Preliminary Exploration of Pedestrian Destinations using Traces from WiFi Infrastructures

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STRC 2012

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Presentation Outline

1. Motivation
2. Data collections
3. Discriminating destinations from signals
4. Future works

1. Motivation

Destinations of pedestrians

- Input for destination choice analysis
- Input for route choice analysis
- Input for pedestrian OD matrix

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Pedestrian data collections

Depends on scale and information you're interested in:

- Dedicated GPS
- Smartphones
- Manual counting
- Single-row laser-range scanners (LD-A)
- Pedometer
- Eye-tracking
- Cameras
- GSM

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How to measure pedestrian destinations?

- Cameras
  - Privacy issues
  - Need of a large coverage
- Smartphones
  - Mode detection
  - Acceptance by the user

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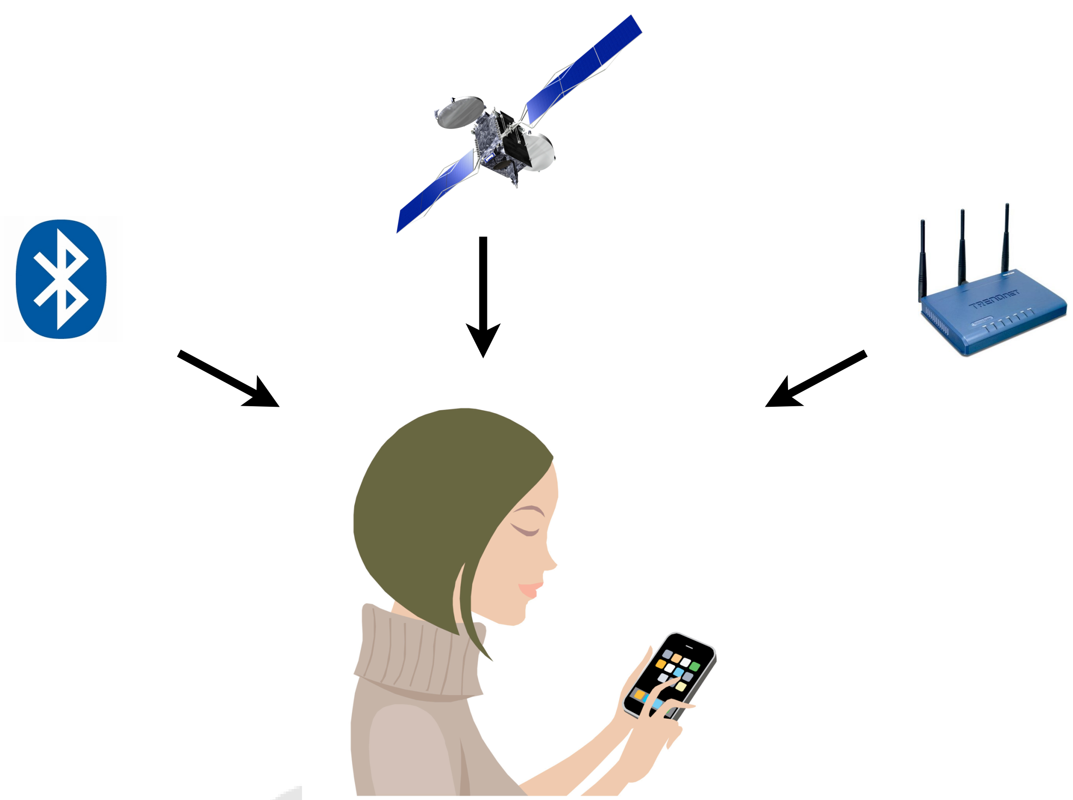
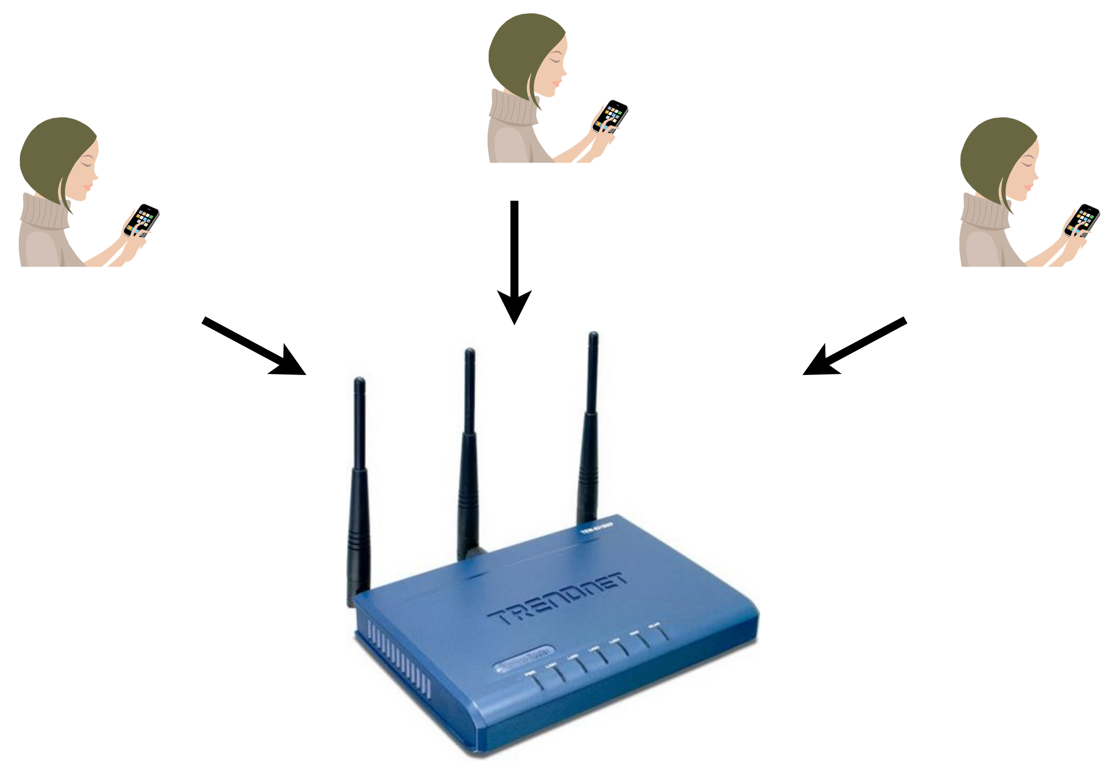
Approach

Everybody has a smartphone in the pocket

Device-centric



Communication infrastructure



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Traces from WiFi infrastructures

- Available in most campuses, transportation hubs, shopping centers and city centers
- Mode is mostly walking in these contexts
- No additional costs required

Literature

- Traces from communication infrastructure used with cell towers (Calabrese et al., 2011)
- With WiFi, destinations are APs or aggregation of APs (Aschenbruck et al., 2011)

2. Data collections

EPFL campus

- Access to WiFi infrastructures
- Most people on campus are pedestrians
- Precise map of campus available

Data collections

- 2 data collections using WiFi infrastructures at EPFL:

