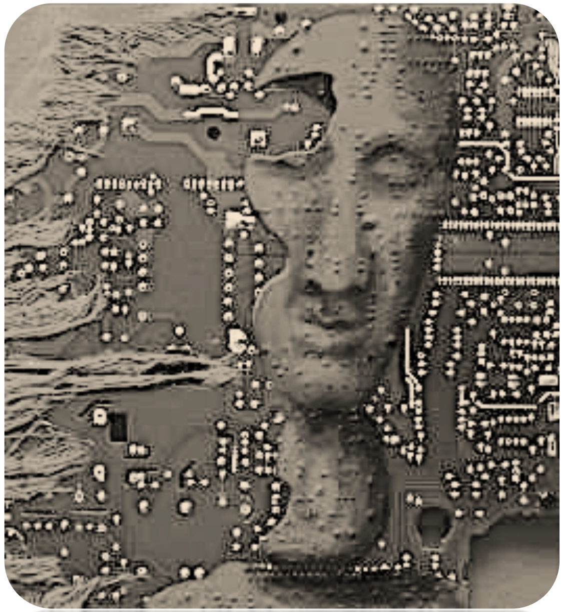
Incorporating Travelers' Mental Representations in Route Choice Modeling

Evanthia KAZAGLI
TRANSP-OR, EPFL



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Mobility Modeling and Big Data Sources
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Outline

- Background
- Trends and current state of the art
- Methodology
- Nokia smartphone dataset
- Conclusion

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Route choice

Identifying the route that a given traveler would choose to go from one location (origin) to another (destination) in a transportation network.

$\Longrightarrow$ Discrete choice analysis

Choice Set (CS): group of alternatives from which a traveler will choose.

Route choice behavior

Frejinger, 2008; Prato, 2009

Probably the most challenging aspect of travel behavior.

Challenges related both to generating the *CS* and to *estimation*:

- High requirements in ***data*** and data processing;
- Physical overlap of paths;
- Size and composition of choice set.

But what is a route?

How does the modeler represent the route?

How does the modeler model the route?

How does the traveler perceive the route?

Think (perceive)

?

How does the traveler choose the route?

Behave (choose)

?

KNOWLEDGE CONSIDERATION

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Trends

Prato, 2009

Past: Focus on enhancement of stochastic route choice models (RCM).

Present: Move towards simplifying models; more realistic behavioral assumptions and enhancing the CS generation.

Issues amount and quality of data; relevance and efficiency measures of the generated CS.

$\Longrightarrow$ Exploit new generation of data.

Current state of the art

<u>Data</u>

- Frejinger, E. (2008). Network free data.
- Chen, J. (2013). Probabilistic map-matching.

<u>Path generation and sampling of alternatives</u>

- Frejinger, E. (2008). Random walk algorithm for importance sampling.
- Flötteröd, G., Bierlaire, M. (2013). Metropolis Hastings sampling of paths.

<u>Correlation</u>

- Frejinger, E. (2008). Sub-networks.

<u>Spatial knowledge</u>

- Ramming, M. (2002). Incorporating network knowledge factors.

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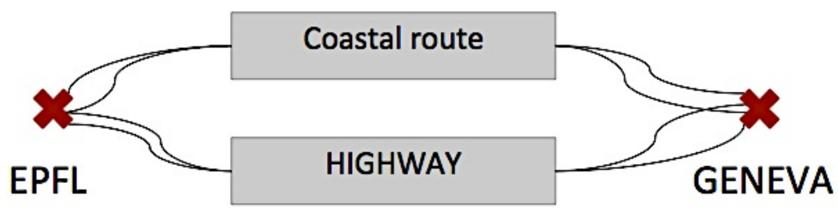
Behavioral hypothesis

Being in the shoes of the drivers motivates a less rigid definition of routes.

⇒ Representation –and modeling– of routes in a higher conceptual level as sequences of *items (anchors)*.

⇒ NOT a path but an item sequence.



Methodological approach

Hypothesis: Not a path but an item sequence.

✓Our own methodological framework and definition;

✓Realistic and operational;

➢ Challenges: definition of items and assign attributes to them; hierarch; match with the network; incorporation in the modeling framework.

