



Be smart in a SNAP!

# Data Analytics vs Smart Applications



11 November 2020, Course <https://www.snap4city.org/577>

SCALABLE SMART ANALYTIC APPLICATION BUILDER FOR SENTIENT CITIES

SNAP4 Appliances and Dockers Installations



UNIVERSITÀ DEGLI STUDI FIRENZE

DINFO DEPARTAMENTO DI INFORMATICA DELL'INFORMAZIONE

DISIT DISTRIBUTED SYSTEMS AND SOFTWARE LAB



UNIVERSITÀ  
DEGLI STUDI  
FIRENZE

**DINFO**  
DIPARTIMENTO DI  
INGEGNERIA  
DELL'INFORMAZIONE

**DISIT**  
DISTRIBUTED SYSTEMS  
AND INTERNET  
TECHNOLOGIES LAB



# SNAP4CITY



Powered by

## *scalable Smart aNalytic APplication builder for sentient Cities: for Living Lab and co-working with Stakeholders*

<https://www.Snap4City.org>

Data Analytics vs Smart Applications

100%  
OPEN  
SOURCE

11 November 2020, Course

<https://www.snap4city.org/577>

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<https://www.Km4City.org>

<https://www.disit.org>



Powered by **FIWARE**

**SNAP4**  
Appliances and Dockers  
**Installations**

**FREE TRIAL**

 **PEN Test Passed**

 **EU GDPR COMPLIANT**

**100% OPEN SOURCE**



**DASHBOARDS AND APPS - CONTROL ROOMS - DECISION SUPPORT SYSTEMS - WHAT-IF ANALYSIS**

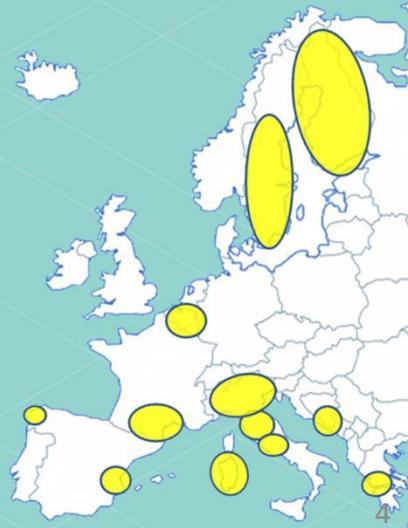


**EXPERT SYSTEM  
KNOWLEDGE BASE  
STORAGE**

**BIG DATA ANALYTICS  
ARTIFICIAL INTELLIGENCE  
BUSINESS INTELLIGENCE  
MACHINE LEARNING**

**DATA FLOWS, WORKFLOWS  
MICROSERVICES  
MANAGEMENT**

**METHODOLOGIES  
COURSES AND COMMUNITY  
LIVING LABS  
DEVELOPMENT TOOLS**

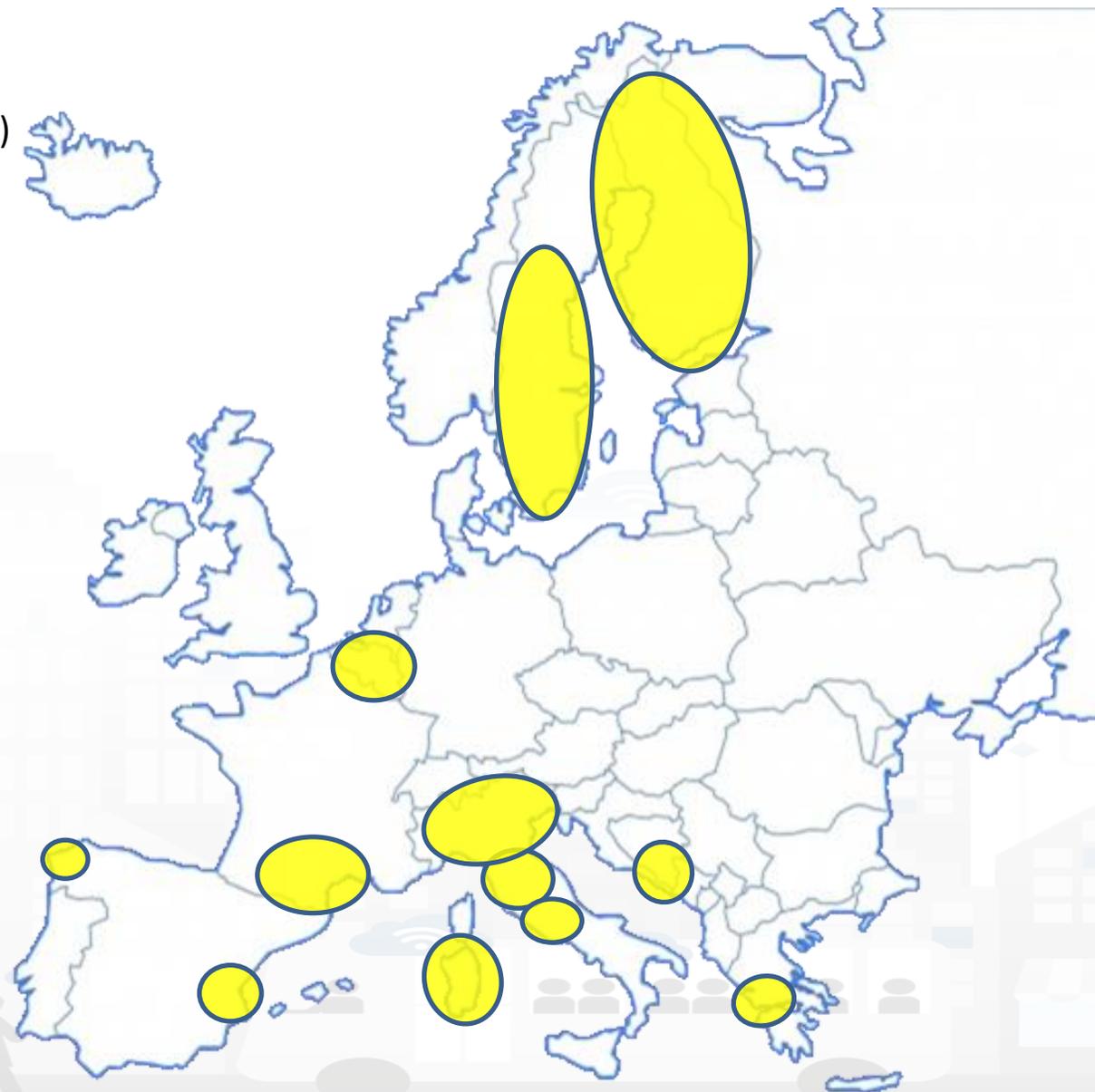


# Snap4City/Industry structure

- The **Snap4xxxx** solution is released in Open Source, VM and Docker with fully support of MultiTenant/multiple-Organizations
  - Each Organization may be configured for a separate environment with a set of Maps, Menus, Users, Data, Dashboards, IOT Apps, MicroApplications, Custom Widgets, Models, resources, open data, etc.
- <https://www.Snap4City.ORG> is the main instance of Snap4xxxx solution managed by DISIT Lab. The main documentation is located and updated on Snap4City.org, GitHUB, dockerHub and Node-Red Library. Snap4City.org is where the last tools are tested and news published.
  - Organizations on Snap4City.org have been created with contracts as for *Platform as a Service*, for testing and for providing *SmartCity as a Service* as well as *Industry 4.0 as a Service*

## Main Organizations/areas

- [Antwerp area \(Be\)](#)
- Capelon (Sweden: Västerås, Eskilstuna, Karlstad)
- [DISIT demo \(multiple\)](#)
- [Dubrovnik, Croatia](#)
- [Firenze area \(I\)](#)
- [Garda Lake area \(I\)](#)
- [Helsinki area \(Fin\)](#)
- [Livorno area \(I\)](#)
- [Lonato del Garda \(I\)](#)
- [Modena \(I\)](#)
- [Mostar, Bosnia-Herzegovina](#)
- [Pisa area \(I\)](#)
- [Pont du Gard, Occitanie \(Fr\)](#)
- [Roma \(I\)](#)
- [Santiago de Compostela \(S\)](#)
- [Sardegna Region \(I\)](#)
- SmartBed (multiple)
- [Toscana Region \(I\), SM](#)
- [Valencia \(S\)](#)
- [Venezia area \(I\)](#)
- [WestGreece area \(Gr\)](#)

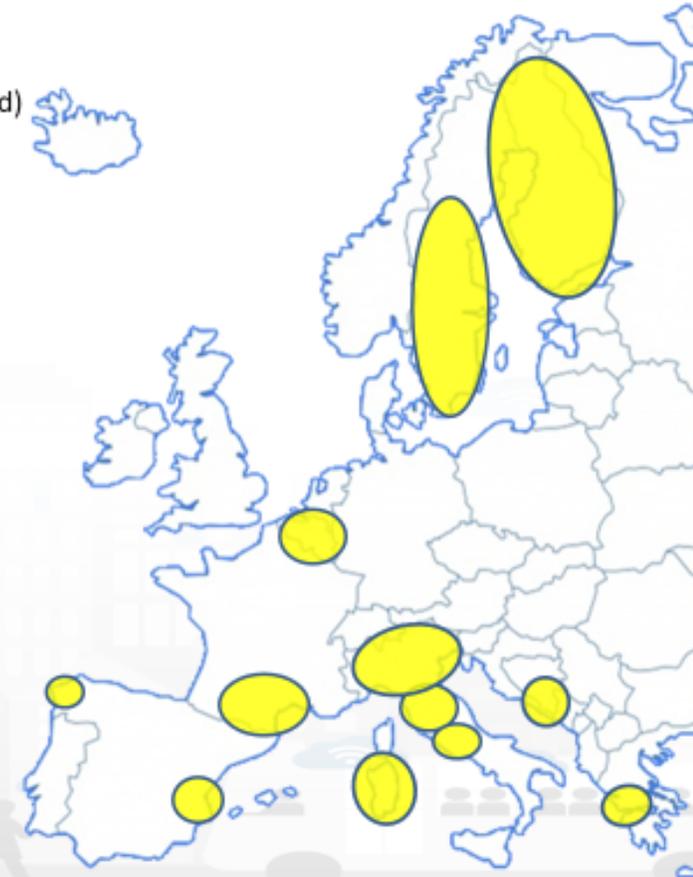


# Snap4City/Industry Community

- Most of Organizations on Snap4City.org also correspond to companies or institutions that have an installation of Snap4City tools on their Premise,
  - such as: Pisa, SmartGarda Lake, Snap4, ALTAIR, etc.
- This double way allows them to:
  - test the news,
  - share experiences with other groups,
  - get visibility,
  - work in the collaborative environment, and
  - be better supported by Snap4City.org and DISIT Lab personnel.
- Each instance of Snap4xxxx solution **can decide to join the federation** of SmartCity API to exploit shared data.
  - This allows to exploit regional data for city installations applications (web, mobile, dashboards, etc.) without reloading them for example.

## Main Organizations/areas

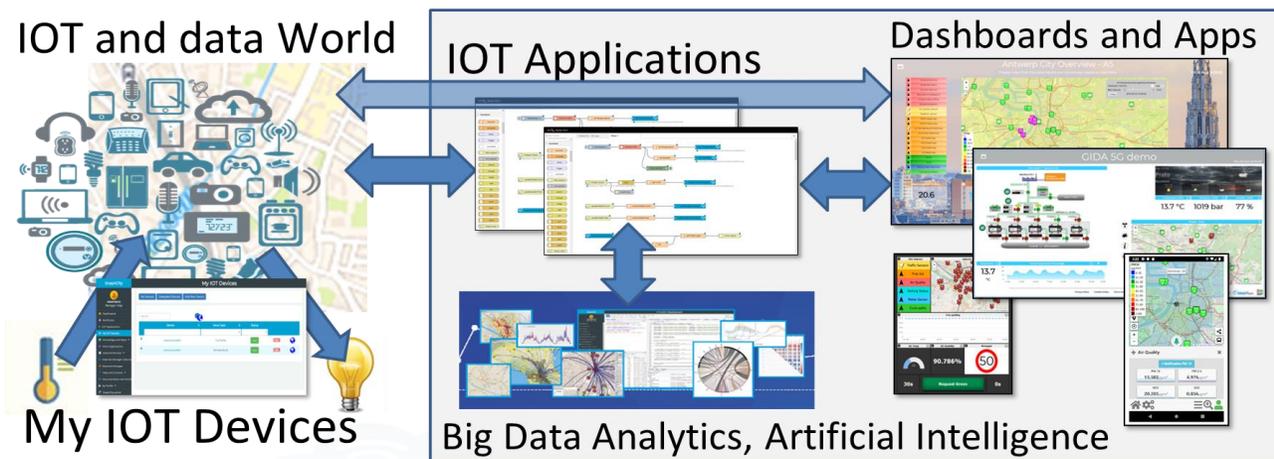
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Snap4City (C), October 2020

# Free Trial

- Register on [WWW.snap4city.org](http://WWW.snap4city.org)
  - Subscribe on **DISIT Organization**
- **You can:**
  - Access on basic Tools
  - Access to a large volume of Data
  - Create Dashboards
  - Create IOT Applications
  - Connect your IOT Devices
  - Exploit Tutorials and Demonstrations



*IF you need to go more in deep you can ask us to pass at the next Role becoming full AreaManager with full rights of development, also for Data Analytics, machine learning, etc.*

**On Line Training Material (free of charge)**

	1st part (*)	2nd part (*)	3rd part (*)	4th part (*)	5th part (*)	6th part (*)	7th part (*)
what	General	Dashboards	IOT App, IOT Network	Data Analytics	Data Ingestion processes	System and Deploy Install	Smart City API: Web & Mob. App
PDF							
Inter active							
Video1	 	 	 	 	 	 	 
Video2	 	 	 	 	 	 	 
Video3	 	 	 	 	 	 	 
Video4	 	 	 	none	 	none	none
duration	2:55	3:16	3:41	2:00	2:48	2:35	1:47

# General Overview of the full Course

- **1st part:** General Overview
- **2nd part:** Dashboards Creation and Management
- **3rd part:** IOT Applications development, IOT Devices, IOT Networks
- **4<sup>th</sup> part:** Data Analytics, in R Studio, in Python, how to Exploit and Manage Data Analytics in IOT Applications
- **5th part:** Data Ingestion, Data Warehouse, Data Gate, IOT Device Data ingestion, IOT App for Data Ingestion, etc.
- **6th part:** Snap4City Architecture, How To Install and Manage Snap4City
- **7th part:** Smart city API (internal and external) Web and Mobile App development tool kit

A number of the training sections include esercitazioni

Updated versions on: <https://www.snap4city.org/577>

See also courses in ITALIANO: <https://www.snap4city.org/485>

## GO • **Data Analytics: Examples from Snap4City**

- GO – Smart parking: Predictions
- GO – Smart Bike Sharing
- GO – User Behavior Analysis, via Wi-Fi, OD, trajectories
- GO – Recognition of Used Transportation means
  - Traffic Flow Predictions,
  - Traffic Flow Reconstruction, from Traffic Sensors Data
- GO – Covid-19 vs other data: traffic and environmental
- GO – Quality of Public Transport Service
- GO – Origin Destination Matrices from: Wi-Fi, Mobile Apps, etc.
- GO – Demand of Mobility vs Offer of Transportation
- GO – Modal and Multimodal Routing for Navigation and Travel Planning
- GO – Environmental Data Analysis and Predictions, early Warning
- GO – Prediction of Air Quality Conditions
- GO – Anomaly Detection
- GO – What-IF Analysis

