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The Mobility Leader

An approach to identify people trips and stops for mobility analysis using mobile network data

Bonvicini, Galieni, Vannacci, Tartaglia | FS Research Centre - Ferrovie dello Stato Italiane;
Agnolon, Bontorin, Busatta | Motion Analytica; Zaramella, Mancino, Di Sorte | Vodafone Italy.

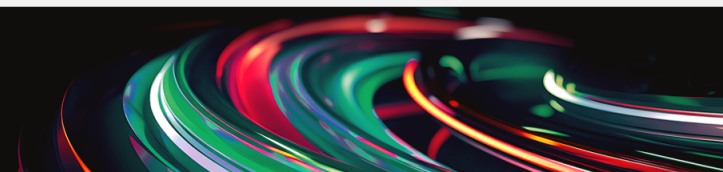


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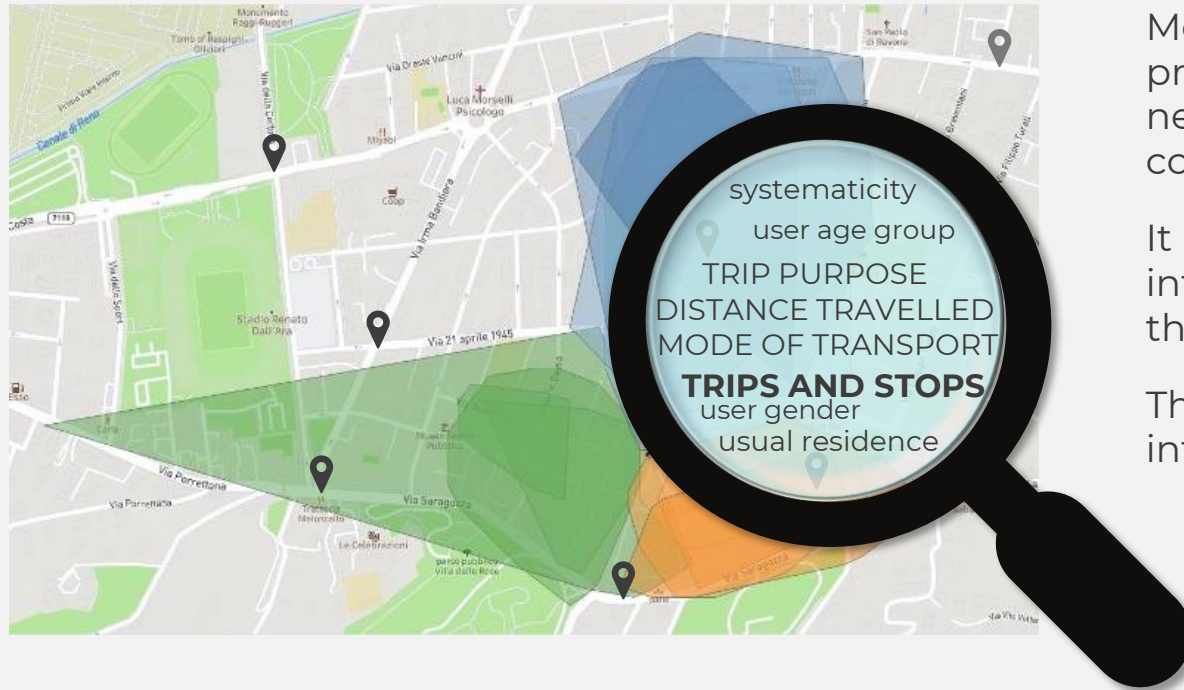
Context

Mobile Network Data



Raw data processing

What features does raw data have? What do we know and what do we have to infer? What do we obtain through algorithms?



Mobile Network Data (MND) = data that is generated as a by-product of the normal interaction of mobile devices with the network, which is essential for providing telephone and internet connectivity services.

It is not just a matter of recording calls or internet traffic, but of information that is generated without any active participation by the user.

The raw data themselves do not contain any type of mobility information.

Data extraction

Data processing

Mobility analysis

About us

FASTWEB +  **vodafone**



Motion Analytica

Insights from people & things in motion

FS Research Centre

Il Centro Studi di Ferrovie dello Stato Italiane

Fastweb and Vodafone, part of the Swisscom Group, are driving digital transformation in Italy through investments in fiber and 5G networks, and innovation in AI, Cloud, and Cybersecurity — enhancing service quality for households, businesses, and public sector.

Motion Analytica, expert in advanced data science and artificial intelligence, leveraging evidence-based approaches to support strategic and operational decision-making.

FS Research Centre, the internal centre of excellence of the FS Group dedicated to advanced studies and research on mobility and related topics.



