Geographic Knowledge Discovery: towards Mobility Data Analysis

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Information Society Technologies

GeoPKDD

http://www.geopkdd.eu

A European FP7 project

Geographic Privacy-aware Knowledge Discovery and Delivery

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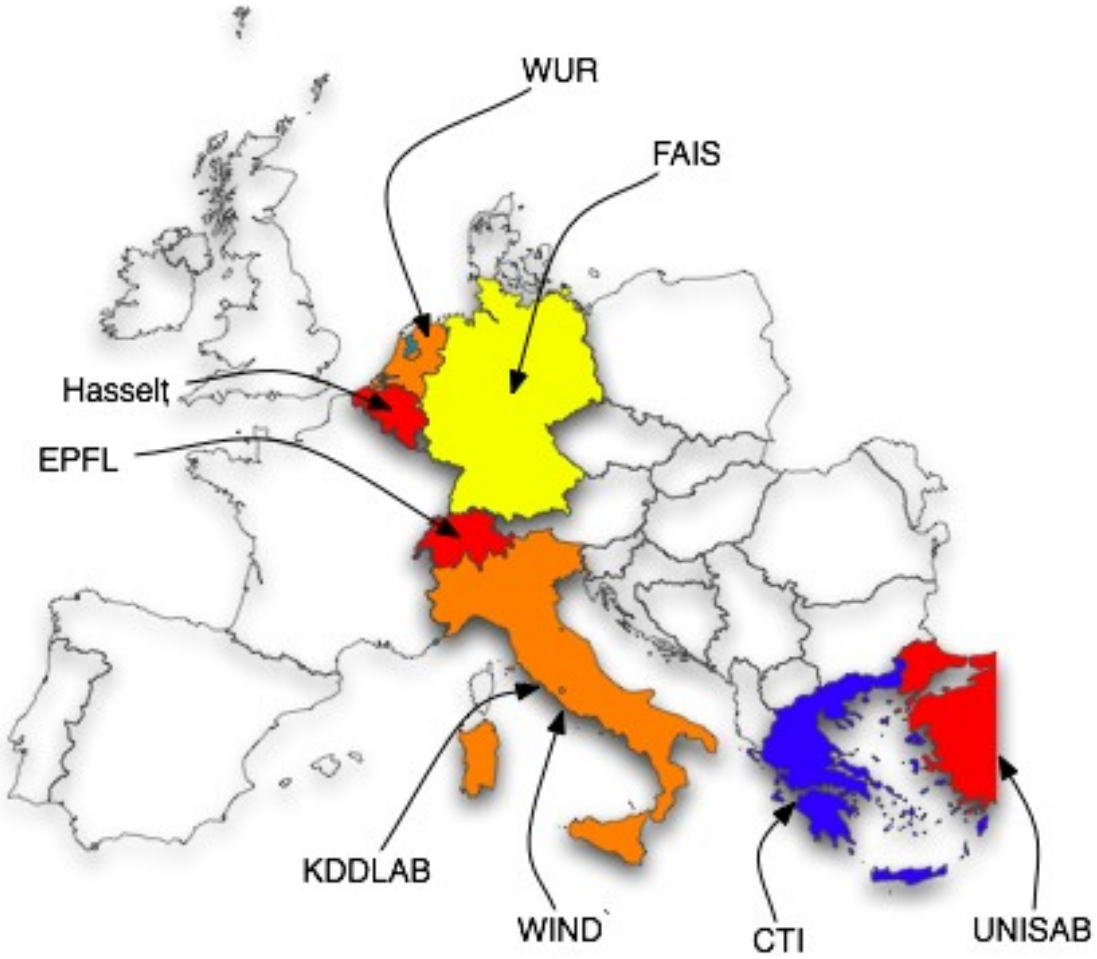
GeoPKDD

Geographic Privacy-aware Knowledge Discovery and Delivery



The Wireless Network

- The pervasiveness of mobile and ubiquitous technologies is increasing day after day
  - GSM wireless phone networks
    - 1.5 billions in 2005, still increasing at a high speed
    - Italy: # mobile phones ≈ # inhabitants
  - GPS and Galileo positioning systems
  - Wi-Fi and Wi-Max wireless networks
  - RFID's and sensor networks
- miniaturization
- positioning accuracy
  - location technologies capable of providing increasingly better estimate of user location

Which new opportunities?

- Location based services:
  - A certain service that is offered to the users based on their locations
- Mobility data analysis:
  - Discovering knowledge from the digital traces of our mobile activity to support decision making in mobility related issues.

Location-based Services: Then

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- **Limited to fixed traffic signs**

Location-based Services: Now

- Location-based traffic reports:
  - ***Range query:*** How many cars in the free way
  - ***Shortest path query***: What is the estimated time travel to reach my destination

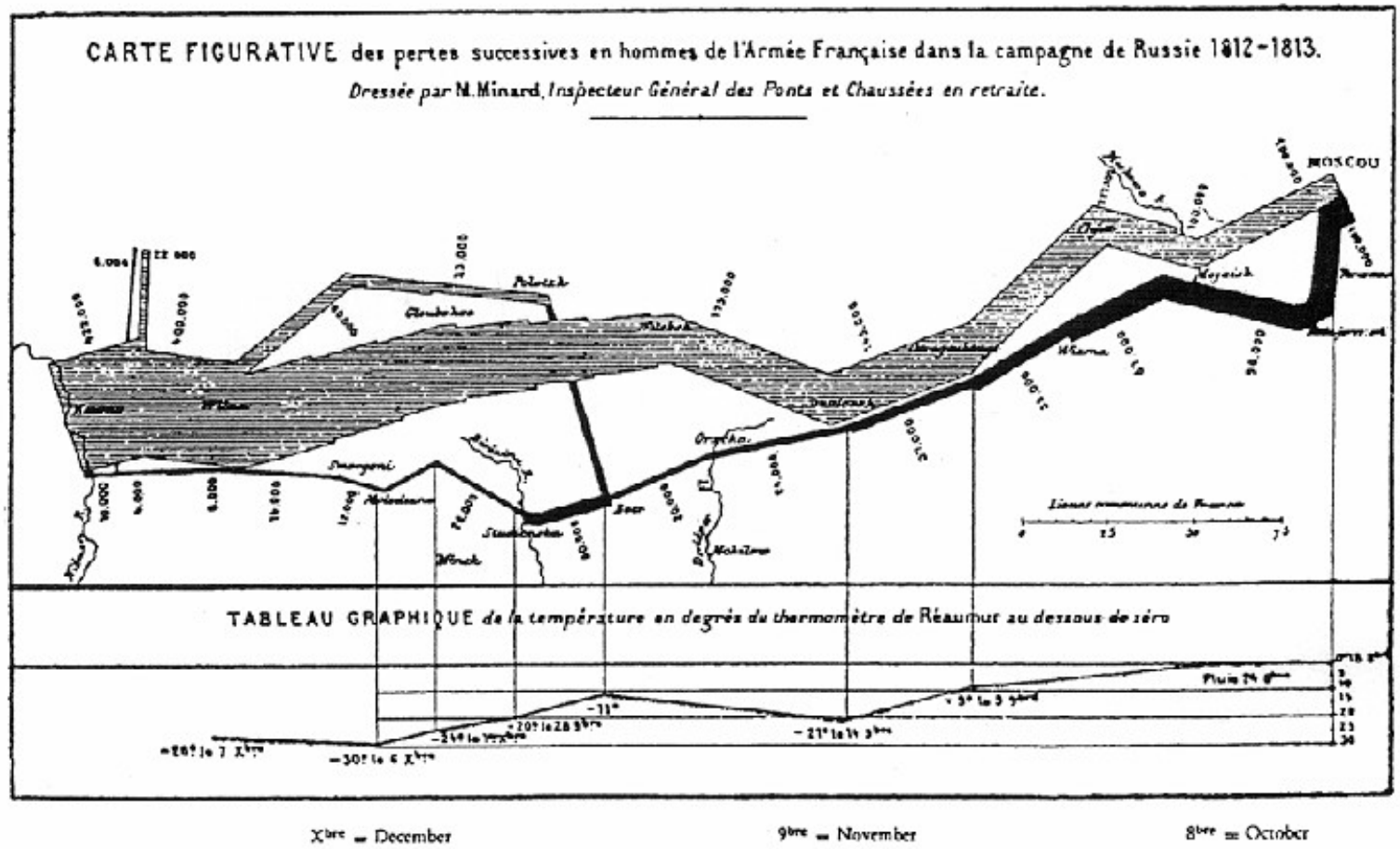
- Location-based store finder:
  - ***Range query:*** What are the restaurants within five miles of my location
  - ***Nearest-neighbor query***: Where is my nearest fast (junk) food restaurant

