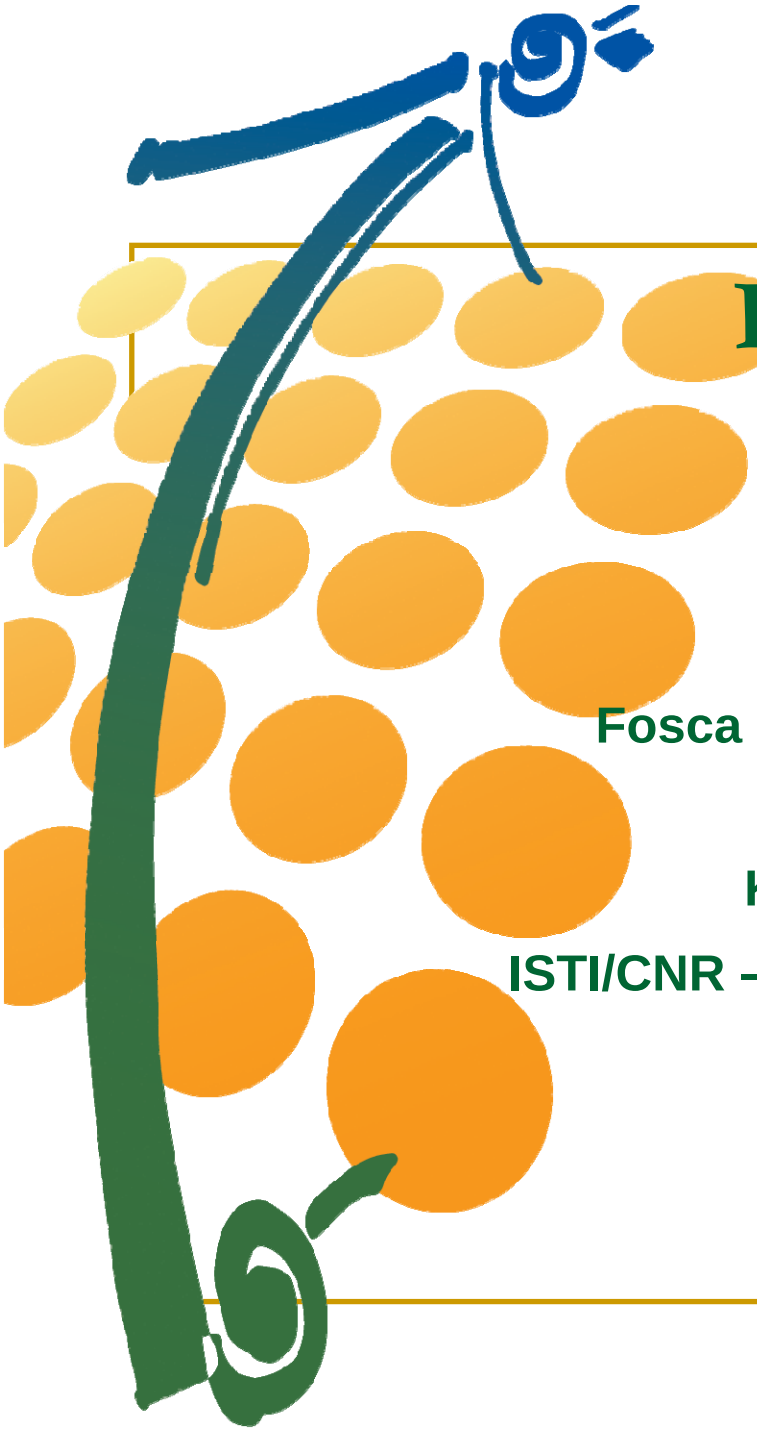

# Privacy and anonymity in mobility data analysis


**Fosca Giannotti, Dino Pedreschi, Franco Turini**

**KDD Lab Pisa, Italy**

**Knowledge Discovery & Data Mining Lab**

**ISTI/CNR – Dipartimento di Informatica/ University of Pisa**


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Information Society Technologies

