Physical Internet in City Logistics: Digital-Twin-driven Modeling and Implementation

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Agenda

1. Research background
2. Methodology
3. First results
4. Future work

Challenges - Urbanization

- Following the UN report in 2018:

By 2030, 43 megacities, each has more than 10 million inhabitants

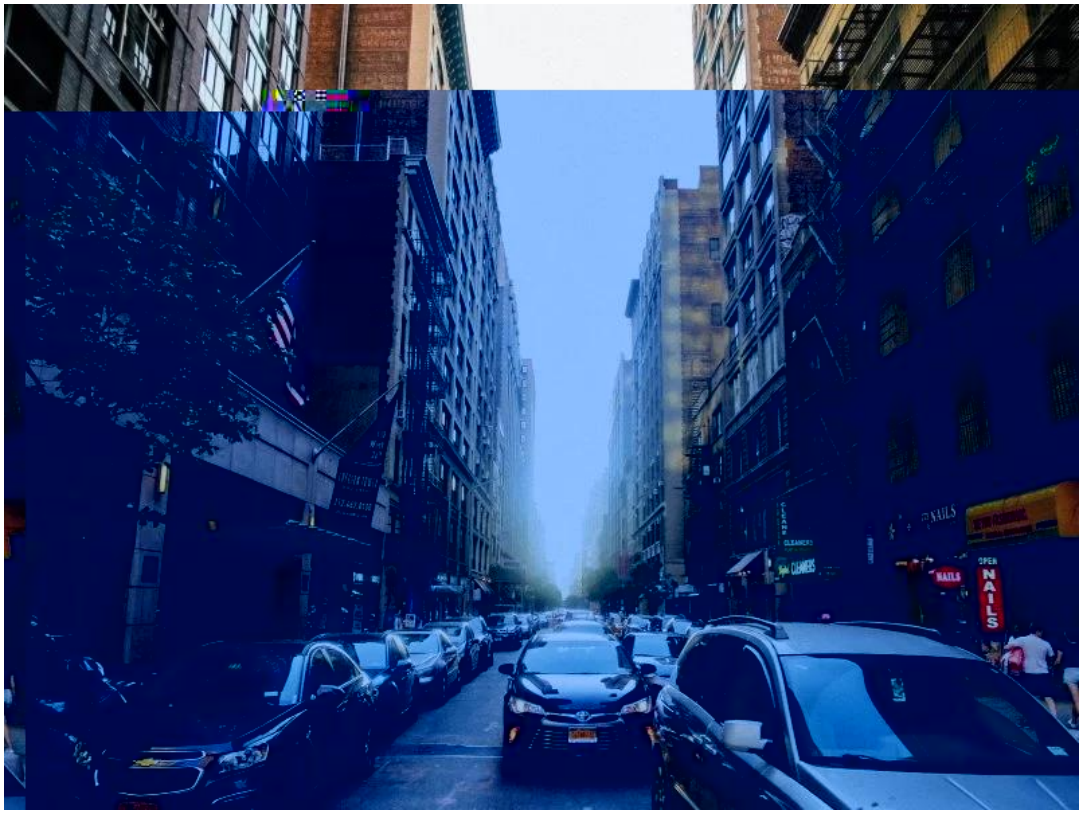
Logistics demand quantity & density surges

City center: Congestion & Parking problems

https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

Challenges - Crusing for parking

An example of Seattle downtown (2020):



2,900 trips of commercial vehicles

Parking cruising time[1]:

2.3 minutes per trip

28% of the trip time

1.1h per tour

Goods movement in the city[2]:

20 ~ 30% of total vehicle kilometers

16% ~ 50% of air-polluted emissions

Land use → Parking, environment, unnecessary congestion

[1] Dalla Chiara, G. & Goodchild, A. Do commercial vehicles cruise for parking? Empirical evidence from Seattle. Transport Policy 97, 26–36 (2020).

[2] Dablanc, L. Goods transport in large European cities: Difficult to organize, difficult to modernize. Transportation Research Part A (2007).

Challenges - Street clogged by delivery

In New York city, more than 1.5 million packages are delivered daily (N.Y. times, 2019).

Truck travel speed:

30 m.p.h (2014)

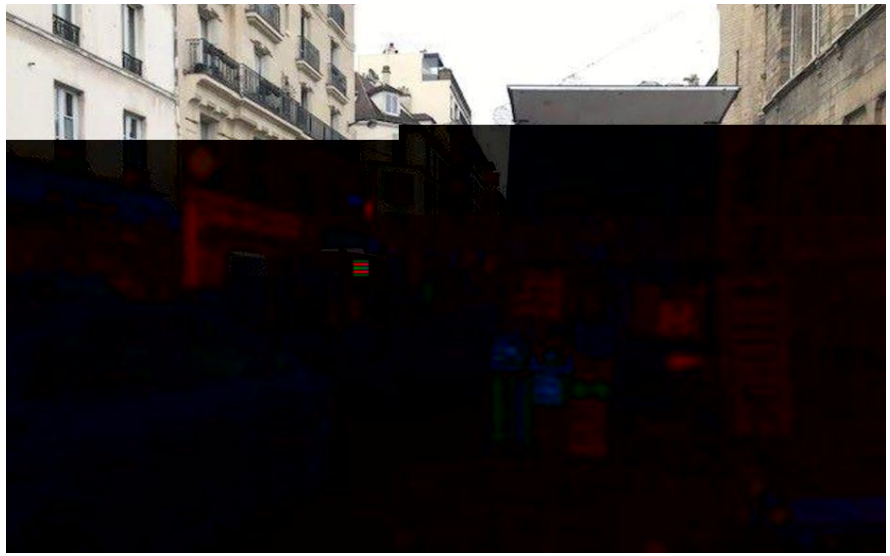
↓

23 m.p.h (2019)

(m.p.h = miles per hour)

Parking → Congestion, land use

In Paris, other problems like illegal parking for cargo handling and delivery...



https://www.nytimes.com/2019/10/28/nyregion/amazon-delivery-nyc.html

Research problem & Research questions

Problem

- Improving the last-mile delivery efficiency and urban sustainability with mitigating the problems of freight parking.