  1. Access points data:
     localization of the AP to which a user is connecting (anonymously for all users)

  2. Cisco Context Aware API:
     triangulation based on signal strength (for 12 known participants)

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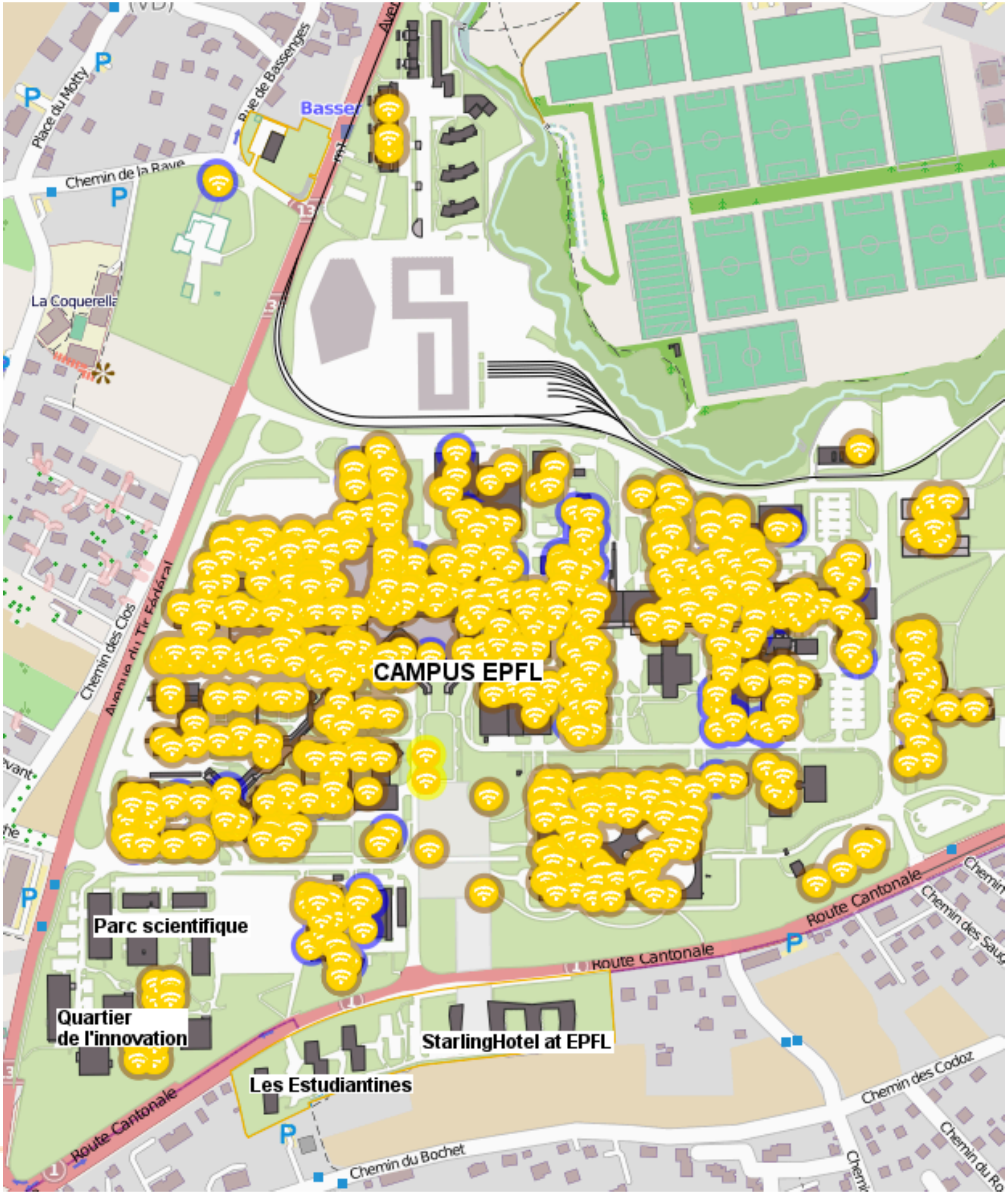
789 APs



