

Human 4.0: the influence of digitalization on human beings

Mathematical modeling of human behavior: from data to applications

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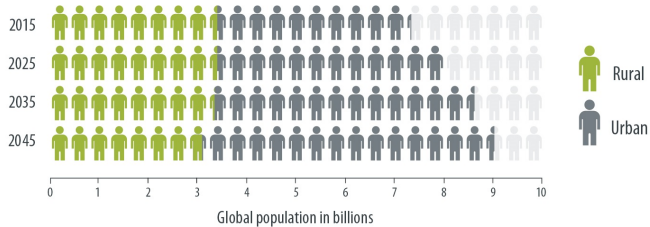
November 21, 2017

From data to knowledge



Urbanization

- 1950: **30%** of the population lives in cities
- 2014: **54%** of the population lives in cities



Source: UN World Urbanization Prospects: 2011 Revision

Smart city: Application of IoT



Challenges

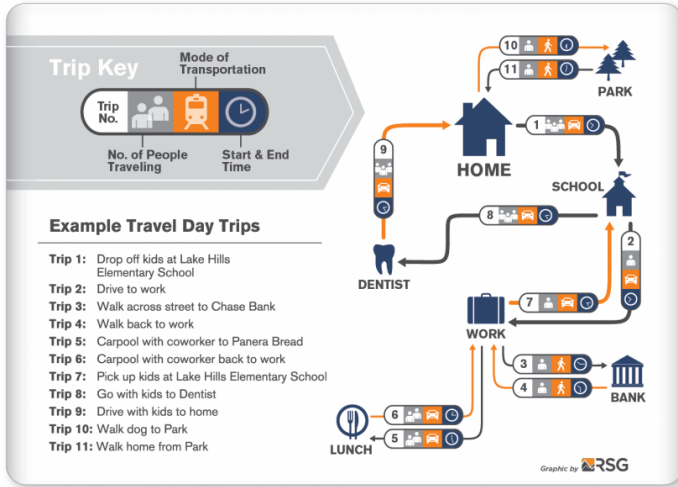
- Climate change
- Energy consumption and pollution
- Increased traffic and congestion

Solution

- Data availability
- Networked technologies

Transportation and mobility

Traditional data sources: Travel surveys



Drawbacks:

Biased response

No response

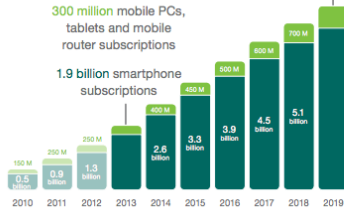
Erroneous reporting

Modern data sources: Smartphones



Smartphones, mobile PCs, tablets and mobile routers with cellular connection

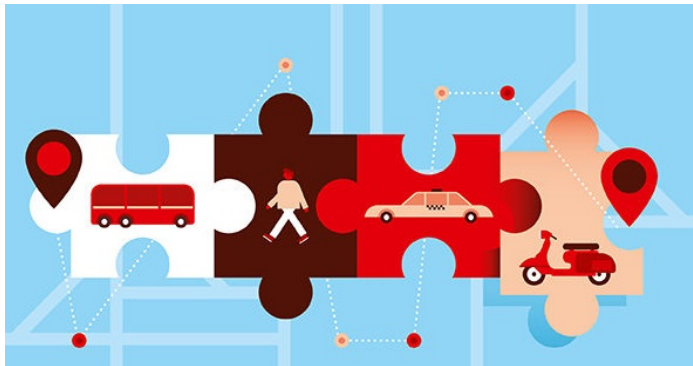
800 million mobile PCs, tablets and mobile router subscriptions



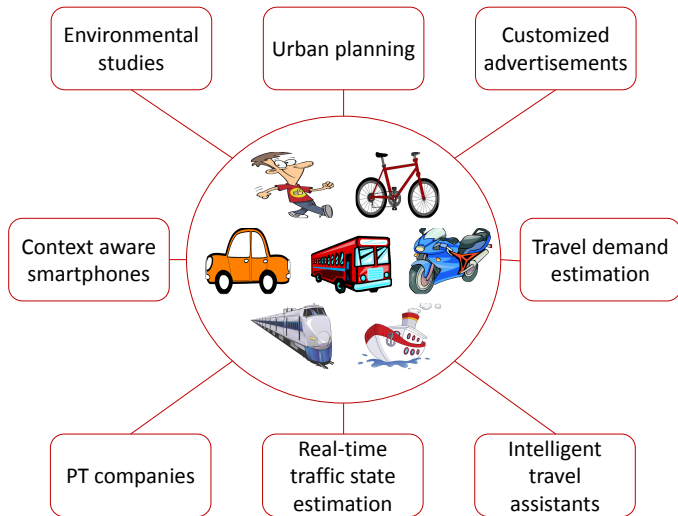
5.6 BILLION
smartphone subscriptions
by the end of 2019