- Location-based advertisement:
  - ***Range query:*** Send E-coupons to all customers within five miles of my store

Mobility data analysis

- How people move around in the town
  - During the day, during the week, etc.
- Are there typical movement behaviours?
- Are there typical movement behaviours in a certain area at a certain time?
- How frequently people access the network?
- How are people movement habits changing in this area in last decade-year-month-day?
- Are there relations between movements of two areas?
- Are there periodic movements?

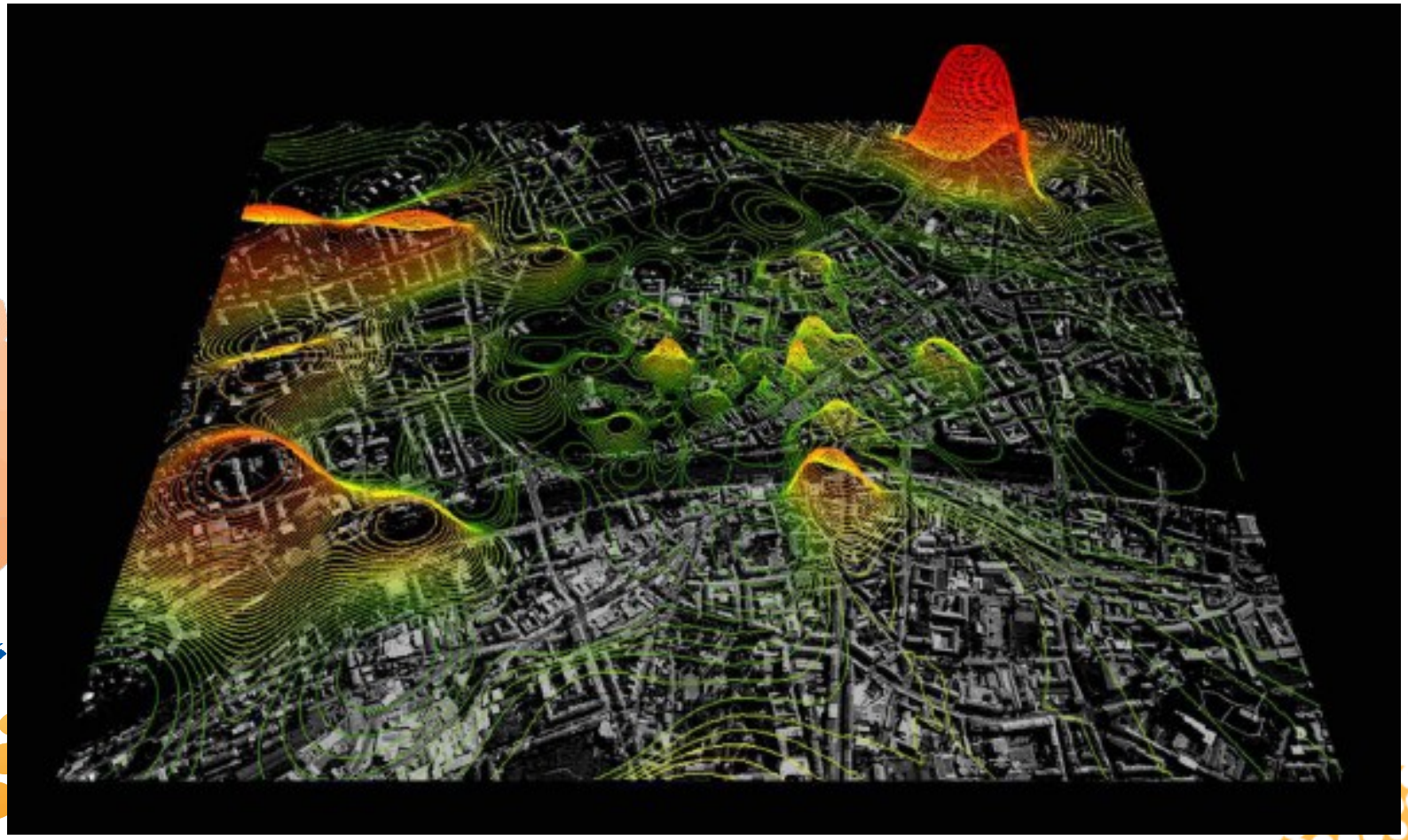
From *time-geography*



The representation of Napoleon's Russian campaign of 1812 produced by Charles Joseph Minard in 1861