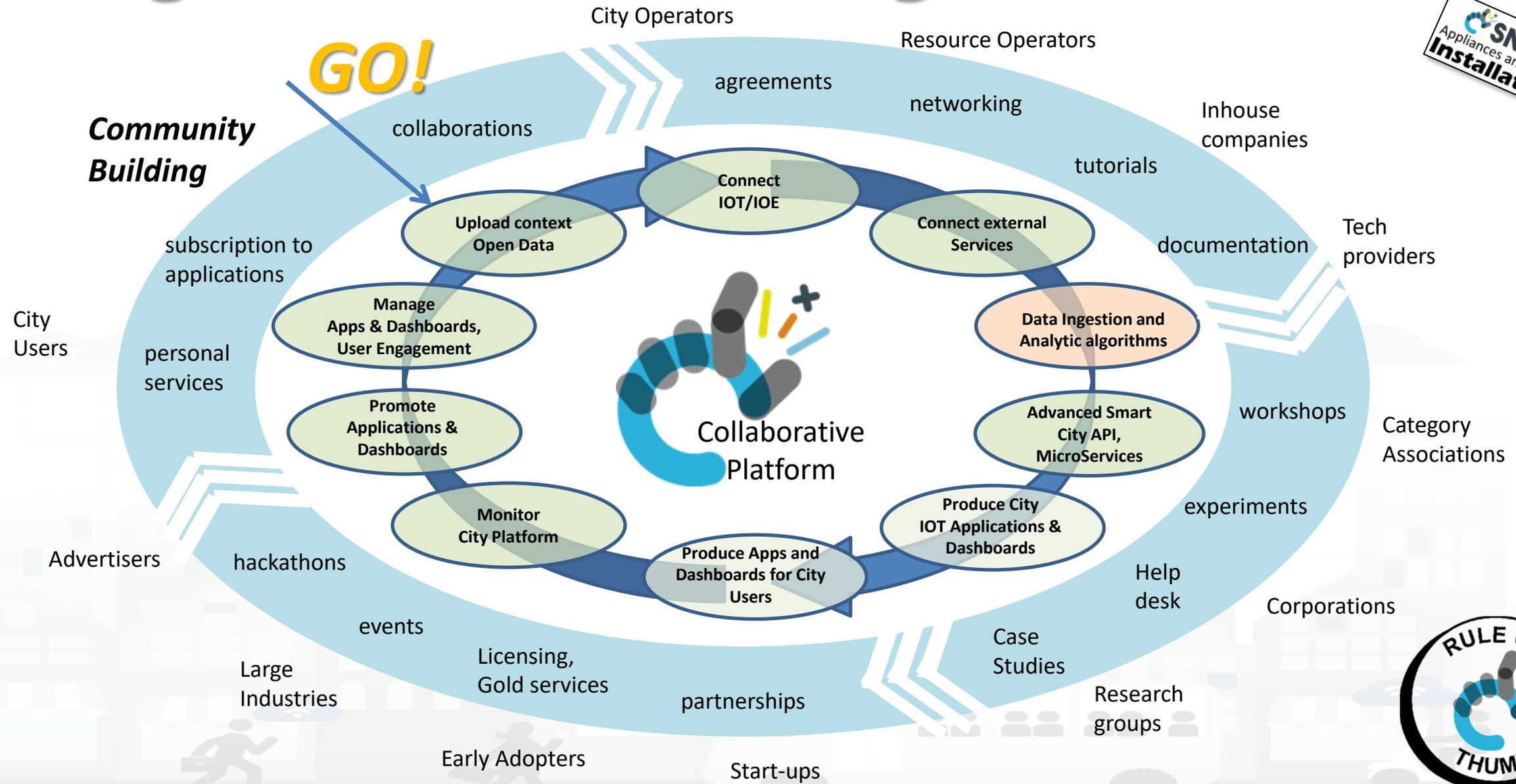
- GO • **Data Analytics: Enforcing and Exploiting**
  - Real Time Data Analytics: using R Studio Exploitation in IOT Applications

- GO • **Engaging City users Towards a Virtuous behavior**

- GO • **Decision Support Systems, Smart DS and Resilience DS**

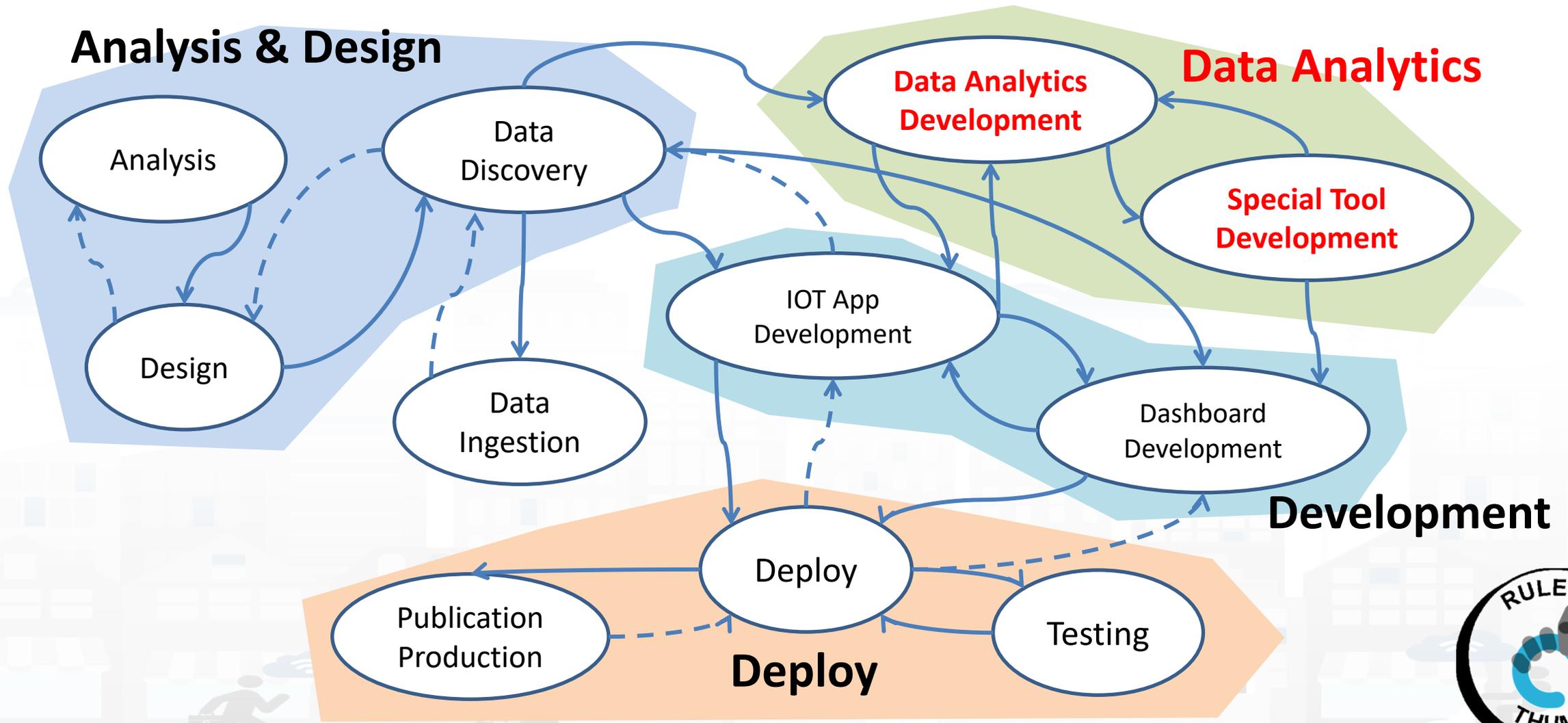
- GO • **Twitter Vigilance: Social Media Analysis: Early Warning, Predictions**

# Living Lab Accelerating



# Development Life Cycle

## Smart City Services



# Levels of Difficulty

- Easy.



non programmer level

- Moderate.



Some JavaScript rudiment coding

- Good.



JavaScript programming

- Golden.



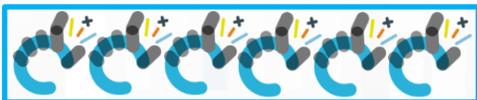
Programming in R Studio

- Professional.



Exploiting Smart City API

- Excellent.

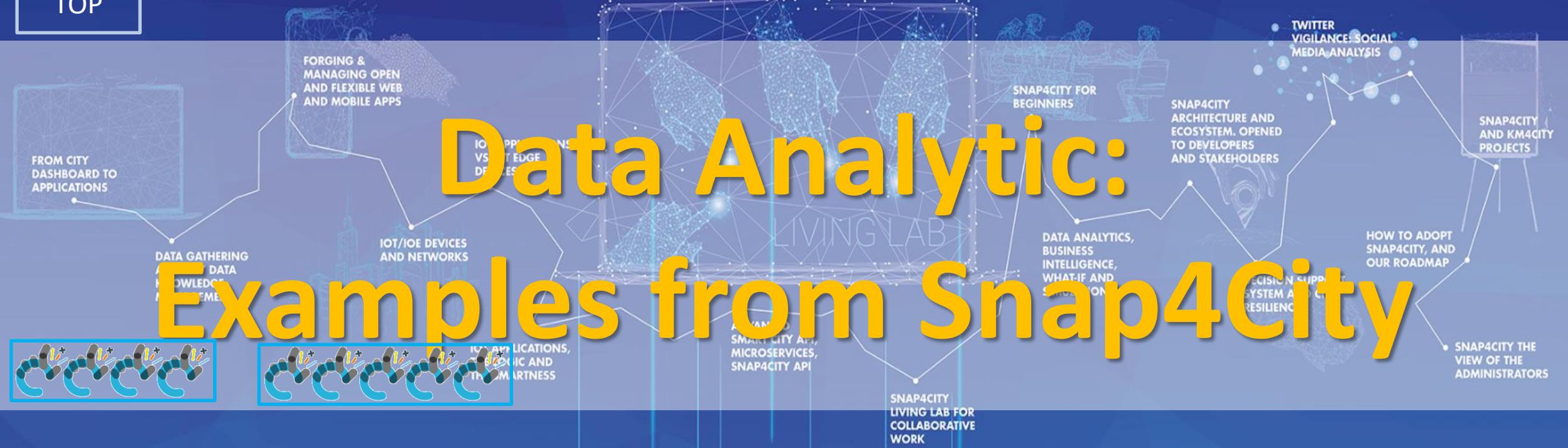


Developing Full IOT Applications,  
Dashboard and Mobile Apps

TOP

# Data Analytic:

# Examples from Snap4City



# Data vs Smart Services enabling on Snap4City

- **Public Transportation and mobility activated services in some where with Snap4City**
  - **Smart parking** (parking locations and real time parking data) ... predictions
  - **Smart Fuel pricing** (fuel station locations and real time prices)
  - **Routing** (detailed GIS information, text indexing of streets, POI, etc.)
    - **Quite routing, perfect shopping, etc. etc.** (more data in needed...)
  - **multimodal routing** (detailed GIS information, Public transport time schedule)
  - **Info traffic** (traffic flow sensors, real time Traffic events, their localization, etc.)
  - **Dense info traffic** (traffic flow sensors and traffic flow reconstruction algorithm)
  - **Car/Bike/Scooter Sharing** (position and availability of Cars/Bikes, Scooters) ... predictions
  - **Smart Biking** (cycling paths, environmental data) ... predictions on bike racks
  - **E-vehicles** (position, status of recharging stations,.. ...) ... predictions vs booking
  - **Smart river crossing** (position and status of Underpass, Ferry) ... prediction
  - **Quality of Public Transport** (actual time of arrival at the bus stops, wrt planned time schedule)
  - **Early Warning vs Resilience** (combination of several data including mobility, events, Social to perform early warning...)

# Data vs Smart Services enabling on Snap4City

## • Social and Users Behaviour

- **Smart First Aid**
- **search for POI and public transport services**
- **Social Media Monitoring and acting**
- **Information to Tourists**
- **Early Warning, prediction of audience**
- **Improvement of services for Tourists**

(Location of First AID, real time status of triage)  
(POI geolocalized, spatial queries, along paths)  
(Identif. of dysfunction, quality of service perceived)  
(Entertainment Events)  
(Twitter data, social media)  
(people flow, usage of services)  
(Origin Destination Matrices, trajectories, heatmaps )  
(People Monitoring, via App, Wifi, PAX Counter)  
(Twitter Data, social mea,....)

## • Weather and environment, quality of life

- **Weather forecast/condition**
- **Air quality Pollution**
- **Pollination**
- **Alerting on Air quality for multiple parameters**
- **Information Heatmaps for weather and air quality**
- **Air quality indexes, and forecast**

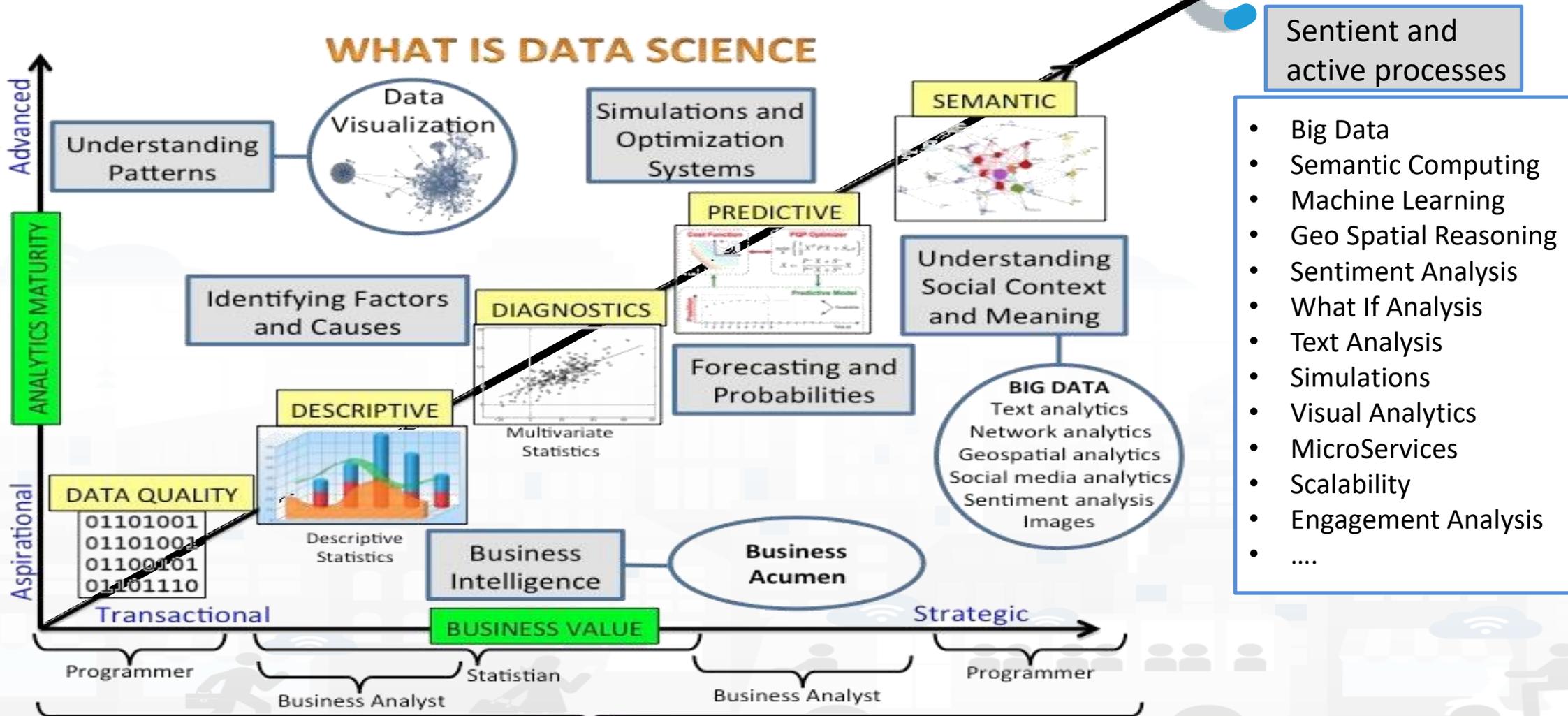
(Weather forecast)  
(pollution sensors, PM10, PM2.5, NOX, etc.)  
(Pollination sensors)  
(Prediction of parameters time slots, notification)  
(air quality sensors, heatmaps, prediction)  
(.....)