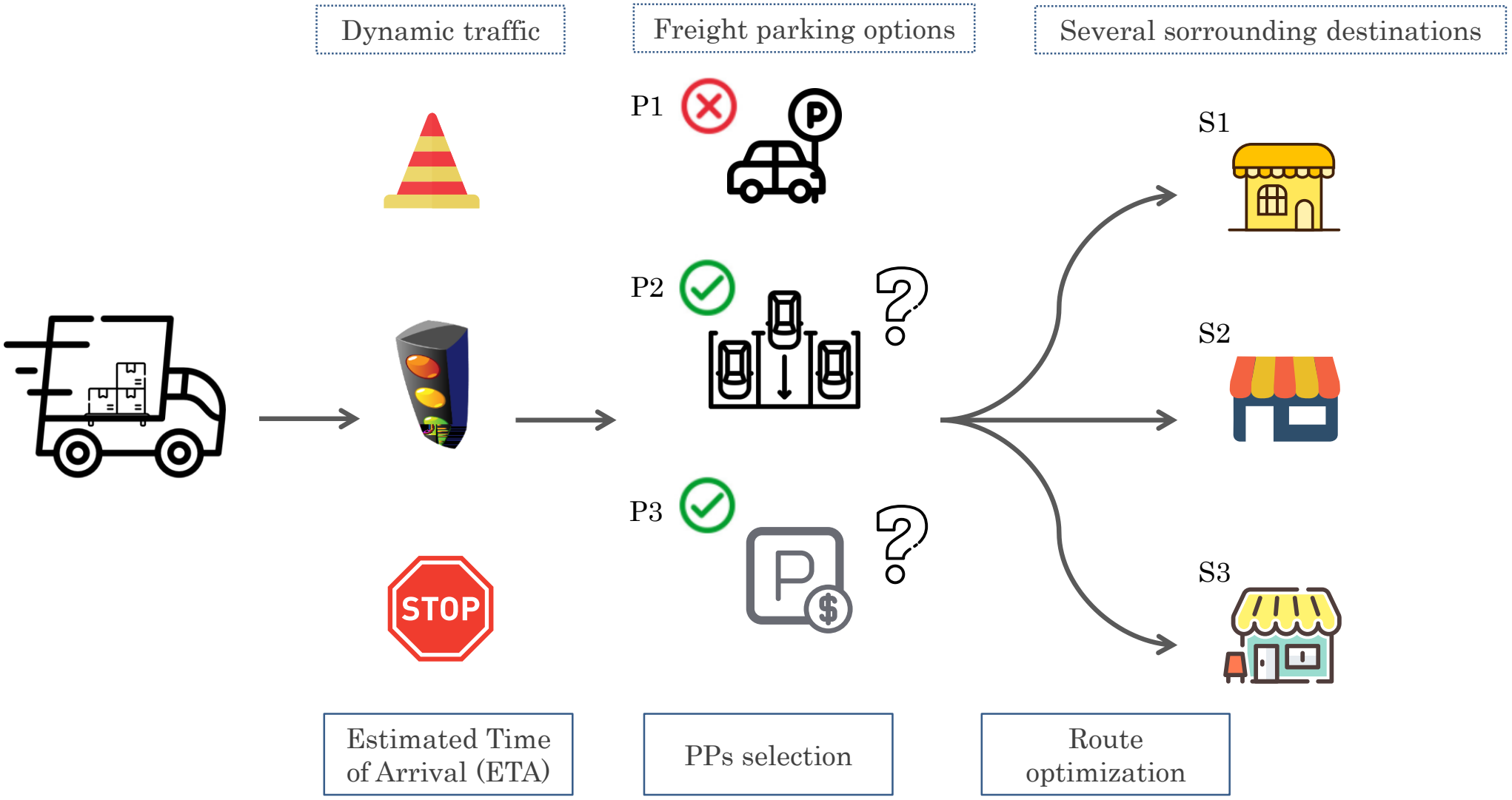
Questions

- How to know the parking places availability around the delivery destinations?
- How to select the best parking place for delivering servral orders at one time?
- How to optimize the route from the parking place to these destinations?