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25 September 2025 – MNO Minds Final Conference

An approach to identify people trips and stops for mobility analysis using mobile network data
Bonvicini, Galieni, Vannacci, Tartaglia, Agnolon, Bontorin, Busatta, Zaramella, Mancino, Di Sorte

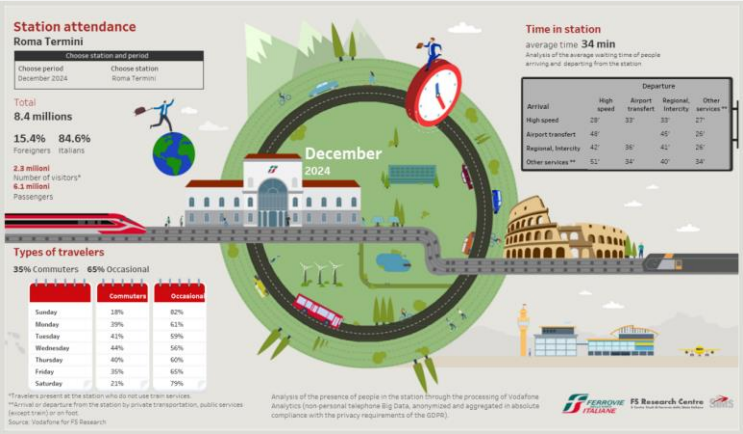


How do we use MND in our activities?

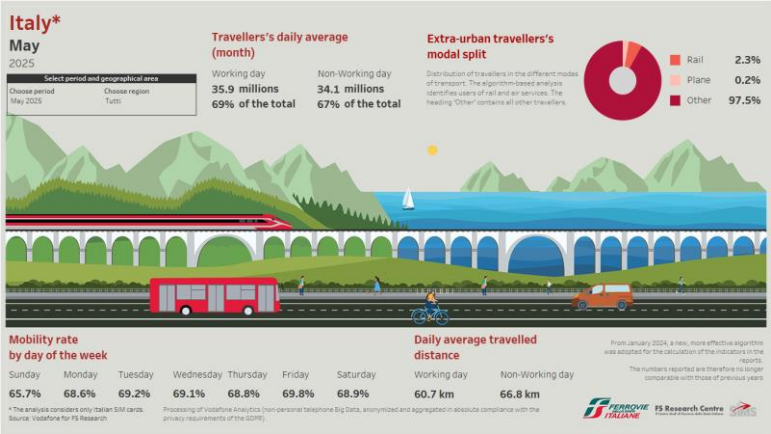
Three main threads



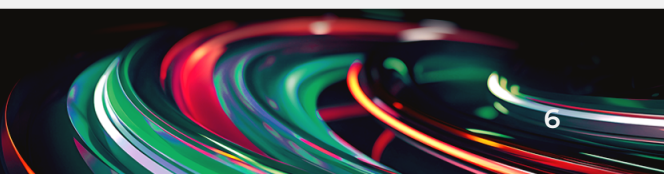
O-D matrices, mobility flows between areas and their features



Mobility patterns within specific points of interest



Overall mobility, territorial specificities, users' features



Our goal

What do we mean by trips?

Which trips are significant to us?

Applying different algorithms leads to different views of mobility.

There is no single right tool, but rather a range of tools that highlight different — and equally interesting — aspects of mobility.

Finding the best and cost-effective way to understand how people move.