# DATA ANALYTICS



- **Resilience**
  - Resilience and risk analysis
  - Early warning computation
  - What-if analysis, dynamic routing, origin destination matrices production from a large range of sources
- **Mobility and transport**
  - Traffic flow reconstruction from sensors and other sources
  - Predictions for: traffic flow, smart parking, smart bike sharing, etc.
  - Analysis of the demand vs offer of mobility according to public transportation and multiple data sources
  - Accidents heatmaps
  - Tracking fleets, people, via devices: OBU, OBD2, mobile apps, etc.
  - Routing and multimodal routing
- **Environment and weather**
  - NOX, PM10 pollution prediction on the basis of traffic flow, 48 hours
  - Long term prediction of European Commission KPIs on NOX, PM10, etc.
  - Heatmaps production, dense data interpolation
- **User and Social**
  - People flows prediction and reconstruction, via Wi-Fi, mobile apps, etc.
  - User engagement for sustainable mobility
  - User's behaviour analysis, origin destination matrices, hot places, time schedule, Recency and frequency, permanence, etc.
  - People flow analysis from PAX Counters
  - Social media analysis on specific channel, specific keywords: see Twitter Vigilance, for NLP and Sentiment Analysis, SA
  - Tweet proneness, retweet-ability of tweets, impact guessing
  - Audience prediction to TV channels and physical events
- **Generic**
  - Data quality assessment, prediction, anomaly detection
  - Maintenance prediction and costs predictions
  - Estimation of KPI and local indexes for: quality of life, 15 minutes, etc.

## WHAT IS DATA SCIENCE



# Disappearing Data Analytics

	Antwerp					Helsinki								Where					Main Data Sources
	City official	ICT official	Developer	Citizen, tourist, visitor	Business owner	City officials	City officials Domain experts	City officials City developers	Third party developers	Citizen	Citizens with respiratory problems	Tourists	Business owners	Mobile	MicroApplication	Tool, via Portal (ICT Developers)	Dashboards		
Discovery near to me	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			POI, OSM	
Discovery along a path	X	X	X	X		X		X	X	X	X	X		X	X			POI, OSM	
Discovery in an area, shape	X	X	X	X	x	X	X	X	X	X	X	X	x	X		X		POI, OSM	
browsing Public Transport	X	X	X	X	x	X	X	X	X	X	X	X	x	X	X			OSM, GTFS	
Full Text search	X	X	X	X	X	X		X	X	X	X	X	X	X		X		POI, OSM	
Routing: pedestrian				X	x			X	X	X	X	X	x	X	X			OSM	
Routing: pedestrian quite				X	x			X	X	X	X	X	x	X	X			OSM	
Routing: private vehicles	X		X	X		X		X	X	X	X	X		X	X			OSM	
Routing: Multimodal Public Transport				X					X	X	X	X		X	X	X		OSM, GTFS	
heatmaps: weather (Temp, Humidity)	X	X		X	X	X	X		X	X	X	X	X	X			X	Sensors data, OSM	
heatmaps: environmental variables, PM10, PM2.5, NO2, EAQI	X	X		X	X	X	X		X	X	X	X	X	X			X	Sensors data, OSM	
heatmaps: environmental variables, Noise						X	X		X	X	X	X	X	X			X	Sensors data, OSM	
heatmaps: safe on bike (Antwerp)	X	X		X	X									X			X	Spec. Portal	
heatmaps: Enfuser prediction, PM10, PM2.5, AQI						X	X		X	X	X	X	X	X			X	Enfuser data	
heatmaps piking values any place	X	X			X	X	X	X	X	X	X	X	X				X	Computed Heatmps	
heatmaps: GRAL prediction, PM10						X	X		X	X	X	X	X	X			X	OSM, Traffic, Weather	
Comparison: Enfuser, Gral, Real Time						X	X										X	Enfuser, Sensors, GRAL	
Sensors Data Time Trends, & drill down	X	X	X		X	X	X						X			X	X	Sensors data, OSM	
Weather Forecast	X	X		X	X	X	X		X	X	X	X	X	X			X	Forecast Service	
Origin Destination Matrices	X	X	X		X	X	X	X	X				X				X	Snap4City Mobile App	
Typical trajectories	X	X	X	X	X	X	X	X	X				X			X	X	Snap4City Mobile App	
Hot Area in the city	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	Snap4City Mobile App	
Hot Places in Smart Zone	X	X	X	X	X									X		X	X	Snap4City PAXcounters	
Services Suggestions on mobiles				X						X	X	X		X	X			Snap4City Mobile App	
Alerts on critical cases: several variables	X			X	X	X	X			X	X	X	X	X				Sensors data, OSM	
The most used services		X		X	X	X	X			X	X	X	X				X	Snap4City Mobile App	
Twitter Trends Daily	X	X	X		X	X	X	X					X			X	X	Twitter Vigilance	
The auditing of user and living lab		X				X	X									X		Snap4City Portal	
Self assessment	X	X	X	X	X	X	X	X	X	X	X	X	X			X		Snap4City Portal	
Trajectories reg from mobile PAX Counters	X	X	X			X	X	X						X			X	PAX Counters	
Engagement real time assessment	X	X	X			X	X	X									X	Snap4City Mobile App	



# From Simple Data Analytic to Complex Tools

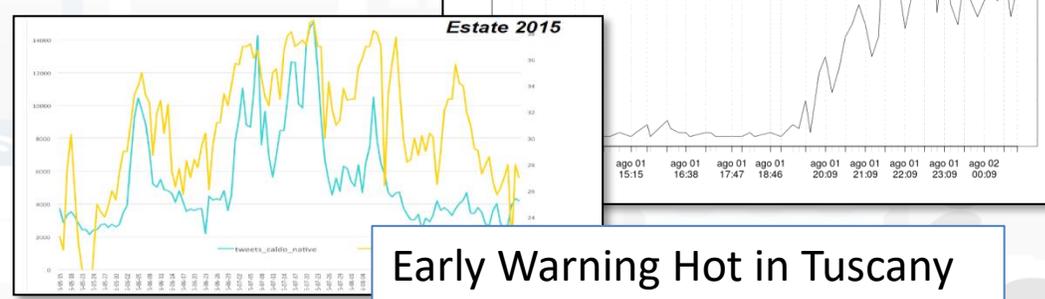
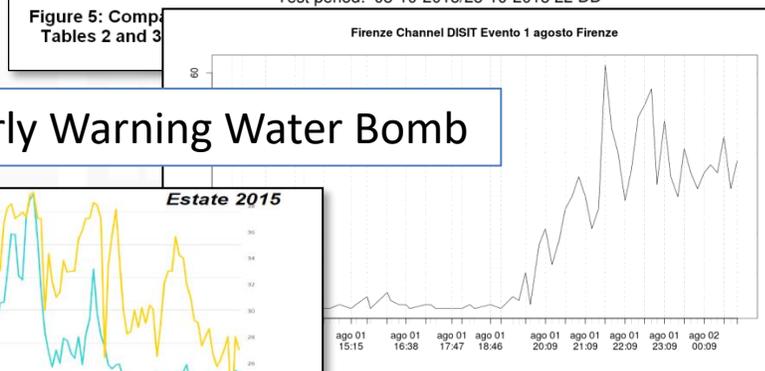
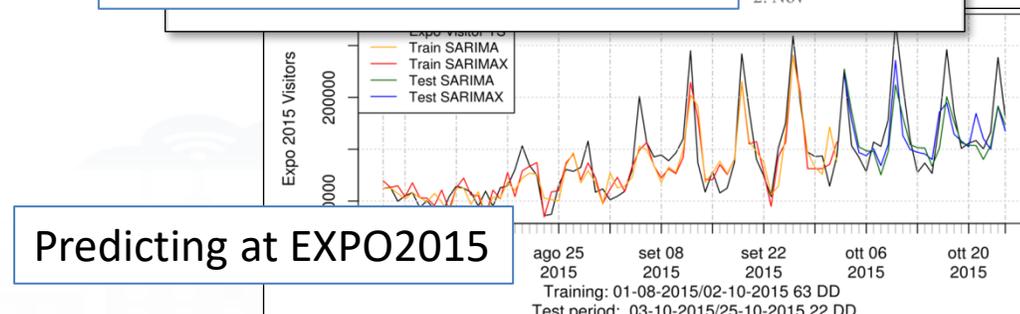
- **Structural:**
  - **Data Ingestion, Quality Control** on data: data mining, anomaly detection, etc.
  - **Typical Time trends:** traffic flow, people flow, sensors data, etc.
  - **Indexing** for fast search and retrieval: Geospatial, textual, temporal, mixt
- **Dynamical:**
  - **Analysis:** heatmap, hot places, distribution, statistical analysis
  - **Predictions** to inform and plan (e.g.: parking, people flow, )
  - **Anomaly detection** for Early Warning, Alerting
- **Special Analytics and Tools** → What-IF Analysis:
  - **Routing** for navigation: modal, multimodal, constrained
  - **Typical Trajectories** of: people flows, vehicles, etc.
  - **Traffic Flow** reconstruction
  - **Origin Destination Matrices:** people and vehicles, ...
  - **Simulations:** demand vs offer, etc.

# Snap4City and Data Analytic (summary)

- allows to create simple data processing as well as massive computing solutions exploiting statistics, machine learning, operating research, etc. for:
  - predictions, anomaly detection, early warning, OD Matrix construction, simulation, trajectories, typical trends, what-if analysis, smart routing, heatmaps, etc.
- **can be developed** in:
  - R Studio / Tensor Flow, Java, Python, ETL, IOT Applications
  - If HDFS/Hadoop/Hbase/Phoenix is installed: MapReduce, Spark, etc.
- **may be shared** with other colleagues, and organizations via the Resource Manager

# Predicting Models for Administrators & City Users

- **Aiming at improving**
  - quality of service, distributing workload
  - early warning
- **Predictions:**
  - Short (15 min, 30 Min), mid Term (1 week), long term (months)
- **Data Analytics: ML/AI, NLP/SA, Clust., ...**
  - Traffic Flows → multi-flow reconstruction
  - Parking Status → free slots
  - Environmental Alarms
  - Air Quality parameters and indexes
  - People Flows (Wi-Fi, Twitter) → crowd, #number of people



# Development in R Studio (self training)

- R Studio Development
- TC7.2 - R Studio for Analytics, exploiting Tensor Flow
- TC7.4 - From R Studio process to MicroService for IOT application, data analytics, machine learning
- TC7.5 - Developing Data Analytics Processes
- US7. Data Analytics and related integration aspects

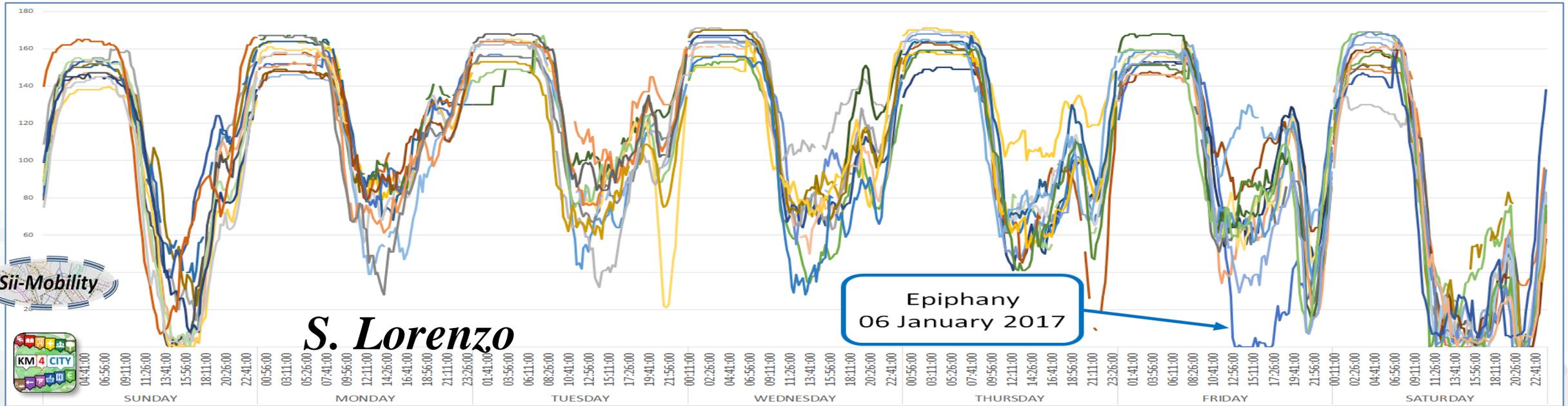
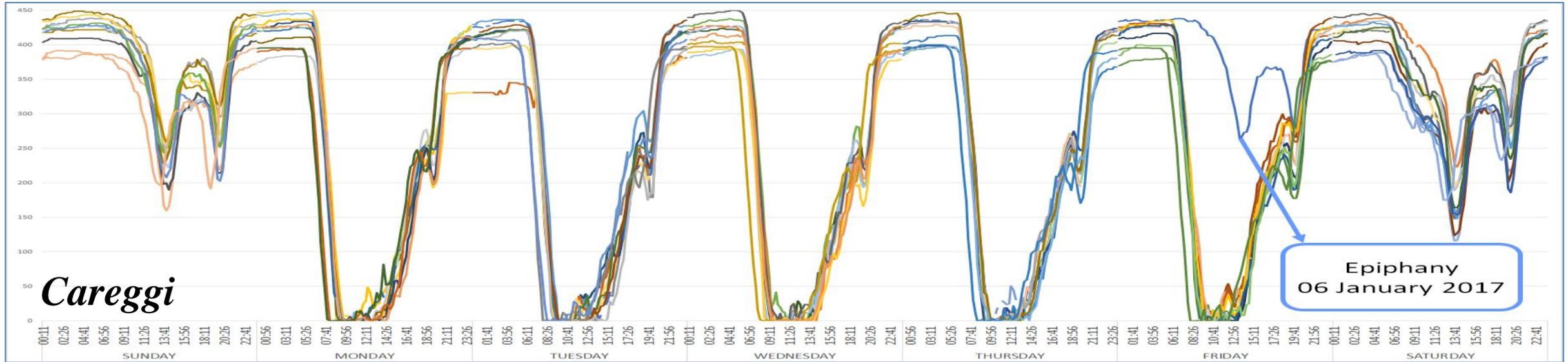
# Smart Parking: predictions