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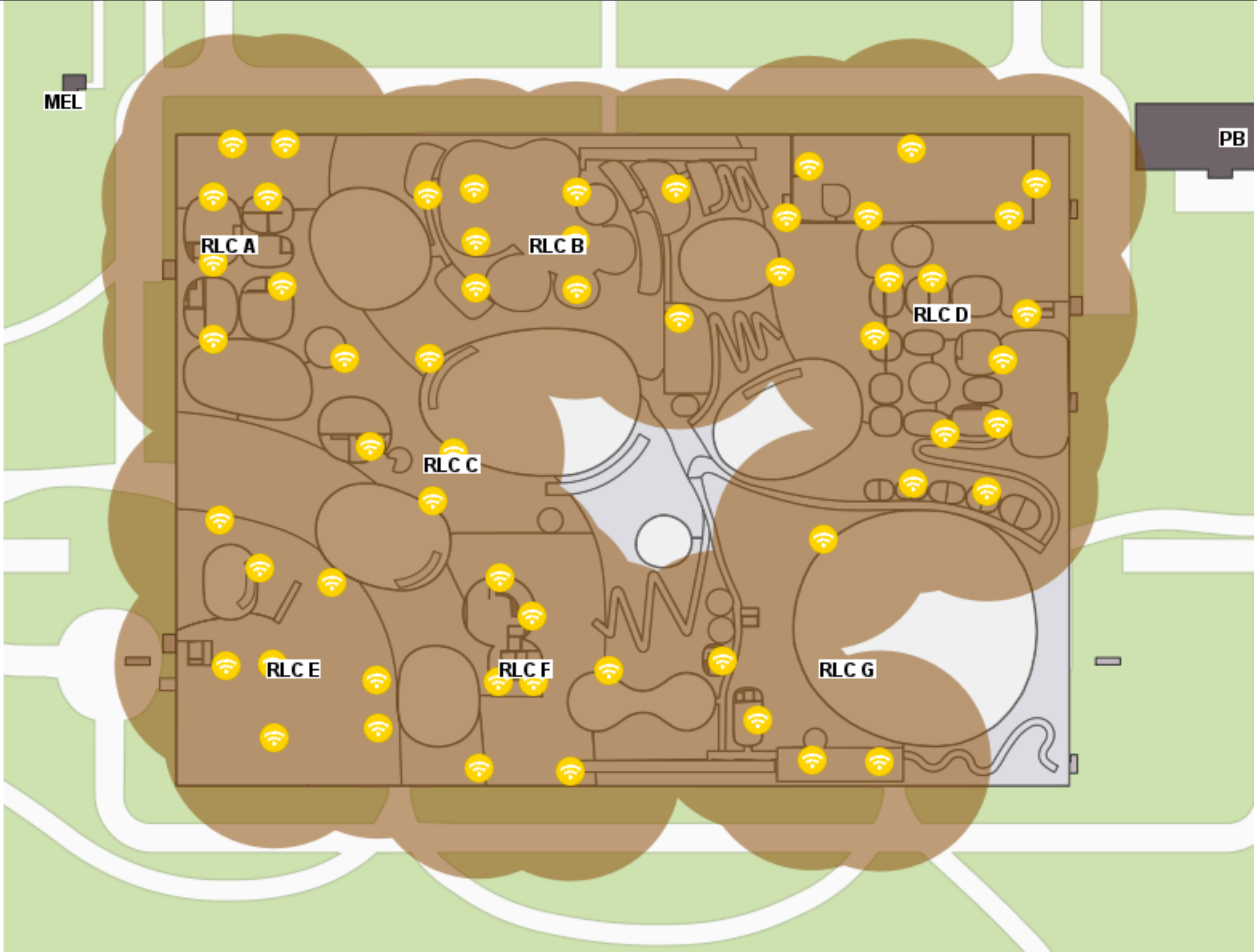
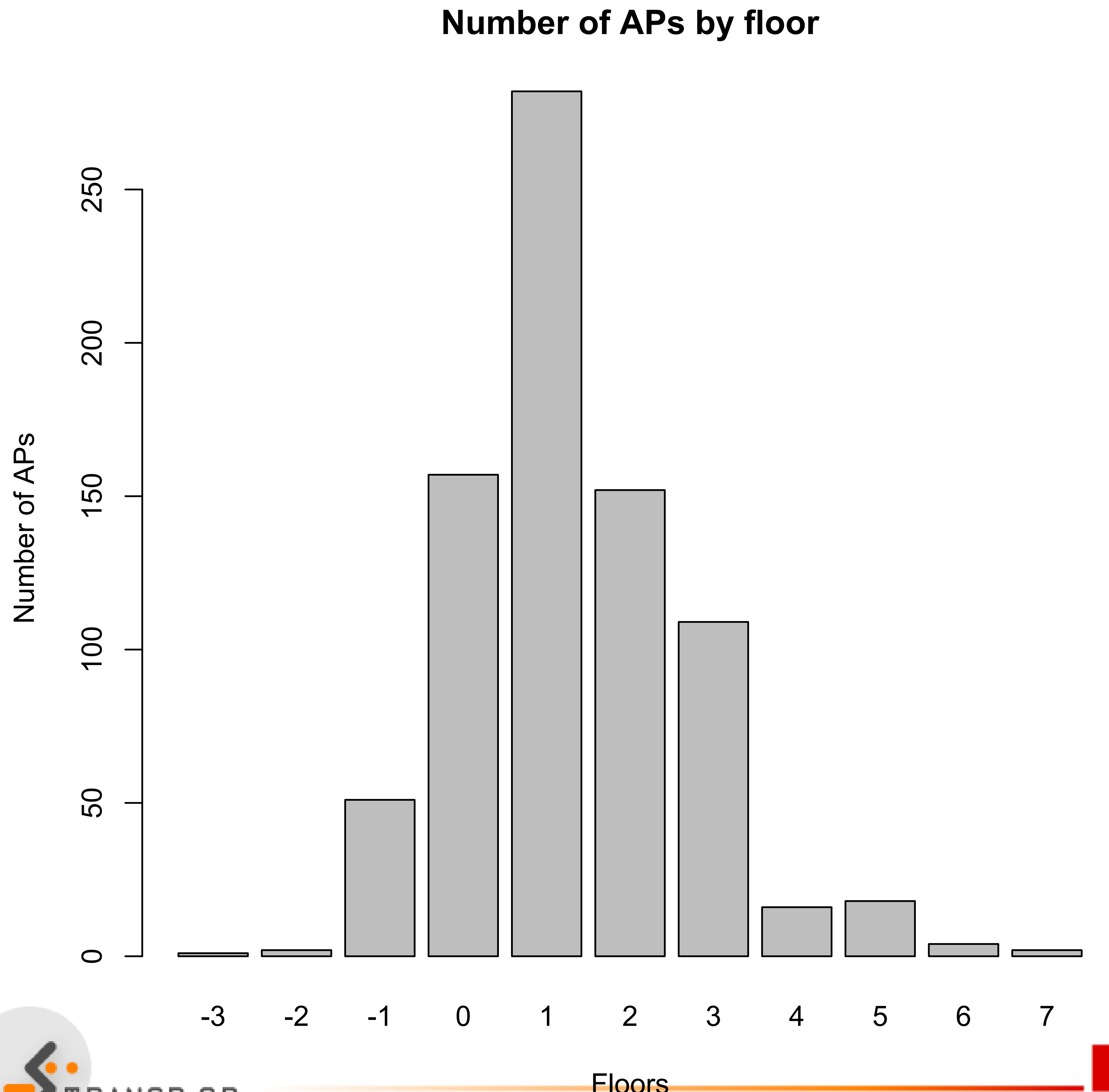
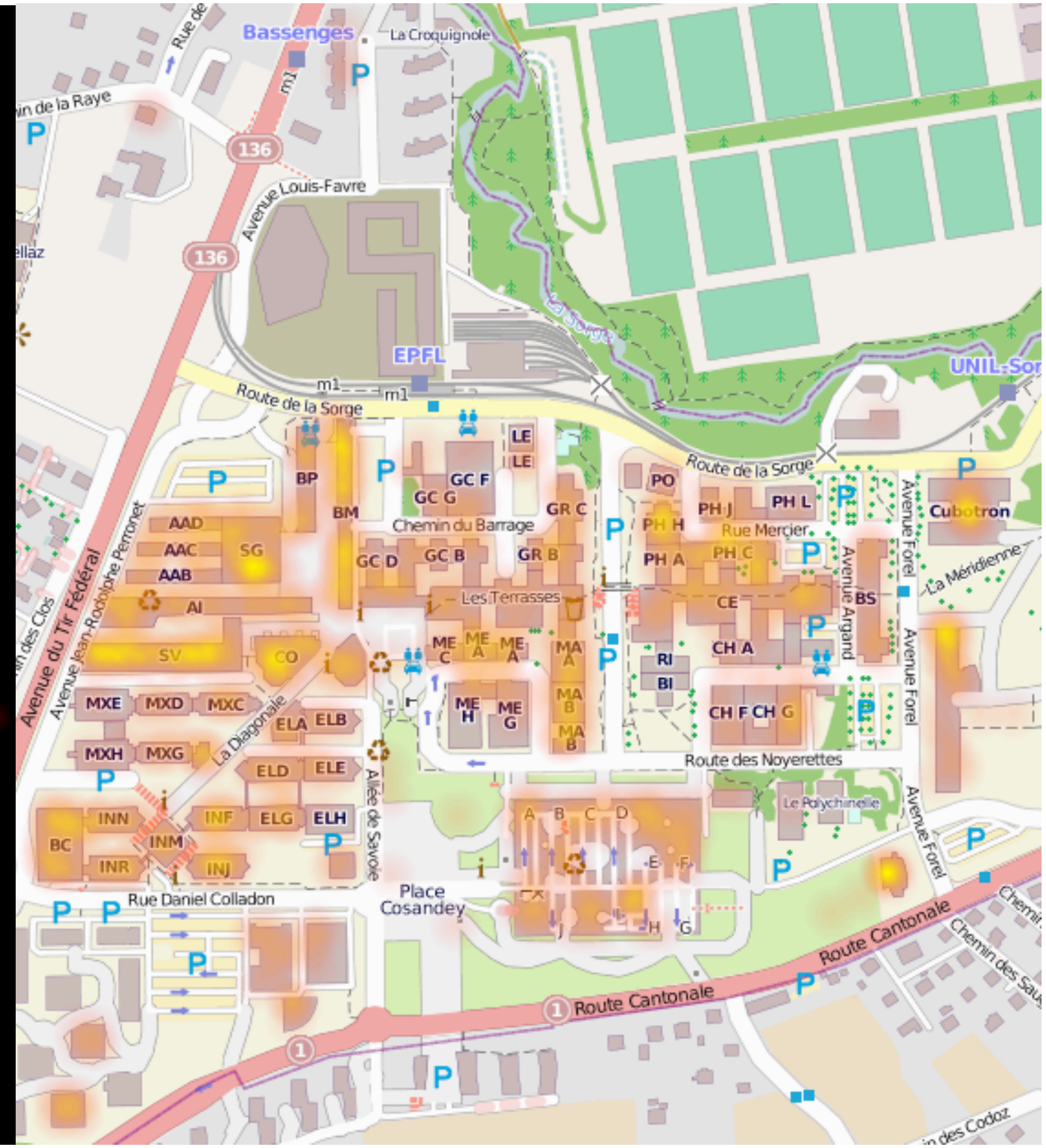

