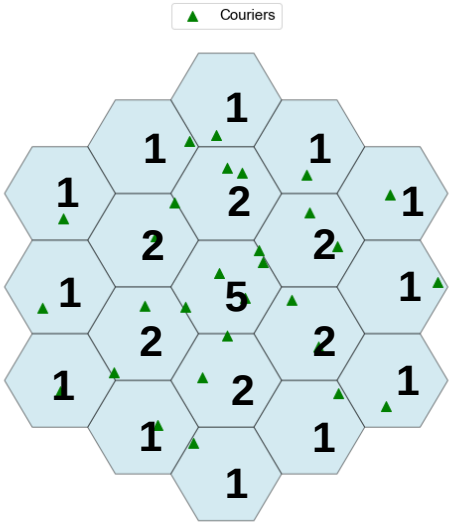
2. Courier-task assignment

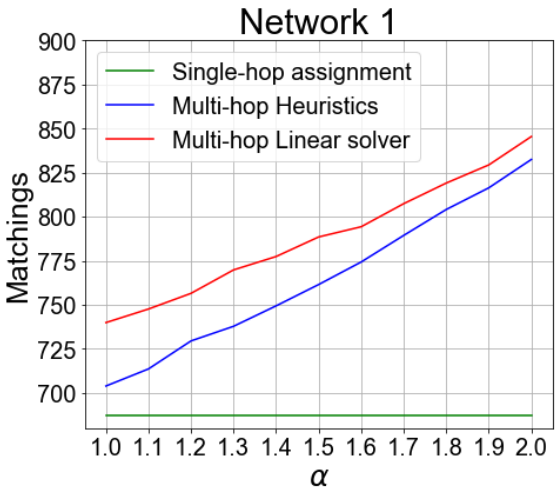


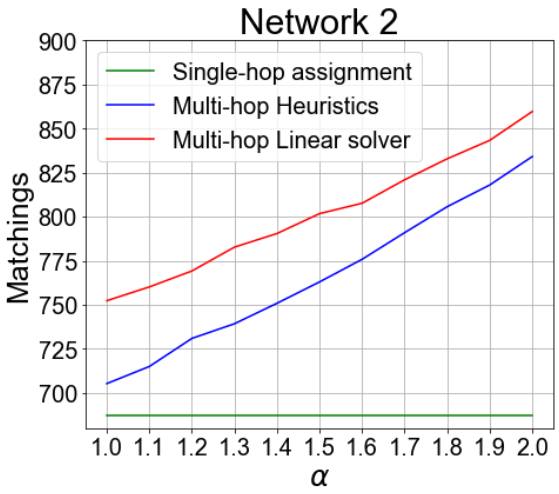
Optimization case study: 1000 parcels and 24 couriers

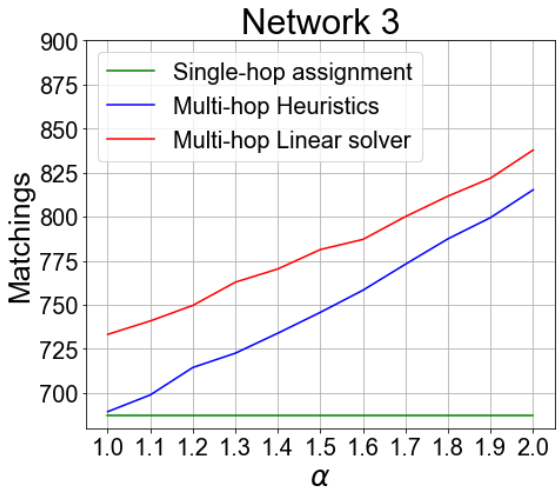




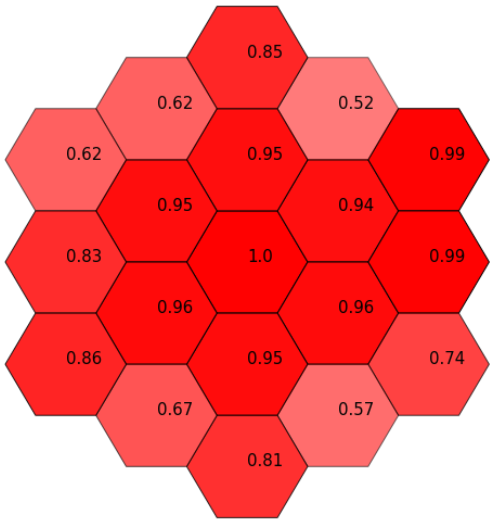




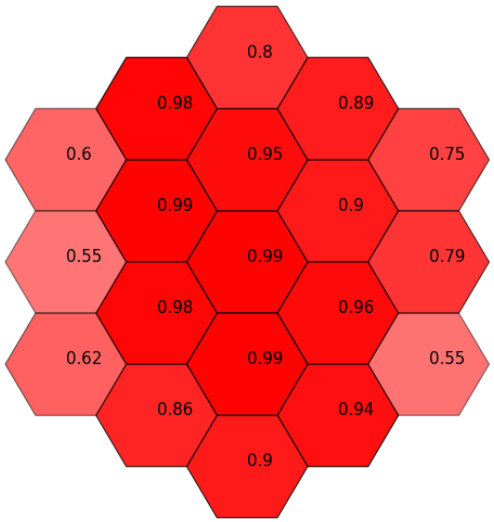




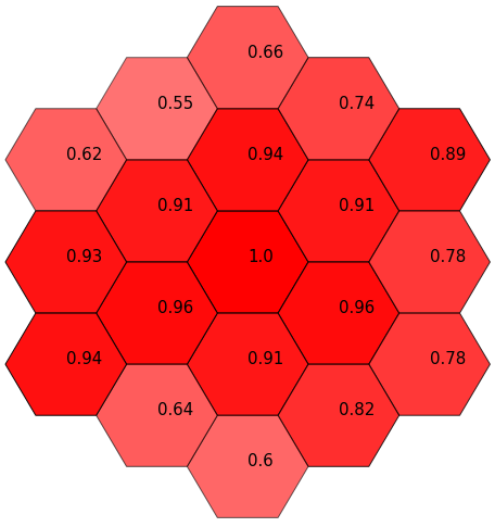
Occupation rate of couriers



Network 1



Network 2



Network 3

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Thanks