# Programma dell'incontro

- **11:00-12:30**
  - L'analisi dei dati di mobilità e lo scenario del progetto GeoPKDD, Fosca Giannotti
  - Privacy ed anonimato nell'analisi dei dati e nel data mining, Dino Pedreschi
  - Analisi previsionale e discriminatorietà, Franco Turini
  - L'Osservatorio sulla Privacy di GeoPKDD
- **12:30-13:30**
  - Discussione

# Plan of the talk (Mobility Data Analysis)

- The wireless explosion:
  - Location Based Services vs Mobility Data Analysis
  - Analytic opportunities
- GeoPKDD vision and goals
  - The movement patterns
  - The impact
- The scenario of ubiquitous computing
- The privacy challenge

# The Wireless Explosion
























*Do you use any of these devices ?*

*Do you ever feel that you are tracked?*

# 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.

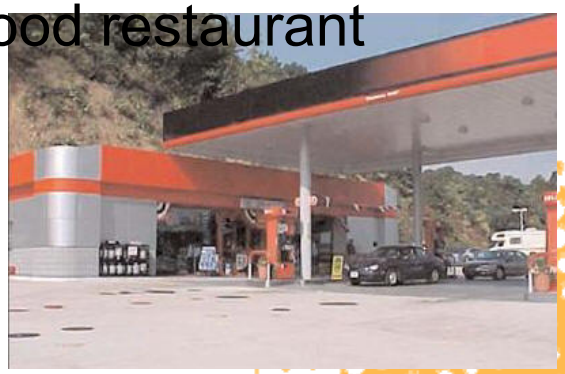
# Location-based Services: Then

- **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

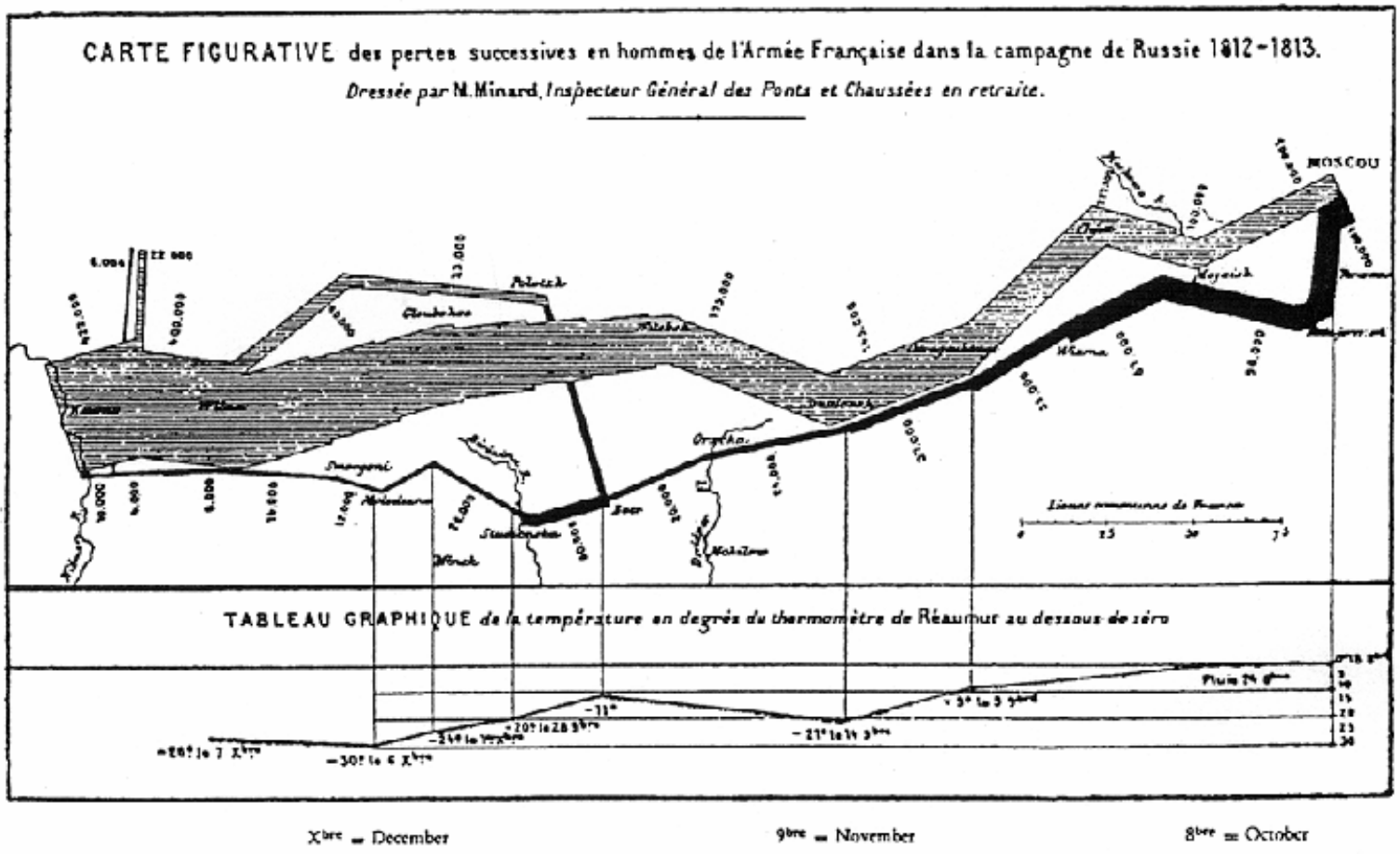


- Location-based advertisement:
  - ***Range query:*** Send E-coupons to all customers within five miles of my store