MEL
PB
RLC A
RLC B
RLC C
RLC D
RLC E
RLC F
RLC G


Number of APs by floor
Number of APs
0
50
100
150
200
250
-3
-2
-1
0
1
2
3
4
5
6
7
Floors


Bassenges
La Croquignole
Avenue Louis-Favre
EPFL
Route de la Sorge
UNIL-Sor
Chemin du Barrage
Les Terrasses
Rue Mercier
Cubotron
La Diagonale
Allée de Savoie
Route des Noyerettes
Le Polychinelle
Rue Daniel Colladon
Place Cosandey
Route Cantonale
Avenue du Tir Fédéral
Avenue Jean-Rodolphe Perronet
Avenue Forel
Avenue Argand
La Méridienne

Video not available in PDF format

Please visit:

http://www.youtube.com/watch?v=bbzkZVmVbVo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plan.epfl.ch
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YOU ARE
BY SCHOOL
ABOUT EPFL
Person
Place
EPFL Web
Find a place
EPFL > Map
English
Français
Search
Points of Interest
Routing
Print
Measure
Reset
Link
Help
Disabled
Let's go!
Reset
Floors
Sky
Zoom
View
3D
Street View
Map
Places
EPFL Campus
IMT Neuchâtel
ECAL Renens
Aula Cour
Middle East
Basel
CHUV
Quartier Mouline
Archives Cantonales
UNIL-Mouline
Quartier Dorigny
Quartier Centre
Quartier Sorge
CAMPUS EPFL
Quartier Lac
Parc scientifique
Quartier de l'innovation
StarlingHotel at EPFL
Les Estudiantines
Avenue du Chablais
Route Cantonale
Chemin du Bochet
Chemin de la Raye
Chemin du Levant
Chemin des Pisons
Chemin de Florel
La Coquerelle

Pedestrian network

- 4 levels of path (major, inter-, intra-building, access to rooms)
- 56’655 edges, 50’131 vertices
- 17’502 public “points of interest”
- 13’783 “rooms”

