Source: https://www.raillynews.com/2020/06/Karsan-won-the-electric-minibus-tender-in-Romania/

Minibuses on demand

Upcomming urban disruption, as envisioned by Kabina project

Bogusz Jelinski
2022, Jan 17th

Bus is cheaper than a cab but …

- it takes longer to travel
- sometimes unpredictable
- need of transfers
- dirty, crowdy, no privacy at all
- not always a sit for everyone
- higher chance for infections with diseases
- hard to drive in narrow European streets

Source: https://www.freeimages.com/photo/bus-ride-1469975

Idea – a taxi trip that costs like a bus ticket

But how to reduce costs without affecting significantly the duration of any passenger's trip:

- By taking **more passengers** than a cab today, even **ten**, that share the same or similar route
- By reducing the operational costs with **electric drive train**
- By matching supply with demand much better that buses today – no empty buses during off-peak hours, smaller but more buses
- Maybe not by getting rid of its driver

Source: https://mms.businesswire.com/media/20200428005241/en/787801/5/4193311cEasyMile_1.jpg?download=1

We might still need the driver

Source: zjol.com.cn

We probably won't be able to get rid of the driver in near future because:

- most legislatures will not allow for self-driving for buses
- or will limit their speed to a ridiculous value
- we might need someone in place to reduce fraud*, misuse, vandalism or sabotage
- driver's presence will improve passengers' comfort and security
- driver might be needed to support disabled, unexperienced or digitally weak customers

* e.g. going in without an order or with an unregistered co-passenger, ordering a shorter trip but staying in for a longer one.

This idea is gaining momentum

Moia: https://www.moia.io/en

Navya: https://navya.tech/en/

EasyMile: https://easymile.com/

2GetThere: https://www.2getthere.eu/

Baidu: https://apollo.auto/

Yutong: https://en.yutong.com/

Coast Autonomous: https://coastautonomous.com/

MillaPod: https://millagroup.fr/fr/tag/millapod/

May Mobility: https://maymobility.com/

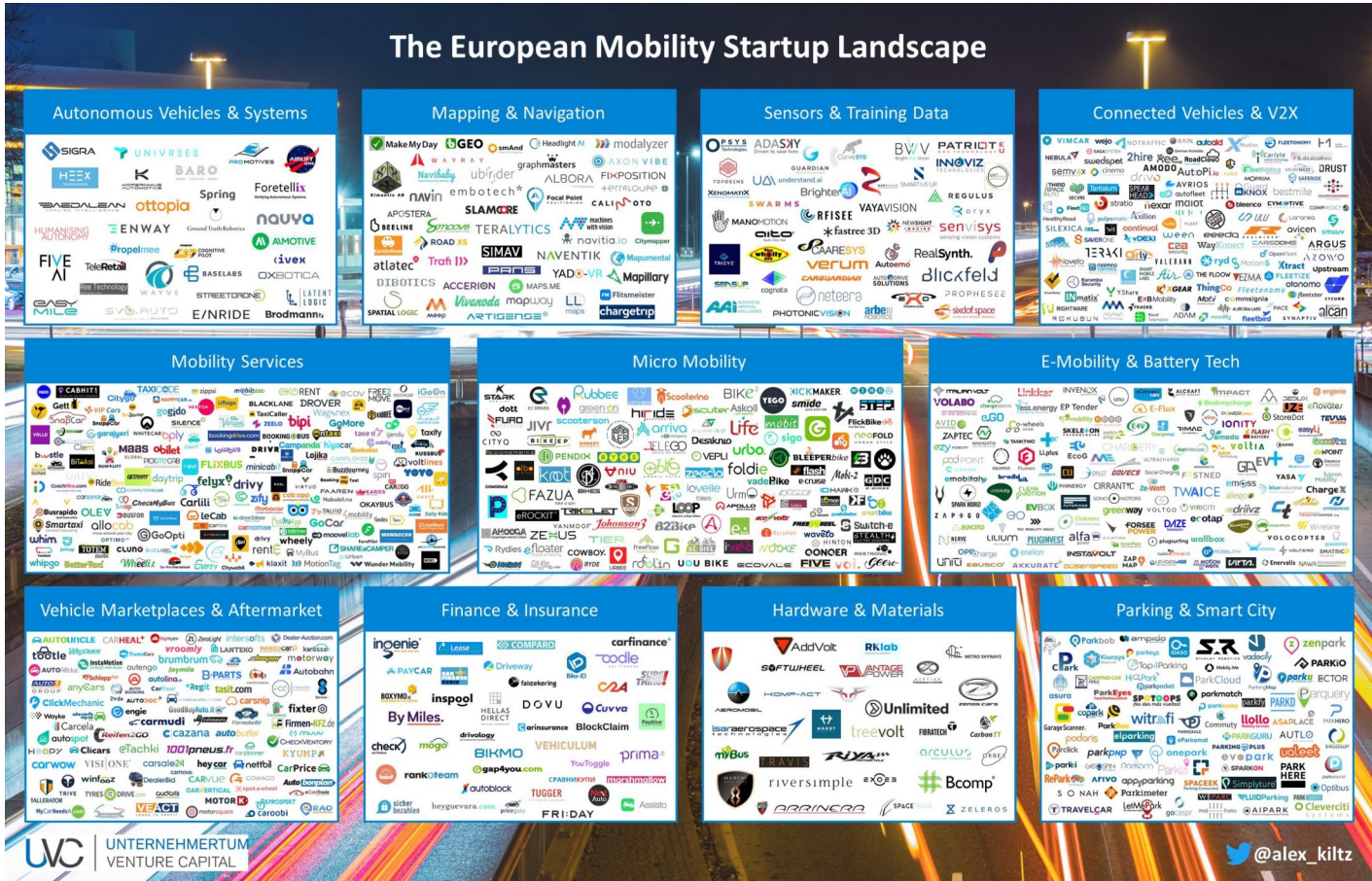
Optimus Ride: https://www.optimusride.com/