# 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?

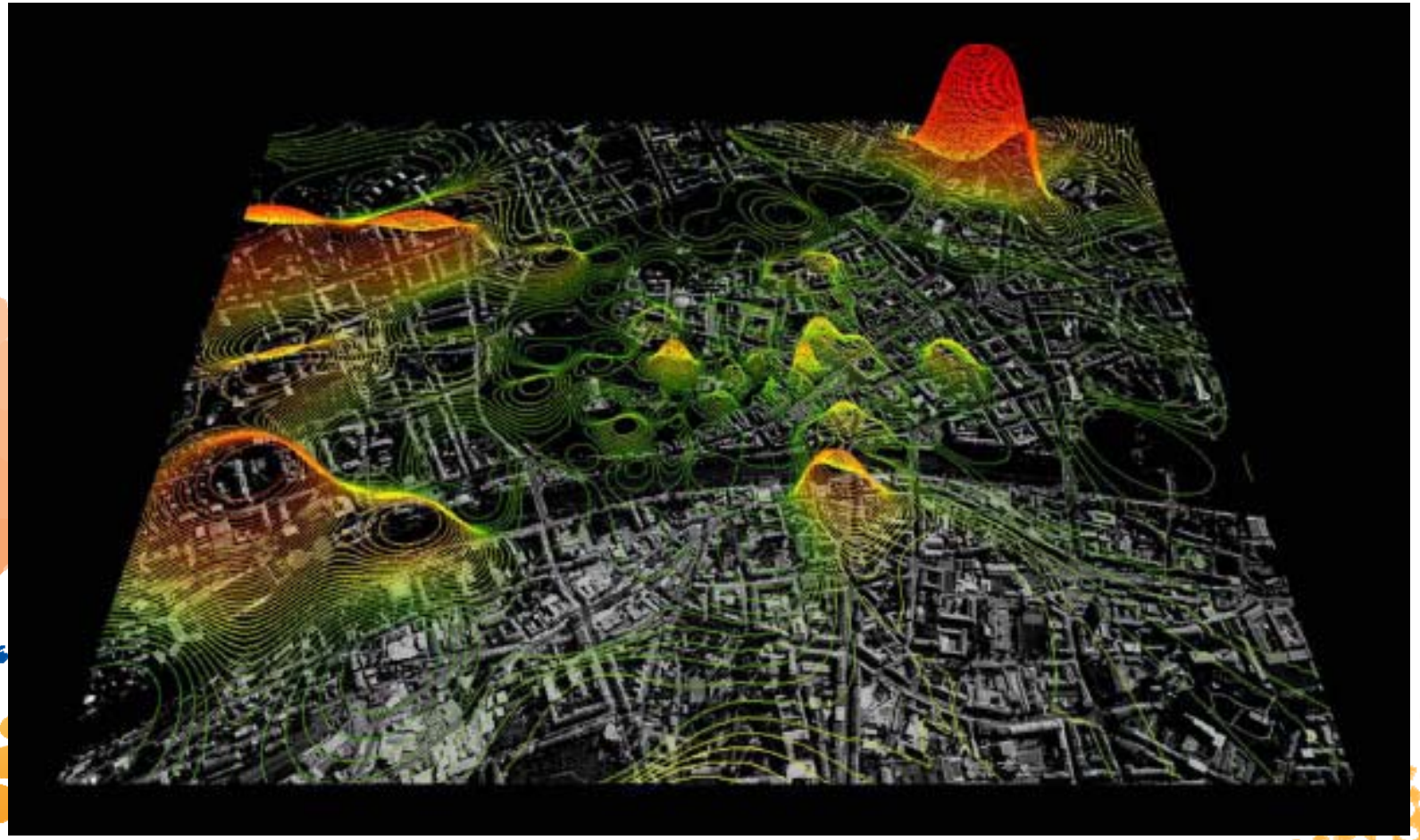
# From *time-geography*




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/

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# A paradigmatic example:

# GeoPKDD

**A European FP7 project**

www.geopkdd.eu

**Geographic Privacy-aware**

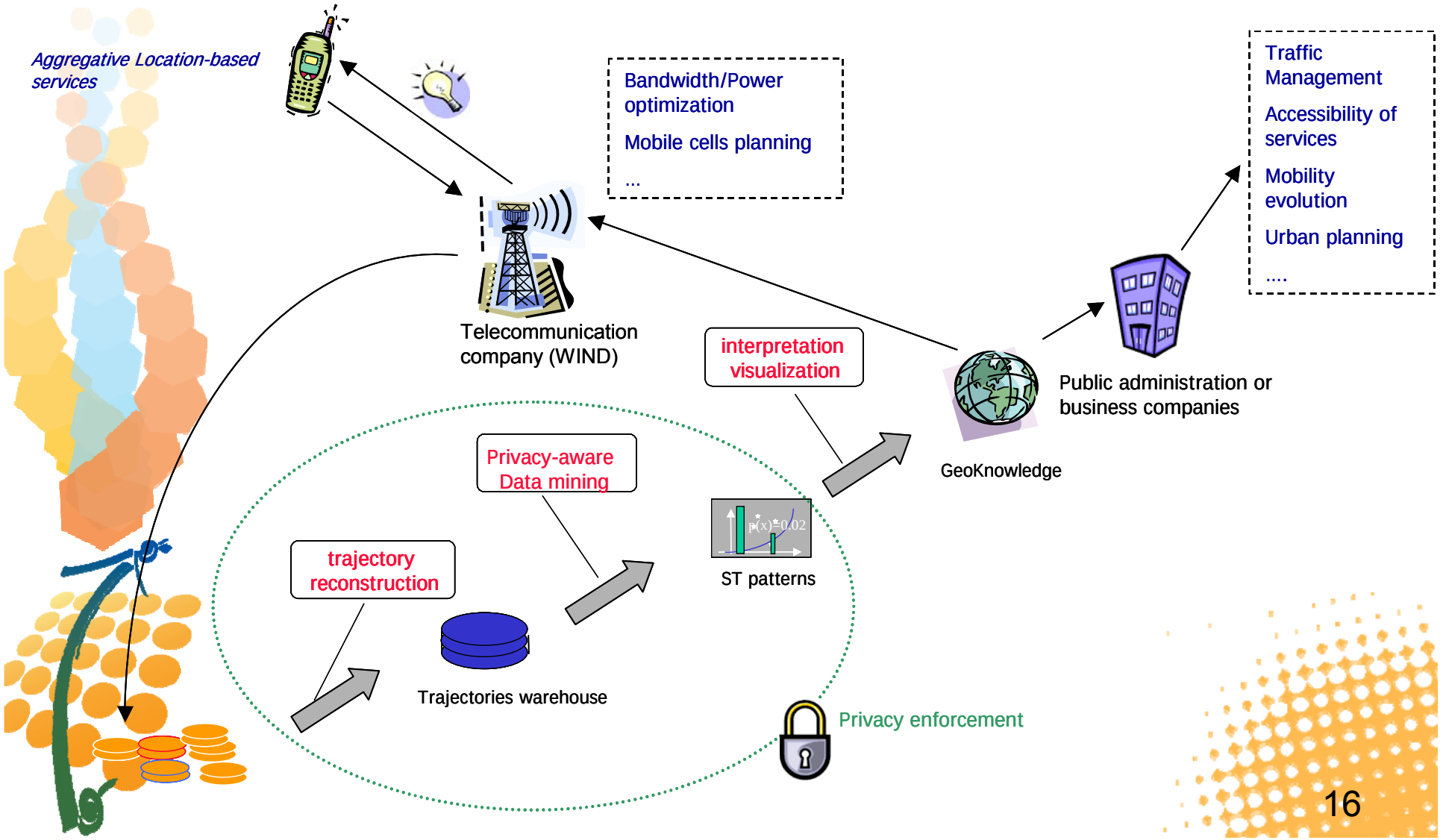
**Knowledge Discovery and Delivery**

Information Society
Technologies

# 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

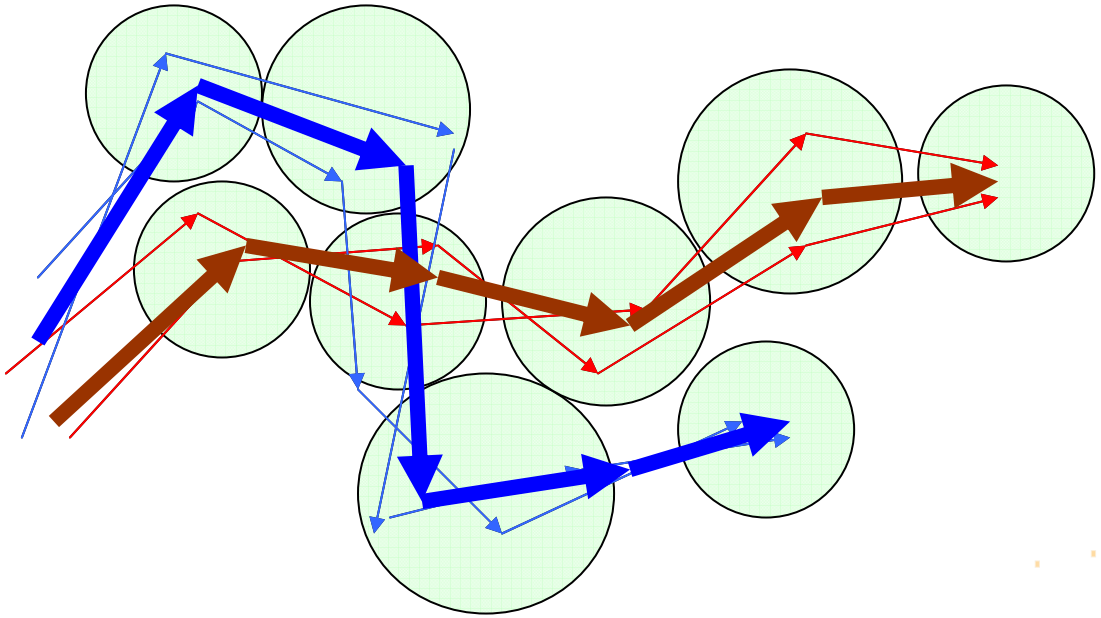


