Your Trajectory Privacy Can Be Breached Even If You Walk in Groups

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Trajectory in a Large-scale Wi-Fi Network

Wi-Fi access point

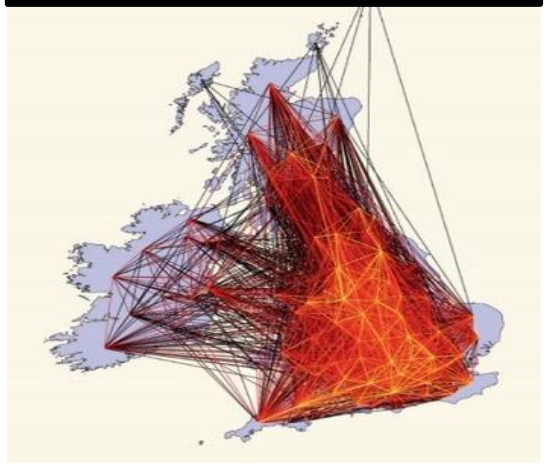
Tsinghua Campus

Trajectory in a Large-scale Wi-Fi Network

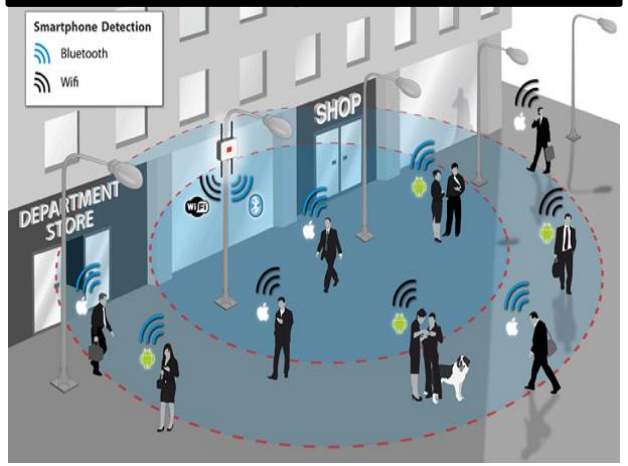
Trajectory in a Large-scale Wi-Fi Network