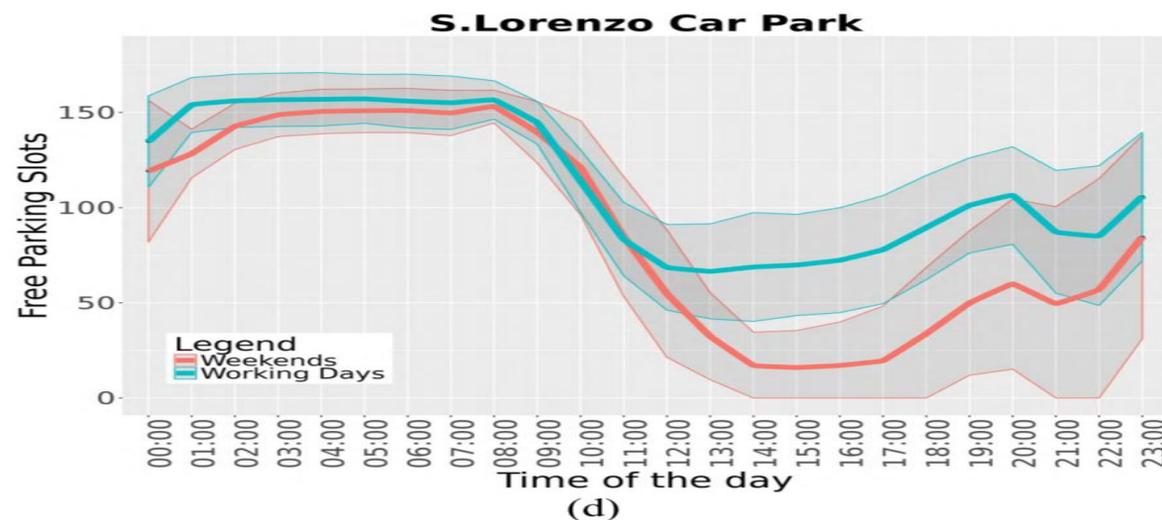
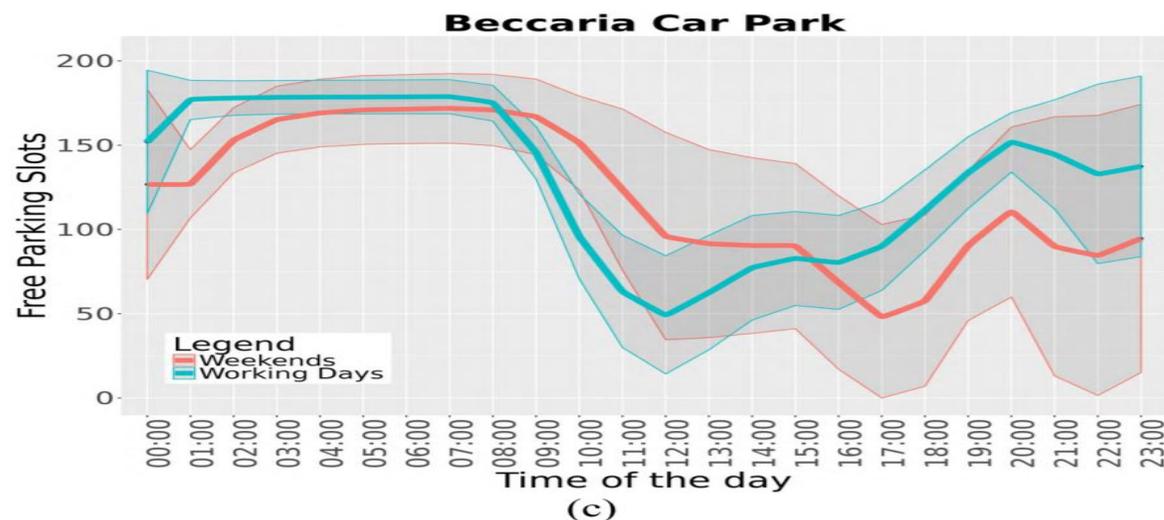
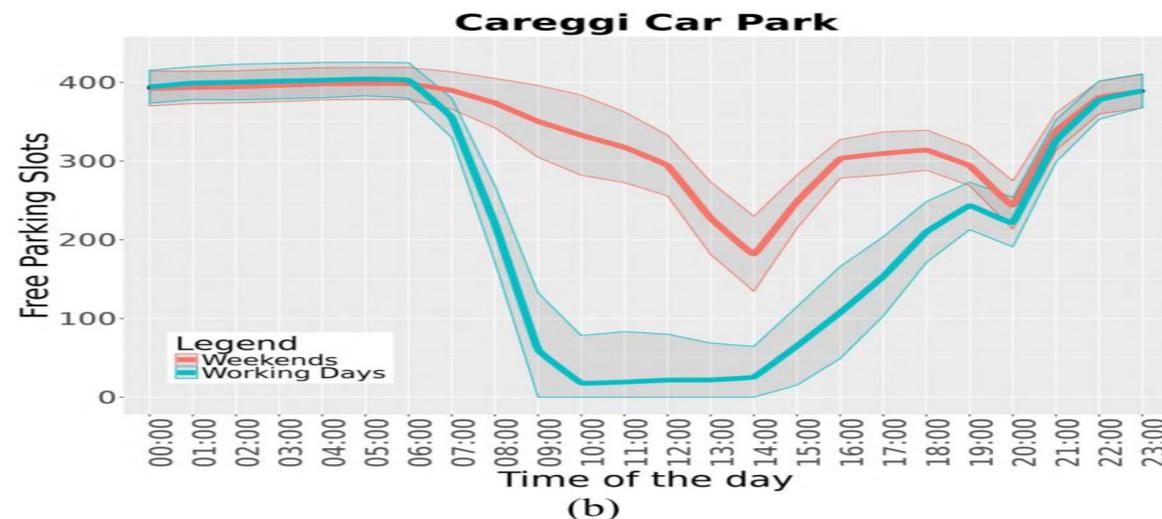
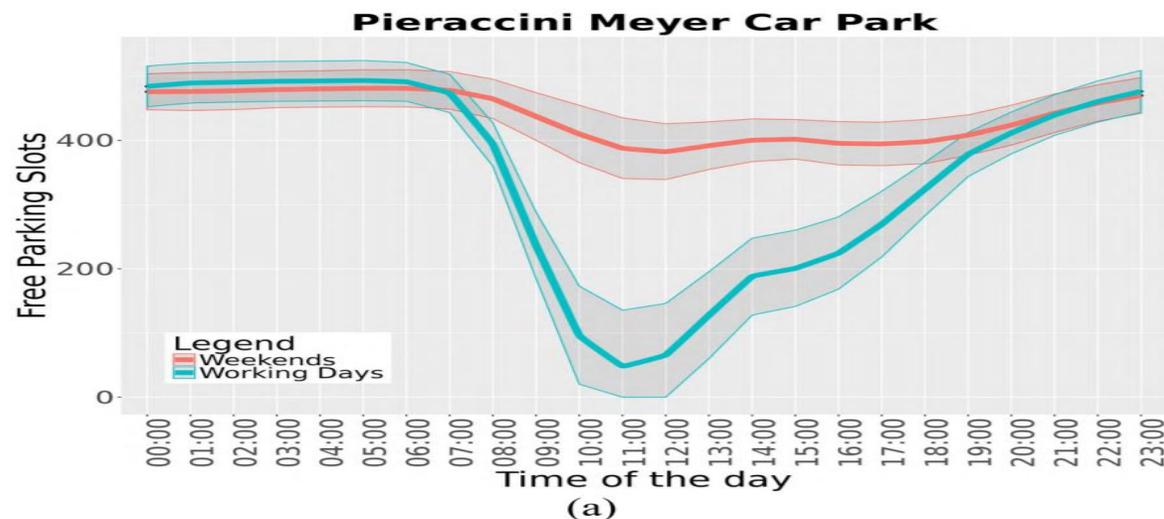




# Free Parking space trends



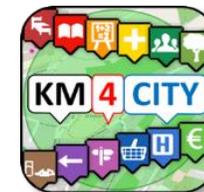
# Free Parking space trends



## 12 parking areas in Florence

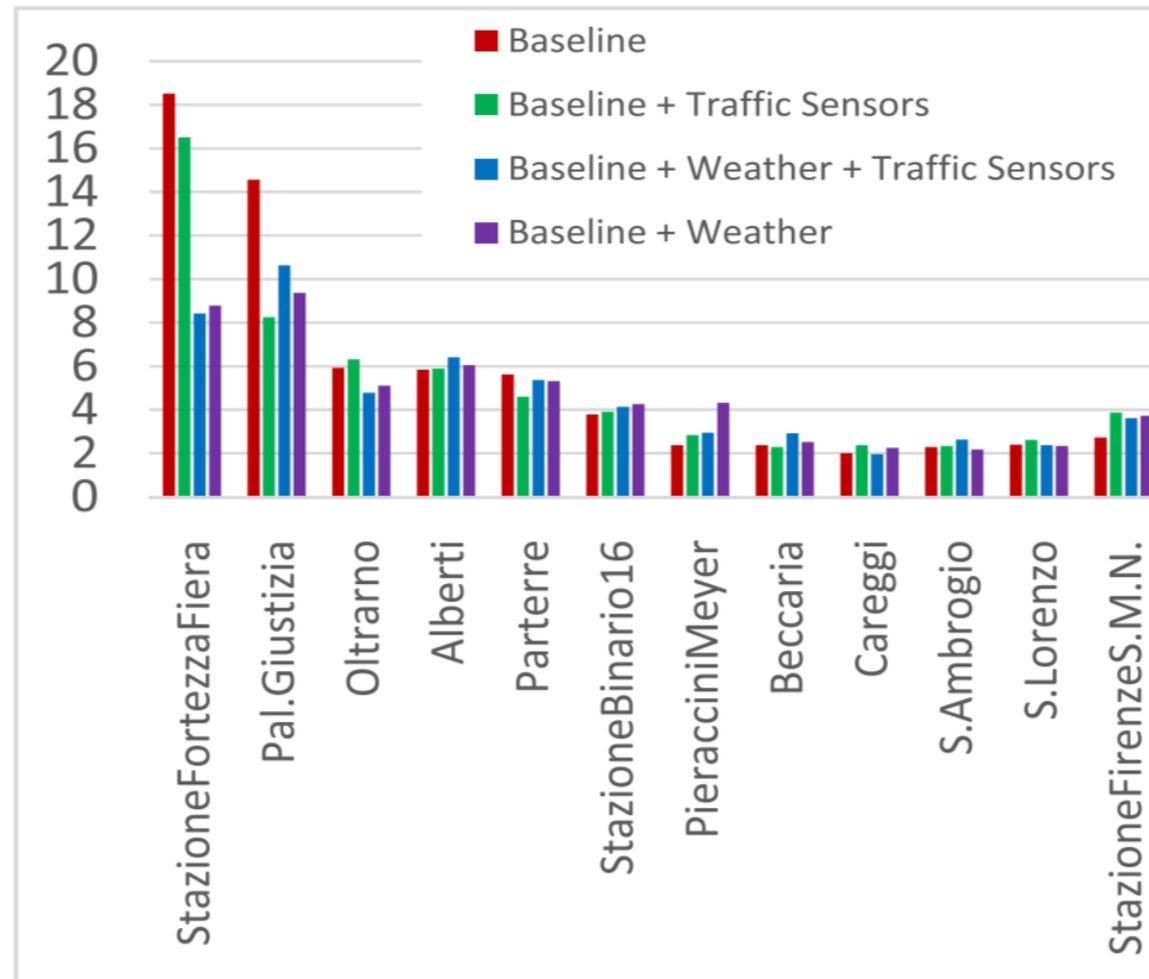


# Free Parking PREDICTIONS



C. Badii, P. Nesi, I. Paoli, "Predicting available parking slots on critical and regular services exploiting a range of open data", IEEE Access, preprint, 2018, <https://ieeexplore.ieee.org/abstract/document/8430514/>

Comparison Error	Forecasting Techniques		
	BRANN	SVR	RNN
<i>Careggi car park</i>			
MASE Night	34.85	16.29	20.01
MASE Morning	0.76	1.42	2.82
MASE Afternoon	1.89	4.34	3.66
MASE Evening	1.99	1.51	2.33
MASE	1.87	2.34	3.16
<i>Pieraccini Meyer car park</i>			
MASE Night	6.08	12.83	10.03
MASE Morning	0.86	1.27	4.90
MASE Afternoon	1.87	2.91	6.75
MASE Evening	1.36	1.57	10.23
MASE	1.37	2.06	6.67
<i>S. Lorenzo car park</i>			
MASE Night	10.33	11.81	18.34
MASE Morning	2.13	1.91	3.93
MASE Afternoon	2.70	3.15	2.37
MASE Evening	2.15	3.09	3.82
MASE	2.72	3.21	4.19
<i>Beccaria car park</i>			
MASE Night	9.32	7.80	12.47
MASE Morning	0.95	1.25	4.87
MASE Afternoon	2.49	2.14	2.45
MASE Evening	2.96	4.75	5.91
MASE	2.13	2.67	4.85



# ML models

The best selected models for the purpose have been:

– BRNN:

- Bayesian Regularized Neural Network

– SVR:

- Support Vector Regression

– ARIMA

- Autoregressive Integrated Moving Average

– RNN

- Recurrent neural networks



# BRNN: Bayesian Regularized Neural Network

$$y_i = g(x_i) + e_i$$

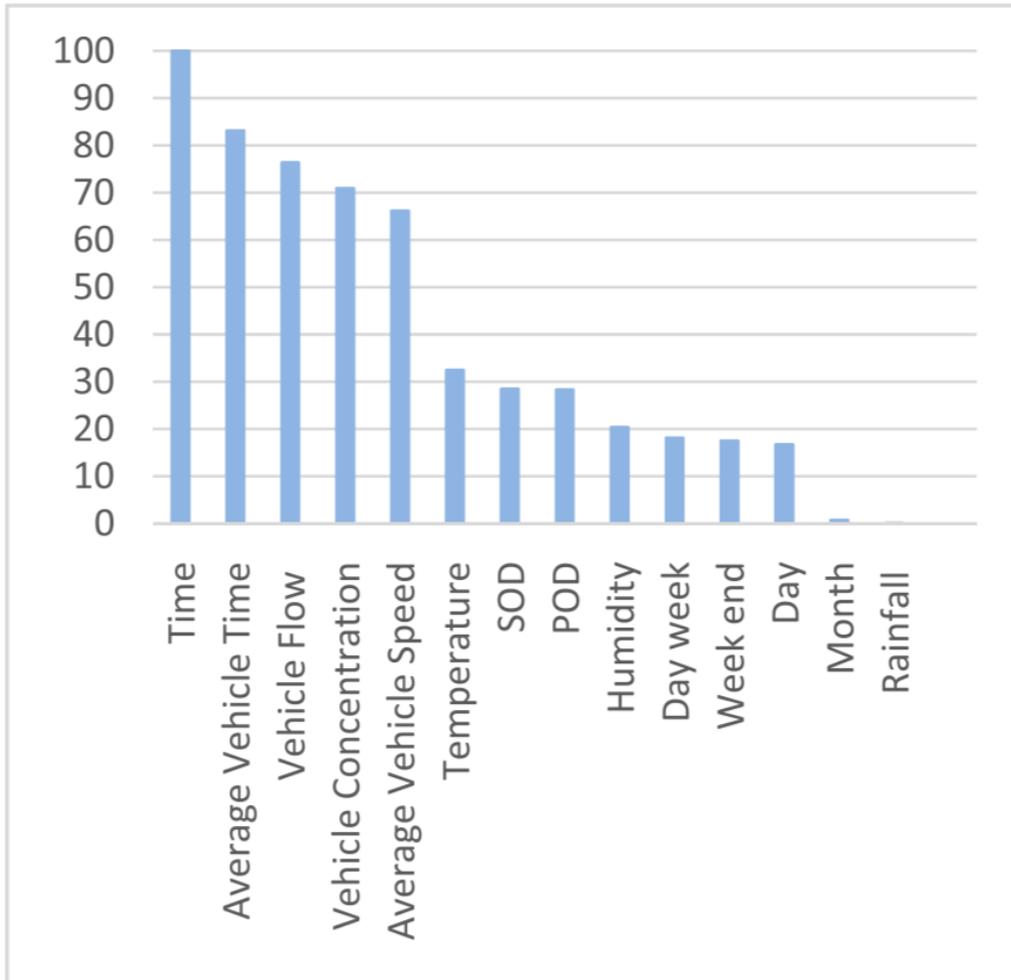
$$y_i = \sum_{k=1}^s w_k g_k \left( b_k + \sum_{j=1}^p x_{ij} \beta_j^{[k]} \right) + e_i, \quad i = 1, \dots, n$$