to interactive (recent/real) *time-geography*

Real-time density estimation in urban areas

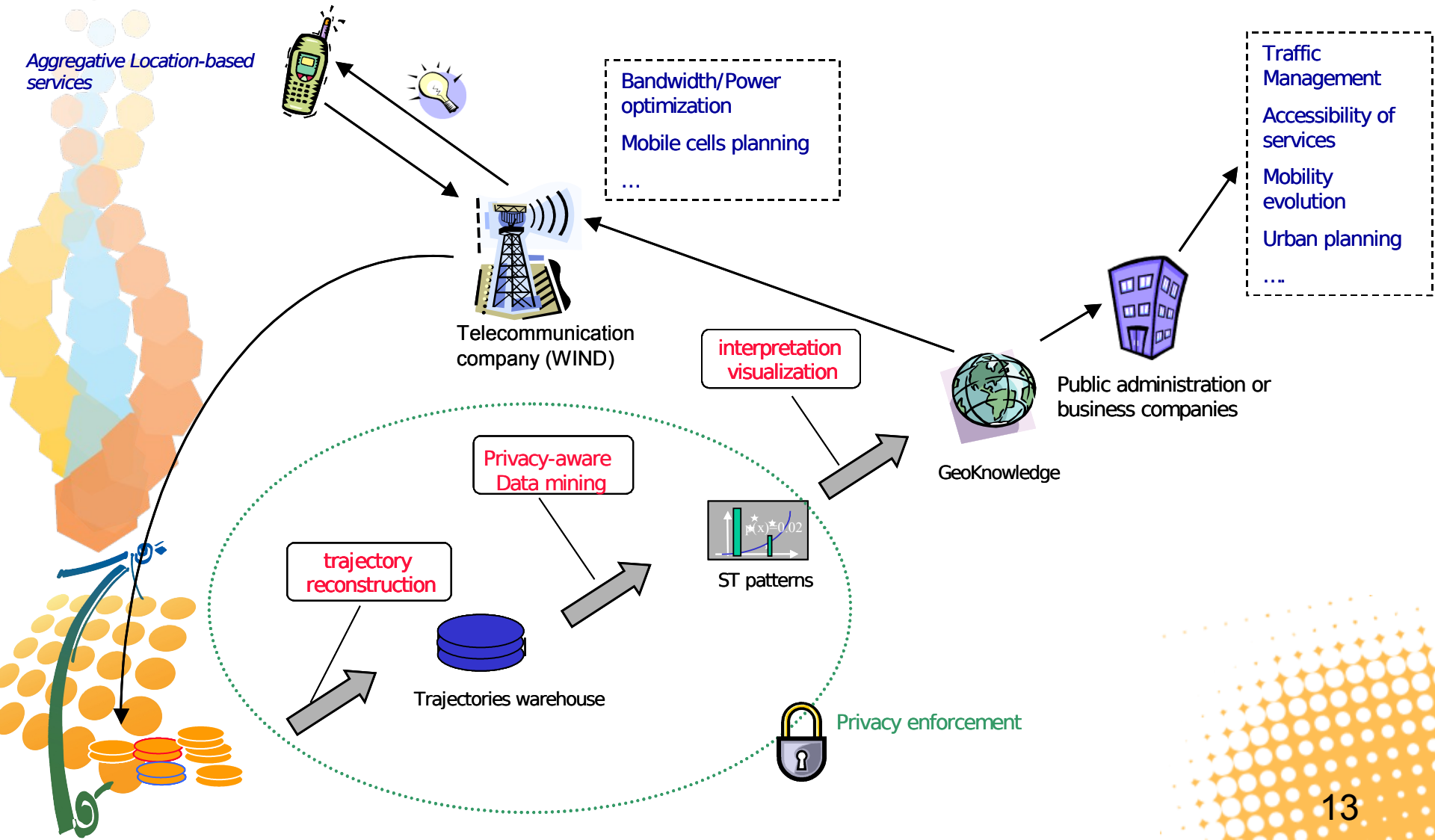


The senseable project: http://senseable.mit.edu/grazrealtime/

GeoPKDD general goal

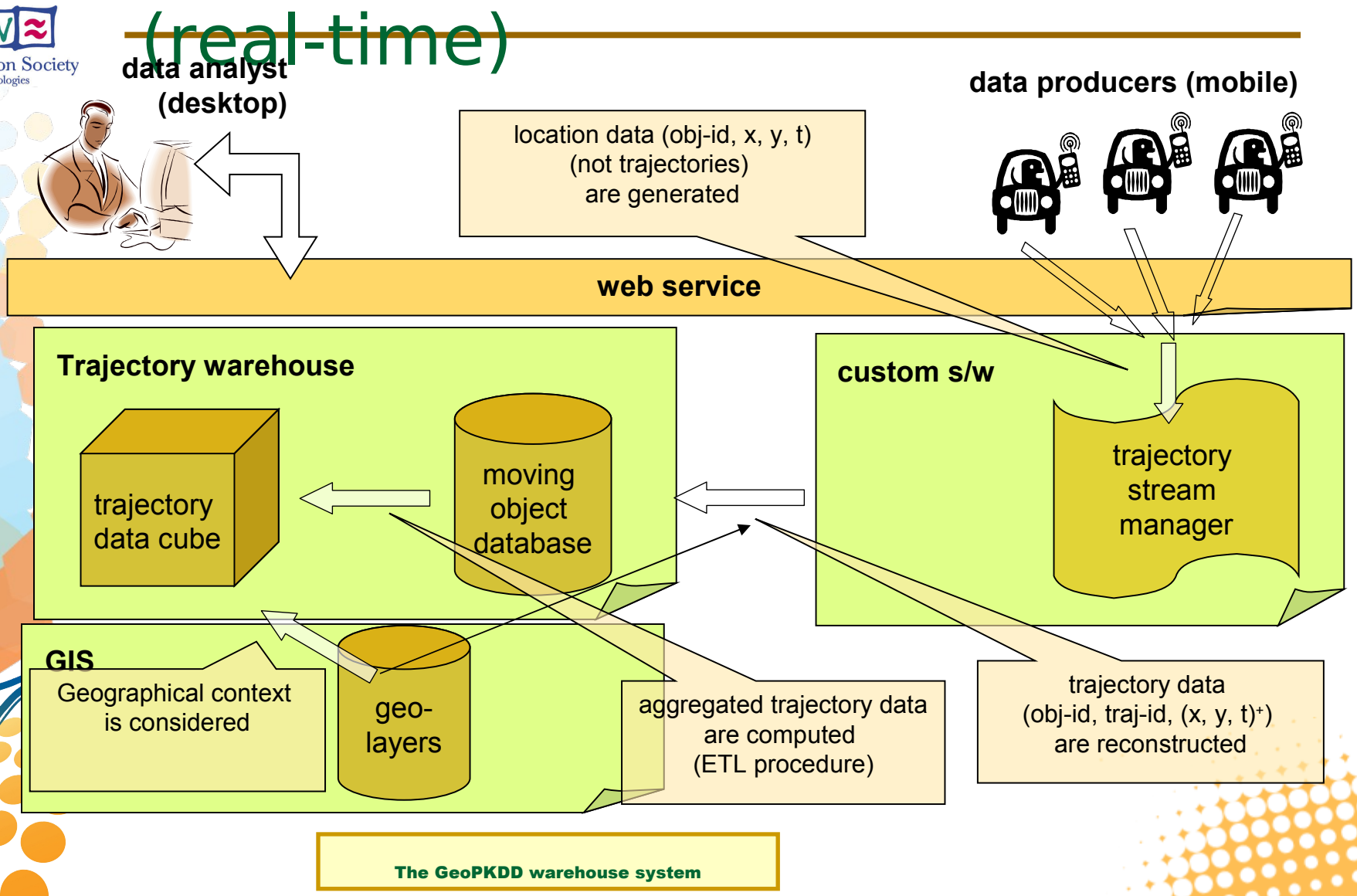
- is to develop
  - theory, techniques and systems for *geographic knowledge discovery and delivery*,
  - based on new automated *privacy-preserving* methods for extracting user-consumable forms of knowledge from large amounts of raw data referenced in *space* and in *time*.