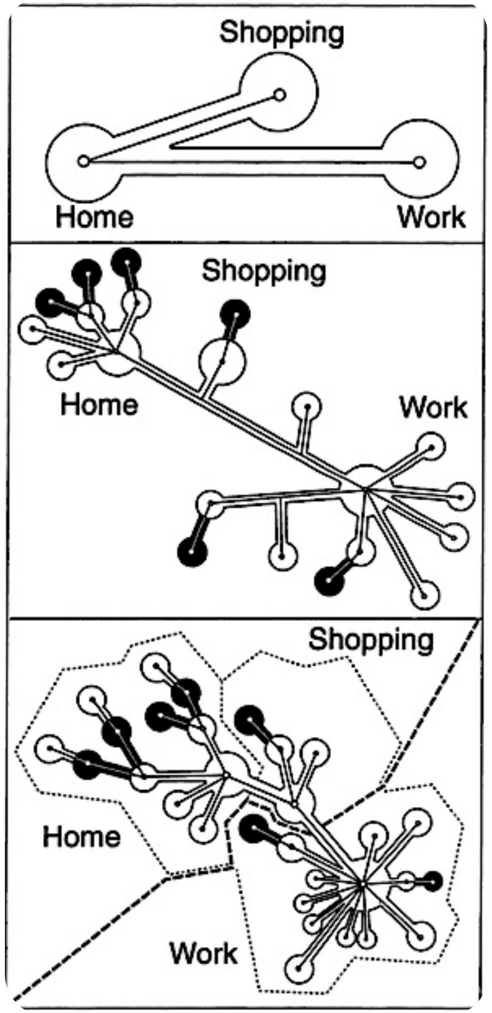
- Operationalization of concepts:
  - Combination of a methodological and a behavioral approach.

Anchor point theory (APT)

Golledge and Spector, 1978

Hierarchical ordering of locations/ areas within the spatial environment –based on the *relative* importance of each to the individual.

- Home, work, shopping places *anchor* the set of spatial information and *condition* the search for paths.
- Anchors may include other places *frequently* used by the individual.



Source: Golledge, 1999

Anchor points (APs)

Anchor nodes not as points but as areal extents that act as anchors for the rest of the cognitive map (Couclelis et al., 1987. Extention of Golledge's APT).

Dual role in the transportation environment (Golledge, 1999):

- Organizing elements of peoples *cognitive maps* → anchors
- Wayfinding (more explorative → use of landmarks)