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State of the art

Previous algorithms



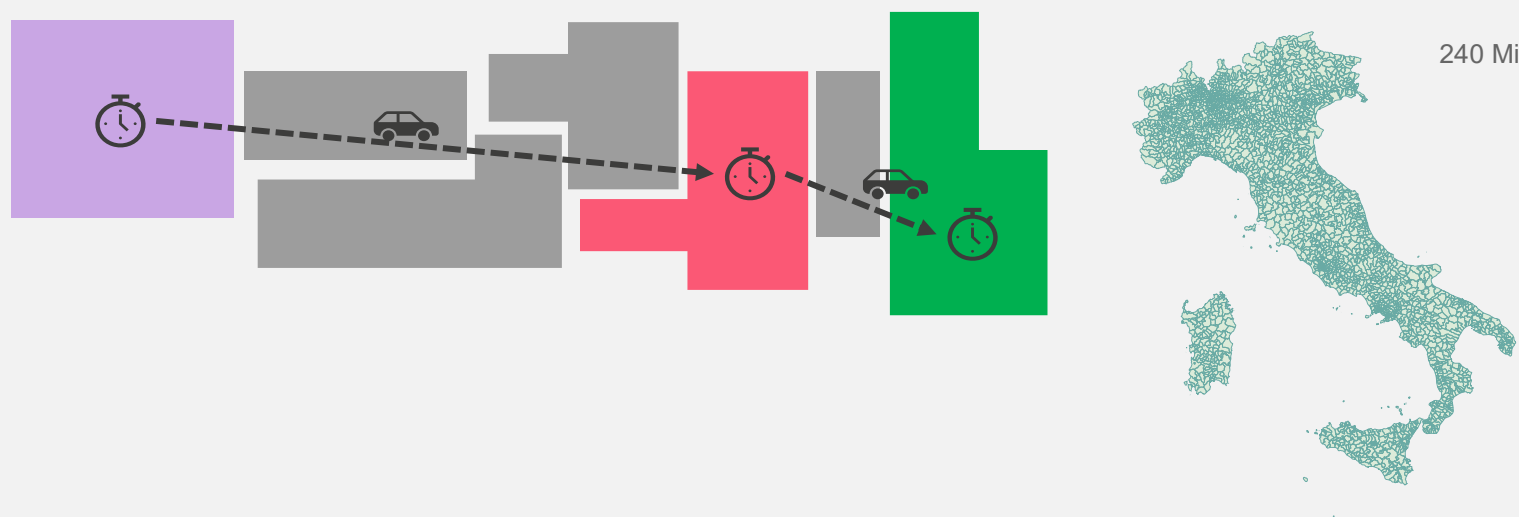
Origin-Destination matrices

State of the art

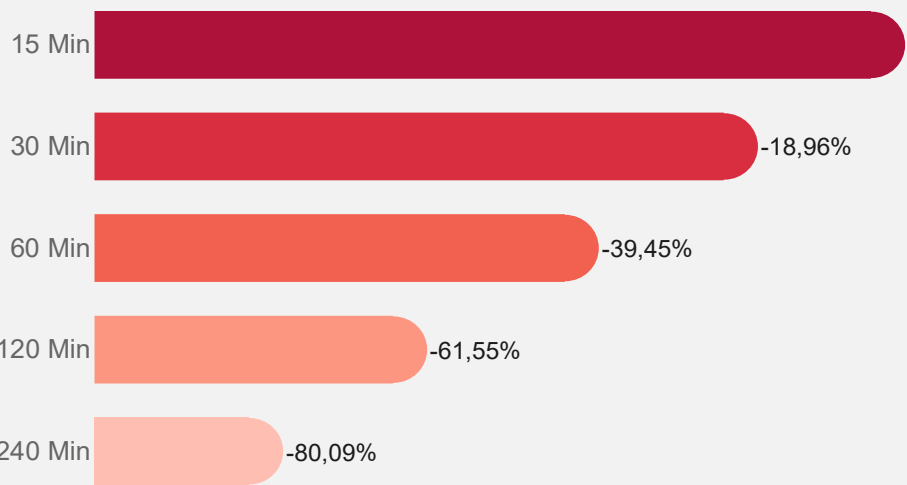
Stationary when you stay in an area for longer than the minimum threshold

Moving when you leave an area where you have stayed for at least the threshold time and then stop in the next one, staying there for at least that time as well.