- $e_i \sim N(0, \sigma_e^2)$ ;
- $s$  is the number of neurons;
- $w_k$  is the weight of the  $k$ -th neuron,  $k = 1, \dots, s$ ;
- $b_k$  is a bias for the  $k$ -th neuron,  $k = 1, \dots, s$ ;
- $\beta_j^{[k]}$  is the weight of the  $j$ -th input to the net,  $j = 1, \dots, p$ ;
- $g_k(\cdot)$  is the activation function: in this case

$$g_k(x) = \frac{e^{2x} - 1}{e^{2x} + 1}$$

The objective function consists of minimizing  $F = \alpha E_W + \beta E_D$ , where  $E_W$  is the sum of squares of network parameters (weight and bias), and  $E_D$  is the error (sum of squares),  $\alpha$  and  $\beta$  are the objective function parameters.

## Relevance of Variable



Category	Features	Description of features variable
Baseline features of free slot data	Free parking slots	Real number of available slots recorded every 15 minutes
	Time	Hours and minutes
	Month	Month of the year (1-12)
	Day	Day of the month (1-31)
	Day week	Day of the week (0-6)
	Weekend	0 for working days, 1 else
	Previous observation's difference (POD)	Difference between the number of free spaces at time $i$ and number of free spaces at time $(i - 15 \text{ minutes})$ recorded in the previous week
	Subsequent observation's difference (SOD)	Difference between the number of free spaces at time $i$ , and the number of free spaces at time $(i + 15 \text{ minutes})$ recorded in the previous week
Weather features	Temperature	City temperature measured one hour earlier than Time ( $^{\circ}\text{C}$ )
	Humidity	City humidity measured one hour earlier than Time (%)
	Rainfall	City rainfall measured one hour earlier than Time (mm)
Traffic Sensors features	Average Vehicle Speed	Average speed of vehicles on the road being closest to the parking, over one-hour period (km/h)
	Vehicle Flow	Number of vehicles passing by closest to the parking, over one-hour period
	Average Vehicle Time	Average of distance between vehicles, over one-hour period
	Vehicle Concentration	Number of vehicles per kilometer, over one-hour period

# Free Parking PREDICTIONS



## Performances

Training	Forecasting Techniques			
	BRANN	SVR	RNN	ARIMA
Average Training processing time (sec)	76.3	9.1	598.7	9.2
Re-Training frequency	Daily	Daily	Daily	Hourly
Training period	3 months	3 months	3 months	3 months
Estimation	BRANN	SVR	RNN	ARIMA
Average Estimation time (sec)	0.0031	0.0052	0.034	0.0015
Estimation frequency	Hourly	Hourly	Hourly	Hourly
Estimation predicted period	1 hour	1 hour	1 hour	1 hour

# Free Parking Predictions



## Careggi car park

Model features	BRNN model results		
	R-squared	RMSE	MASE
Baseline	0.974	24	1.87
Baseline + Weather	0.975	24	1.75
Baseline + Traffic sensors	0.975	24	2.04
Baseline + Weather + Traffic sensors	0.975	24	1.87



Active on Mobile Apps as:

- «Firenze dove cosa»
- «Toscana dove cosa»

Precision: 97,5%

# Monitoring Station for Parking

Sat 3 Nov 23:39:55

**Car Park Stazione Binario 16**

**Parceggio Stazione Binar...**

Around Here

Real time	Time
120	11-03-2018 23:26

Predictions	Time
69	11-03-2018 23:45
28	11-04-2018 01:30
28	11-04-2018 01:45
69	11-03-2018 23:45

Daily Trend

Saturday

Abbonamenti: - Tessera a scalare dal valore di ? 120,00 Euro al costo di 100,00 \*salvo disponibilità tariffe attivabile esclusivamente per il giorno anticipato. L'abbonamento mensile potrà essere utilizzato anche in un mese successivo a quello dell'acquisto.---

Abbonamenti\_autovetture: N/A----

Abbonamenti\_moto: N/A----

**Car Park Stazione Firenze S.M.N.**

**Parceggio Stazione Firen...**

Around Here

Real time	Time
370	11-03-2018 23:26

Predictions	Time
112	11-03-2018 23:45
544	11-04-2018 01:30
545	11-04-2018 01:45
112	11-03-2018 23:45

Daily Trend

Saturday

Car park

Abbonamenti: N/A----

Abbonamenti\_autovetture: N/A----

Abbonamenti\_moto: N/A----

Tariffa\_giornaliera: N/A----

Tariffa\_oraria\_autovetture: - Prima ora non frazionabile: ? 3,00 - Seconda ora e tutte le ore successive frazionabili alla 1/2 ora: ? 3,00 ----Tariffa\_oraria\_ordinaria\_lun\_sab: N/A----Tariffa\_oraria\_speciale\_lun\_sab: N/A----

Tariffe: N/A----Tariffe\_dom\_festivi: N/A----

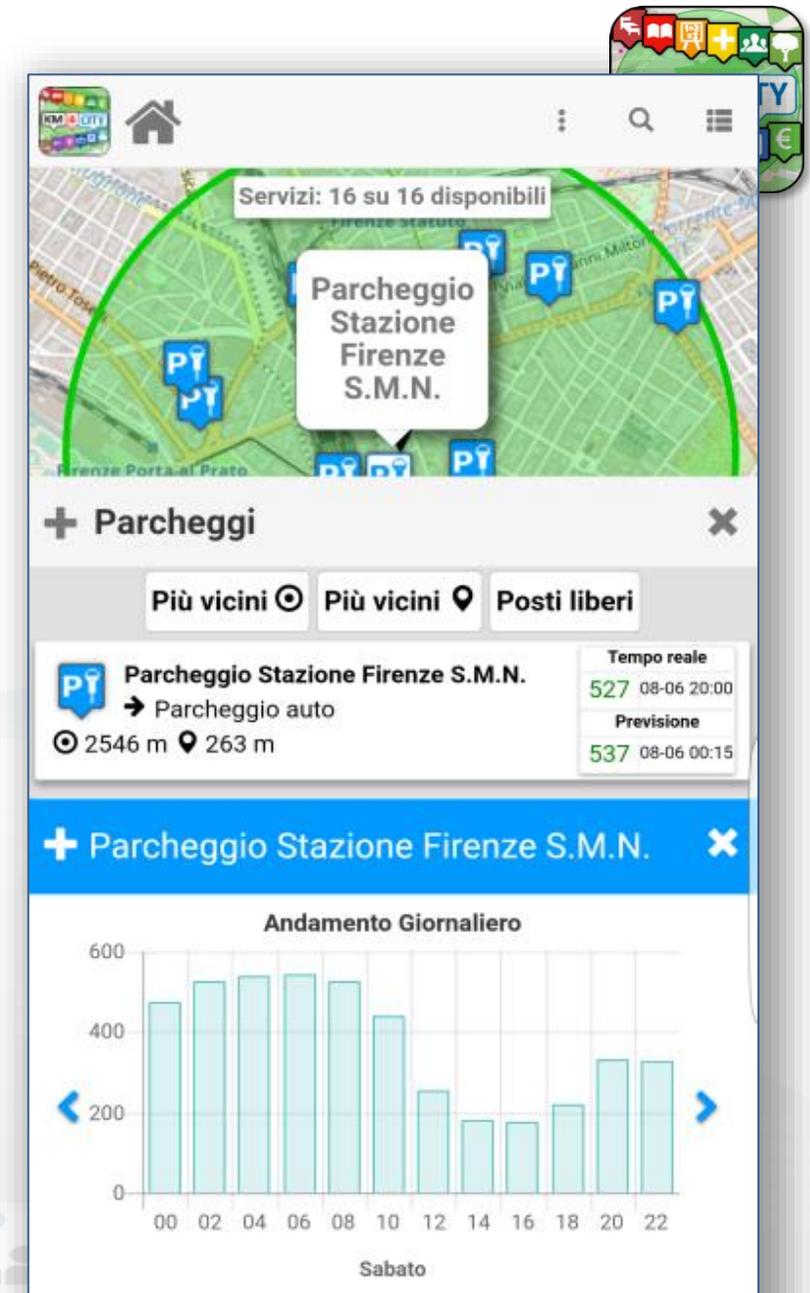
Tariffe\_moto: - Tariffa oraria: ? 0,50 ogni ora o frazione di ora - Tariffa giornaliera: dalle

<https://www.disit.org/dashboardSmartCity/view/index.php?iddashboard=MjQ2>

# Predictions on Parking

- C. Badii, P. Nesi, I. Paoli,  
"Predicting available parking  
slots on critical and regular  
services exploiting a range of  
open data", IEEE Access,  
preprint,  
2018, <https://ieeexplore.ieee.org/abstract/document/8430514/>

IEEE  
Access®



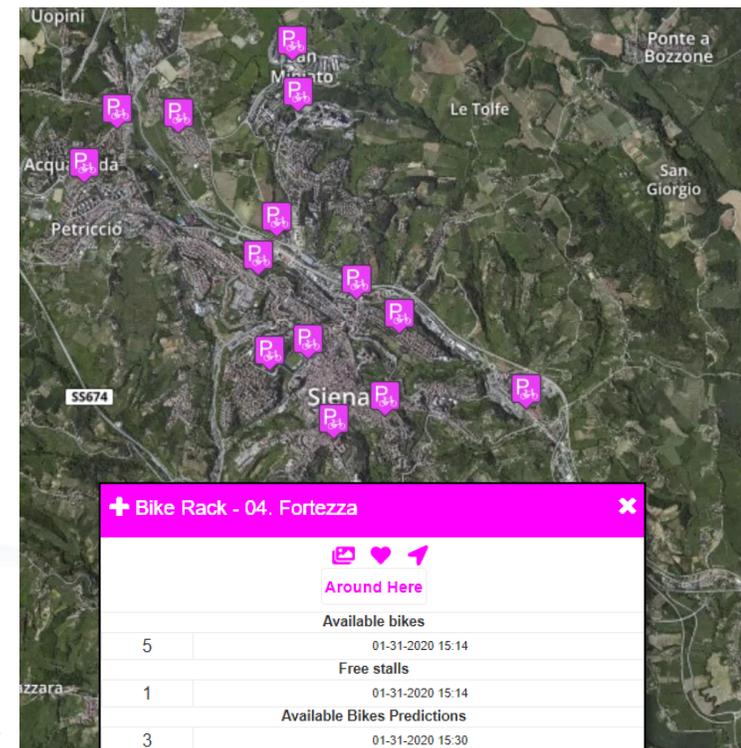
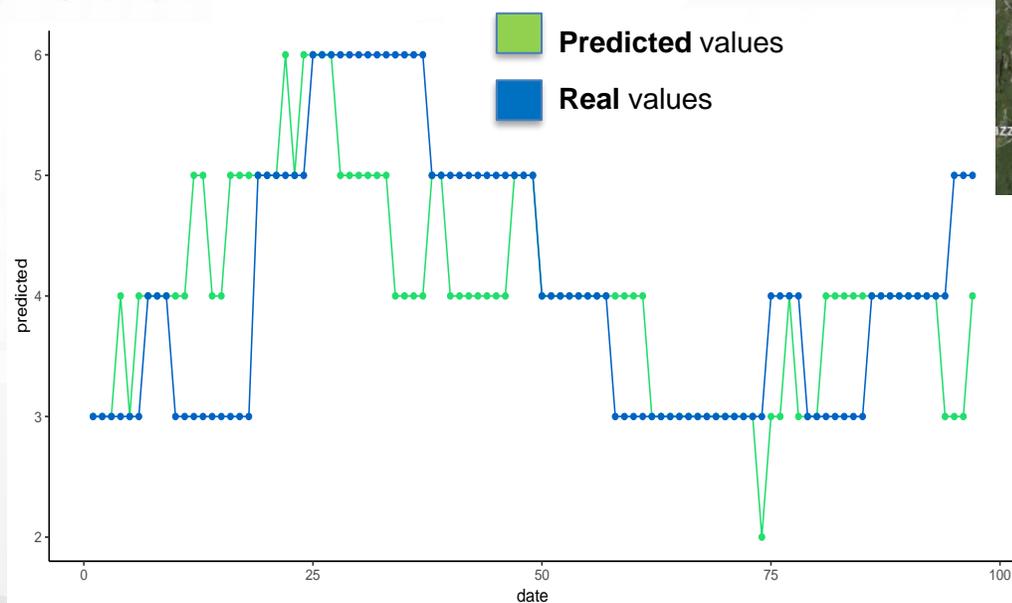
# Smart Bike Sharing



- For each Bike Rack, Prediction of the number of
  - available bikes in sharing
  - free slots for leaving the bike

## • Machine Learning Model

- Recurrent NN
- MASE 3-4.5
- MAE <0.7-0.8



**+ Bike Rack - 04. Fortezza**

**Around Here**

Available bikes	Time
5	01-31-2020 15:14

Free stalls	Time
1	01-31-2020 15:14

Available Bikes Predictions	Time
3	01-31-2020 15:30
2	01-31-2020 15:45
2	01-31-2020 16:00
2	01-31-2020 16:15