■ Mobile PCs, tablets and mobile router subscriptions
■ Smartphone subscriptions

From smartphone data to transportation mode detection

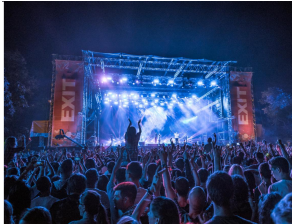


Transportation mode detection: Applications



Pedestrian movements

Congestion



Research challenges

- Understand, describe and predict
- Optimization of current infrastructure and operations
- Efficient planning and management of future pedestrian facilities

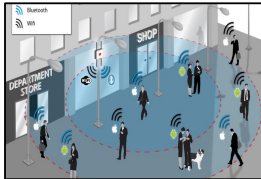
Data sources



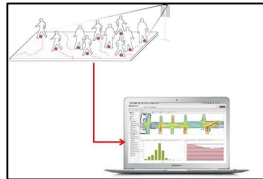
Survey



Counts

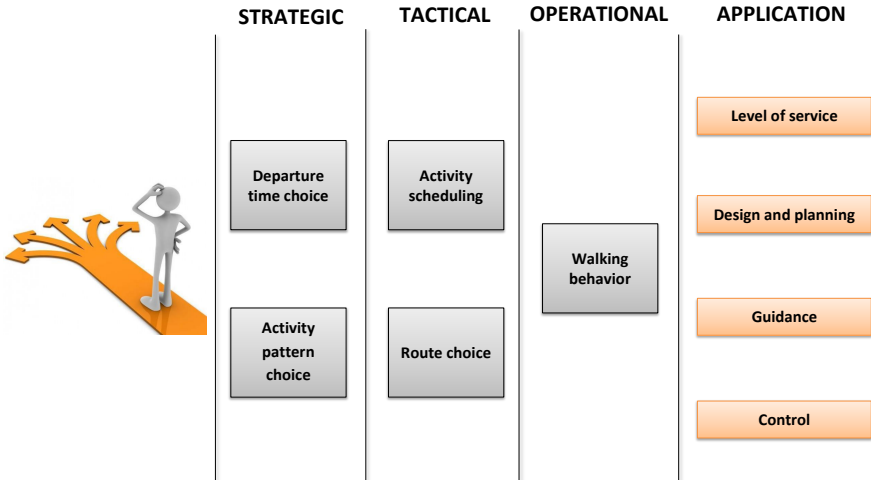


Wireless technologies



Automated detection and tracking

Models and applications



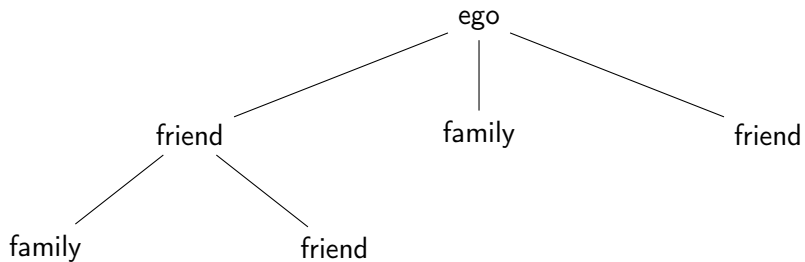
An example: reconstructing actual itineraries

Nokia data collection campaign

- Funding source: Nokia Research Center (NRC) at EPFL.
- Participants: About 185.
- Since: September 2009.
- Phone: Nokia N95.
- Collaborators: NRC Lausanne, IDIAP (Switzerland).

Recruitment

Snow ball sampling



Participants

- About 185 participants.
- Mostly from Lausanne area.
- $\sim 1/3$ females.
- $< 1/4$ students.

Privacy and security

- Data is owned by participants. They can delete their data from DB A.
- The campaign is permitted and controlled by an ethical committee.
- Nokia and authorized research partners (in CH) get access to the data.