Value of Trajectory datasets

Mobility pattern mining

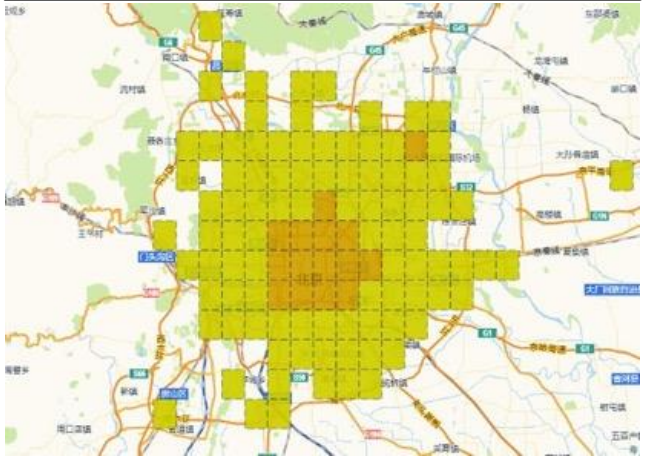


Proximity marketing



Location-based service

Transportation control



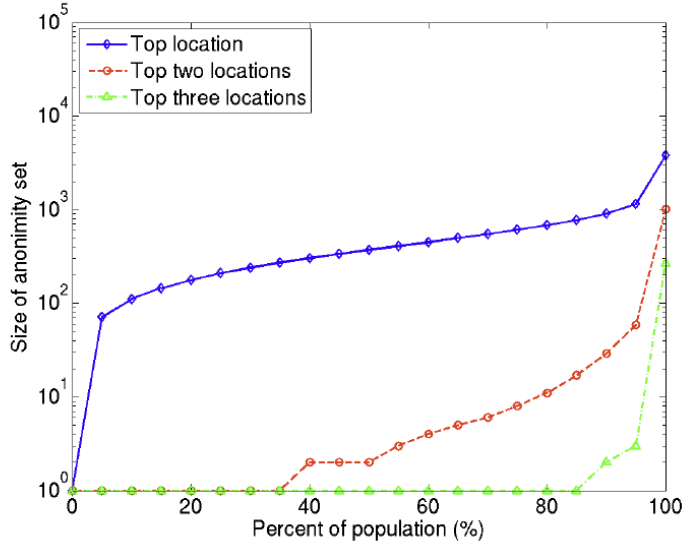
Privacy Issue of Trajectory datasets

Mobile Trajectories are **highly unique**

→ **Potential re-identification**