**Daily Trend - Available bikes**

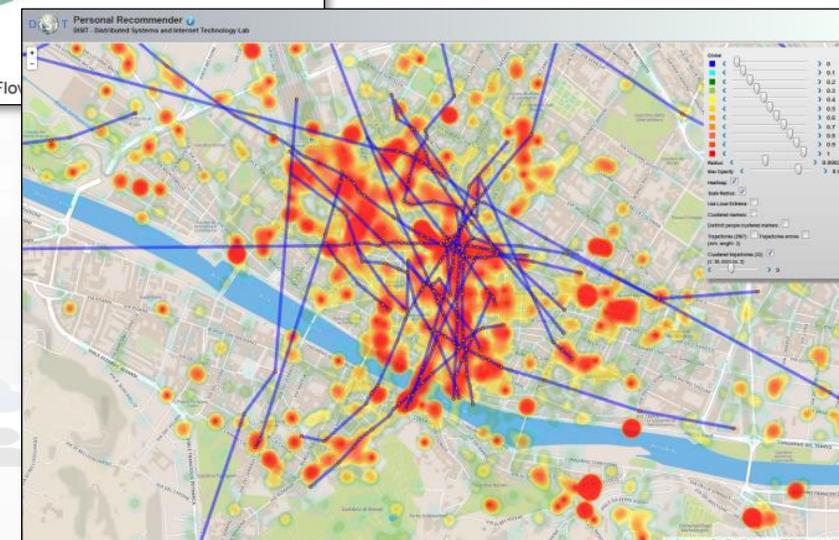
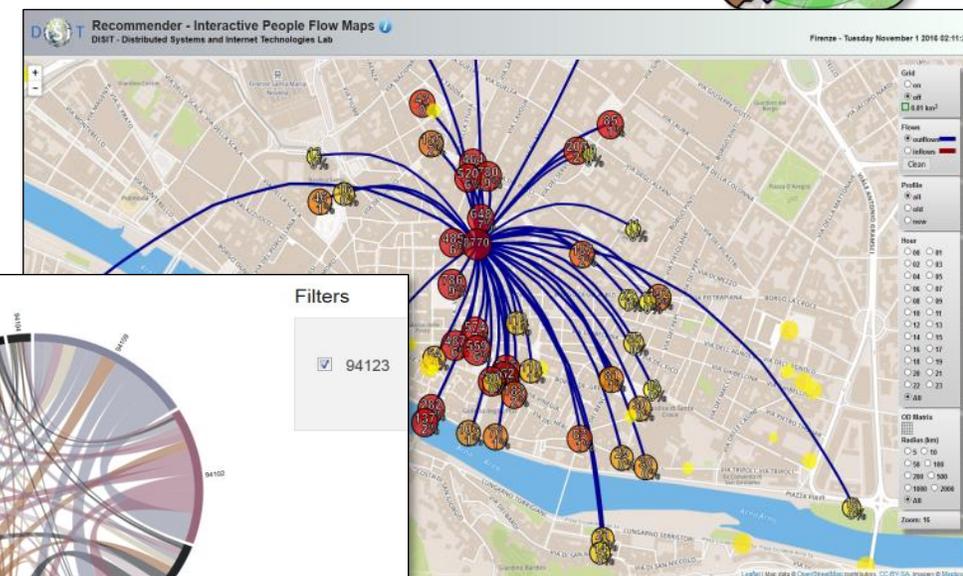
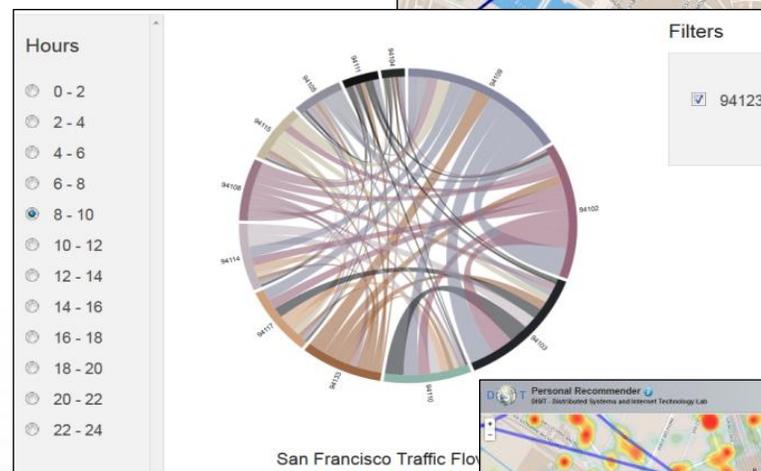
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# *User Behaviour Analysis via Wi-Fi, OD Matrices*



# User Behaviour Analysis

- **Monitoring movements by traffic flow sensors**
  - Spires and virtual spires
- **Monitoring movements from Mobile Cells**
  - Unsuitable for precise tracking and OD production
- **Monitoring movements from Wi-Fi**
- **Monitoring movements and much more from mobile Apps**

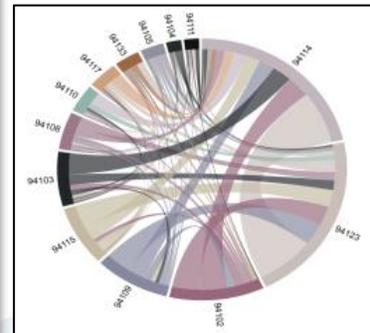
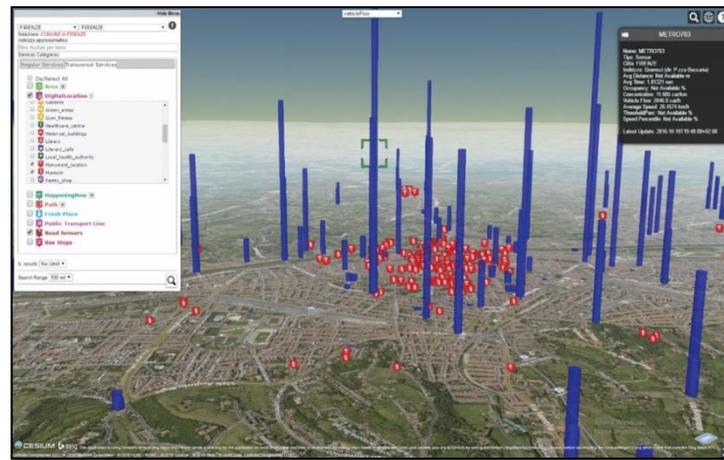
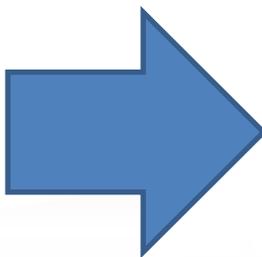




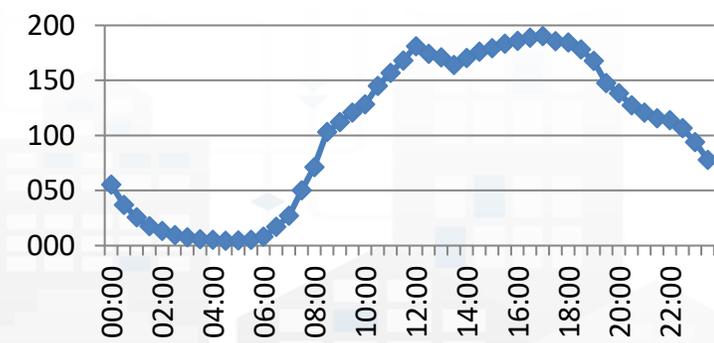


# Predicting City users movements

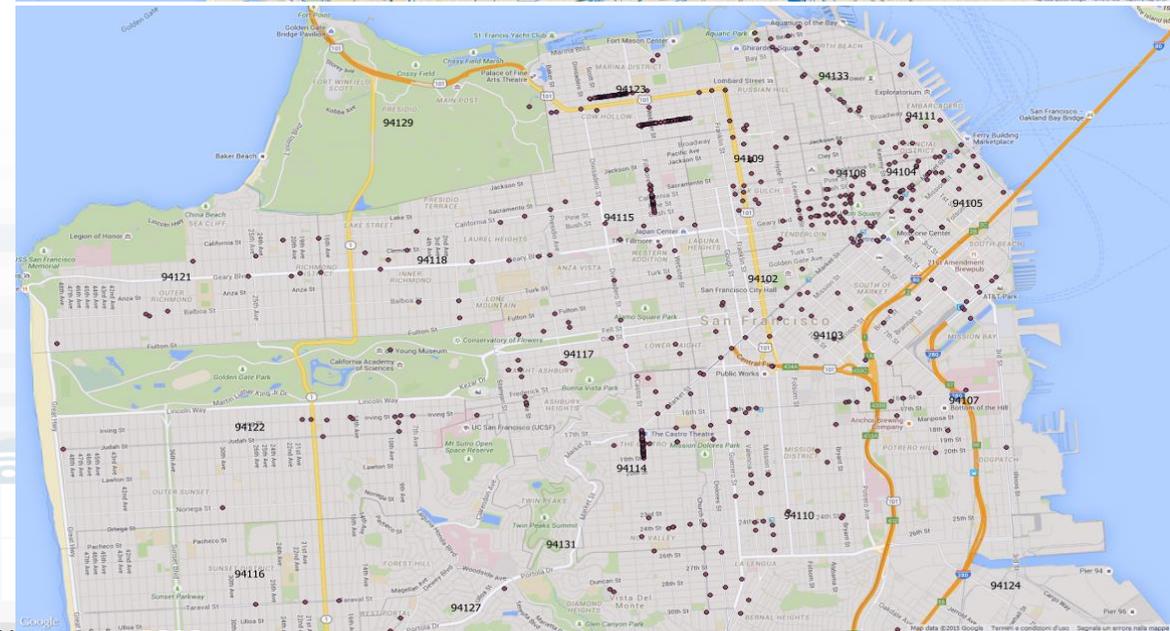
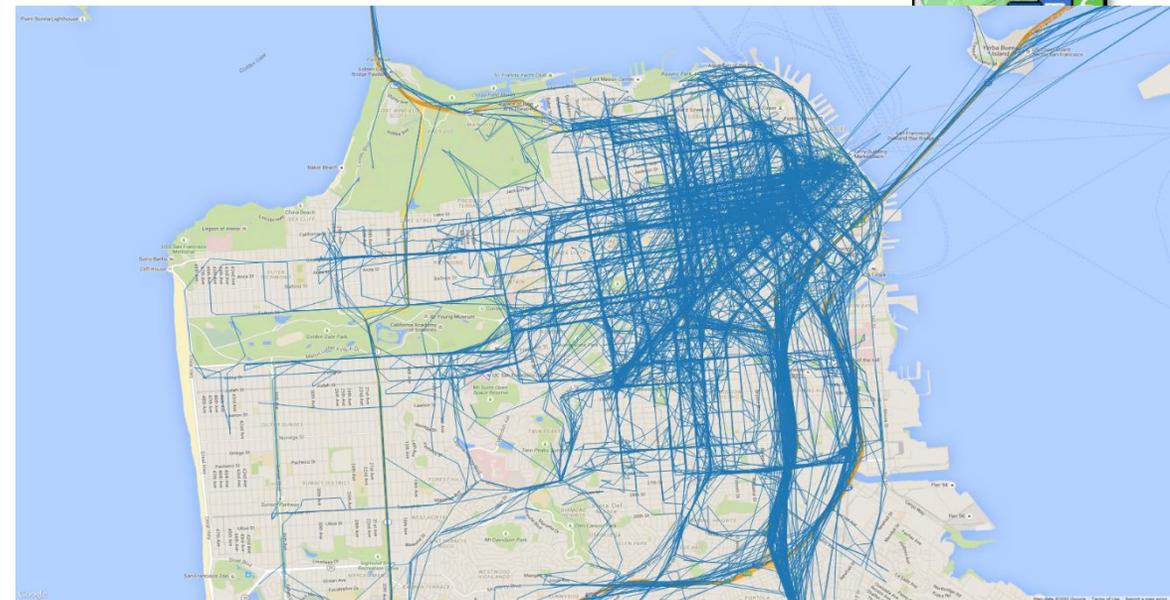
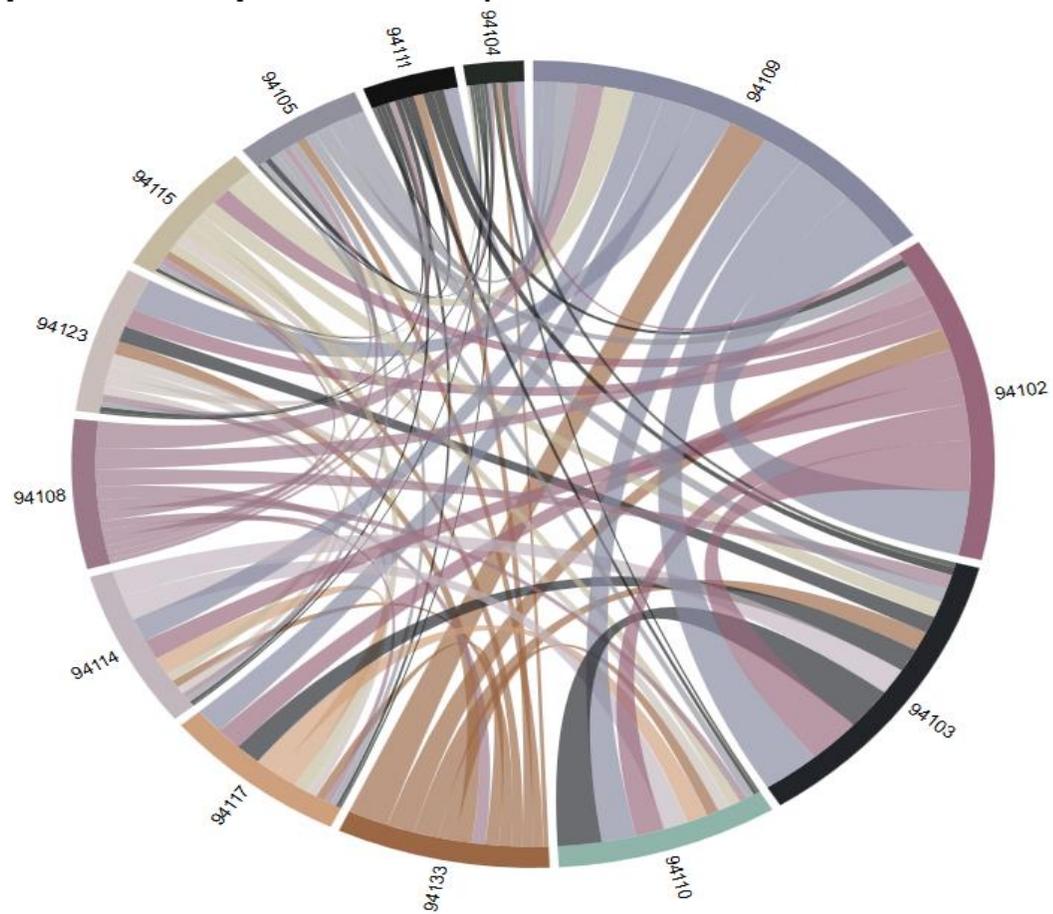
- **Issue:**
  - How they move: vehicles, pedestrian, bike, ferry, metro,
  - Where they go....
- **Impact:**
  - Tuning the services: cleaning, police, control, security
- **Several metrics related to**
  - Knowledge of the city
  - Monitoring traffic and people flow
  - .....