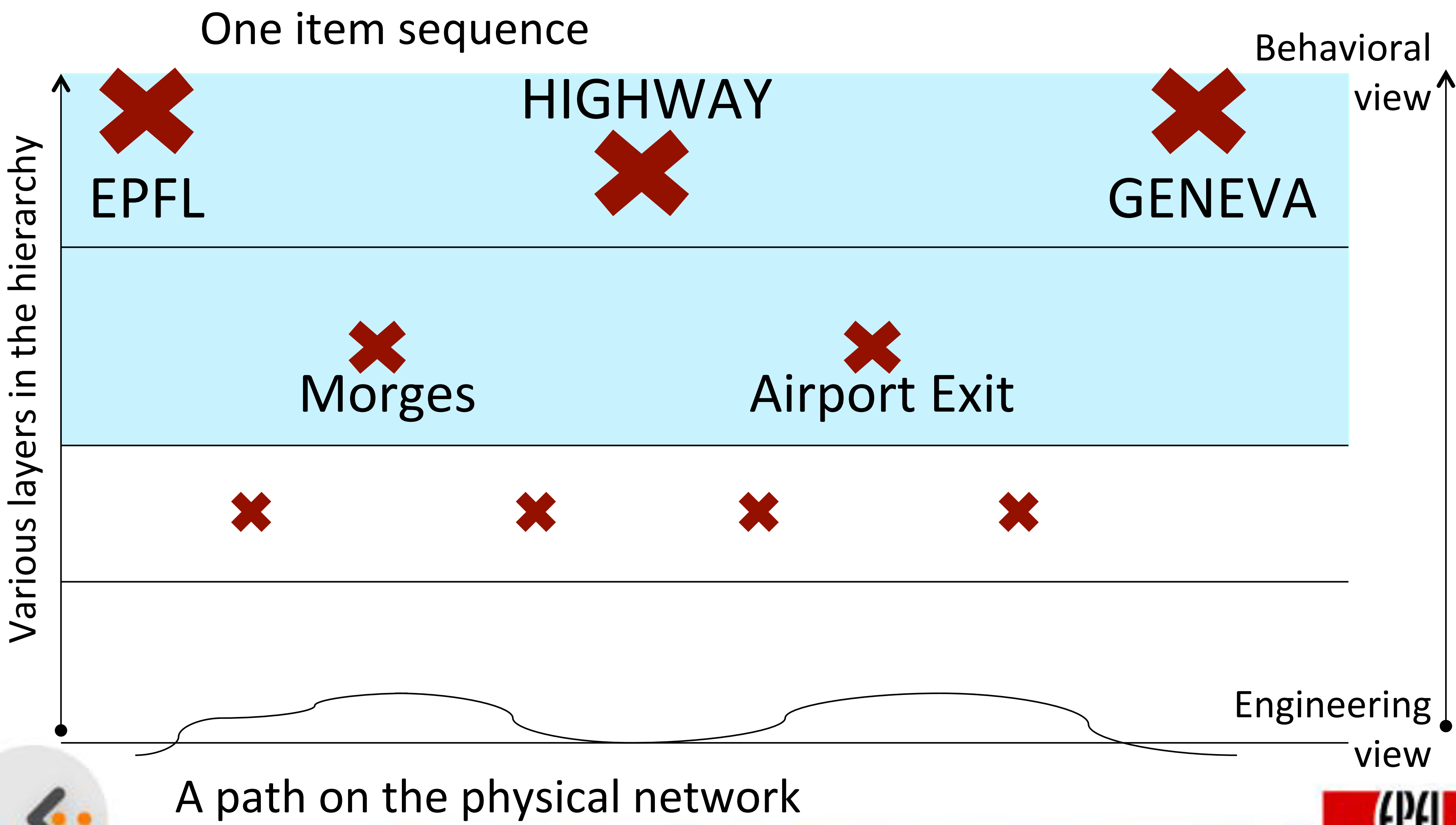
Anchor points can be demarcated in (Golledge, 1999):

- Common anchors
- Individual (personalized) anchors.