Paths given by the distance between pairs of successive stationary zones

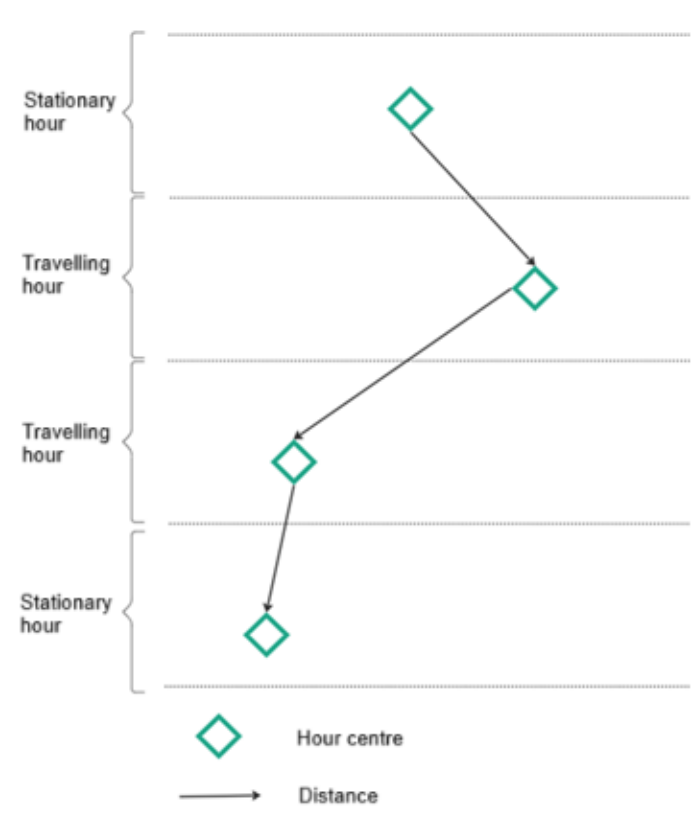


Trips decrease compared to the minimum threshold as the threshold rises



Mobility Indices

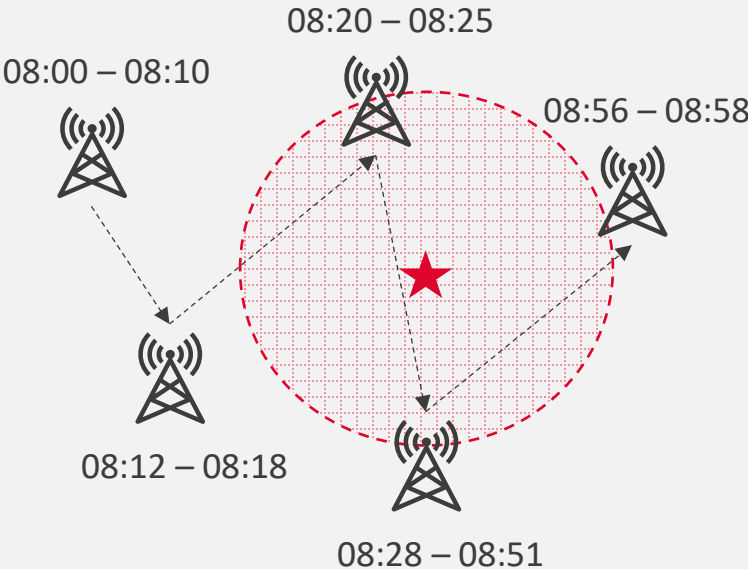
State of the art



Stationary when your range of mobility in that 1-hour time slot is shorter than 800m

Moving when your range of mobility in that time slot is greater than 800m

Paths given by the trajectory passing through the hourly centres of gravity of the hours



	time constraint
	distance threshold

Why a new algorithm?

FEATURE	MOBILITY INDICES	O-D MATRICES
TIME SPLITTING	1-hour slots	None
SPACE SPLITTING	None	Zones
DISTANCE THRESHOLD	800 m on hour average range	None
STOP THRESHOLD	None	1h – 4h
ORIGIN AND DESTINATION	Averaged by hour	Yes
FULL POPULATION	Yes	No
TRAVEL TIME	Rounded	Underestimated
TRAVEL DISTANCE	Underestimated	Centroids
INNER TRIPS	Mostly	No

We realised that we needed a new **non-parametric** method





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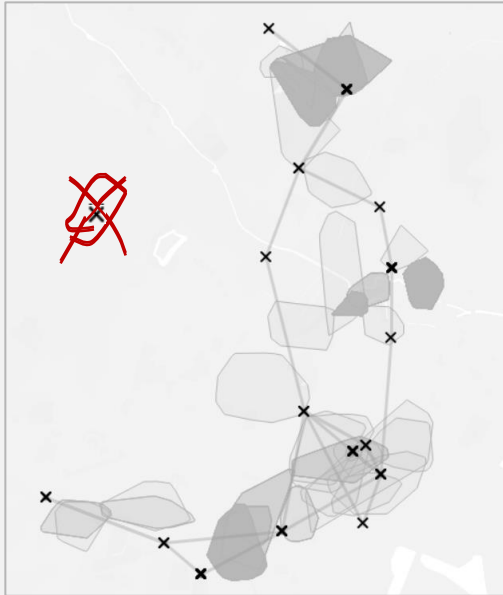
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The PathShift algorithm

What's new?

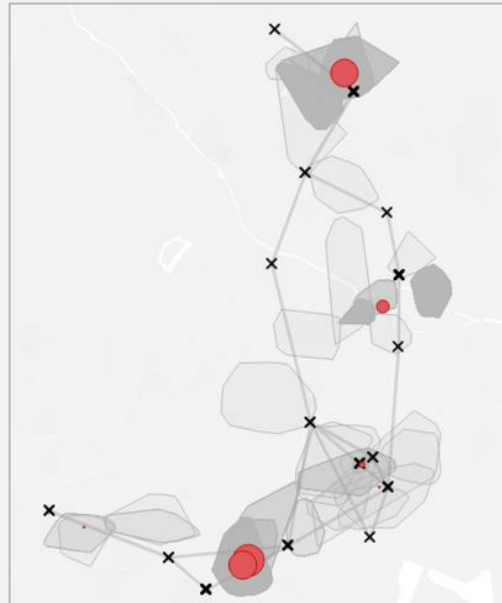


Data pre-processing



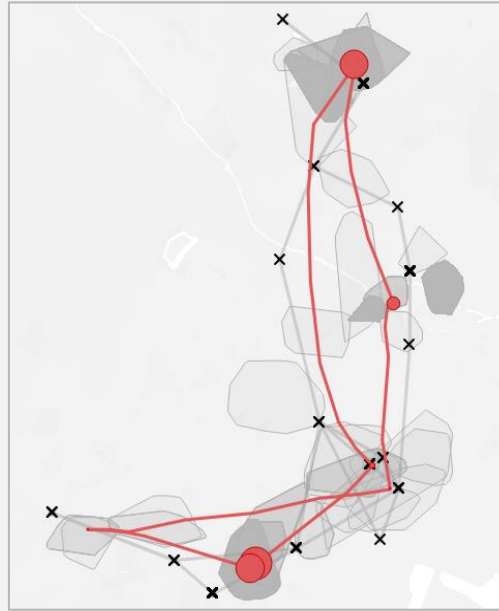
DATA PREPARATION

Discarding any structural anomalies due to the type of data.