- Daily trends
- OD matrices
- Trajectories
- Prediction models

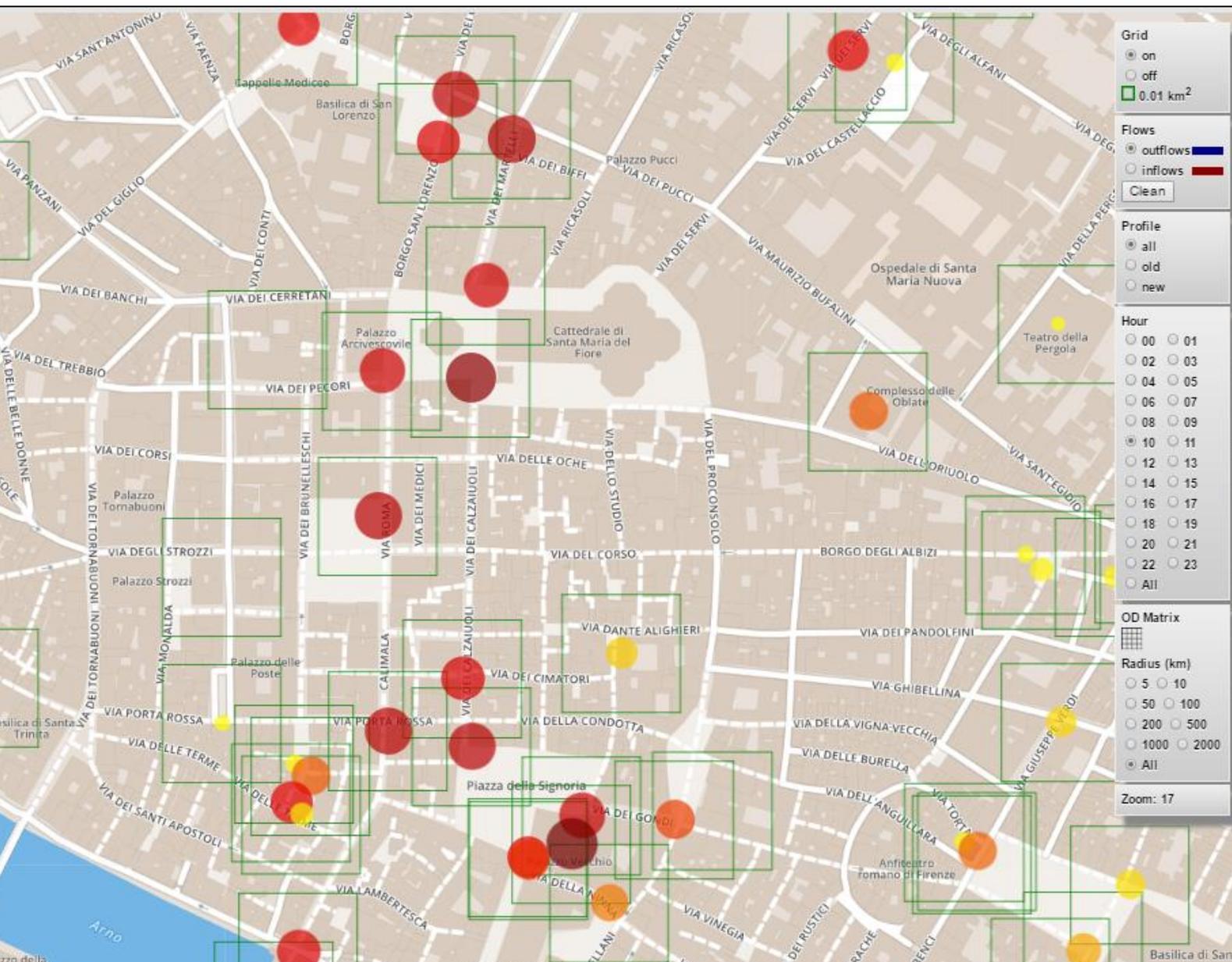


# San Francisco Case



San Francisco OD matrix as a chord diagram among the 13 central ZIP areas of the city (real cab flows)

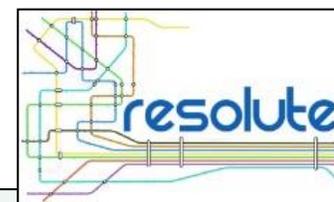
# Firenze Wi-Fi



- AP → heatmap sparsa
- Inflow/outflow
- New/Old users
- per fascia oraria



# Wi-Fi Monitor Tool



**DISIT WiFi Firenze**  
DISIT - Distributed Systems and Internet Technology Lab

### FirenzeWifi

Utenti FWIFI: 4357  
Eventi FWIFI: 17001  
AP FWIFI: 233

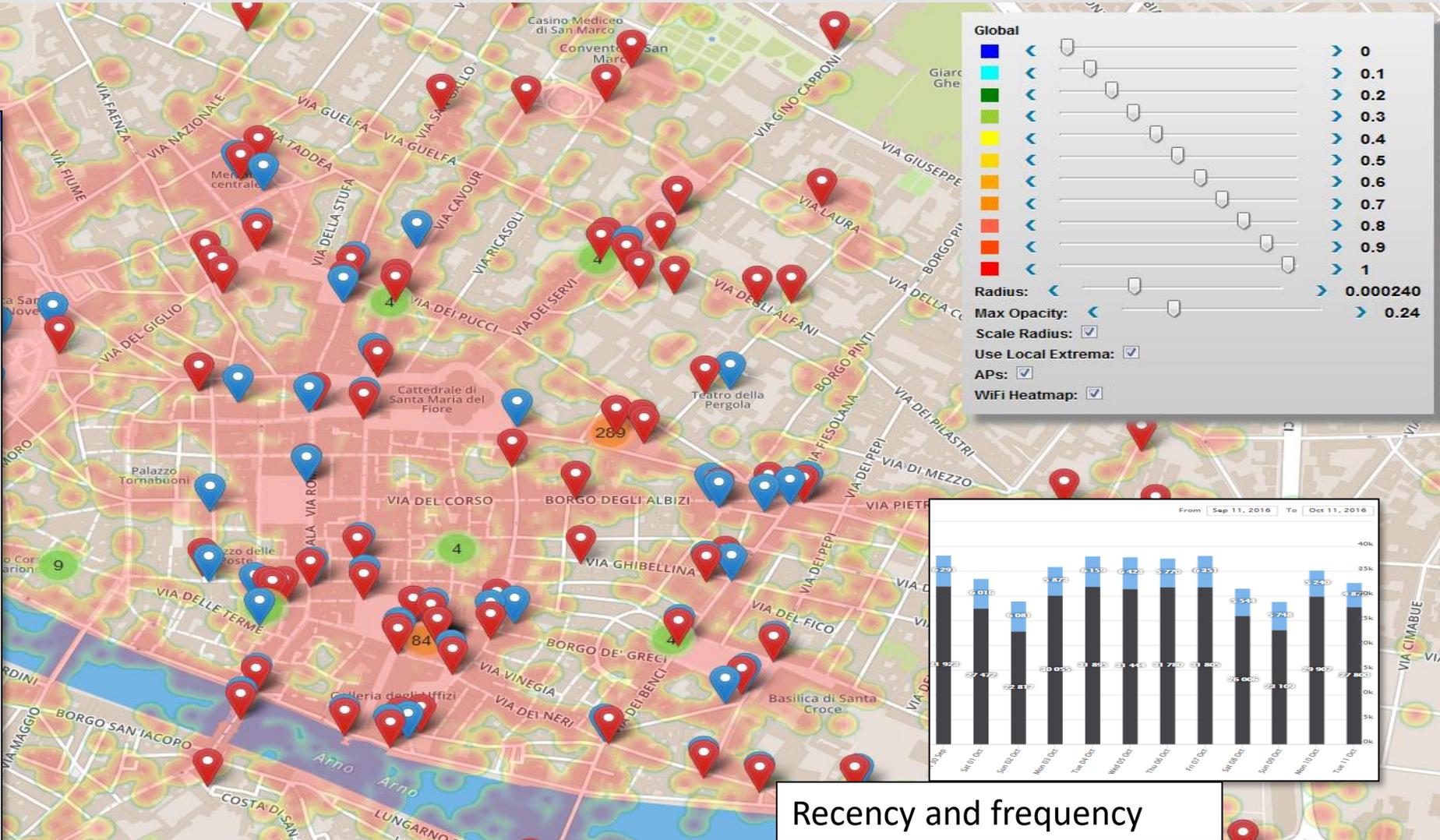
Utenti FWIFI (weekly): 11740, 8805, 5870, 2935

Utenti FWIFI (mensile): 11740, 8805, 5870, 2935

AP FWIFI (mensile): 320, 160, 80

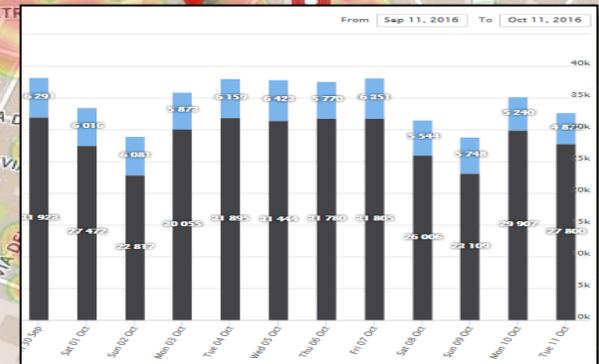
AP FWIFI (weekly): 320, 160, 80

Twitter Vigilance



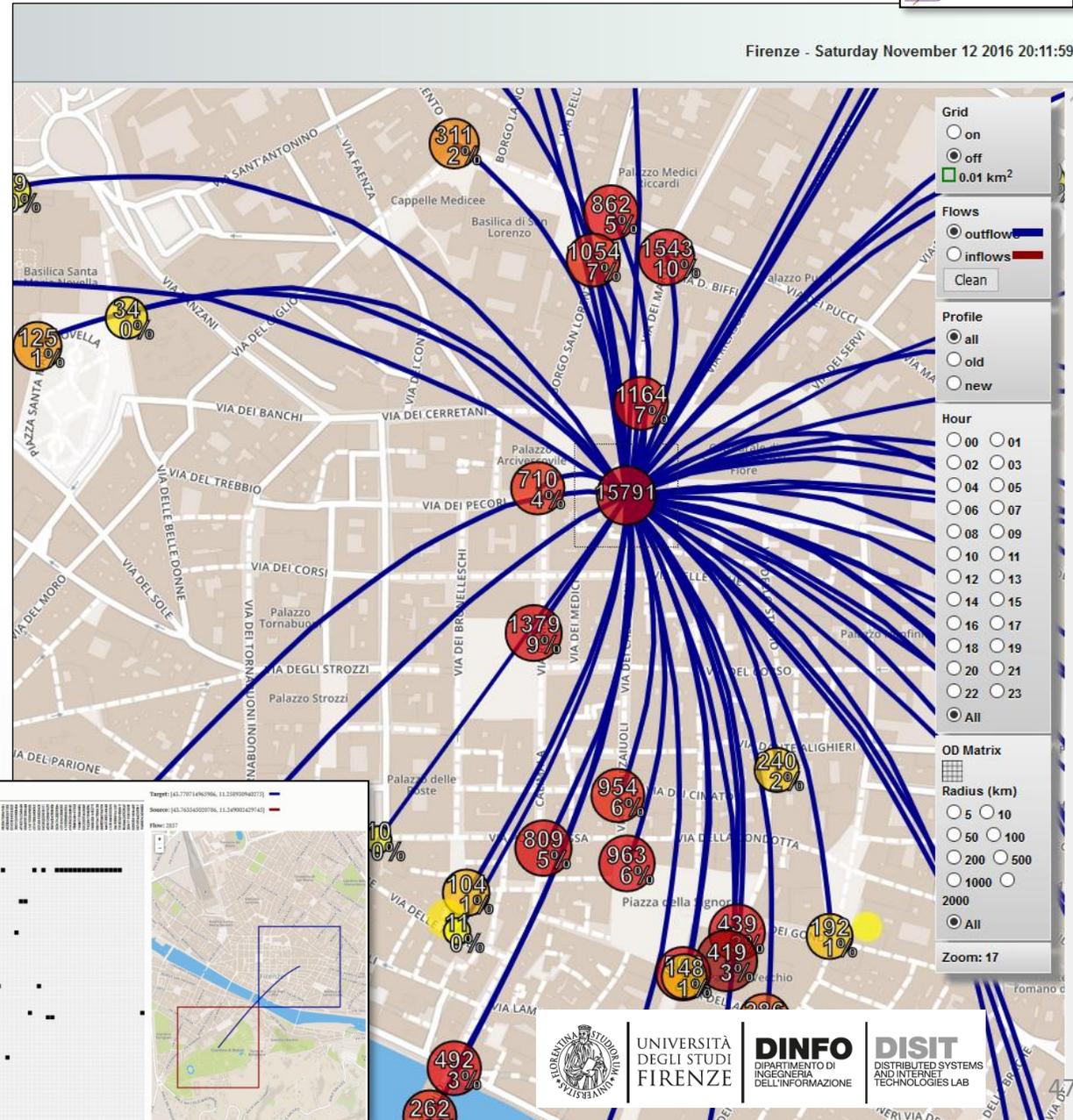
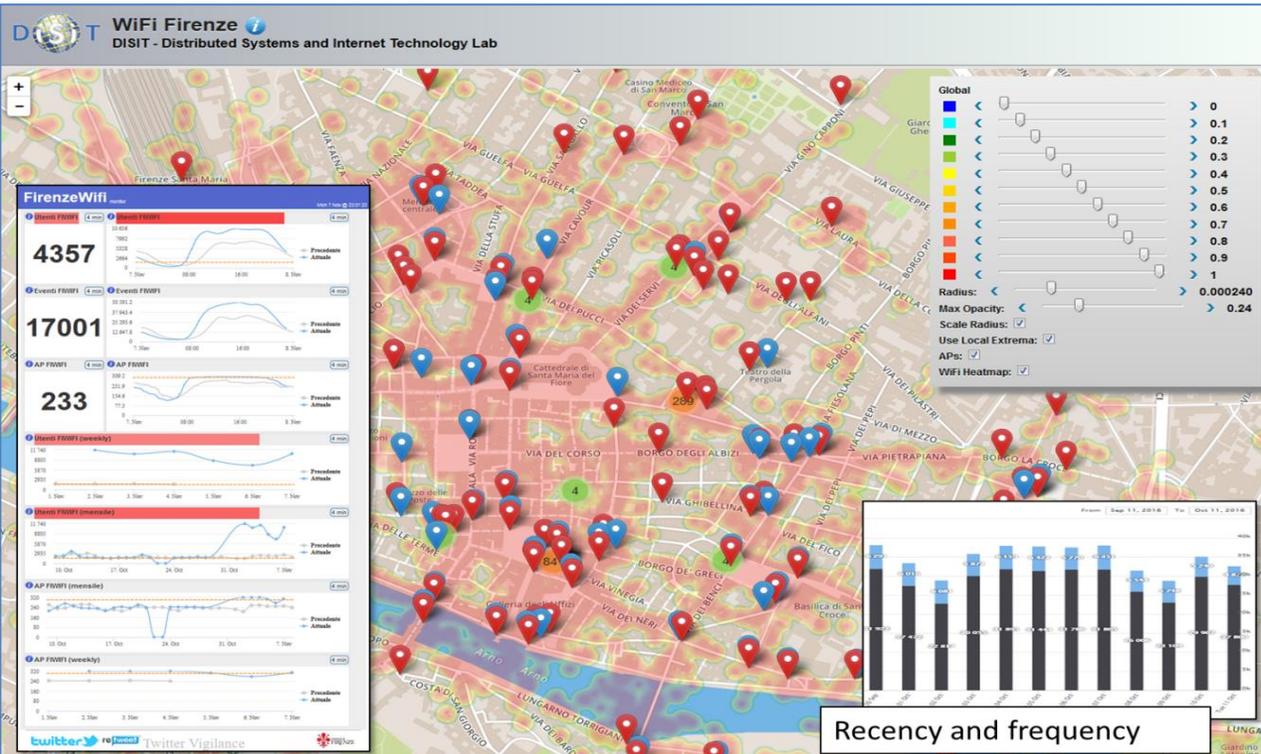
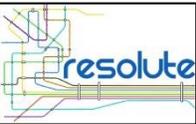
#### Global