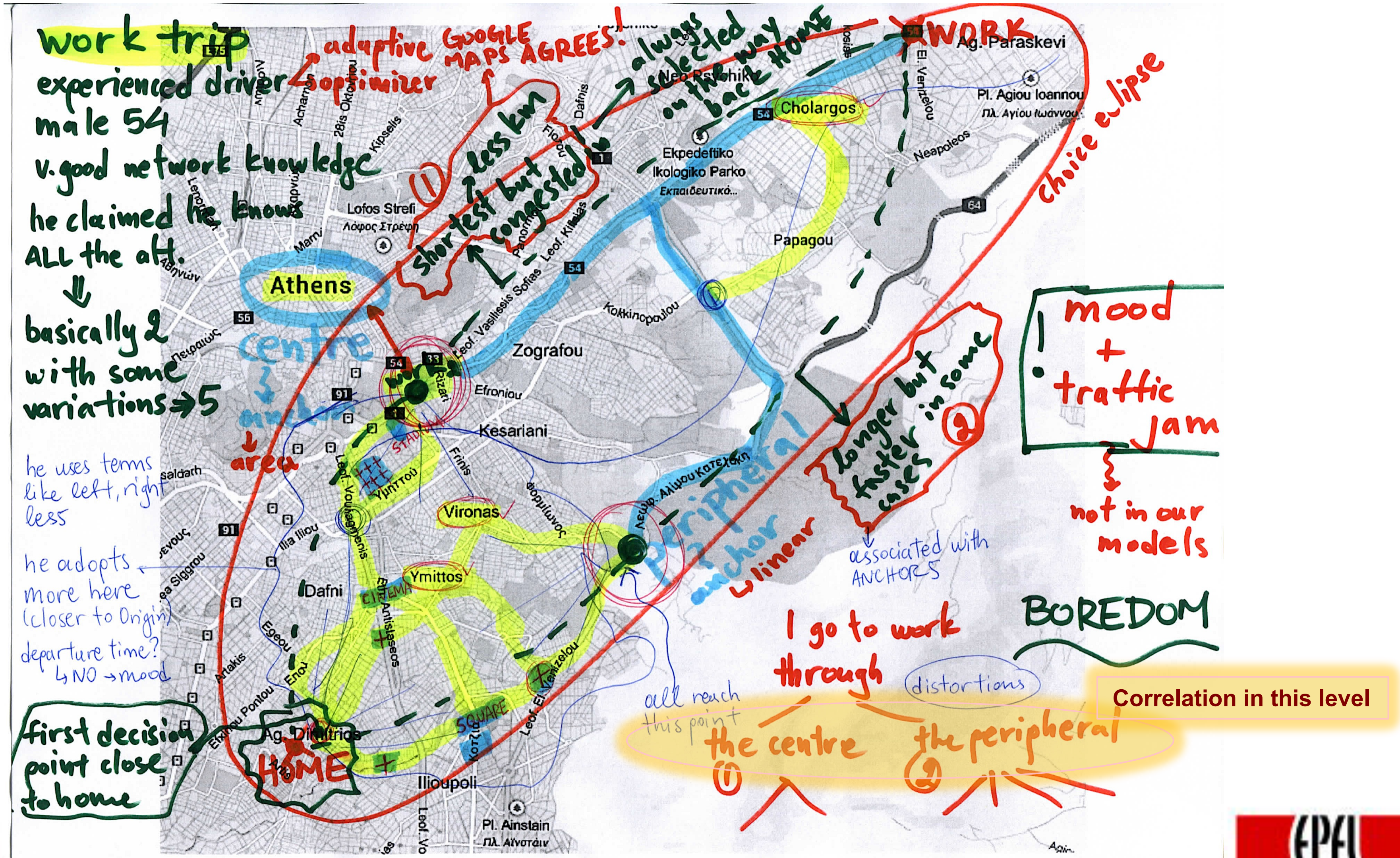
Cognitive (mental) map

- Whole of spatial and travel related information used and stored in memory (Hannes et al., 2006).
- Frame of collected memories: Mixture of qualitative and spatial information that allows us to make decisions in a spatial context (Suttles, 1972).
- Components: points, lines, areas, surfaces (Lynch, 1960).
- MAP: Does not imply that an individual has a cartographic or any other type of map in the head.

From network to lists of mental items



My dad's work trip



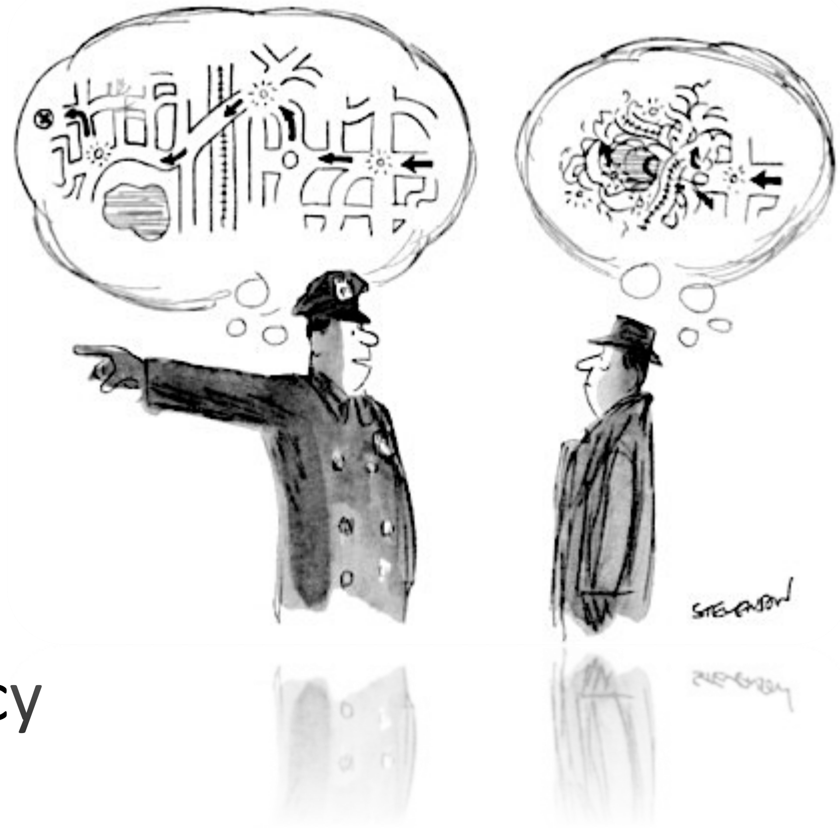
Eliciting the elements of the mental map…