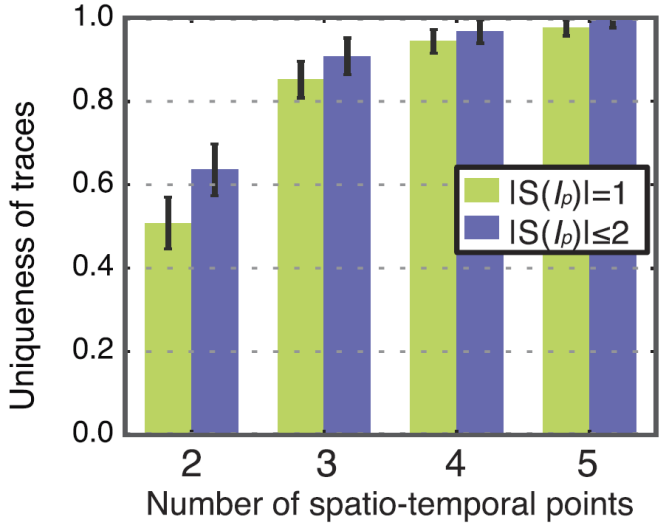
→ **Privacy risk**

MobiCom 2011



Three top locations pinpoint 50% users

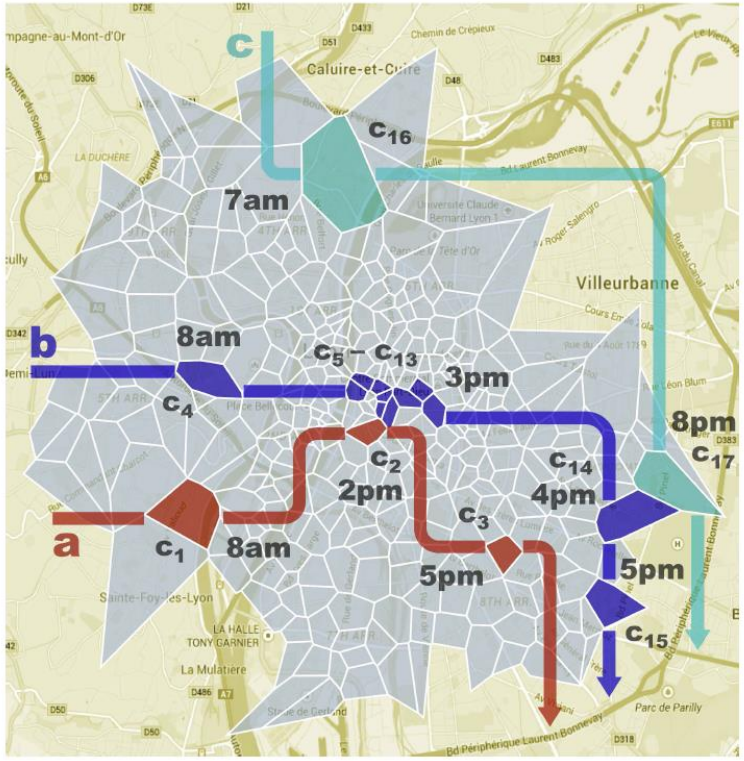
Nature Scientific Reports 2013



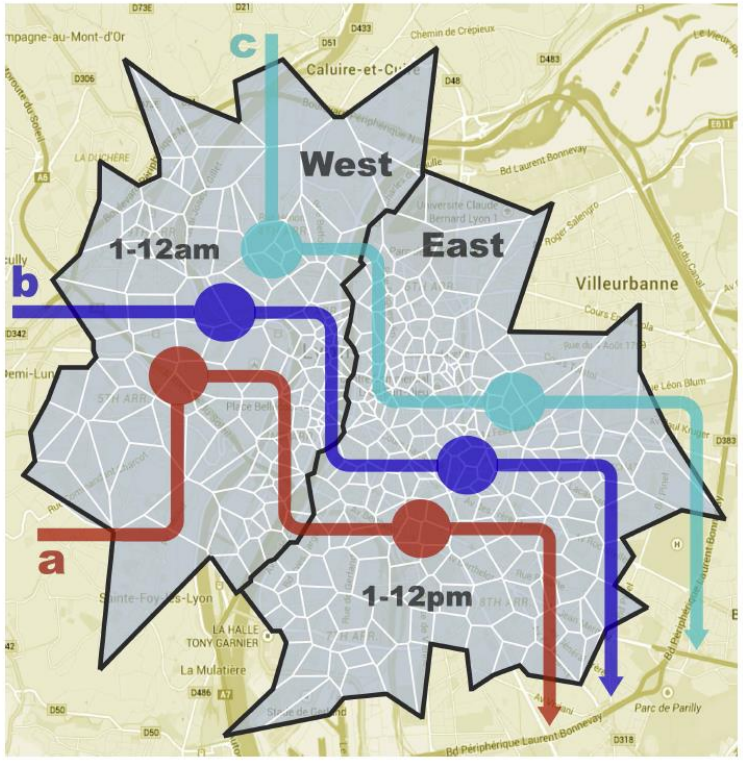
Five random points pinpoint 95% users

Counter-measure: K-anonymity