Research view

- Internet of Things (IoT) as the technical support
- Digital Twin for physical objects visibility and real-time status
- Urban distribution environment awareness

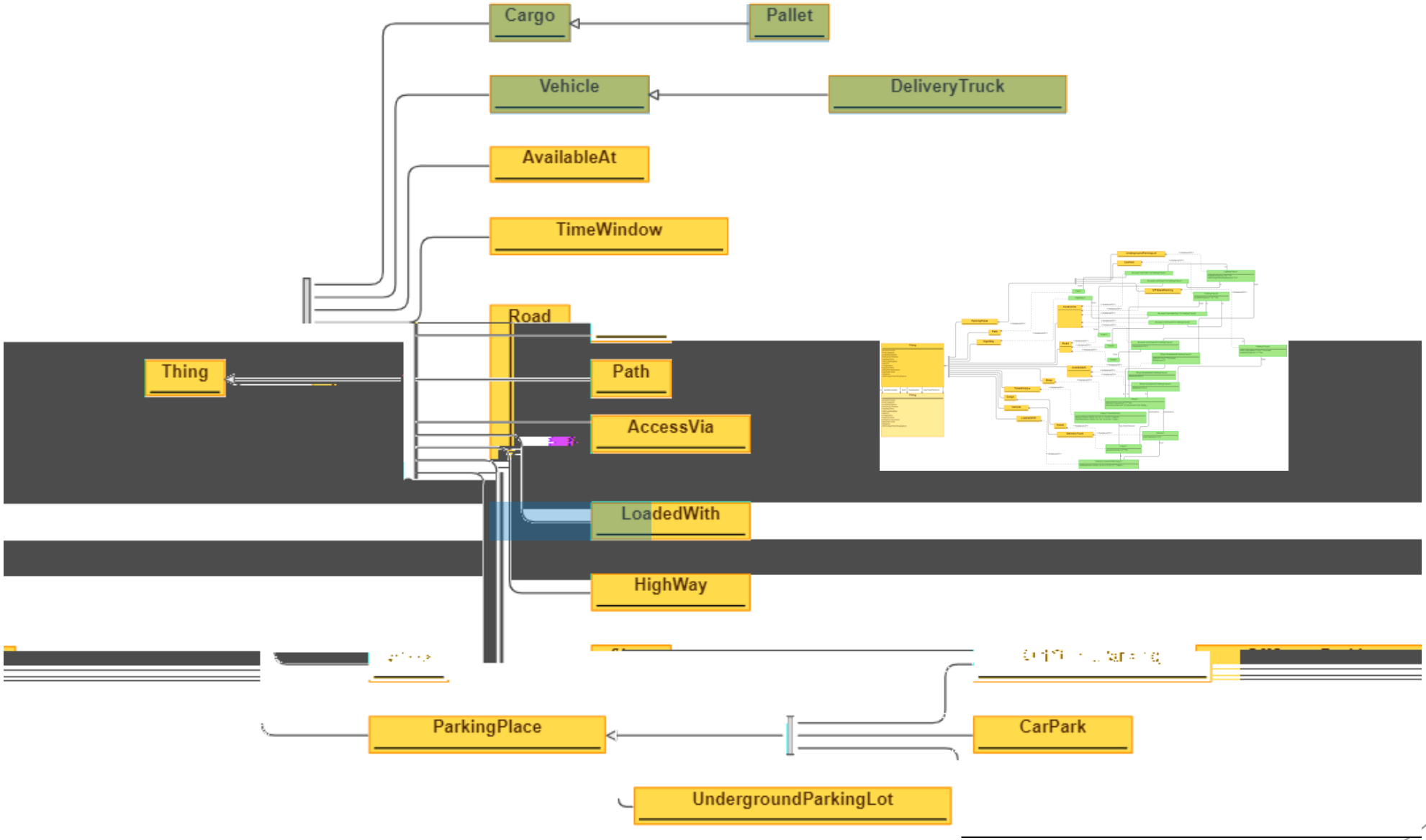
Conceptualization



Data / Object connectivity → Ontology