IDENTIFICATION OF STOPS

A stop is defined every time the user is detected in the same position, without space-time constraints.



SMOOTHING PATHS

Travel position are calculated by interpolating the remaining antennas coordinates.



SPATIAL DISCRETIZATION

Each user's stops are projected onto a uniform grid of 200m x 200m cells.

The essence of the new algorithm

Step 1: find relevant stops – user level

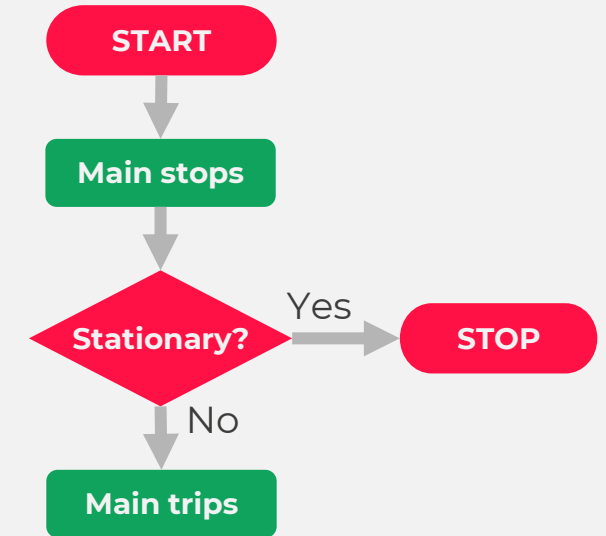
For each user

Find the first significant stop, i.e. the **longest one** of that day (e.g. night at home, work)

Find the most relevant stop for the following day

If there is an additional stop between these two (case 1) **or** the two stops **do not occur** in the same place (case 2), then **at least one trip has occurred**

Otherwise, the user remained stationary the entire time



The essence of the new algorithm

Step 2: the recursion – trip level

For each trip

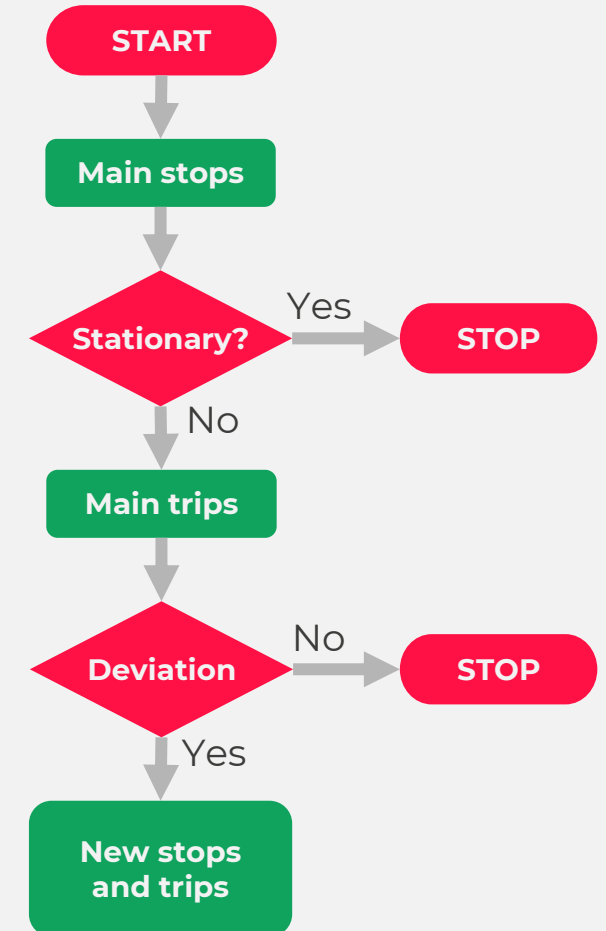
Let's see what route all the users with the same O-D took

Did you take a longer route, i.e. is your route **unusual**?

That means you had another significant stop to make!