# From movement data to movement patterns

# From movement data to movement patterns

# Mining Trajectories: Clustering

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



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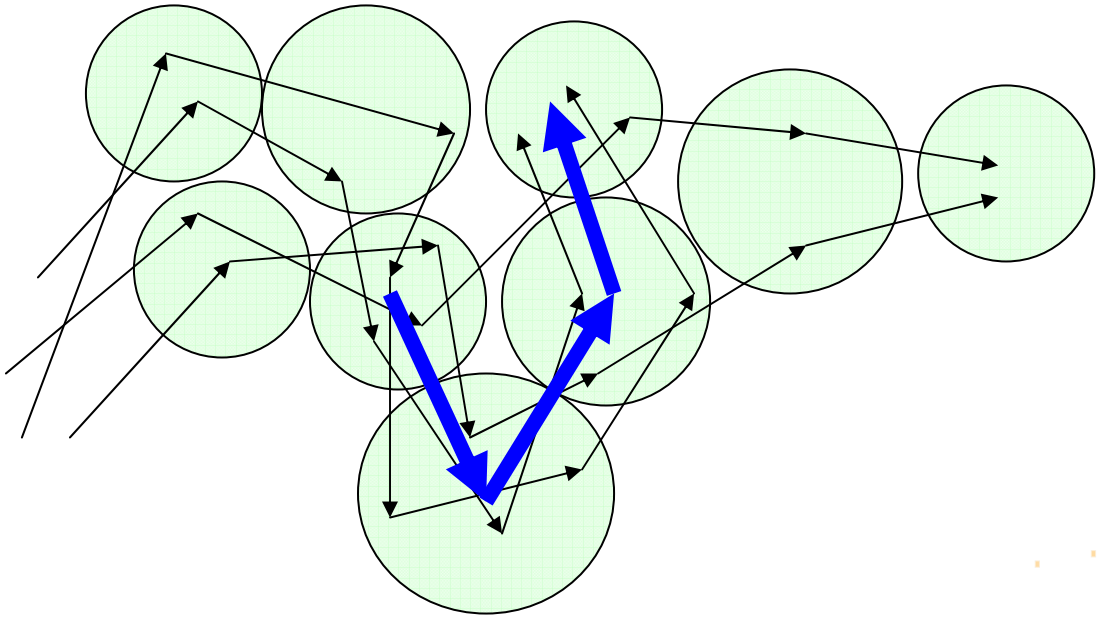