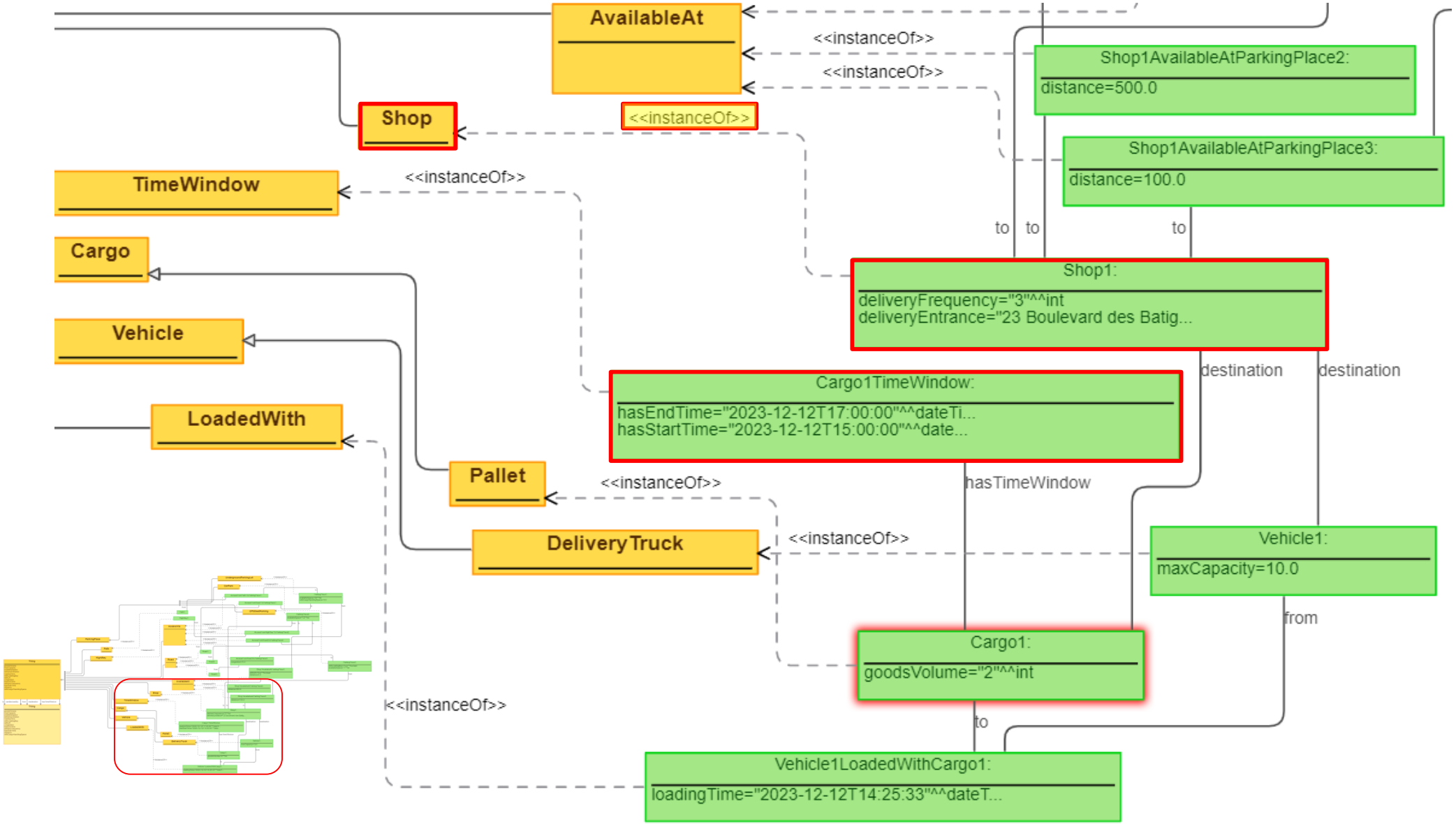
Modeling (data connection) - Ontology

- Classes, subclasses, relationships in the scenario:



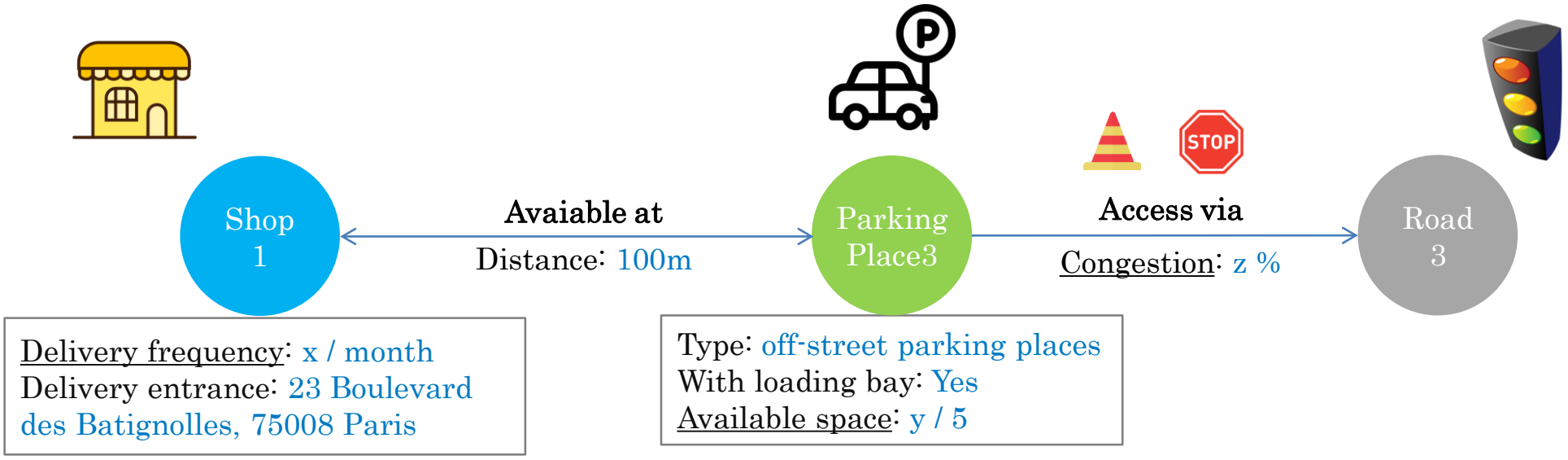
Modeling (data connection) - Ontology

- Specific instances describe the data needed:



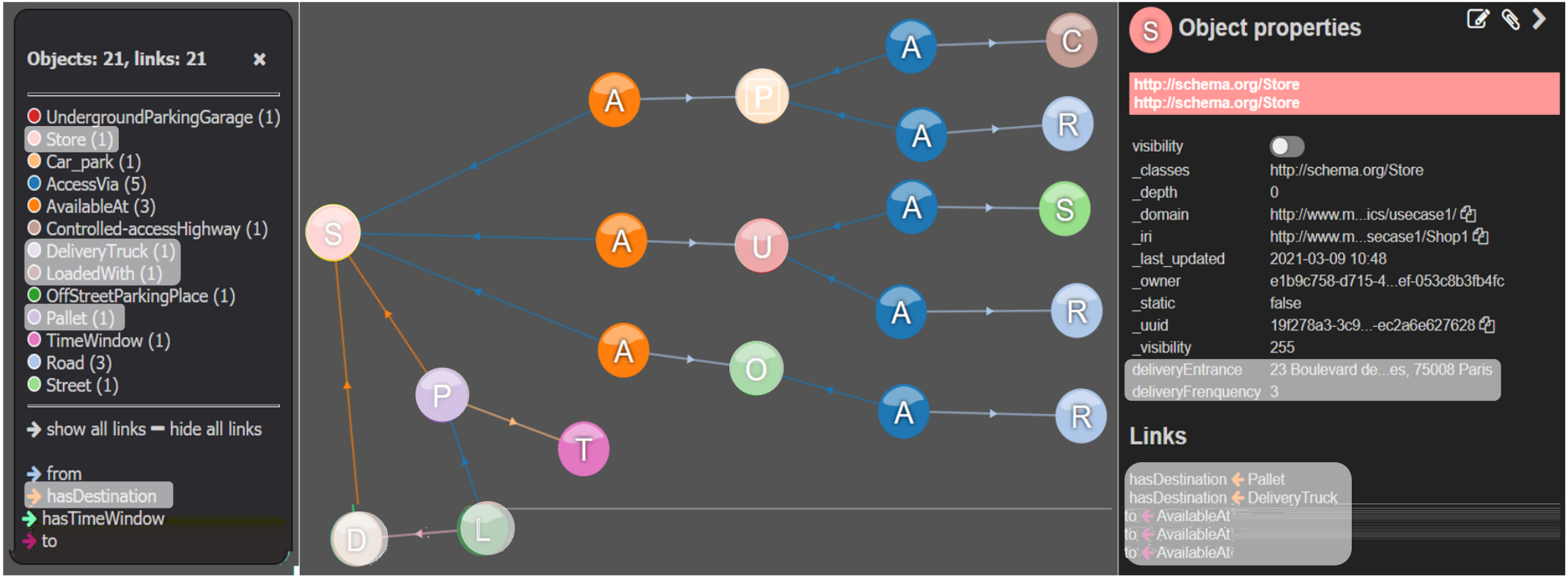
Modeling (objects connection) - Digital Twin

- Conserve the dynamic and real-time states:



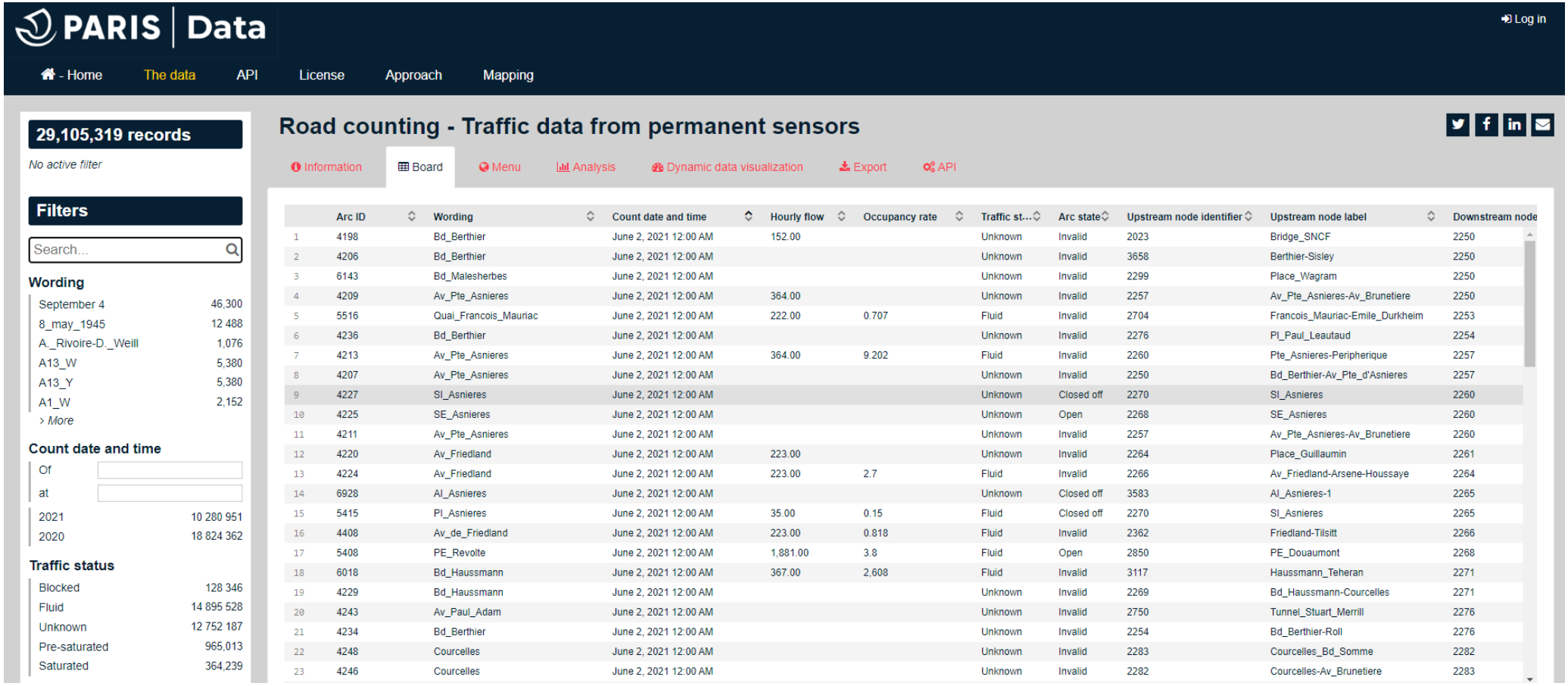
Implementation - Digital twin platform

- Sync the real-time physical world in the platform named *Thing'in* :