Transdev https://www.transdev.com/en/

Ohmio: https://ohmio.com/

Neolix: https://www.linkedin.com/company/neolix-autonomous-driving/

National Electric Vehicles Sweden: https://www.nevs.com/en/



Source: https://cdn-images-1.medium.com/max/2600/1*oMiHKEIY6Pb_dB5xdCEQtA.jpeg

Idea behind Kabina project

The idea behind Kabina is to provide an enabler (a software skeleton, testing framework and RestAPI standard proposal) for a TaaS service that can assign even 10 passengers to one minibus, thus reducing cost of the driver per passenger, among other things. Such extended cab service would allow for the shift to sustainable transport, it might be cost-competitive with the public transport while providing better service quality including shorter travel time.

Fast dispatcher – key technology enabler

An effective dispatcher is needed to process thousands of requests per minute*, Kaboot is intended to cover the need with:

- A multi-threaded pool finder with 4+ shared orders
- Route extender – to add passengers to currently executed routes, which match or are close to new requests
- Effective linear solver which tackles one million variables
- Rest API for easy client integration

All that is available now here: https://gitlab.com/kabina/kaboot

* A linear transportation model with 1 million variables (1k passengers * 1k cabs) has more feasible solutions than the number of atoms in the universe

Kaboot- implementation details

- It is all open-source with non-restrictive licensing
- Based on industry-leading SpringBoot and Java
- Any database, tested extensively with PostgresQL
- Pool finder implemented in C, Java version available but 3x slower
- Uses GLPK solver to find optimal routing plans
- greedy (low-cost method) heuristic used to support the solver in most challanging scenarious
- Client software implemented with React
- Work in progress: taking stops' bearing into account; distances based on real traffic data reported by cabs (including rush hours).

Kabina subrojects

- **Kabina**: mobile application for cab/minibus customers
- **Kab**: mobile application for cab drivers
- **Kid**: authentication module in the cab with trip requester
- **Kaboot**: dispatcher with RestAPI*
- **Kavla**: routing table on a stop
- **Kadm**: administration and surveillance