Geographic privacy-aware Knowledge Discovery process



From movement data to movement patterns

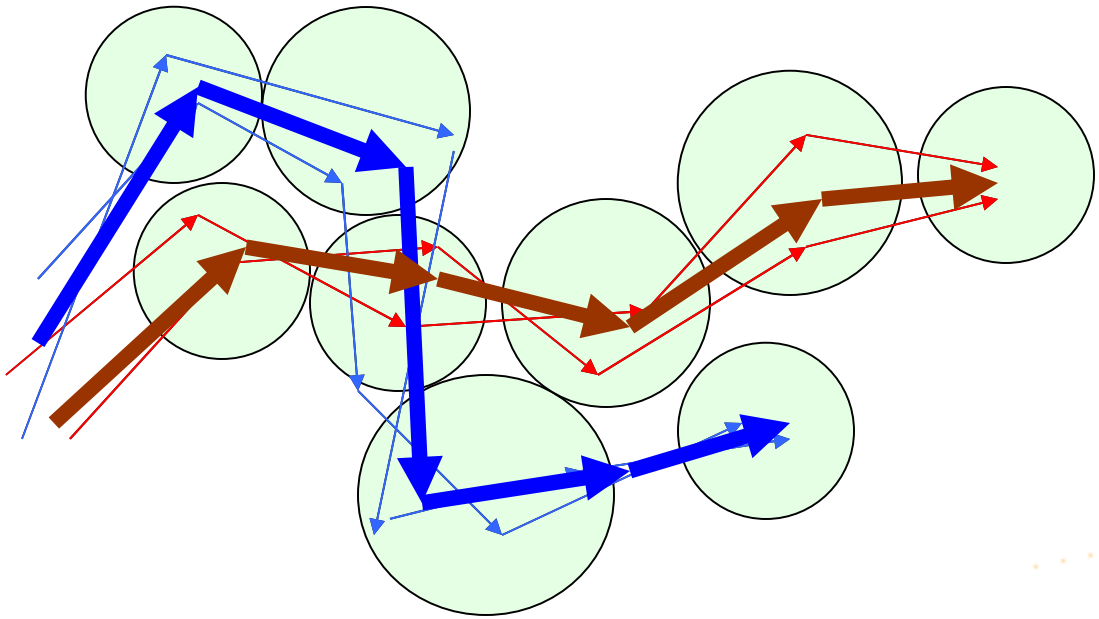
The GeoPKDD system architecture (real-time)



The GeoPKDD warehouse system

Mining Trajectories: Clustering

- Group together similar trajectories
- For each group produce a summary



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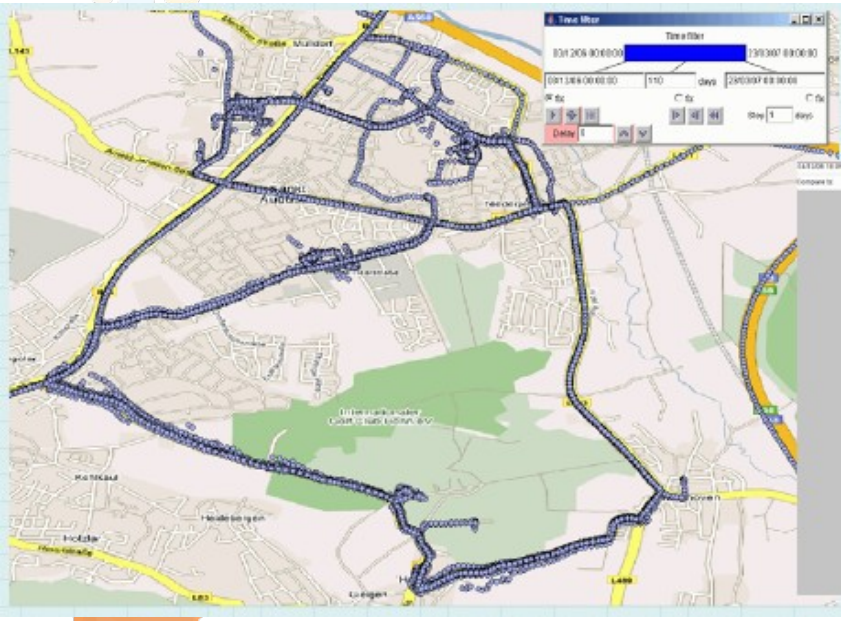
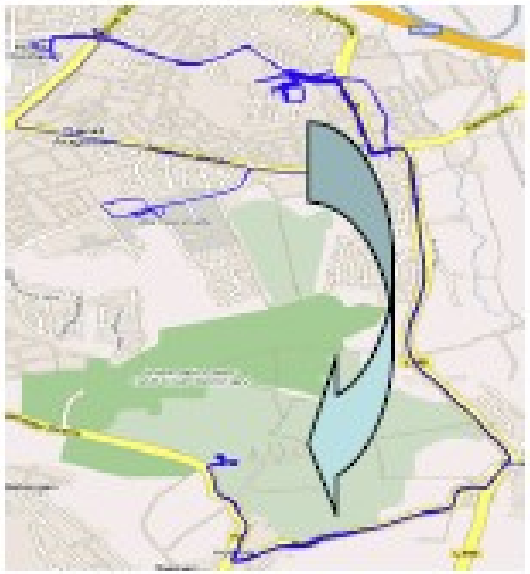
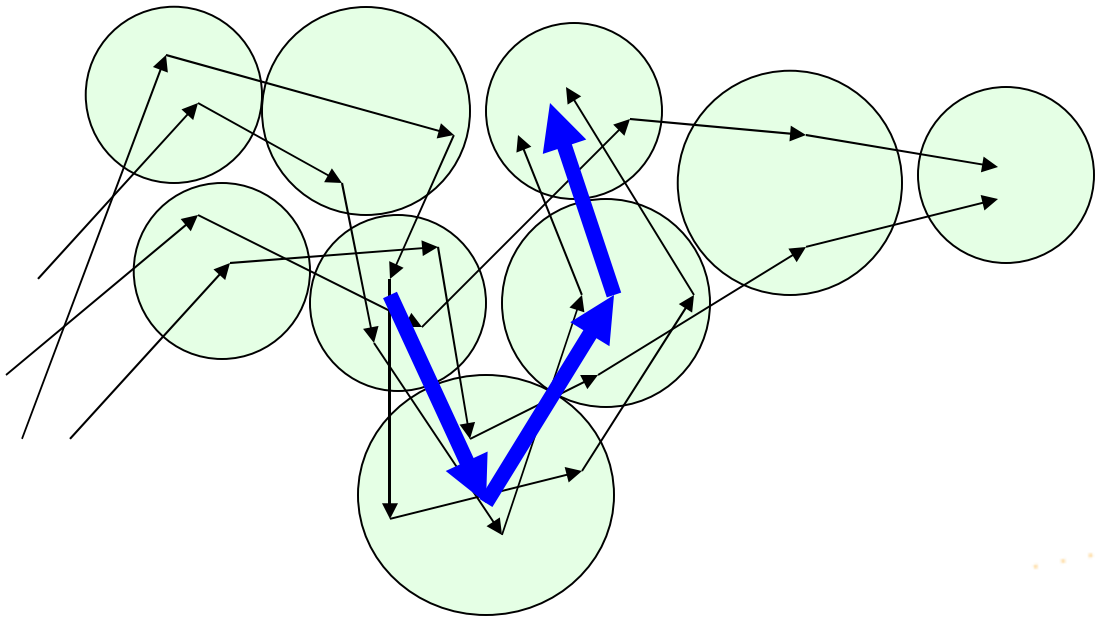
Trajectory Clustering