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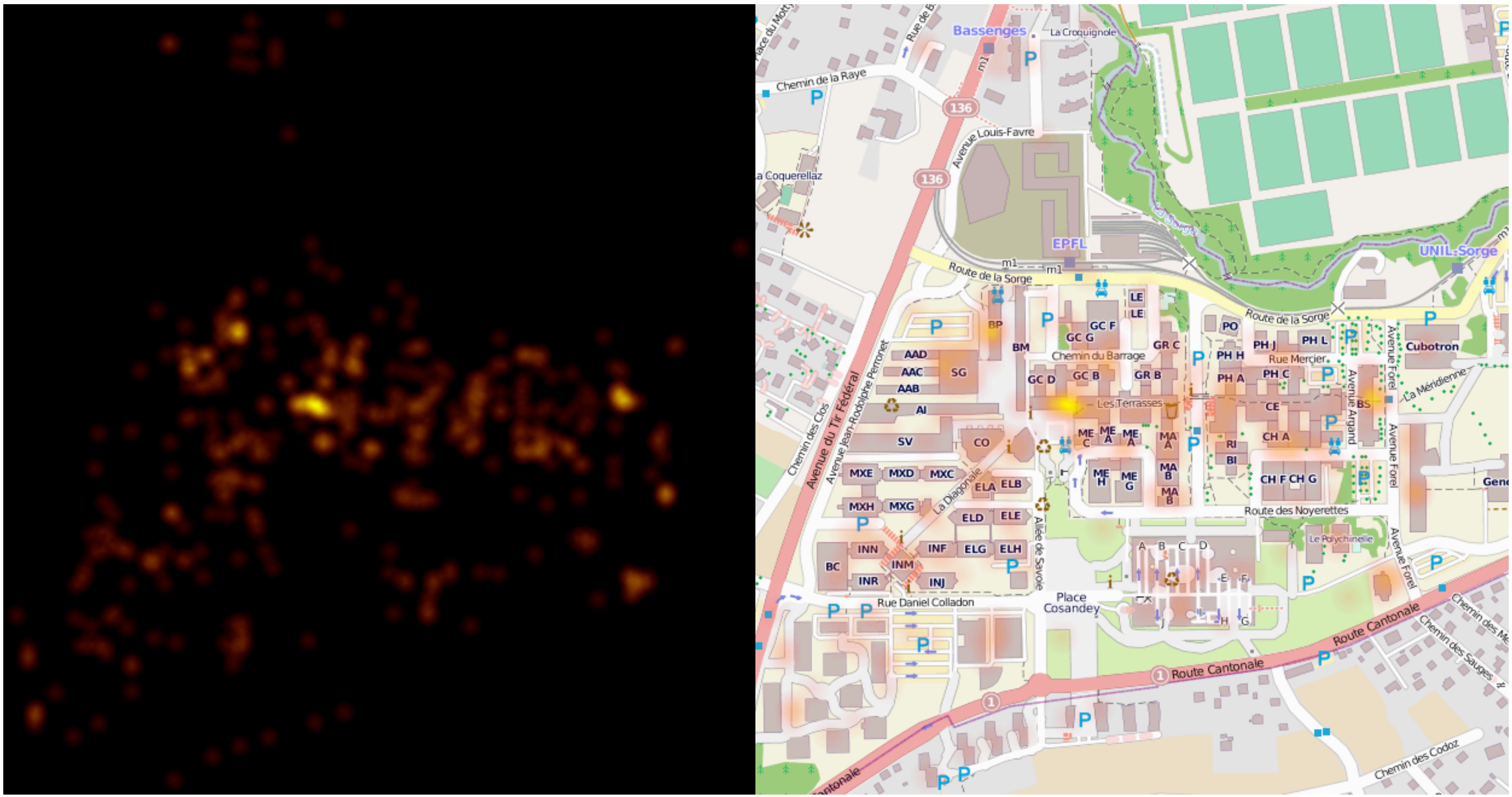
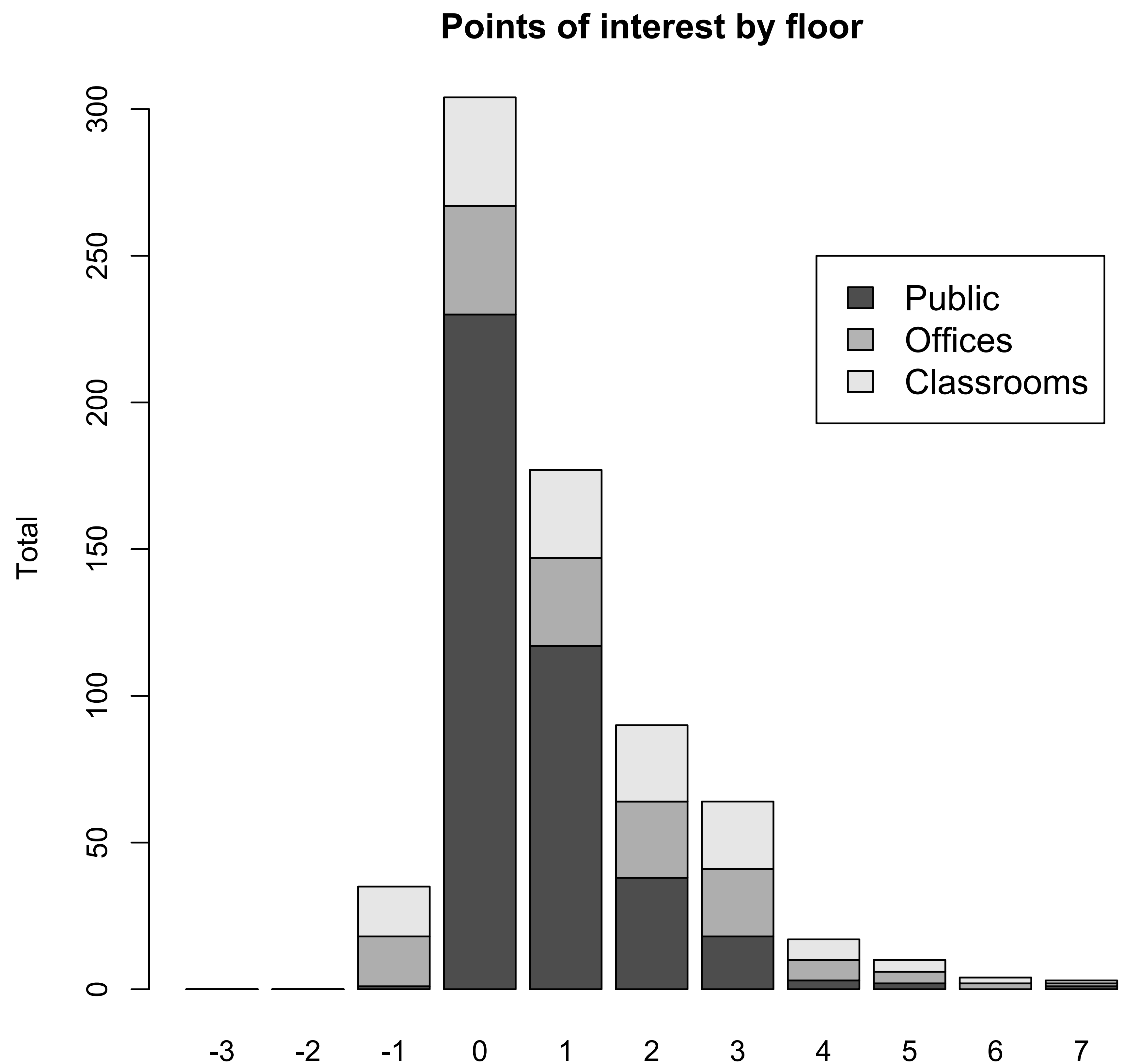
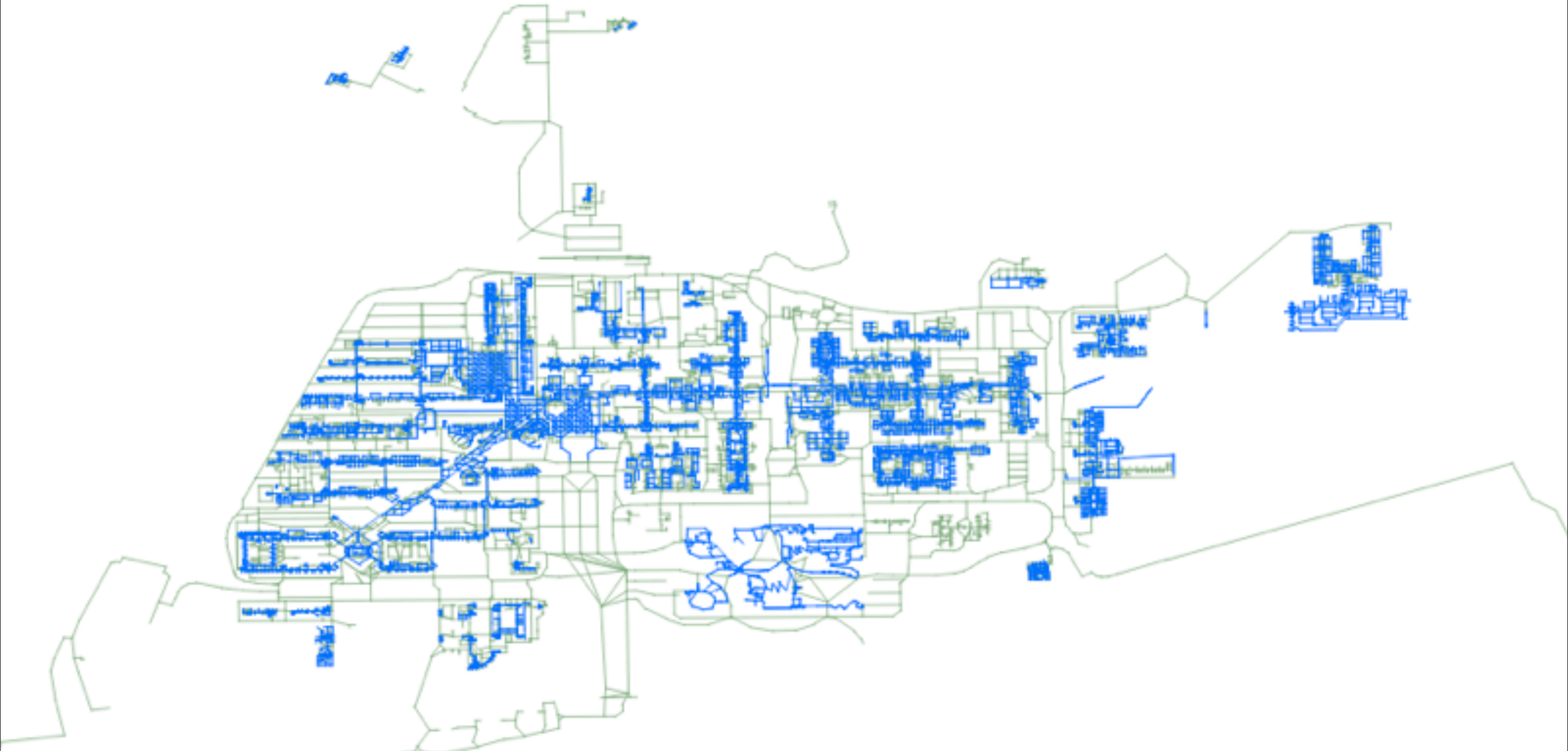
Categories	Destinations		Count	In the model
Access	Information Desk		1	Yes
	Entrances		42	No
	Car	Parking lots	55	Yes
		Electric plug	1	No
	Public transportations (bus stops, ticket machines)		9	Yes
	Bike	Parkings	93	Yes
		Electric plugs	1	No
		Center	1	No
	Road accesses		5	No
	Delivery Point		1	Yes
	Disabled (obstacles, WC, automatic doors)		20	No
	Meeting points		5	No
Education	Schools		9	No
	Auditorium		23	Yes
	Librairies		2	Yes
Services	Restaurants		21	Yes
	Snack bars		17	Yes
	Shops		7	Yes
	Caretakers		11	Yes
	Associations		9	Yes
	Museums, exhibitions		2	Yes
	Services (child care, travel agency, language center, ...)		19	Yes
	Secretariats		12	Yes
	Workshops		29	Yes
	Hotels		2	Yes
	Student housing		4	Yes
Utilities	Post stations		22	Yes
	Bornes camipro		9	Yes
	Electronic money chargers		3	Yes
	Cash		2	Yes
	Xerox machines		12	Yes
	Public printers		77	Yes
	Phones		32	No
	WiFi		791	No
	Showers		42	No
	Recycling		175	No
Infrastructure	Network plugs (802.1x, DHCP, ...)		15024	No
	Camipro		870	No
	Fire safety		11	No
Pictures	Panoramas		20	No