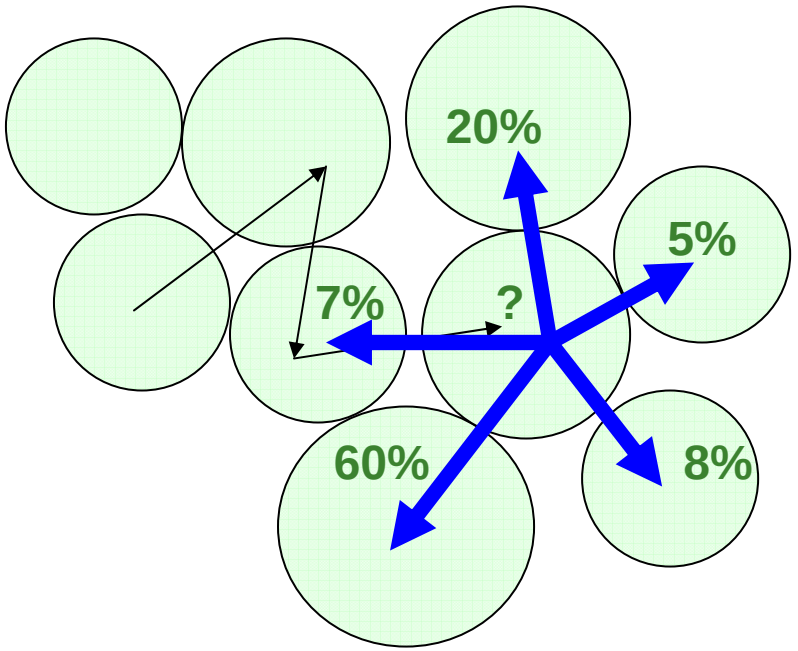
# Mining Trajectories : Frequent patterns

- Discover frequently followed (sub)paths



# Mining Trajectories: classification models

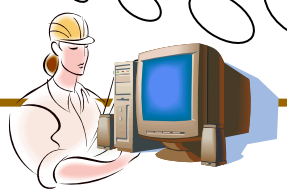
- Extract behaviour rules from history
- Use them to predict behaviour of future users