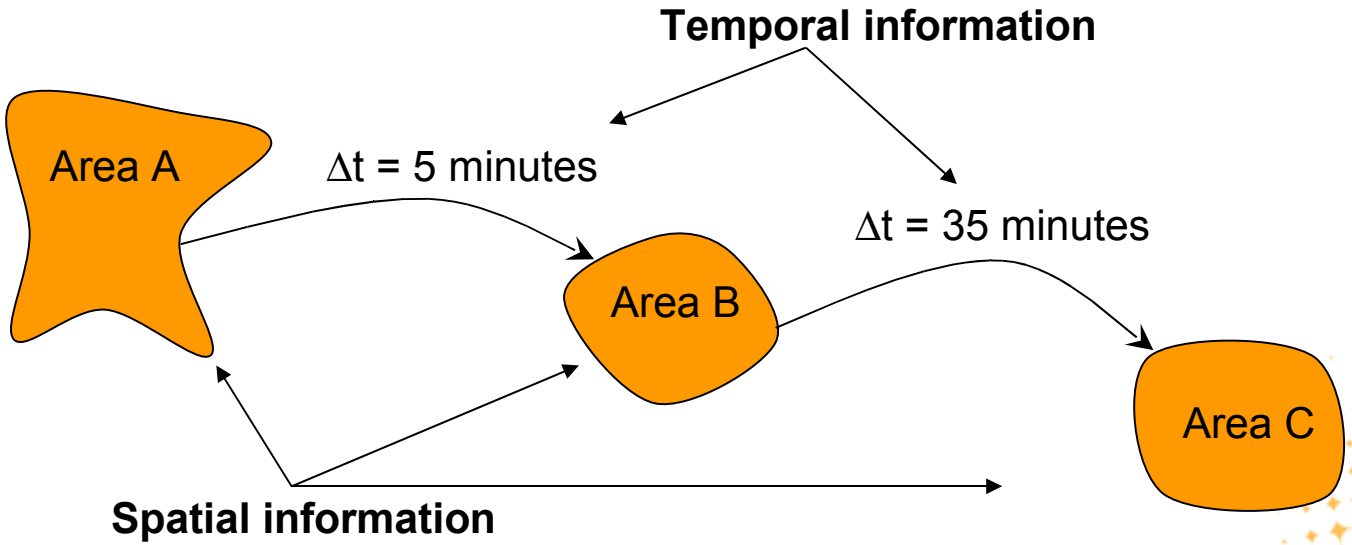
Mining Trajectories : Frequent patterns

- Discover frequently followed (sub)paths



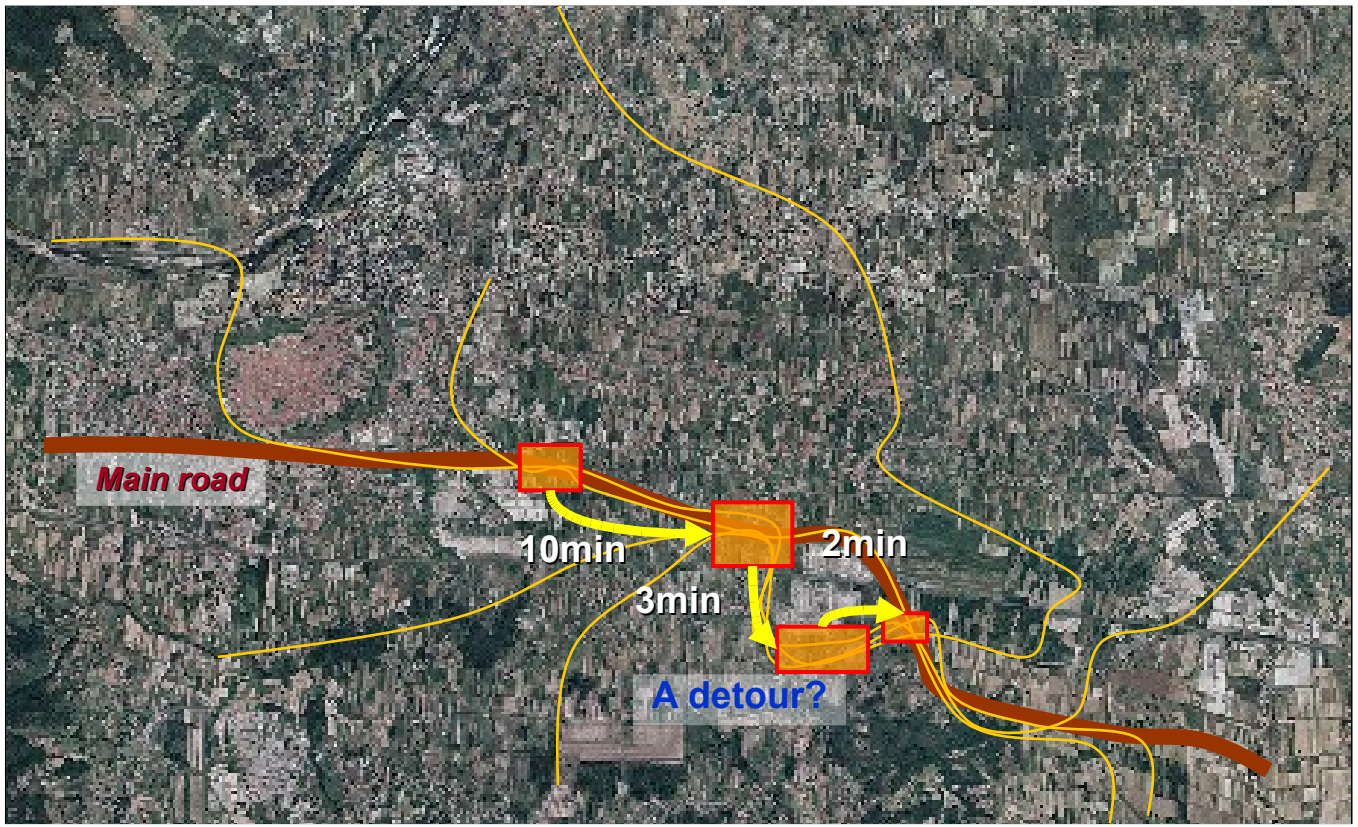
What is a trajectory pattern?