https://www.thinginthefuture.com/

Data - Paris Open Data



	Arc ID	Wording	Count date and time	Hourly flow	Occupancy rate	Traffic st...	Arc state	Upstream node identifier	Upstream node label	Downstream node
1	4198	Bd_Berthier	June 2, 2021 12:00 AM	152.00		Unknown	Invalid	2023	Bridge_SNCF	2250
2	4206	Bd_Berthier	June 2, 2021 12:00 AM			Unknown	Invalid	3658	Berthier-Sisley	2250
3	6143	Bd_Malesherbes	June 2, 2021 12:00 AM			Unknown	Invalid	2299	Place_Wagram	2250
4	4209	Av_Pte_Asnieres	June 2, 2021 12:00 AM	364.00		Unknown	Invalid	2257	Av_Pte_Asnieres-Av_Brunetiere	2250
5	5516	Quai_Francois_Mauriac	June 2, 2021 12:00 AM	222.00	0.707	Fluid	Invalid	2704	Francois_Mauriac-Emile_Durkheim	2253
6	4236	Bd_Berthier	June 2, 2021 12:00 AM			Unknown	Invalid	2276	Pl_Paul_Leautaud	2254
7	4213	Av_Pte_Asnieres	June 2, 2021 12:00 AM	364.00	9.202	Fluid	Invalid	2260	Pte_Asnieres-Peripherique	2257
8	4207	Av_Pte_Asnieres	June 2, 2021 12:00 AM			Unknown	Invalid	2250	Bd_Berthier-Av_Pte_d'Asnieres	2257
9	4227	Sl_Asnieres	June 2, 2021 12:00 AM			Unknown	Closed off	2270	Sl_Asnieres	2260
10	4225	SE_Asnieres	June 2, 2021 12:00 AM			Unknown	Open	2268	SE_Asnieres	2260
11	4211	Av_Pte_Asnieres	June 2, 2021 12:00 AM			Unknown	Invalid	2257	Av_Pte_Asnieres-Av_Brunetiere	2260
12	4220	Av_Friedland	June 2, 2021 12:00 AM	223.00		Unknown	Invalid	2264	Place_Guillaumin	2261
13	4224	Av_Friedland	June 2, 2021 12:00 AM	223.00	2.7	Fluid	Invalid	2266	Av_Friedland-Arsene-Houssaye	2264
14	6928	Al_Asnieres	June 2, 2021 12:00 AM			Unknown	Closed off	3583	Al_Asnieres-1	2265
15	5415	Pl_Asnieres	June 2, 2021 12:00 AM	35.00	0.15	Fluid	Closed off	2270	Sl_Asnieres	2265
16	4408	Av_de_Friedland	June 2, 2021 12:00 AM	223.00	0.818	Fluid	Invalid	2362	Friedland-Tilsitt	2266
17	5408	PE_Revolte	June 2, 2021 12:00 AM	1,881.00	3.8	Fluid	Open	2850	PE_Douaumont	2268
18	6018	Bd_Haussmann	June 2, 2021 12:00 AM	367.00	2,608	Fluid	Invalid	3117	Haussmann_Teheran	2271
19	4229	Bd_Haussmann	June 2, 2021 12:00 AM			Unknown	Invalid	2269	Bd_Haussmann-Courcelles	2271
20	4243	Av_Paul_Adam	June 2, 2021 12:00 AM			Unknown	Invalid	2750	Tunnel_Stuart_Merrill	2276
21	4234	Bd_Berthier	June 2, 2021 12:00 AM			Unknown	Invalid	2254	Bd_Berthier-Roll	2276
22	4248	Courcelles	June 2, 2021 12:00 AM			Unknown	Invalid	2283	Courcelles_Bd_Somme	2282
23	4246	Courcelles	June 2, 2021 12:00 AM			Unknown	Invalid	2282	Courcelles-Av_Brunetiere	2283

https://opendata.paris.fr/explore/dataset/comptages-routiers-permanents/table/?disjunctive.libelle&disjunctive.etat_trafic&disjunctive.libelle_nd_amont&disjunctive.libelle_nd_aval&sort=t_1h