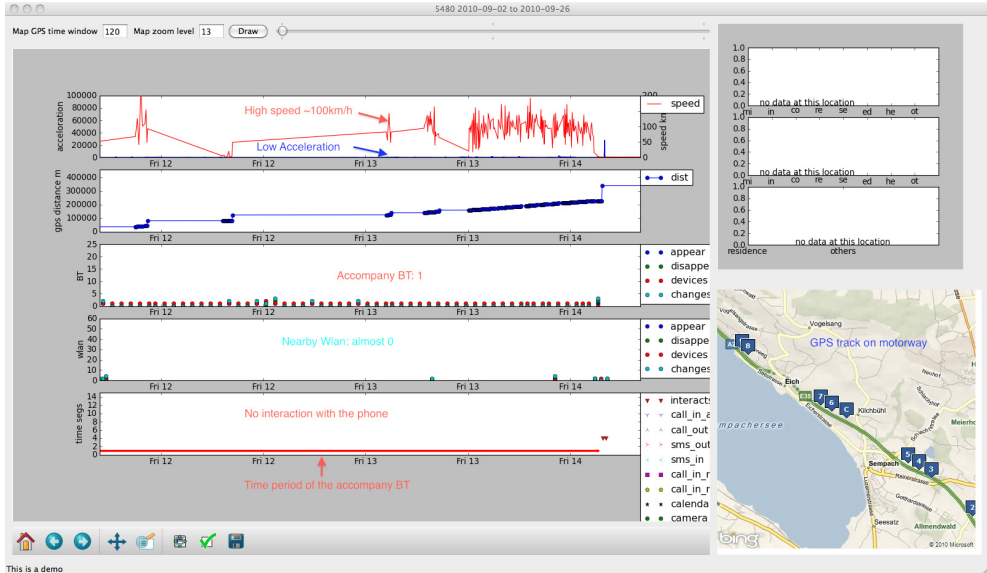
It took **ONE YEAR** for EPFL to get data access (although data had already been in Nokia's databases).

Data volume

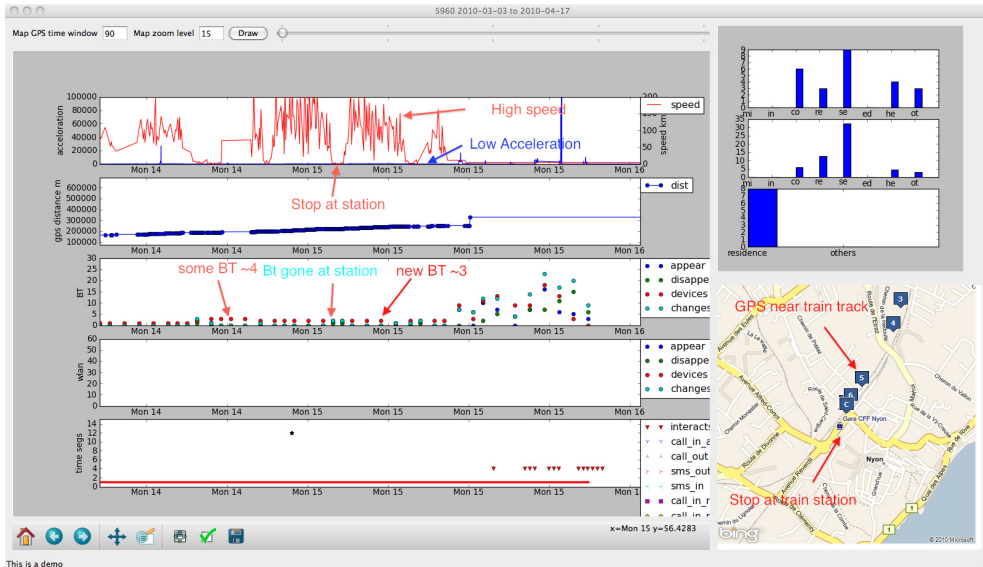
~ 150k-entries/100MB of data per user per month

Number of GPS points	11,531,652
Number of calls	247,448
Duration of calls	6,903h
Number of sms	179,358
Number of video made	3,890
Number of pictures taken	54,537
Number of unique BT	543,517
Number of unique WIFI	572,910
Number of unique cell towers (63 countries)	100,505
Number of unique cell towers (CH)	28,945
Number of acceleration samples	1,344,198
Number of application events captures	8,280,554
Number of phone book entries	115,134