The stop is the reason for your deviation

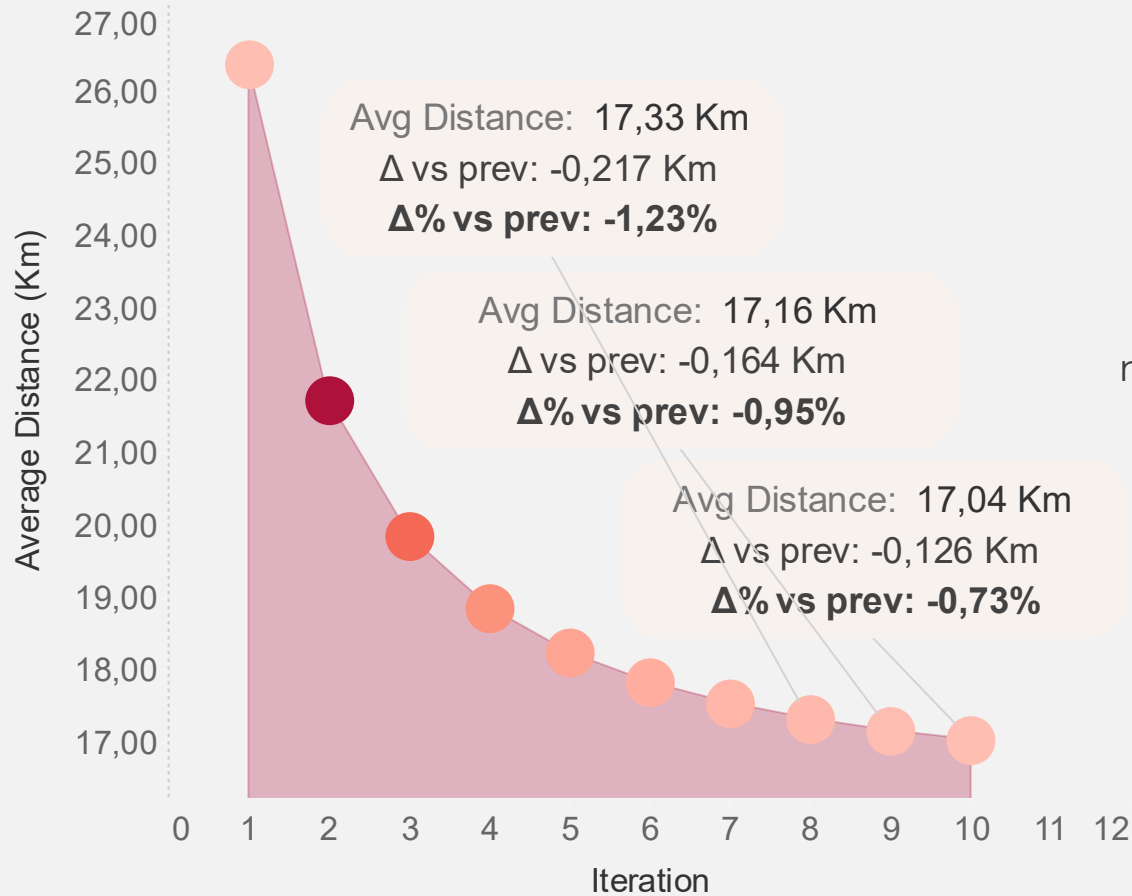
Your trip is splitted, taking that stop into account, and repeat recursively on the two generated routes.