Behavioral input:

- Survey

Methodological input:

- Measurement model
  - Longitudinal data: frequency
  - Network attributes
  - POI



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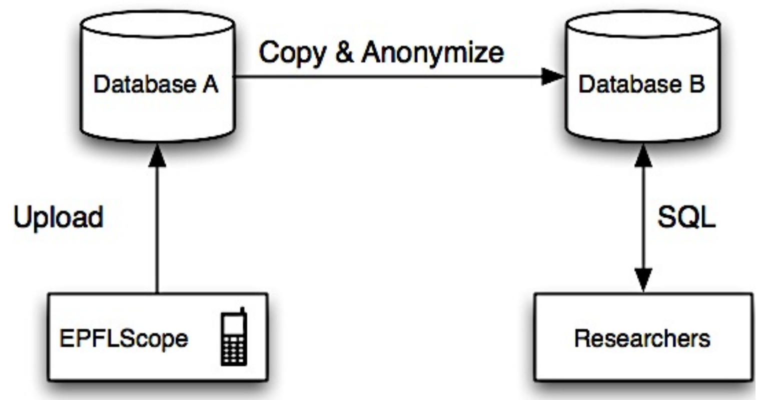
Overview of the collected data

Nokia Data Collection Campaign (LDCC), 2009-2011

- ~200 Nokia N95 smartphone users in Geneva Lake area
  - GPS points;
  - Nearby Wi-Fi and blue tooth APs;
  - Acceleration records;
  - SMS and call log records;
  - calendar entries; …



- Basic socio-economic information for 158 users
- Home, work and main grocery addresses for 21 users

Overview of the collected data (cont.)

- GPS records: 11,570,000
- BT records: 705,000
- WiFi access points: 590,000
- WiFi AP with coordinates: 403,000

Previous work on the data (Chen, 2013)

- Challenges related to measurement errors and low frequency in reported data.
- Framework to infer paths:
    - Probabilistic path observations comprising of sets of candidate paths, each associated with a corresponding measurement likelihood.
    - Extension: multimodal map-matching.

Exploiting the smartphone data: HOW?

Map-matched GPS trajectories

"Well-known and frequently used path segments provide linear anchors for portions of cognitive maps. Thus internal spatial representations of what is known about surrounding networks influences the choice of routes to be followed for any given trip purpose". (Golledge, 1999)