Points of interest on campus





Points of interest by floor
Total
0
50
100
150
200
250
300
-3
-2
-1
0
1
2
3
4
5
6
7
Public
Offices
Classrooms



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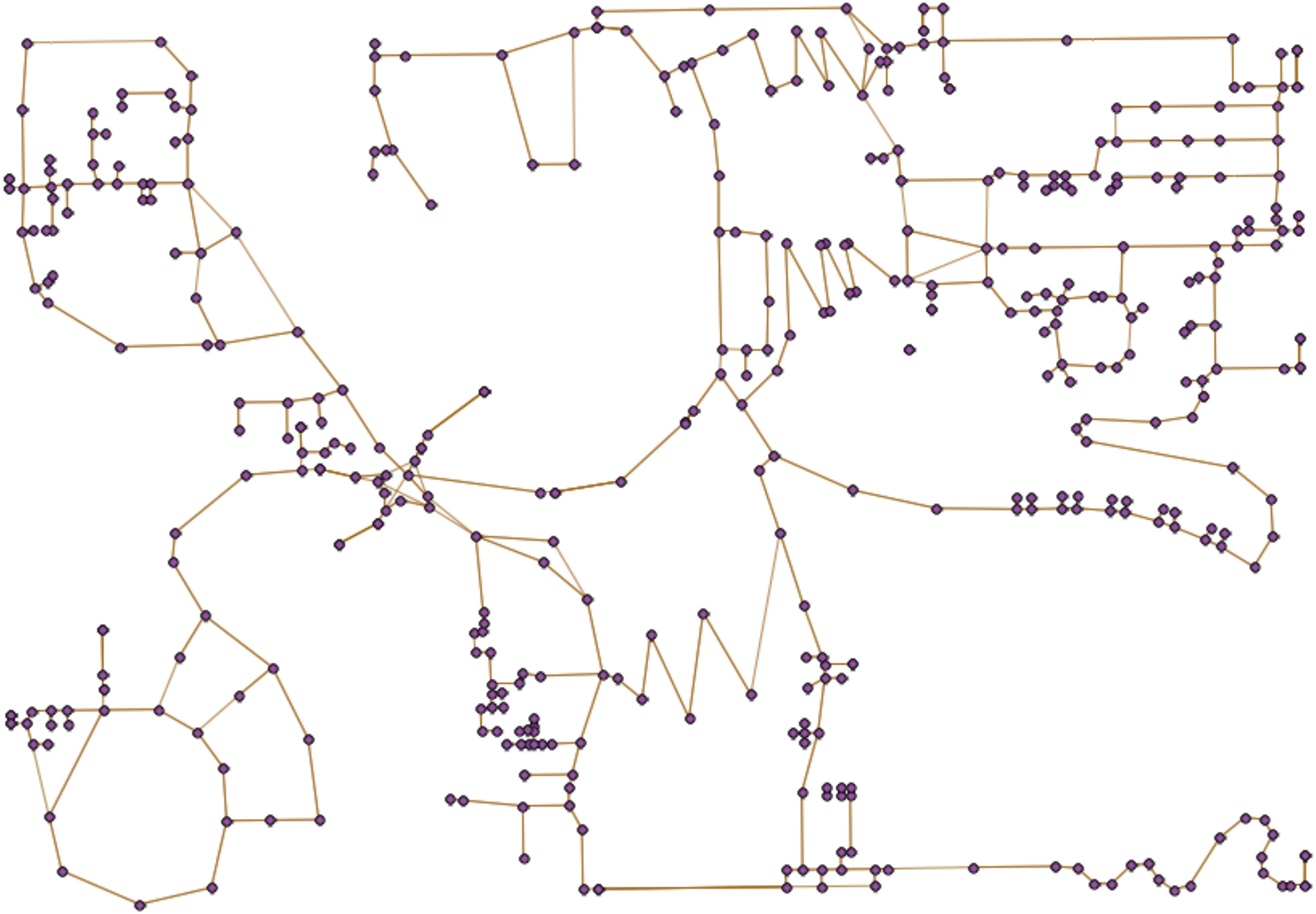

3. Discriminating destinations from signals

Probabilistic measurement model

- Goal:
  - Extract possible lists of destinations visited by pedestrians (and their likelihood)
  - using:
    - Traces from WiFi infrastructure
    - Pedestrian network

Definitions and goal

- Measurement: $\hat{s} = (\hat{x}, \hat{t})$
- State variable: $d = (x, t^-, t^+)$
- Goal: Associate a likelihood to each list of destinations with arrival and departure times $P(\hat{s}_1, ..., \hat{s}_n | d_1, ..., d_n)$

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Generation of x

- For each signal $\hat{s}$, define a domain of data relevance (Bierlaire and Frejinger, 2008) and consider all destinations x in it
- For AP data: a 50-meter radius circle around each AP
- For Cisco data: a square with a 95% confidence interval