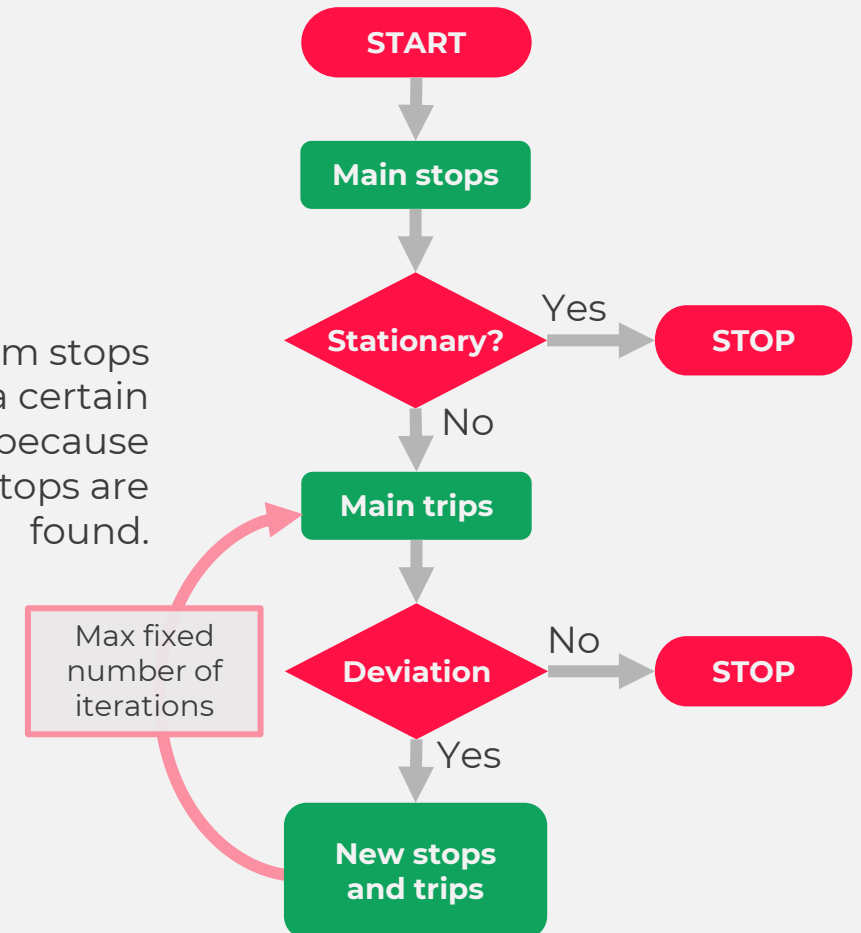
The essence of the new algorithm

Technical remarks

Trip average distance by iteration



The algorithm stops **automatically** after a certain number of iterations because no more relevant stops are found.





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Findings & future implications

How can we improve?



PathShift algorithm vs previous algorithms

An overall picture

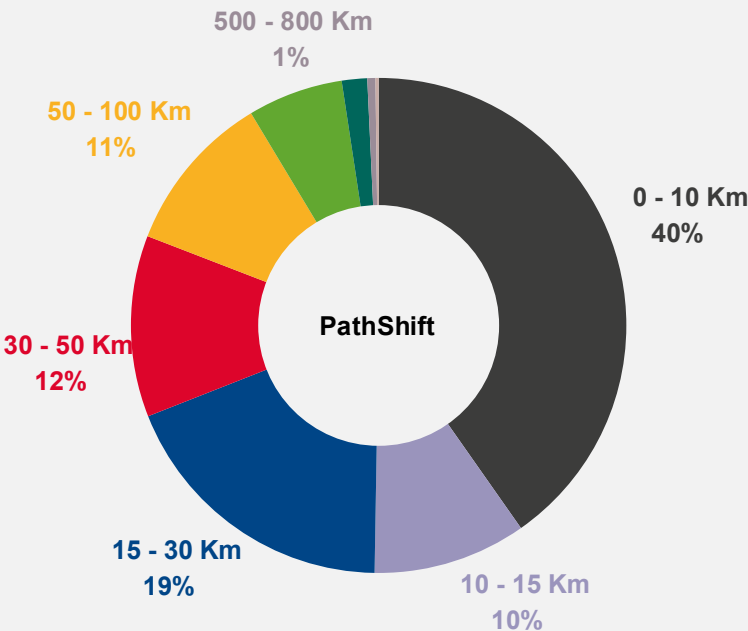
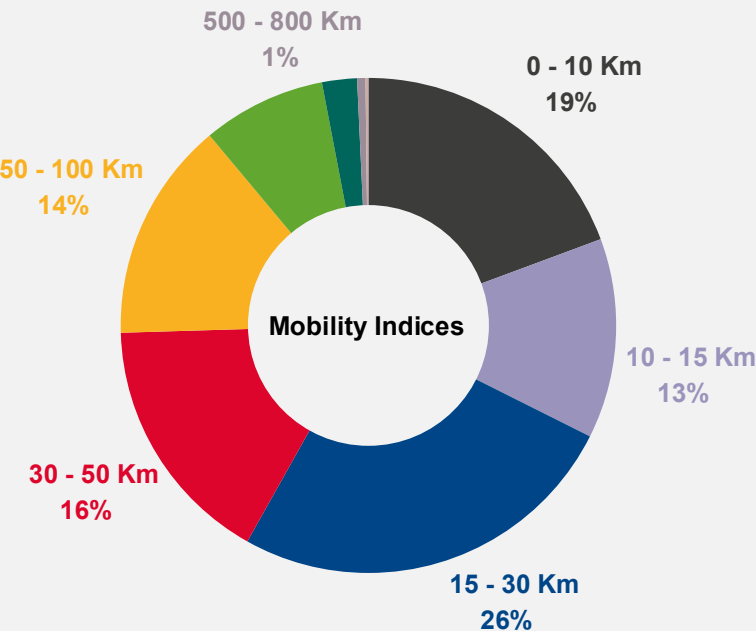
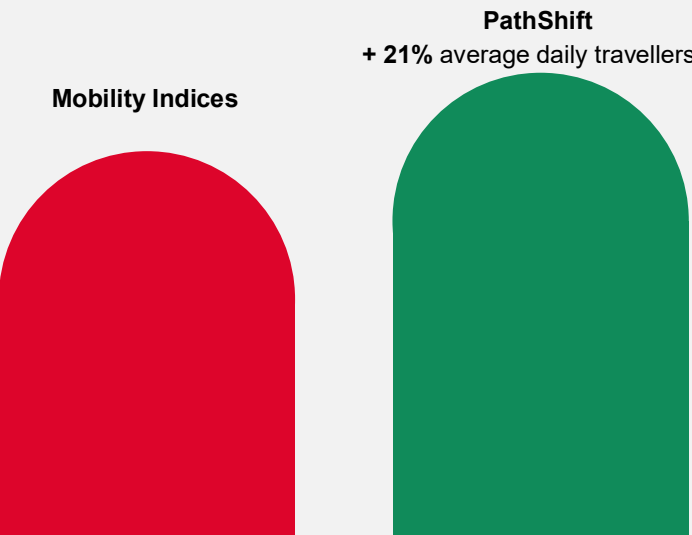
FEATURE	MOBILITY INDICES	O-D MATRICES	PATHSHIFT
TIME SPLITTING	1-hour slots	None	Day
SPACE SPLITTING	None	Zones	200m grid
DISTANCE THRESHOLD	800 m on hour average range	None	None
STOP THRESHOLD	None	1h – 4h	None
ORIGIN AND DESTINATION	Averaged by hour	Yes	200m grid
FULL POPULATION	Yes	No	Yes
TRAVEL TIME	Rounded	Underestimated	Unbiased
TRAVEL DISTANCE	Underestimated	Centroids	Less biased
INNER TRIPS	Mostly	No	Yes