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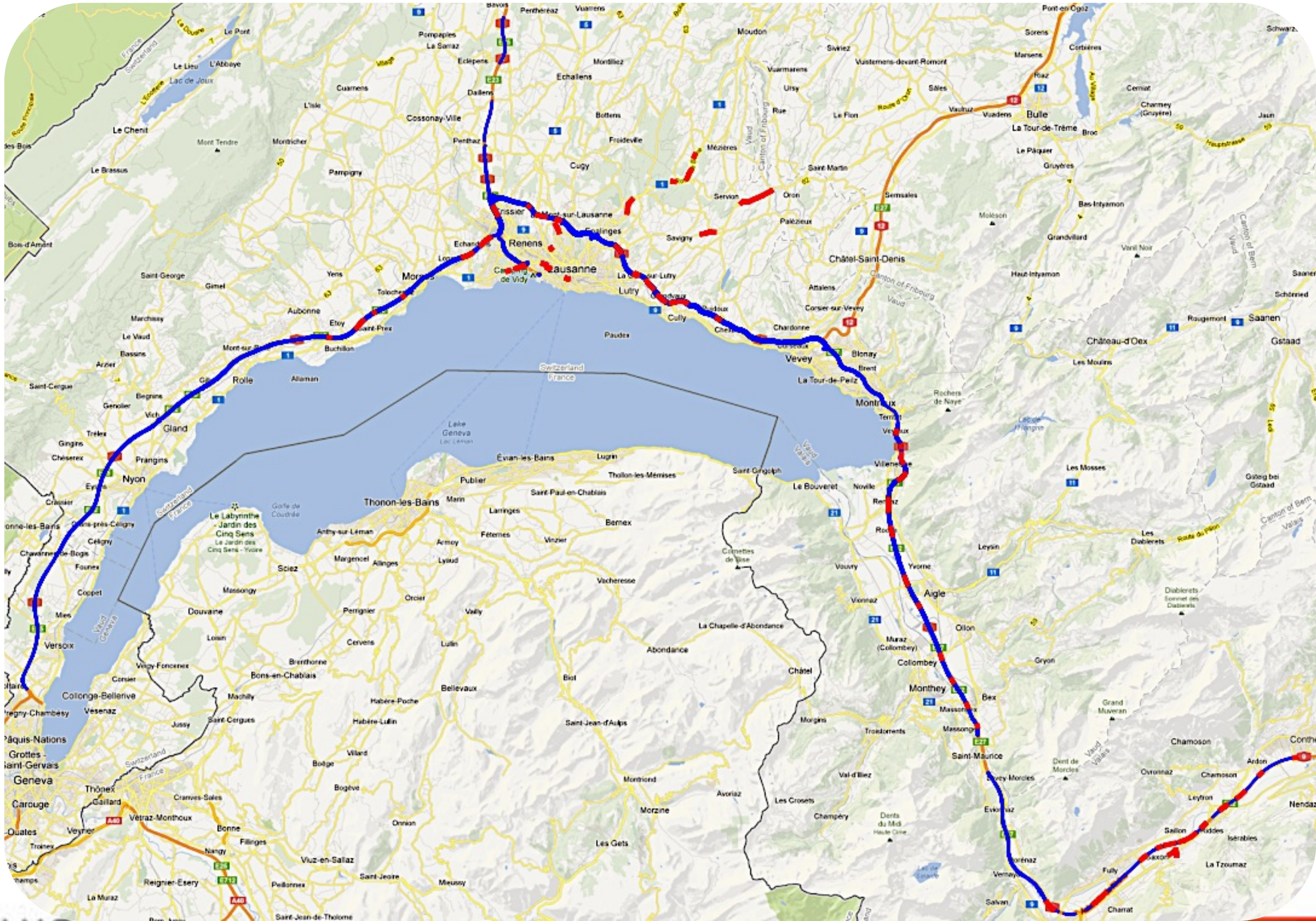
Most visited links by all users (min. 30 distinct users)

Common anchors

Most visited links by all users and 5 most visited per user (min. 10 visits)

Common and individual anchors



Exploiting the smartphone data

WiFi records. Complementary to GPS!

Most frequently viewed WiFi access points per user. Can we assign a meaning to these locations (Buisson, 2013)?

- ✓ Using temporal and spatial dimensions we extract home and work location!
- ✓ Trip purpose is missing. Maybe we can exploit the WiFi records to infer it.