# The GeoPKDD impact

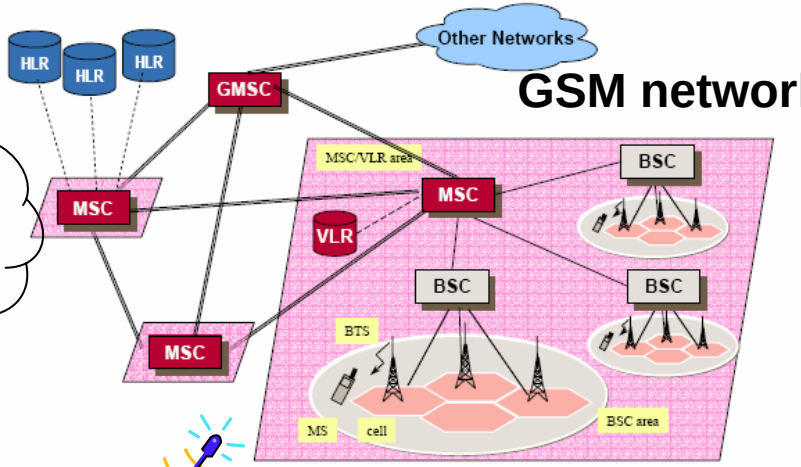
- Improving decision-making in mobility-related issues:
  - Planning traffic and public mobility systems in metropolitan areas;
  - Planning physical communication networks
  - Localizing new services in our towns
  - Forecasting traffic-related phenomena
  - Organizing logistics systems
  - Avoid repeating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