PathShift algorithm vs Mobility Indices

Comparison on real applications

- ▶ A higher number of travelers
- ▶ More short-distance journeys

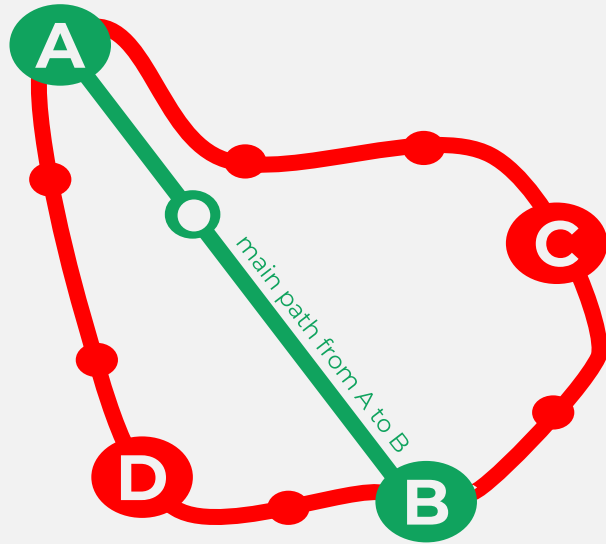


➡ more people are found to be in motion



Where the algorithm hits its limits

Improvement and next steps



- ▶ Significant stops  along the route are not detected unless they require the user to deviate from the common trajectory.
- ▶ Information about the reason for the trip is still missing
- ▶ A ground-truth is required to validate the models.
- ▶ Transparency, governance and shared validation are necessary



Conclusions

- Overcame the limitations of traditional methods,
- Reconstructed movements in a more realistic way
- Detected even short and complex journeys

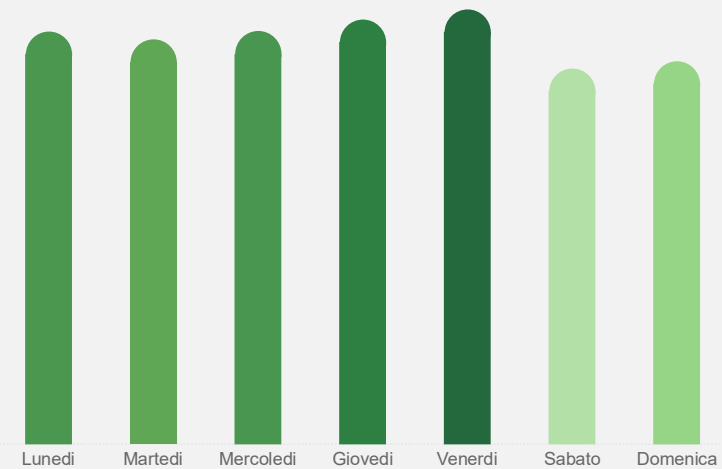
A **paradigm shift**, from rigid thresholds to a flexible, adaptable and transparent people-driven approach.

A single process, multiple applications.

A collaborative model, ready for future challenges.

Metropolitan City of Milan			
Average daily km per user	Average distance (km)	Number of trips per traveller	Percentage of Travellers
34,65	14,50	2,39	77%

Trend in kilometres travelled per day





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Thank you