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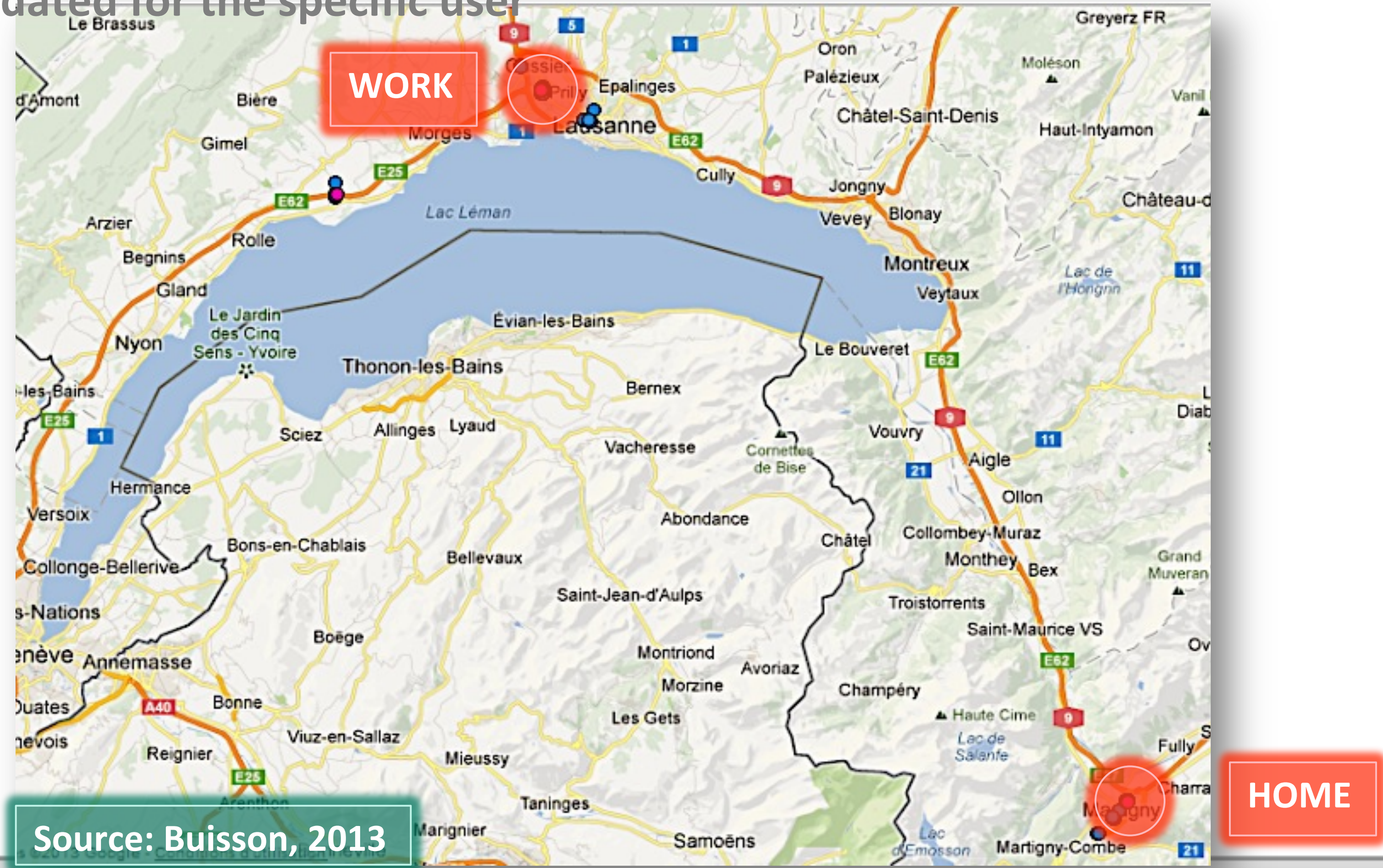
Exploiting the smartphone data (cont.)

Example: Most viewed WiFi access points for a specific user

Source: Buisson, 2013

Exploiting the smartphone data (cont.)

Example: Validated for the specific user



Source: Buisson, 2013

User id	Hour of the day																							
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
5976																								

Exploiting the smartphone data (cont.)

WiFi records. Complementary to GPS!