Data - Paris Open Data

Traffic data - visualization, traffic status

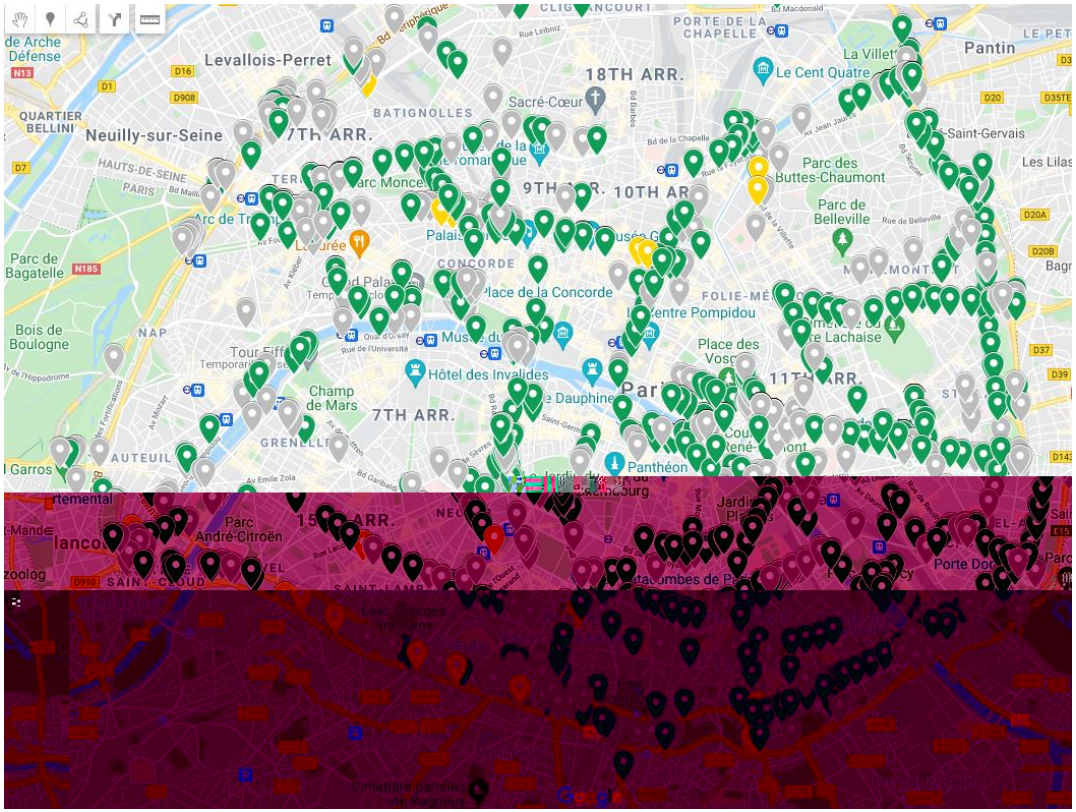
Traffic
4 views

All changes saved in Drive

traffic.xlsx

Styled by Traffic status

- Fluid (1064)
- Unknown (880)
- Pre-saturated (40)
- Saturated (11)
- Blocked (5)



Bd_Pasteur

Arc ID	5767
Date and time of counti...	2020-11-01 20:00:00+01:00
Hourly flow rate	No value
Occupancy rate	63.46444
Traffic status	Blocked
Identifier upstream node	3017
Name upstream node	Bd_Pasteur-Catalogne
Identifier downstream ...	3016
Name downstream node	Bd_Pasteur-Armorique
Arc status	Invalide
Start date data availabi...	1/1/2005
End date data availability	6/1/2019
geo_point_2d	48.8382142, 2.3175211
geo_shape	{"type": "LineString", "coordinates": [[2.3184667687, 48.8374912295], [2.3182579837, 48.83753955], [2.3166210563, 48.8390244575]]}