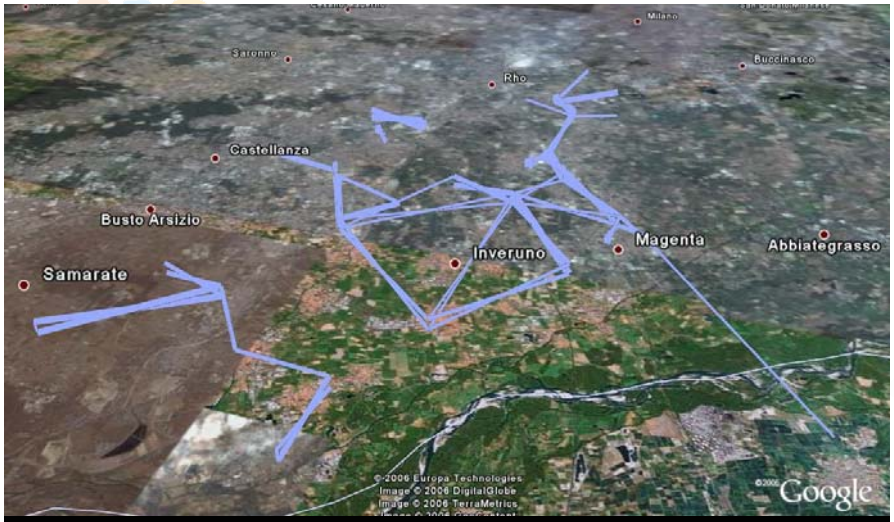
# Mobility Manager Office

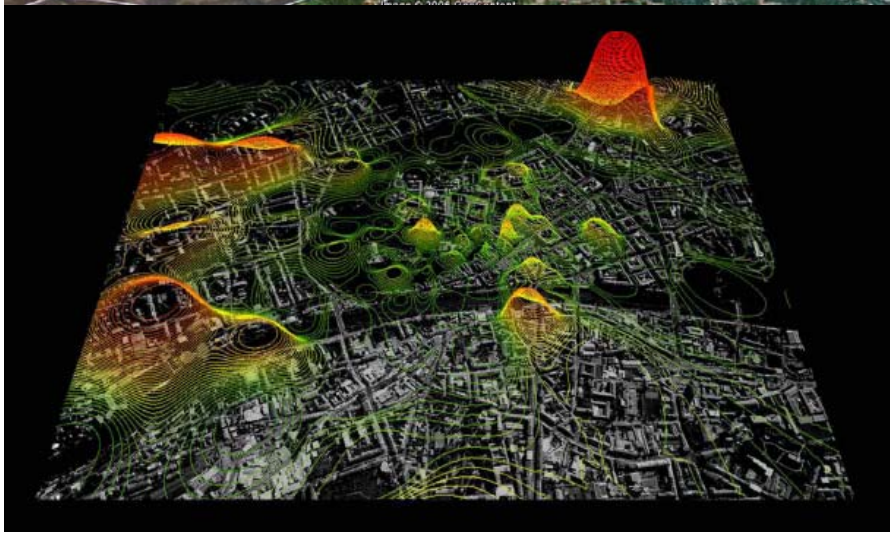


Sustainable Mobility?

## GSM network



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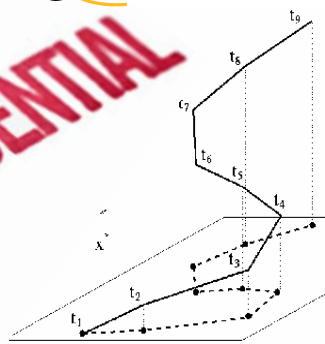
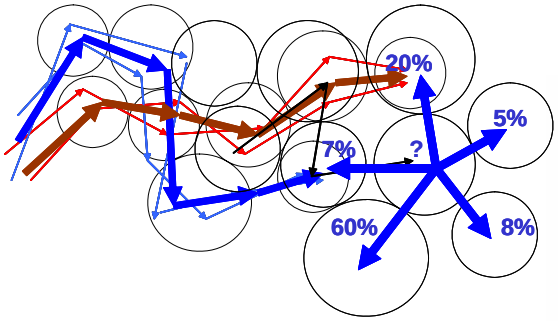
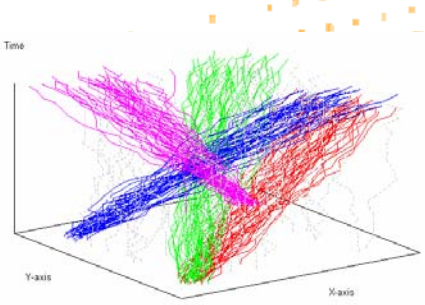


Position logs




## Mobility Models



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# From wireless networks to Ubiquitous Computing environments

- Log data from mobile phones, i.e. sampling of localization points in the GSM/UMTS network.
- Log data from GPS-equipped devices
- Log data from
  - peer-to-peer mobile networks
  - intelligent transportation environments
  - ad hoc sensor networks, RFIDs
- Increasing precision and pervasiveness

# Intelligent Transportation & Infomobility

# Plan of the talk (Mobility Data Analysis)

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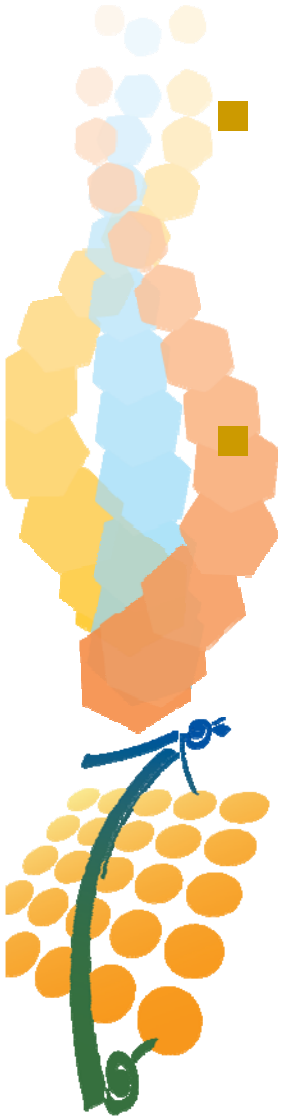
# Why emphasis on privacy?

- 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

# Ethical, Legal and Sociatal Privacy Issues in GeoPKDD

- Harmonization with national privacy regulations and authorities – **privacy observatory**
- Privacy Observatory (see our last talk)