- A trajectory pattern is a **sequence of spatial regions** that, on the basis of the source trajectory data, emerge as frequently visited in the order specified by the sequence;
- in addition, the transition between two consecutive regions in such a sequence is annotated with a **typical travel time** that, again, emerges from the input trajectories.



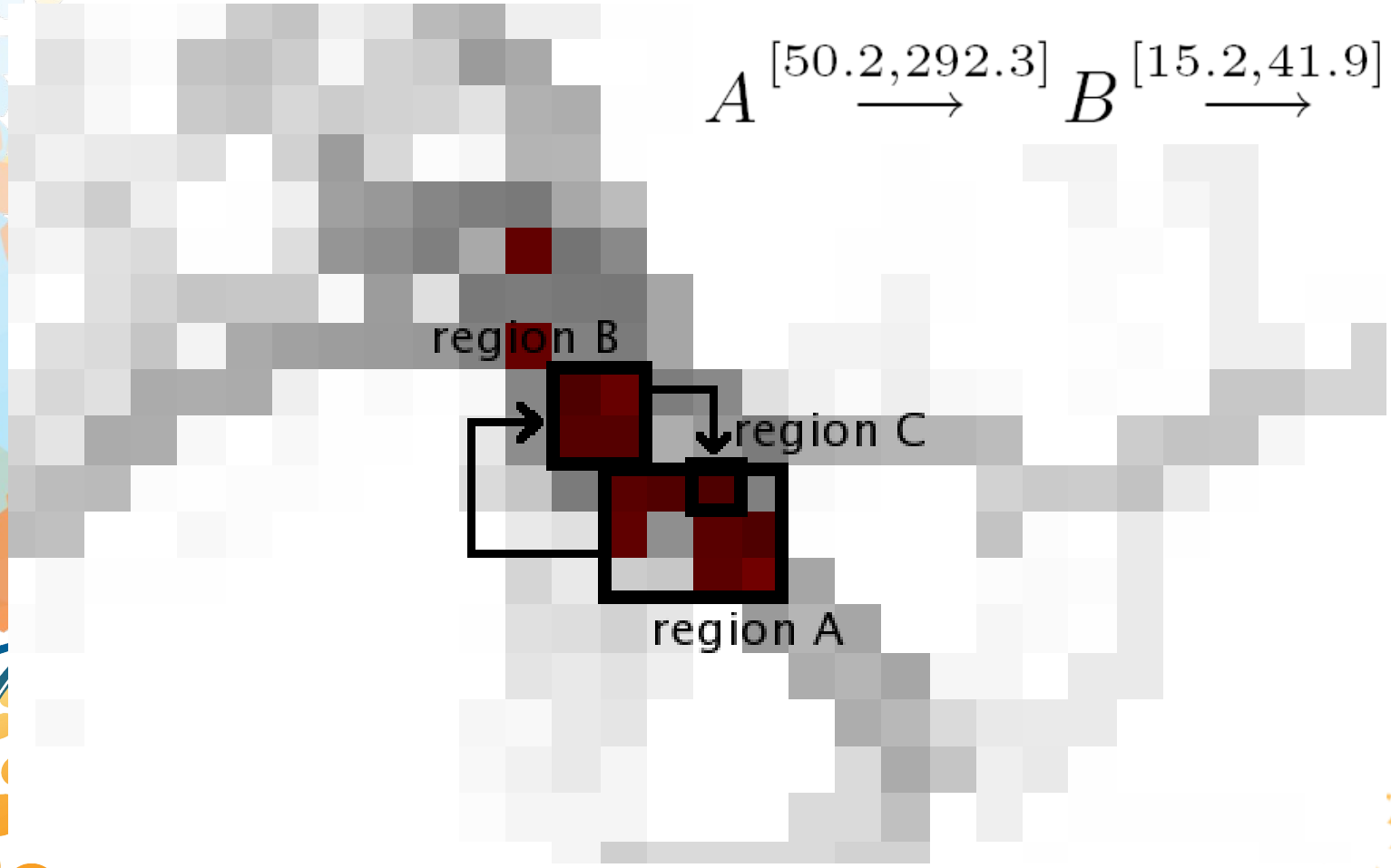
Visualizing T-patterns

Example



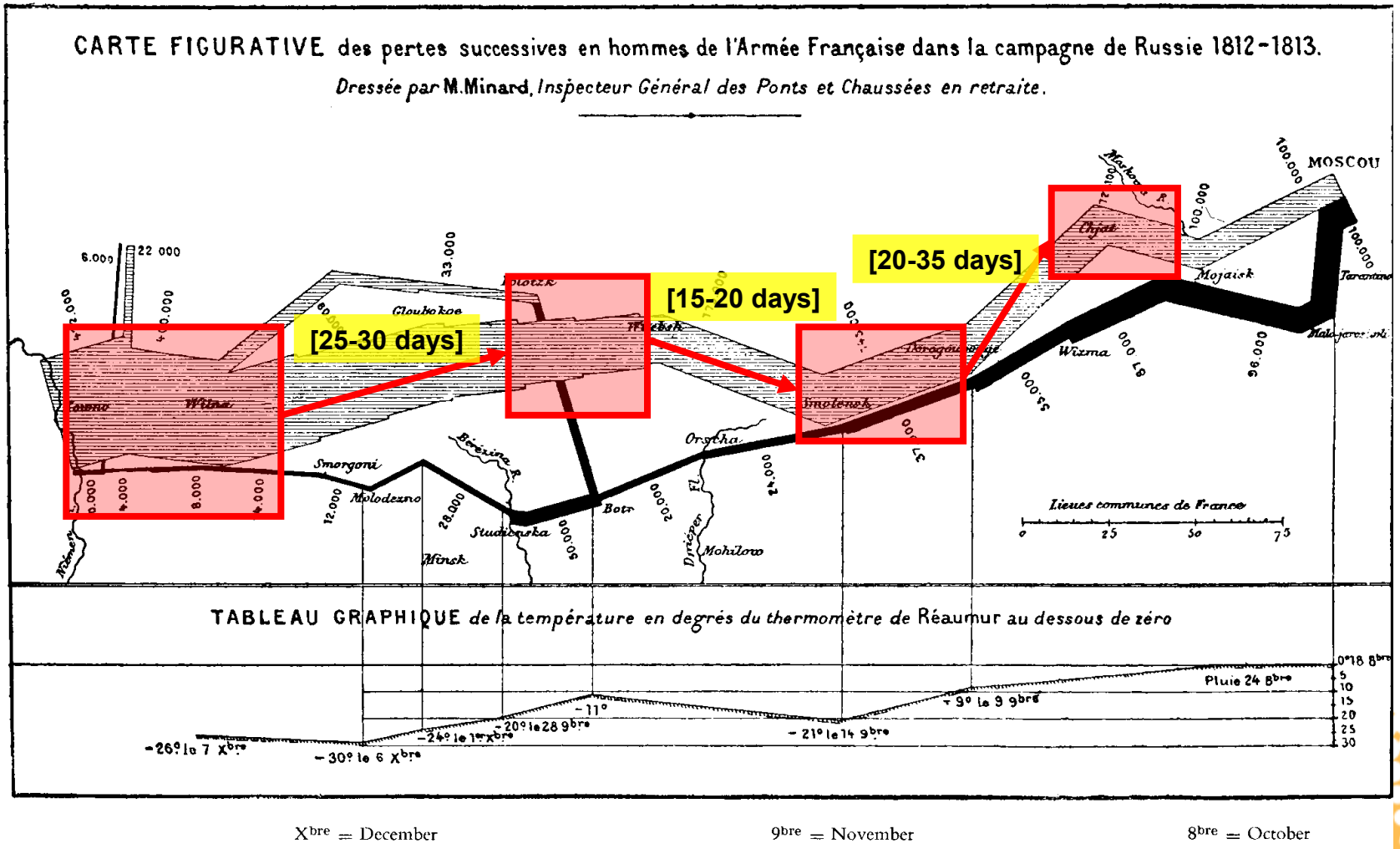
Visualizing T-patterns
Sample pattern (Athens trucks)