48.83821, 2.31752

Traffic status → Congestion degree → ETA

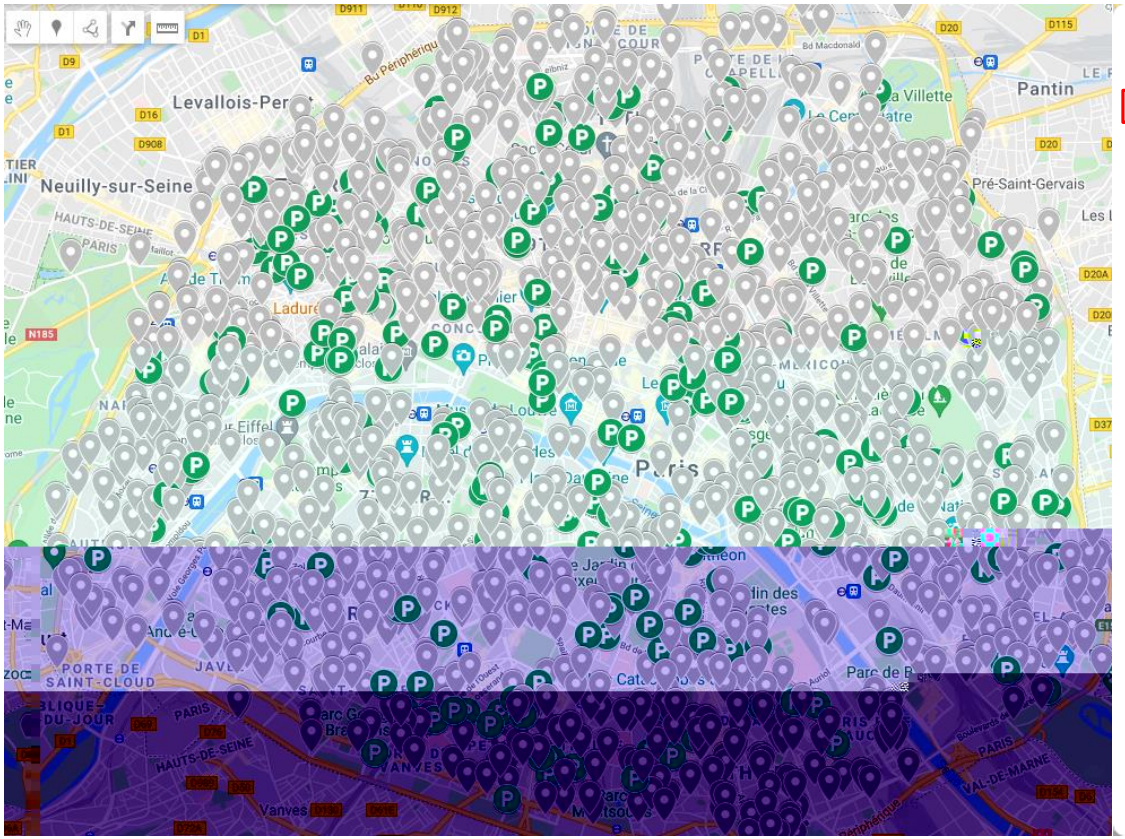
Data - Paris Open Data

Parking data - visulization, parking for delivery

Parking in Paris
4 views

All changes saved in Drive

- PAYING MIXED (552)
- 2 WHEELS (360)
- DELIVERY (224)
- GIG/GIC (115)
- OTHER REGIME (100)
- PAYING ROTARY (58)
- LOCATION (57)
- FREE (19)
- ELECTRIQUE (11)
- AUTOCAR (3)



750594961

Priority regime	DELIVERY
Special regime	ZL permanente
Type of parking	Longitudinal
District	20
Calculated number of s...	3
Actual number of spaces	3
Residential zones	20H
Pricing	2.40€/h
Parking type	Lincoln
Lane number	138
Lane type	RUE D
Lane name	AVRON
Complementary lane n...	No value
Location number	Droit
Parity	Pair
Length	14.97521249
Width	2
Calculated surface area	29.95122801
Horizontal signage	Abimé

48.85323, 2.40935

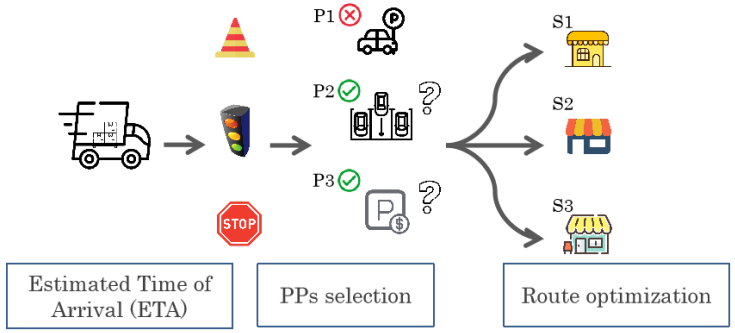
Future work - DT platform and simulator

DT platform

Orders boudling (Criteria)
Surrounded PPs pool for each bundle

Simulator

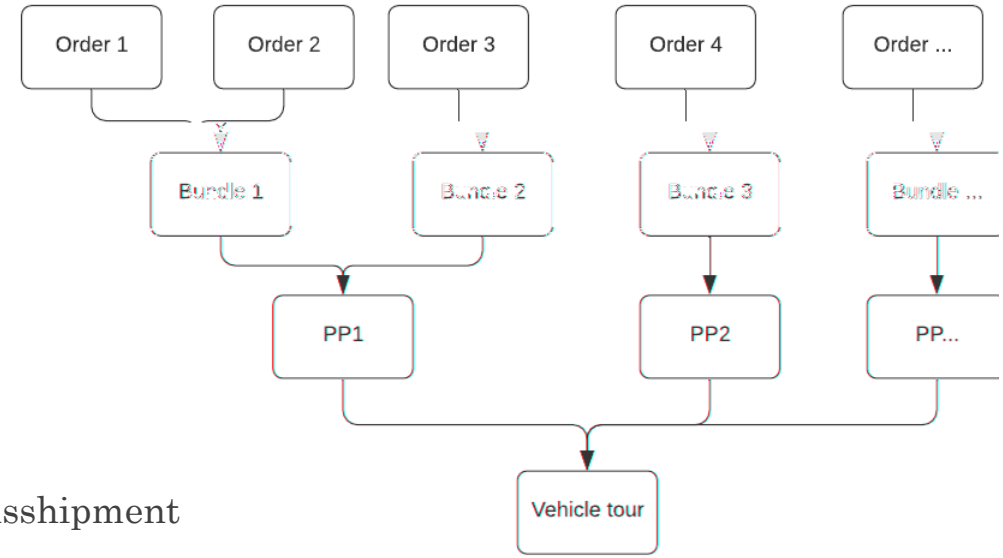
PPs performance calculation
KPI: environment, economic
Routing (O-P, P-D)



Synchonize to simulate DT and physical objects

(DT + physical world) * Logistics = ?

PI scheme application: parking places as micro-hubs for transshipment



Conclusion

First results

- Conceptualization: freight parking management
- Modeling: Ontology model & Digital Twin model
- Implementation: DT platform for DT of objects
- Open data: parking information & real-time traffic data

Contribution

- Explore the value of the connectivity between data from physical objects in logistics
- Real-time states of vehicle, parkings, roads… → Delivery environment awareness
- For logistics players: improve the decision-making processes
- For other stakeholders (municipality, policy makers…): delivery ineffectiveness, behavior patterns → urban planning

Thank you!

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