- **Key idea: each user should be indistinguishable from at least k − 1 others (hidden in an anonymity set no smaller than k)**



e.g.
3-anonymity



Counter-measure: K-anonymity

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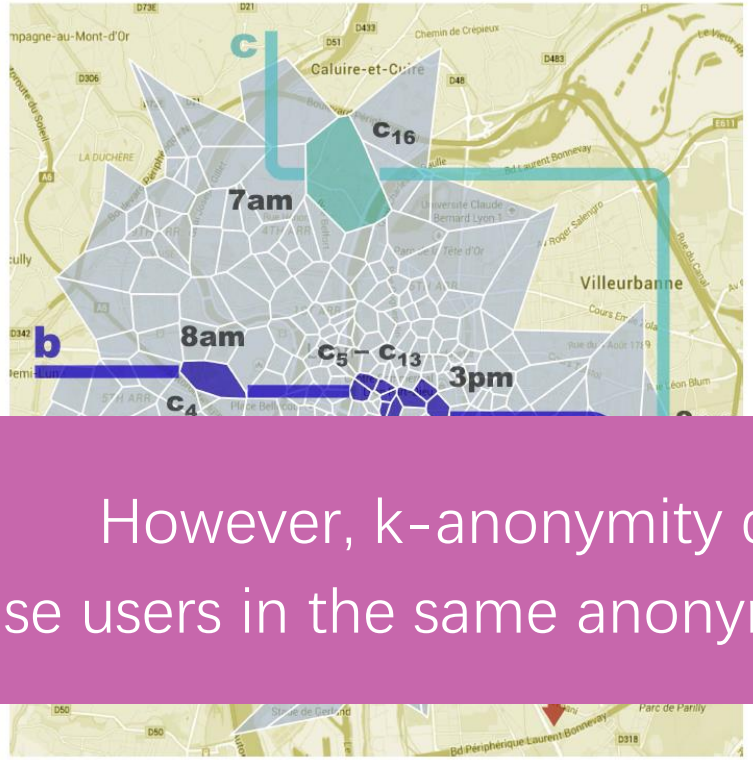
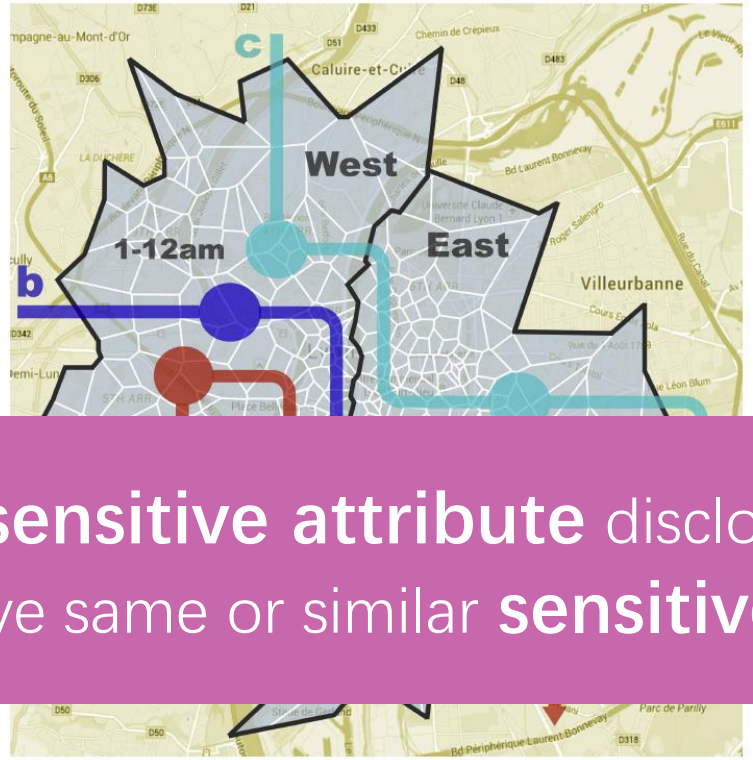