$$A \overset{[50.2,292.3]}{\longrightarrow} B \overset{[15.2,41.9]}{\longrightarrow} C$$



Visualizing T-patterns

Minard's map

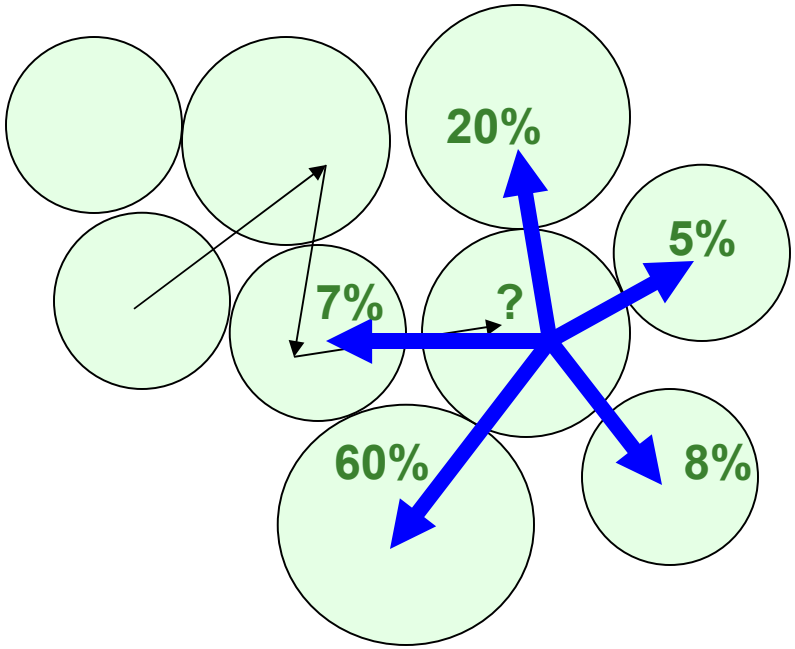


Visualizing T-patterns

Example

Mining Trajectories: classification models

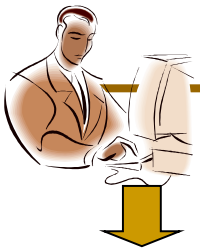
- Extract behaviour rules from history
- Use them to predict behaviour of future users

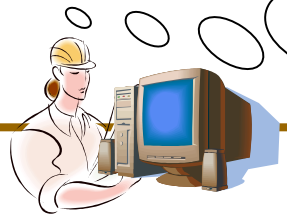


The GeoPKDD impact

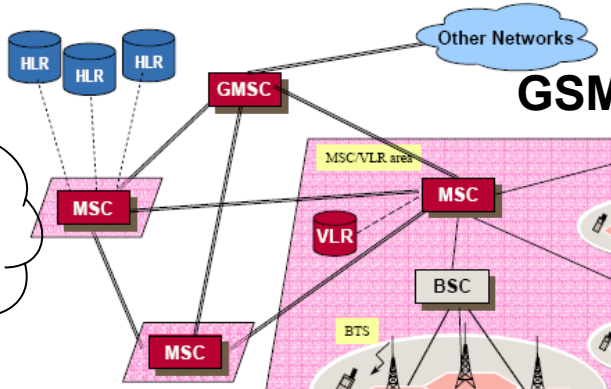
- Improving decision-making in mobility-related issues:
  - Planning traffic and public mobility systems in metropolitan areas;
  - Planning physical communication networks
  - Localizing new services in our towns
  - Forecasting traffic-related phenomena
  - Organizing logistics systems
  - Avoid repeating mistakes
  - Timely detecting changes.

Mobility Manager Office

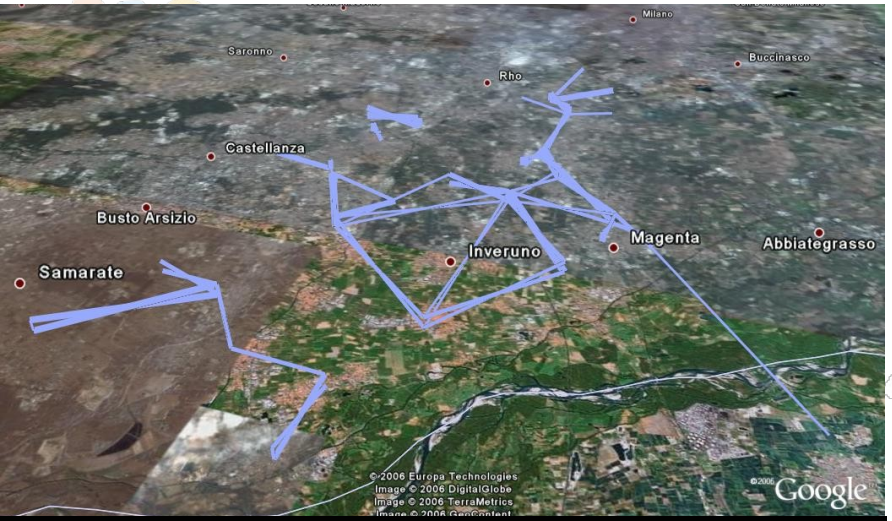


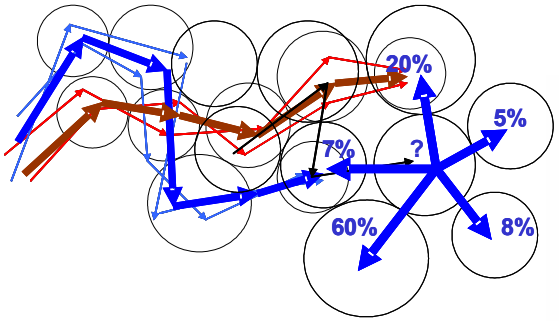


Sustainable Mobility?