Problems with GPS records:

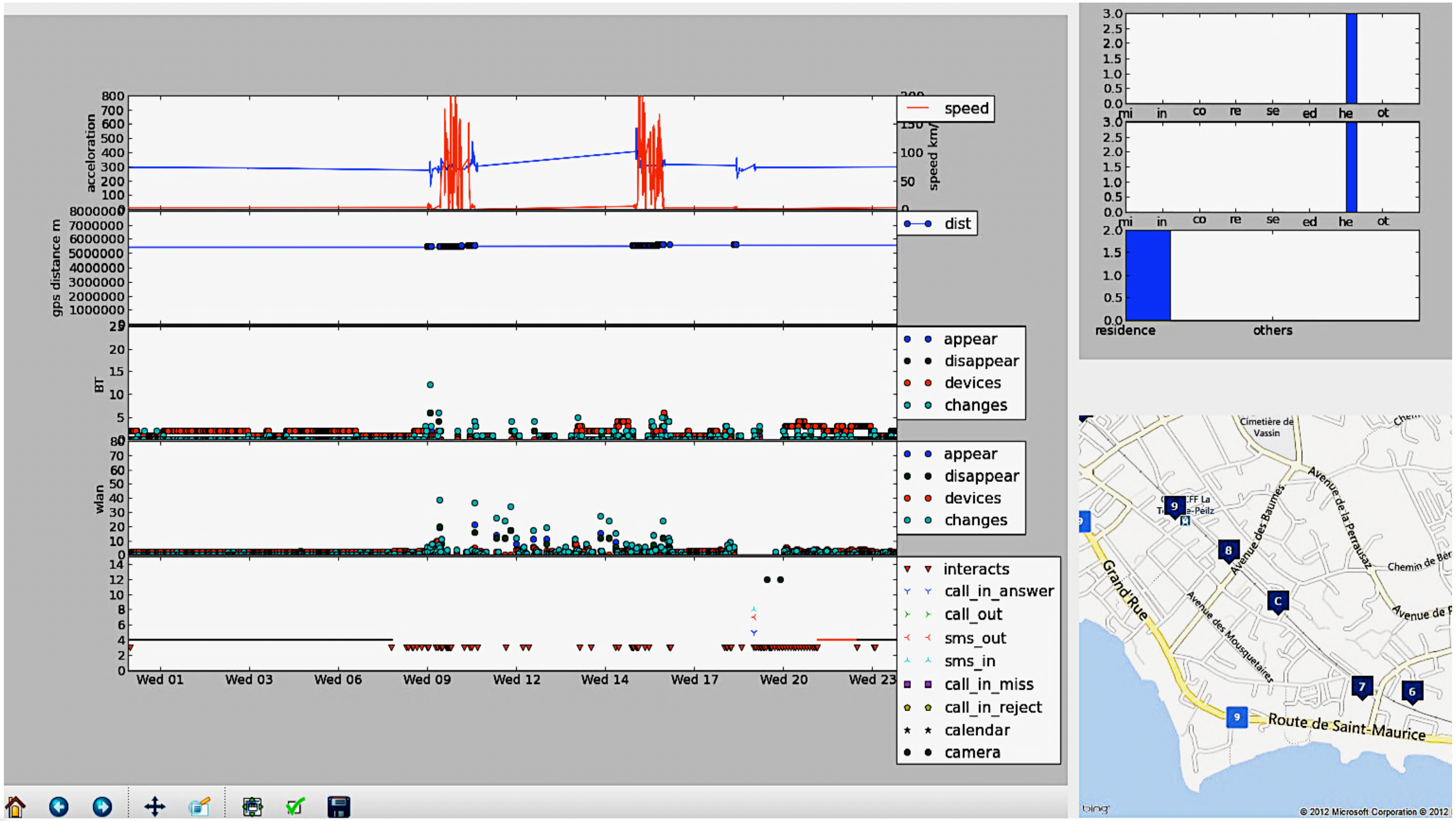
- Missing the beginning and end of trips;
- Errors in the trip identification algorithm.

↓

WiFi records:

- Clustering to infer home and work location according to time pattern;
- Trip detection based on detected clusters.

Data visualization (one day)



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Conclusion

✓ More *realistic* representation of the man-environment interface

✓ Simpler: Attempt to break down the combinatorial complexity in RCM

✓ Consistent with behavior

➢ Identification issues

➢ Hierarchy of items

➢ Assignment of attributes → establishment of links to behavior

⇒ Exploratory work

⇒ Toy example to illustrate the concept and the model specification

⇒ Pilot survey to gain insights

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Route choice

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A picture is worth a thousand words...