* undergoing work to implement the dispatcher in C as a separate module

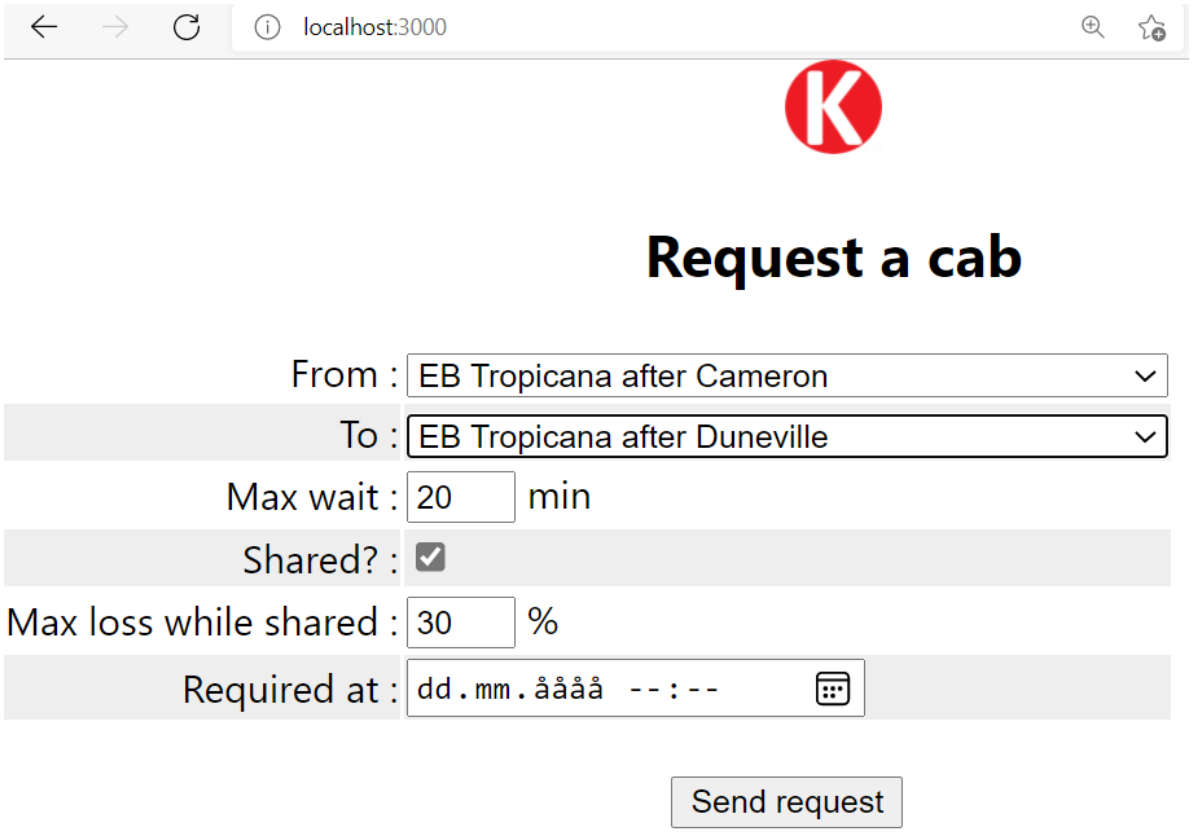
Kabina- ordering a minibus

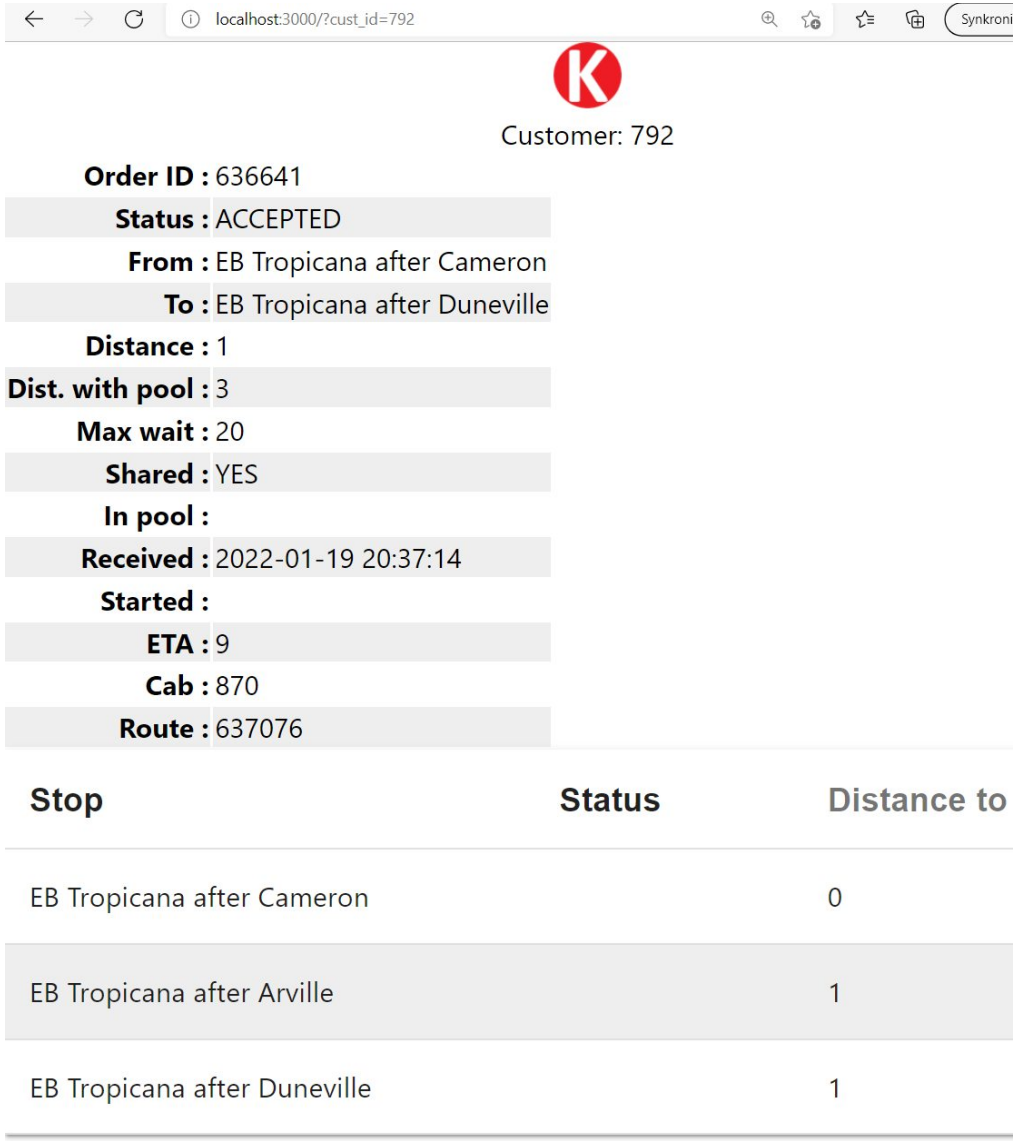
Ordering and use should be convenient:

- From a mobile app
- From ticket machines available at least at hubs – temporary user authenticating with QR code (Kid module)
- By just entering the cab (participation in current route or taking an idle cab) and authentication with mobile app or RFID card – Kid
- By being a paid co-passenger

Kabina- ordering a minibus

https://gitlab.com/kabina/kabina





Kavla – routing table in a bus stop

https://gitlab.com/kabina/kavla

EB Tropicana after Cameron

Bus	Next stop	Destination	ETA
A228	EB Tropicana after Burnham	EB Tropicana after Burnham	1
870	EB Tropicana after Arville	WB Russell after Rainbow	2
622	WB Tropicana after Decatur	EB Tropicana after Burnham	2

Kab – cab’s current route

https://gitlab.com/kabina/kab

Bus: 870, Route: 637076

Stop	Status	In	Out
EB Tropicana after Pecos	LEFT	968, 888,	
WB Russell after Polaris	APPROACHING	898,	
EB Tropicana after Polaris			968,
EB Tropicana after Cameron		831, 792,	
EB Tropicana after Arville			831,
EB Tropicana after Duneville			792,
EB Tropicana after Rainbow			888,
WB Russell after Rainbow			898,

Pool – implementation details

- A pool is a shared route - a sequence of stops where passengers are picked up and dropped off, in such an order that passengers individual time constraints are met – wait time and loss due to shared route.
- Each passenger can have its own time preferences
- An example of a pool with three passengers and 6 stops (7 if minibus has to move to pick up the first passenger):

1 in → 2 in → 1 out → 3 in → 3 out → 2out

- But it may very well be 2 stops: 1 in, 2 in, 3 in → 1 out, 2 out, 3 out
- It is a computationally demanding task solved by Kaboot with dynamic programming – task is devided in stages.

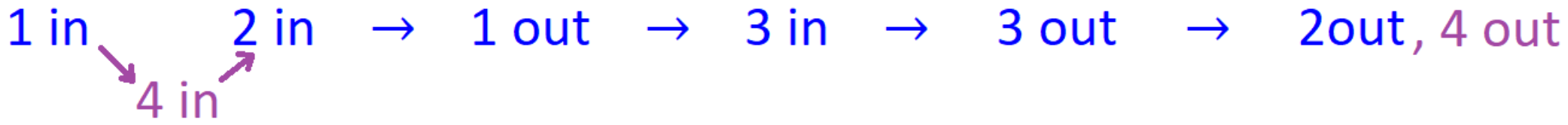
Route extender – implementation details

- Route extender tries to match new cab requests to existing routes, more precisely – to its legs that has not been started yet.
- It can be an exact match or not - with a pre-defined deviation
- En example – 4th passenger is waiting not far away from the route leg between the first and second stop, and wants to go out exactly at the last stop:

1 in → 2 in → 1 out → 3 in → 3 out → 2out, 4 out

4 in

- After extension the route will have one more stop (and leg):



Why we need a solver

Low-cost method (aka greedy) assigns the nearest cab. In the example below the green cab would be assigned to passenger “1”, the blue one to the passenger “2”, resulting in total trip length = 7. The other plan would give 5. This is obvious here but not with hundreds of passengers and cabs. Simulations with matrix of size n=100 show that LCM can give 78% deviation from the optimal plan on average. That could mean 78% more fuel consumption and 78% longer wait time.