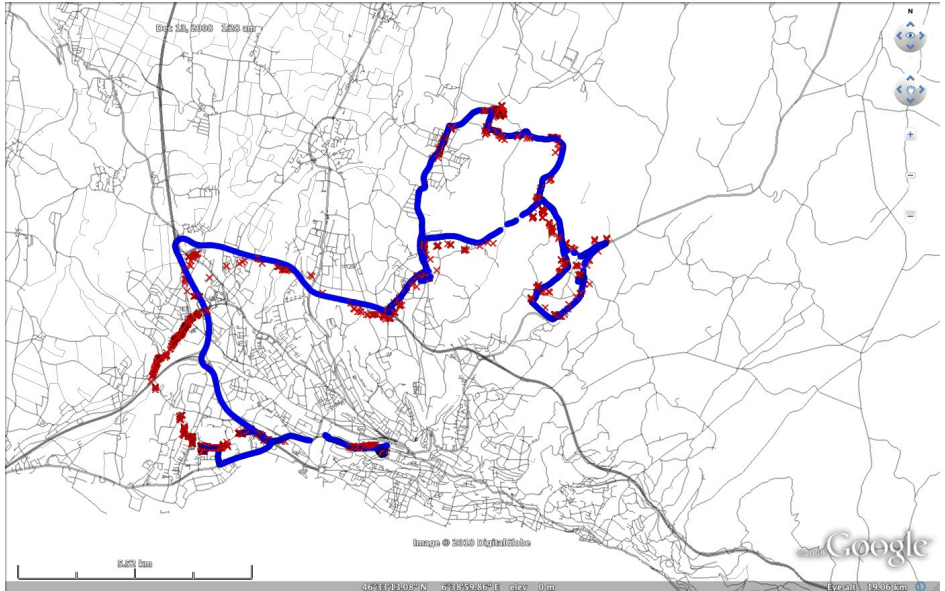
Mobility patterns: car



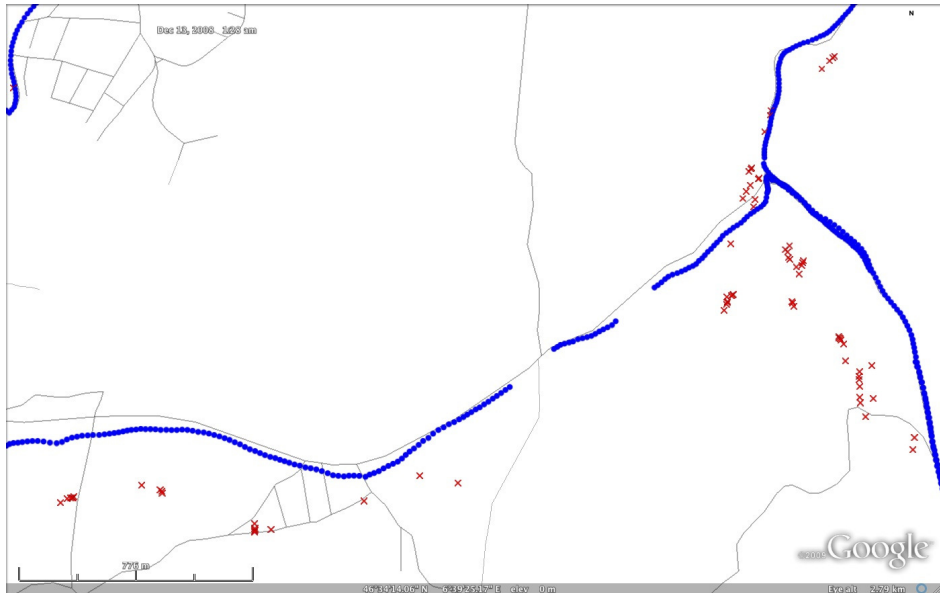
Mobility patterns: train



Issues



Issues



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- Low data collection rate to save battery (every 10 seconds)
- Inaccuracy due to technological constraints
- Smartphone carried in bags, pockets: weaker signal
- Map matching algorithms do not work with this data

Conclusions

SWOT

Strengths

- Pervasive
- Non intrusive

Opportunities

- Your phone at your service
- Your phone must understand your preferences

Weaknesses

- Data \neq information \neq decisions
- Big data \neq useful data

Threats

- Privacy
- Biases