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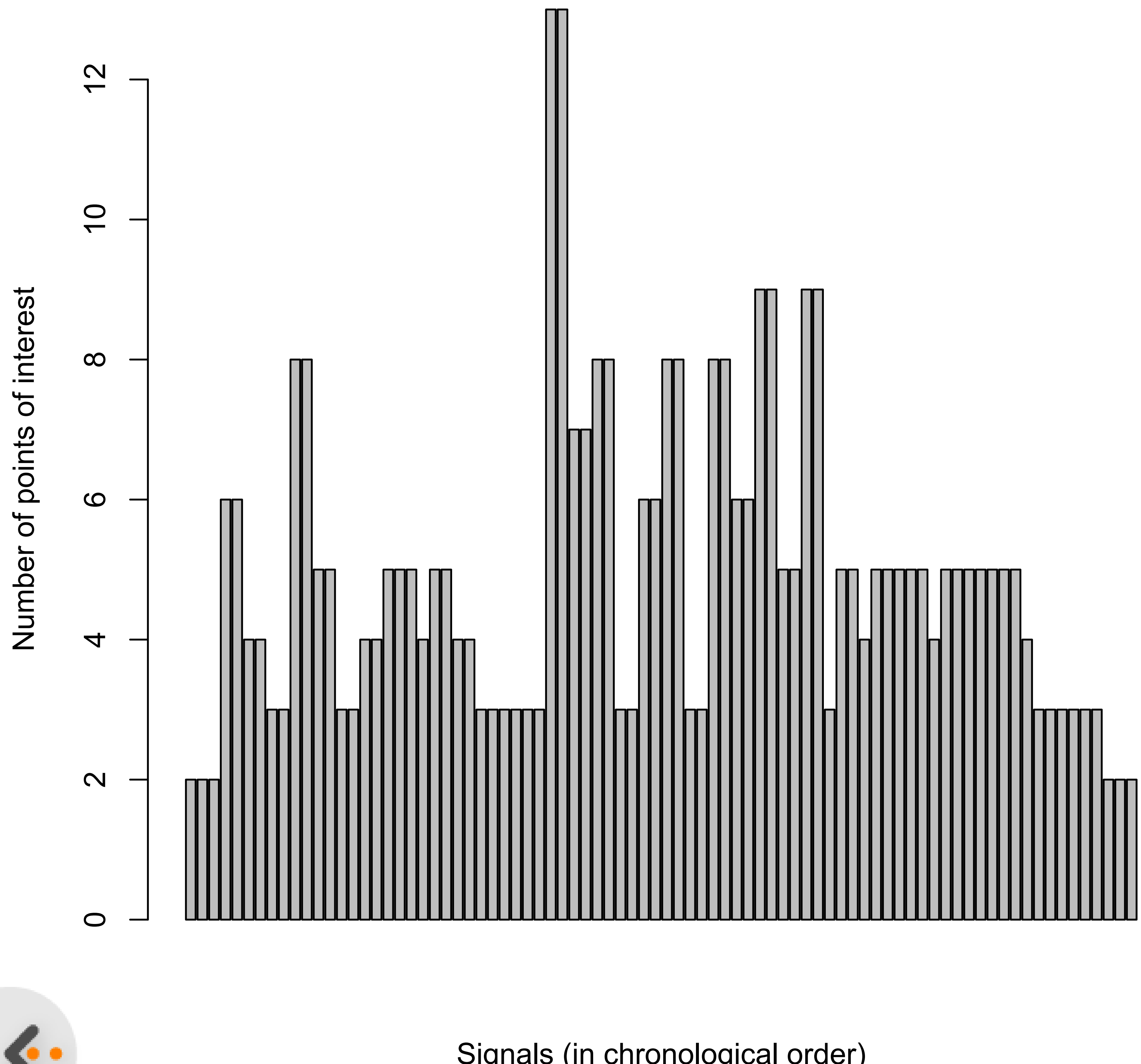
Number of points of interest for each signal



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Generation of t^-, t^+

- $t_i^- \in [\hat{t}_{i-1} + tt_{x_{i-1},x_i}, \hat{t}_i]$
- $t_i^+ \in [\hat{t}_i, \hat{t}_{i+1} - tt_{x_i,x_{i+1}}]$

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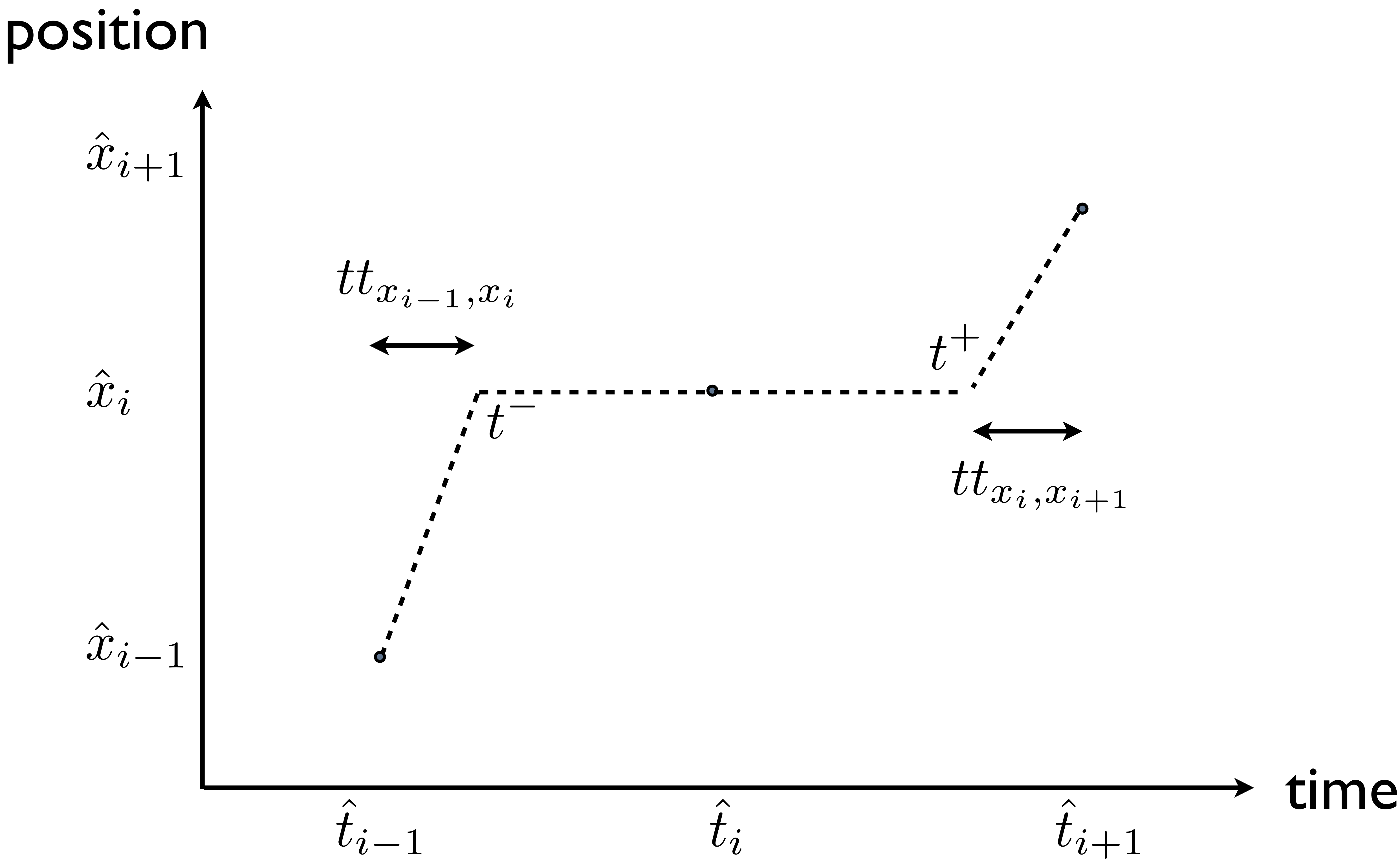