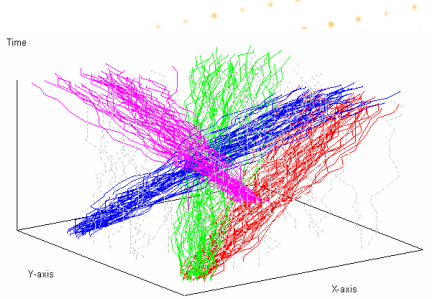


GSM network





Mobility Models



We are looking for real case to experiment on:

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Application Demonstrators

Amusement park Amsterdam

Brasilian Governamental Trasportation Management

GPS data from trucks in Athens

Comune di Milano ?

We are looking for case studies:

- **data sets, cartography and problems. The project will apply the mehods for free!**
- **Is there any public administration interested in experimenting on their data?**

We have a telecom. operator within the consortium, others may be involved.

Other experiments may be interesting: GPS data from car, or trucks

Why emphasis on privacy?

- More, better data are gathered, more vulnerability from linkage
- On the other hand, more and new data bring new opportunities
  - Public utility, new markets/paradigms, new services
- Need to maintain privacy without giving up opportunities
- Need to obtain social acceptance through demonstrably trustworthy solutions

Privacy in Mobility Data and Services

- Trusted/secure storage/Management of Mobility Data
- Privacy in Location Based Services:
  - the right of a user to receive a service without revealing his/her identity
  - Trade-off between quality of service and privacy protection
- Privacy and Anonymity in Mobility Data Analysis
  - Trade-off between privacy protection and analysis opportunities

Privacy in GeoPKDD

- How to design Data Analysis methods that, **by construction**, meet the the privacy constraints?
- How to develop trustable data mining technology capable of producing
  - ***provably/measurably*** privacy-preserving patterns
  - which may be safely distributed

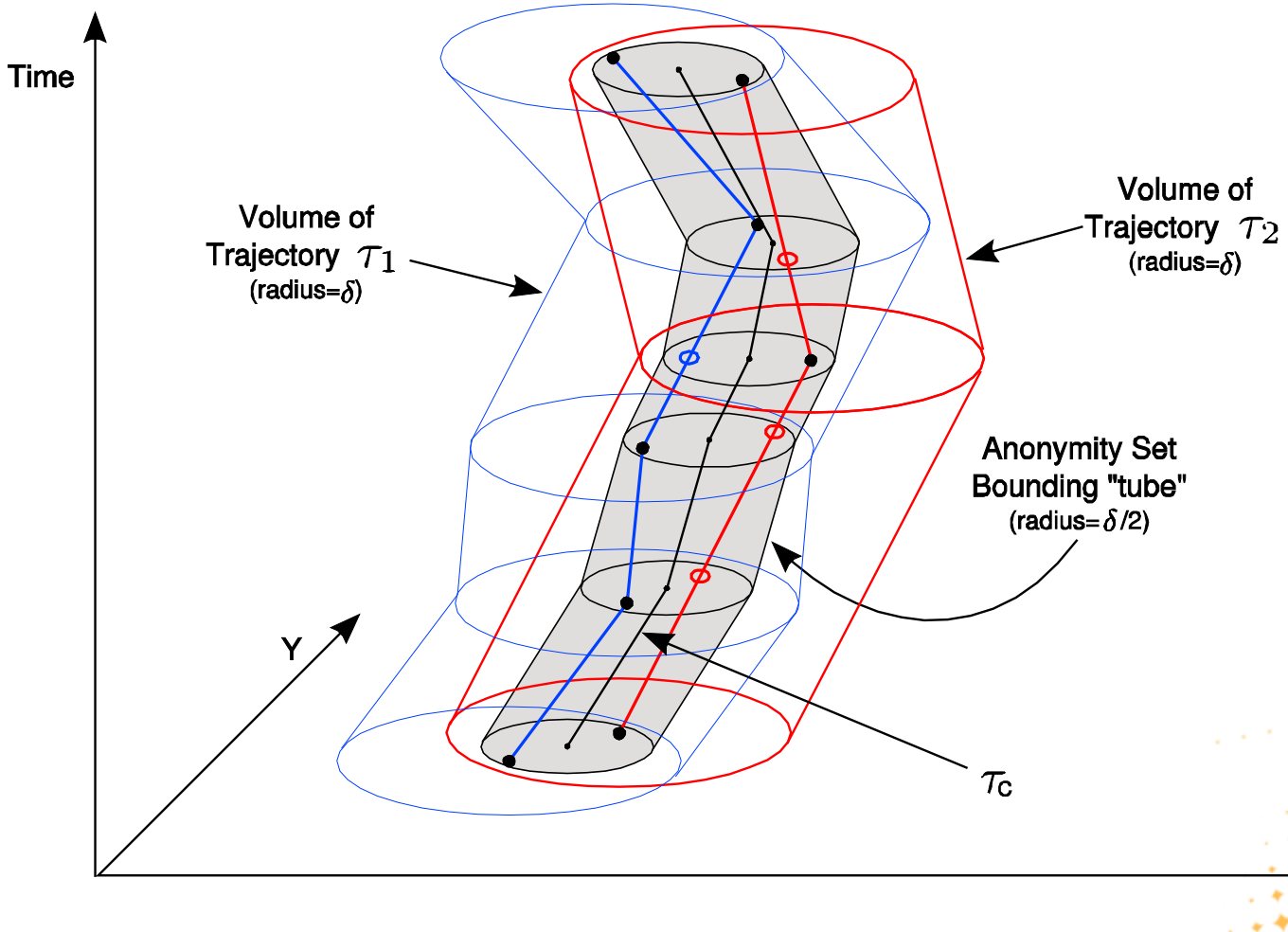
Scientific Privacy Issues in GeoPKDD

- Is there any specific challenge/risk/opportunity in the context of ST data?
  - New threats from traces analysis: learning who you are from where you have been (Malin et al 2003)
  - Space and Time in a trajectory can act as quasi-identifiers (Bettini and Jajodia 2005)
- How to formalize privacy measures over Spatio-Temporal data and Spatio-Temporal patterns?
  - E.g., anonimity threshold on clusters of individual trajectories

GeoPKDD Privacy Observatory

- Privacy cannot be achieved by technology alone
  - it's a combined social, ethical, legal and technological matter.
- The GeoPKDD Observatory interacts with stakeholders in privacy issues. Activities:
  - create and maintain relationships with European and national authorities for data protection and other privacy related organizations,
  - implement regulations into KDD methods and tools,
  - provide ideas for revisions of regulations themselves by means of novel privacy preserving technologies.
- http://www.geopkdd.eu/pro
- Tight collaboration with KDubiq's WG5

Anonymity and Trajectories



Announcements

Information Society
Technologies

The GeoPKDD boo

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Fosca Giannotti and Dino Pedreschi (Eds.)

Mobility, Privacy, and Data Mining.

Springer, Dec. 2007.