e.g.
3-anonymity



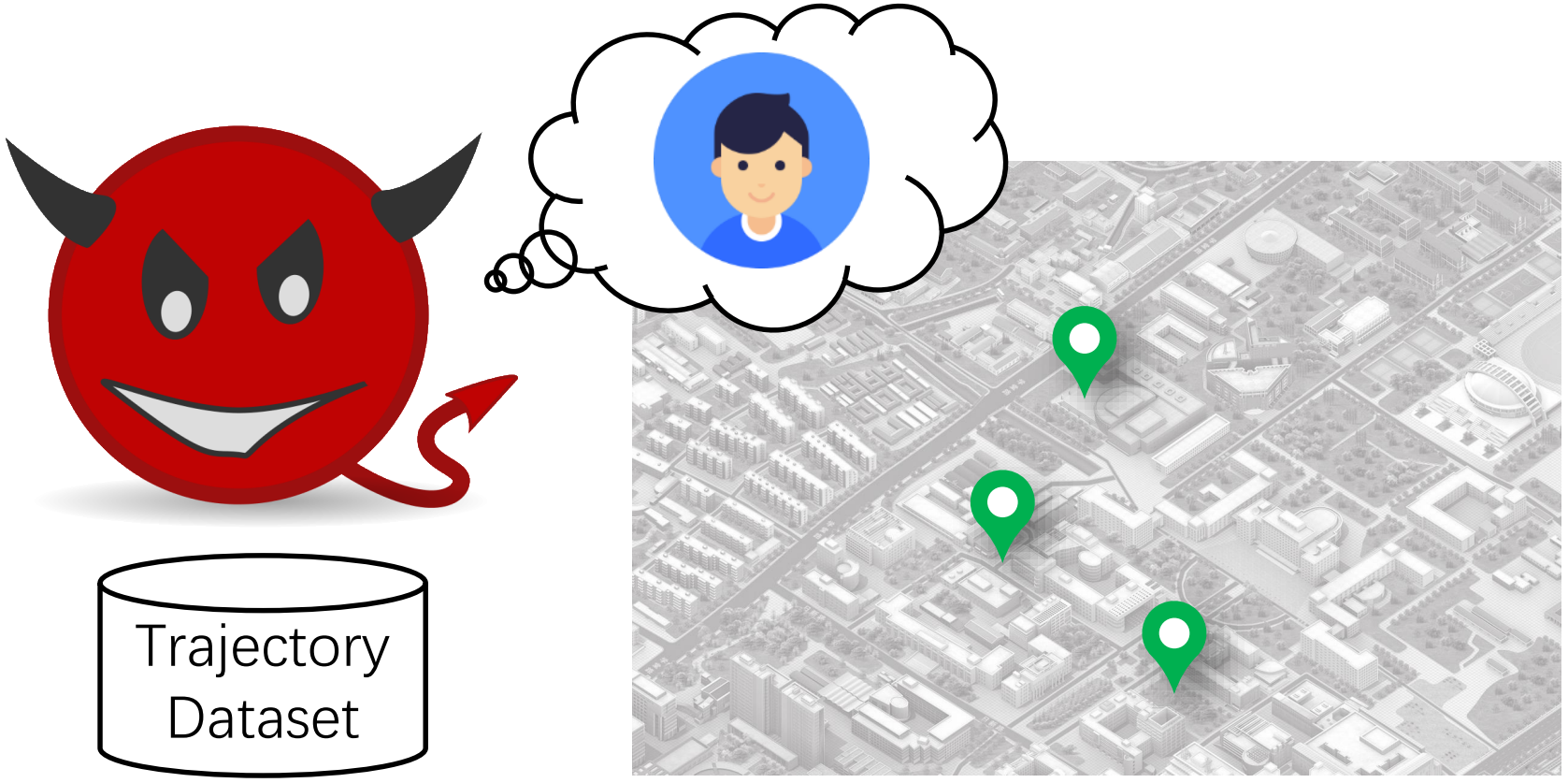
However, k-anonymity cannot prevent **sensitive attribute** disclosure
Because users in the same anonymity set may have same or similar **sensitive attributes**