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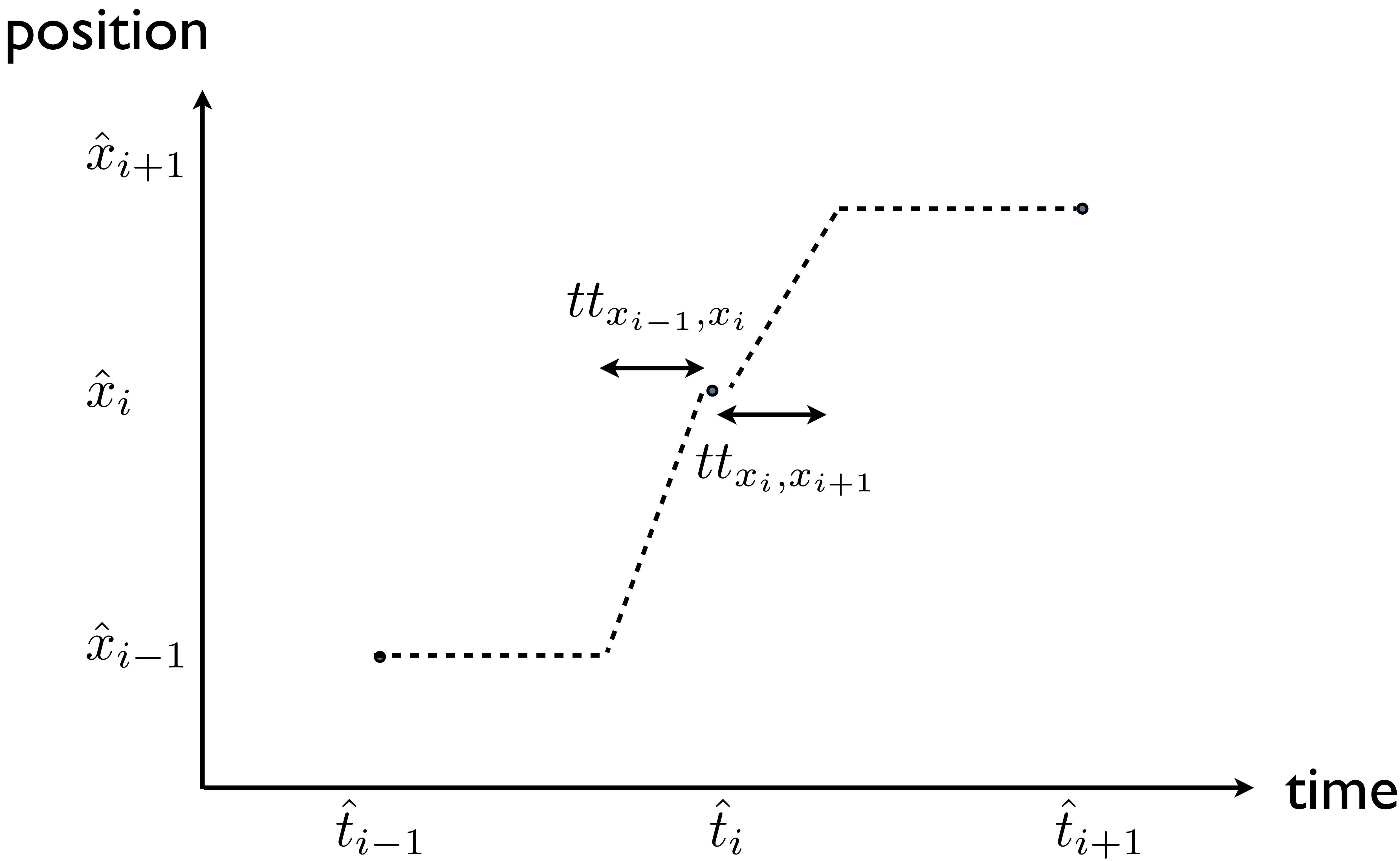
position
$\hat{x}_{i+1}$
tt_{x_{i-1},x_i}
$\hat{x}_i$
$tt_{x_i,x_{i+1}}$
$\hat{x}_{i-1}$
time
$\hat{t}_{i-1}$
$\hat{t}_i$
$\hat{t}_{i+1}$

Travel time

- $$tt_{x_i,x_{i+1}} = \frac{dist(x_i, x_{i+1})}{v}$$
- Chen, 2012: Speed distribution for pedestrians from smartphone data
$$f(v) = \omega\lambda e^{-\lambda v} + (1-\omega)\frac{1}{v\sqrt{2\pi\tau^2}}e^{-\frac{(\ln v-\mu)^2}{2\tau^2}}$$

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Algorithm 2: Weight definition procedure for each edge in the pedestrian network

```
if door = closed then
    weight = ∞;
else
    if Major Route then
        hierarchical factor = 1;
    else if Inter-building Route then
        hierarchical factor = 1.2;
    else if Intra-building Route then
        hierarchical factor = 1.5;
    else if Access to Offices then
        hierarchical factor = 2.0;

    floor factor = 1;
    if Up then
        if Ramp then
            floor factor = 3 ;
        if Stairs then
            floor factor = 15;
    if Down then
        if Ramp then
            floor factor = 2 ;
        if Stairs then
            floor factor = 12;

    lift factor = 0;
    if Elevator then
        elevator factor = 40;

    weight = length · hierarchical factor · floor factor + elevator factor;
```

Measurement model: $P(\hat{x}|x)$

- Friis law for free-space environment: $\propto \dfrac{1}{dist(p,\hat{p})^2}$
- In case of absorption by obstacles, reflection, scattering, refraction: more complicated. 2 solutions:
  - fingerprinting
  - relate RSS to distance
- Wang et al. (2003), Cisco: $\propto \dfrac{1}{dist(p,\hat{p})^3}$

Future works

- Develop the probabilistic model
- Explore the outcome for route choice
- Explore the outcome for OD matrix estimation

Slides and contact information:
http://people.epfl.ch/antonin.danalet