Example

The adversary

knows his **three spatiotemporal samples** e.g. from social networks

and wants to know his **top two most visited locations** e.g. home and work place



Example

The adversary

finds **four** people with the same **three spatiotemporal samples**

Trajectory Dataset

Example

The adversary

cannot identify the target (thanks to 4-anonymity!)

Example

The adversary

cannot identify the target (thanks to 4-anonymity!)

But, what if these people's top two locations are the same ?

Trajectory Dataset

Problem

low diversity of the sensitive attributes

We present a large-scale measurement study to answer:

- What is the diversity of the trajectory dataset?
- What is the relationship between k and the diversity?
- Does a larger k help improve the diversity?

Wi-Fi Based Trajectory dataset from Tsinghua University

$4km^2$

150,000
Mobile devices

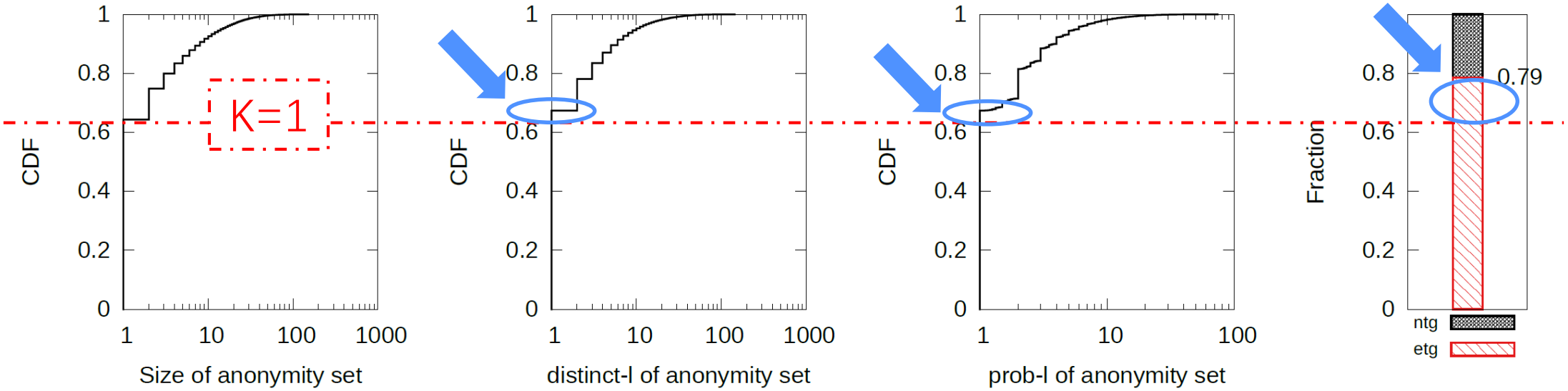
2,670
Access points

111
Buildings

4
Weeks

Observation #1

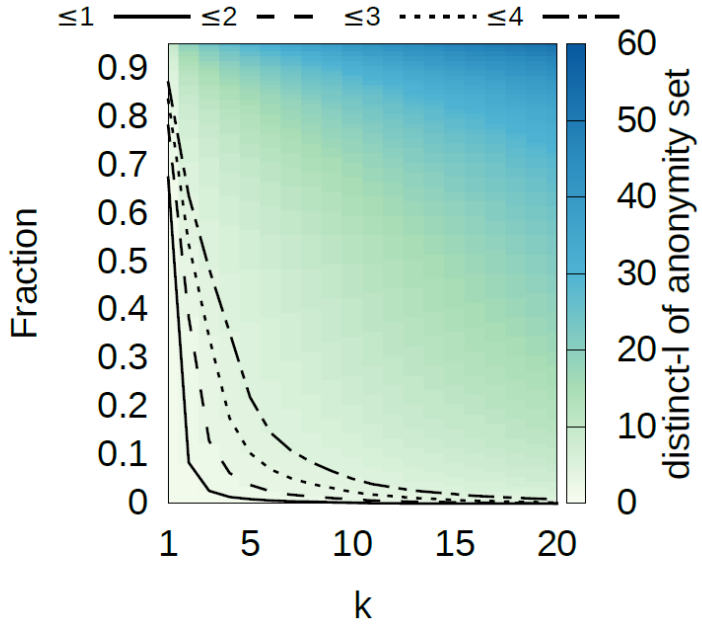
The risk of low diversity is high, even for K>1

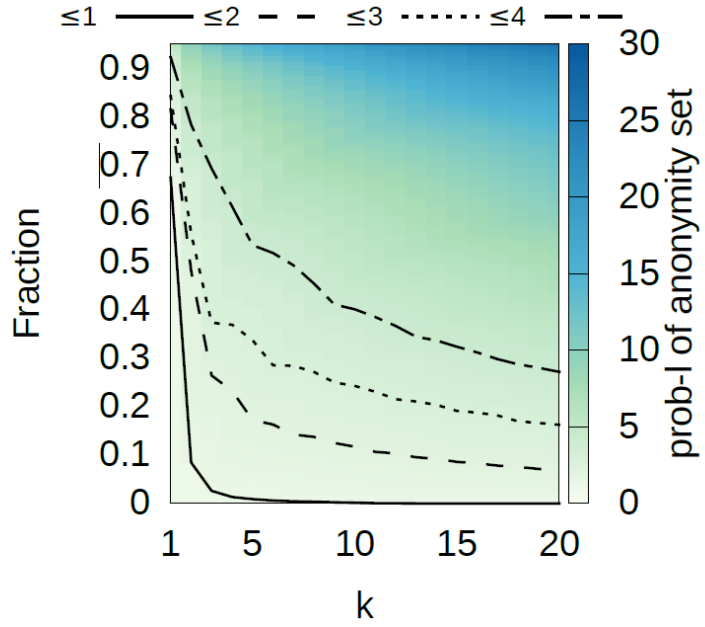


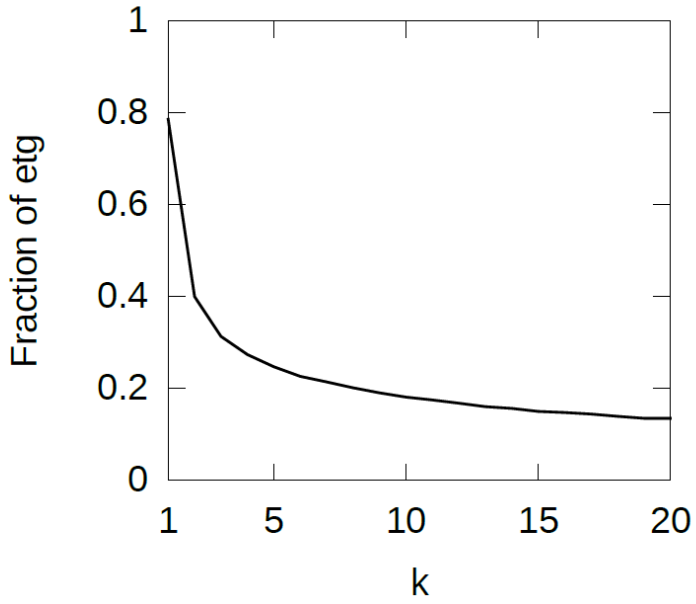
Three metrics that measure the diversity

Observation #2

Larger k helps improve the diversity, but the effect degrades exponentially



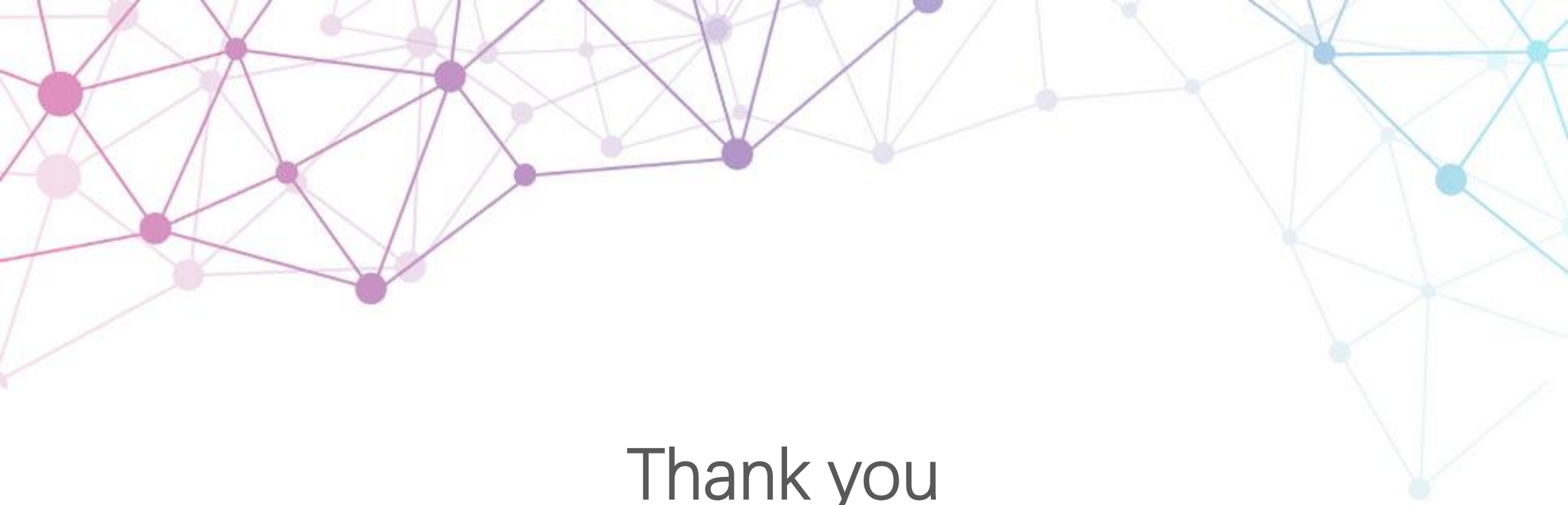




See more results in the paper

Conclusion

- A large-scale trajectory measurement shows that
  - The risk of low diversity is high for the trajectory dataset
  - K-anonymity cannot help solve the problem effectively
  - Calls for diversity-oriented solutions beyond k-anonymity (future work)



Thank you

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