- Color scale: 0 (blue) to 1 (red)
- Radius: 0.000240
- Max Opacity: 0.24
- Scale Radius:
- Use Local Extrema:
- APs:
- WiFi Heatmap:

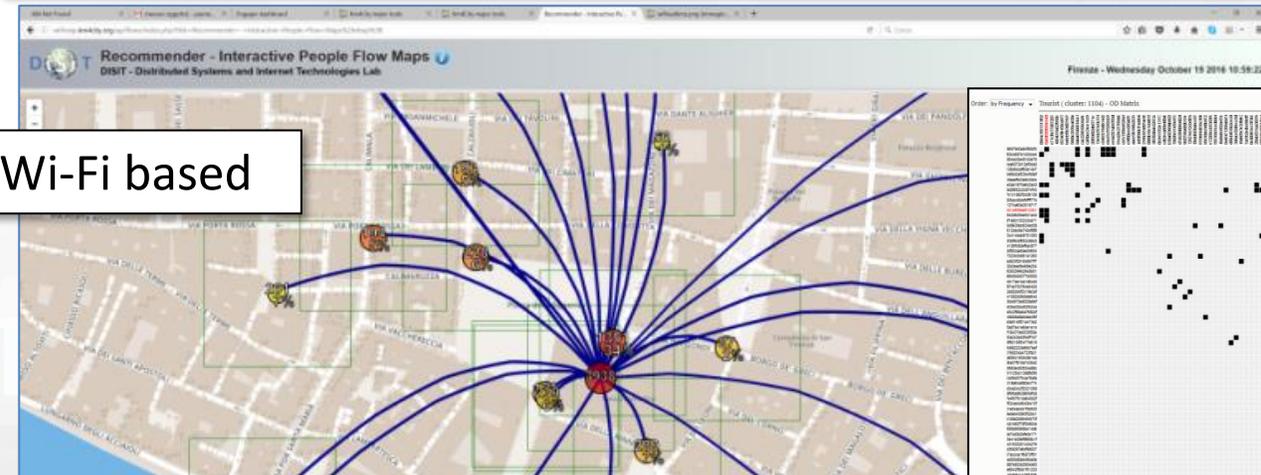


Recency and frequency

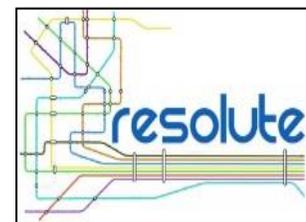
# Origin Destination Matrix Estimation



Wi-Fi based

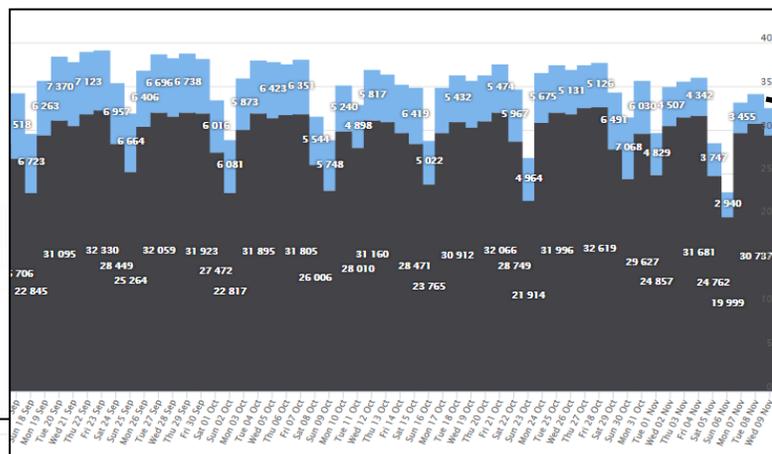
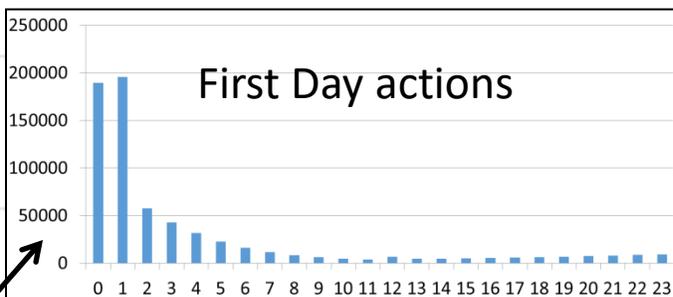
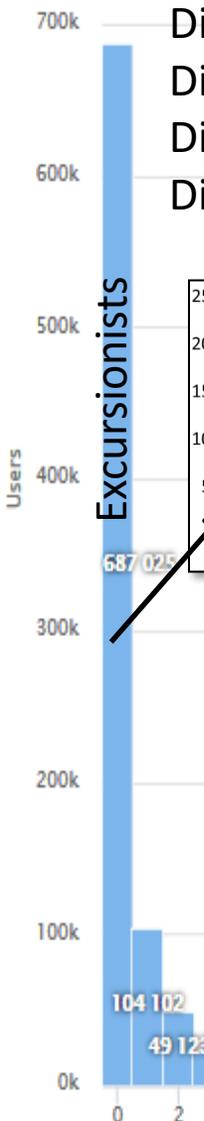


# User Behaviour Analysis

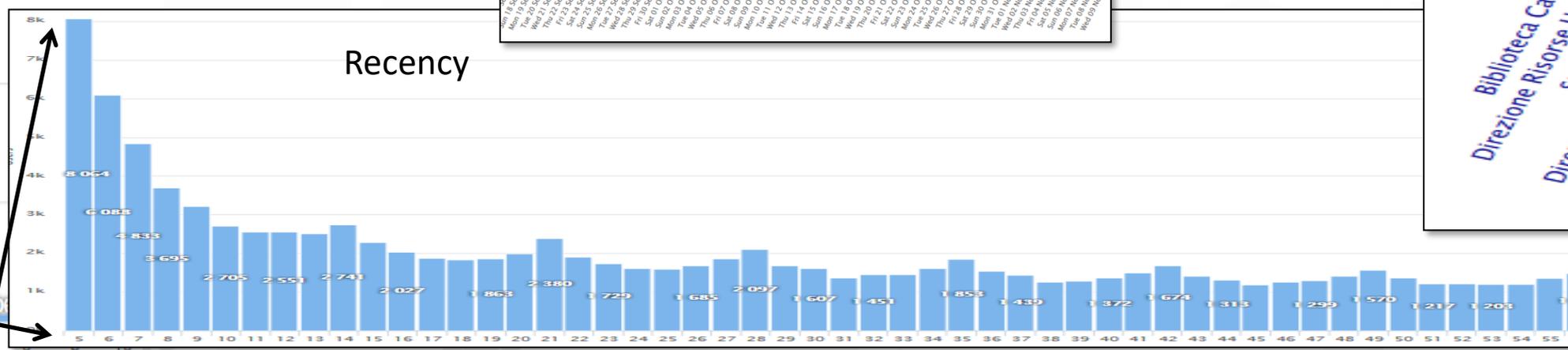
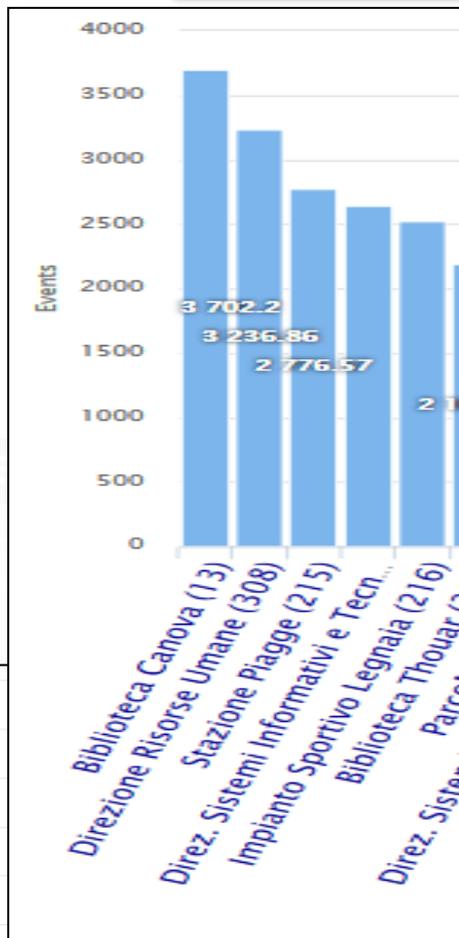


Distinct APs: 343  
 Distinct APs (last 24 hours): 311  
 Distinct Users (last 180 days): 1102098  
 Distinct Excursionists (last 180 days, < 24 h): 687025

Where



New City Users  
VS  
Returning



Recency



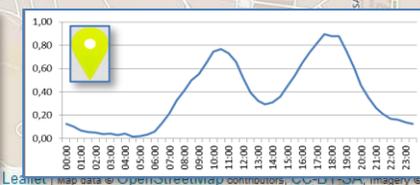
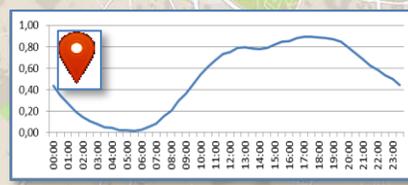
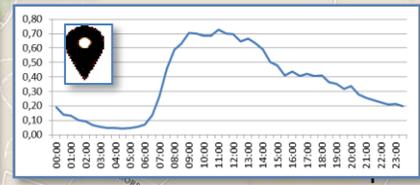
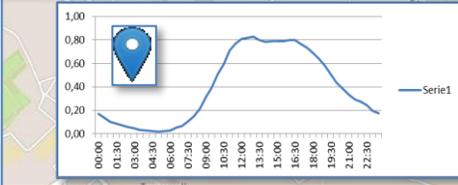
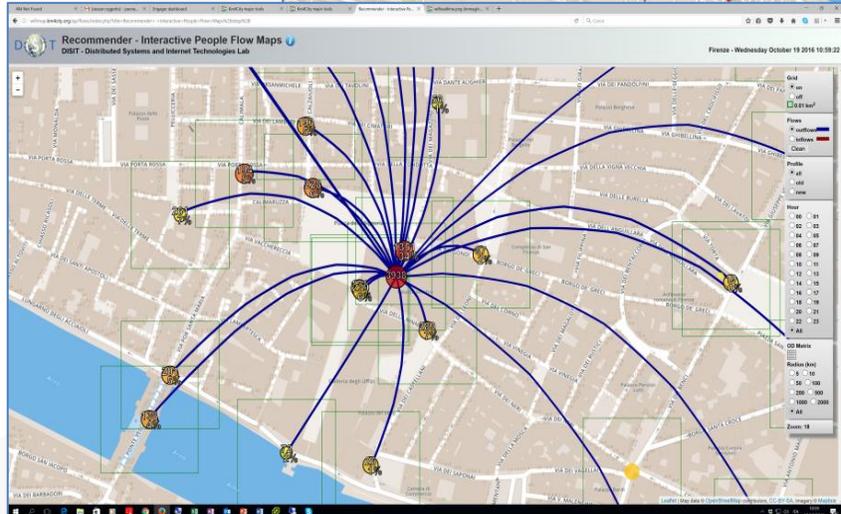
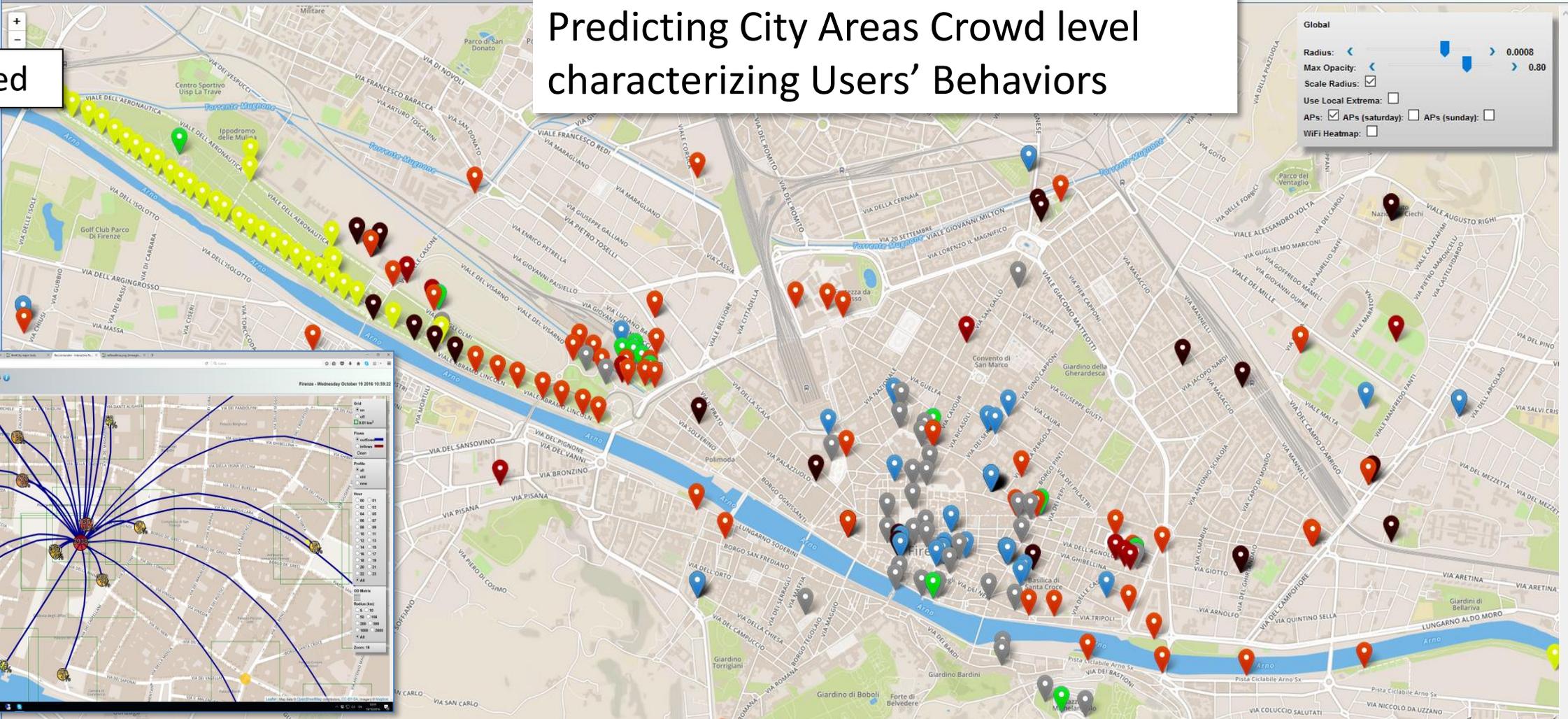
# Characterizing City Areas by User Behavior

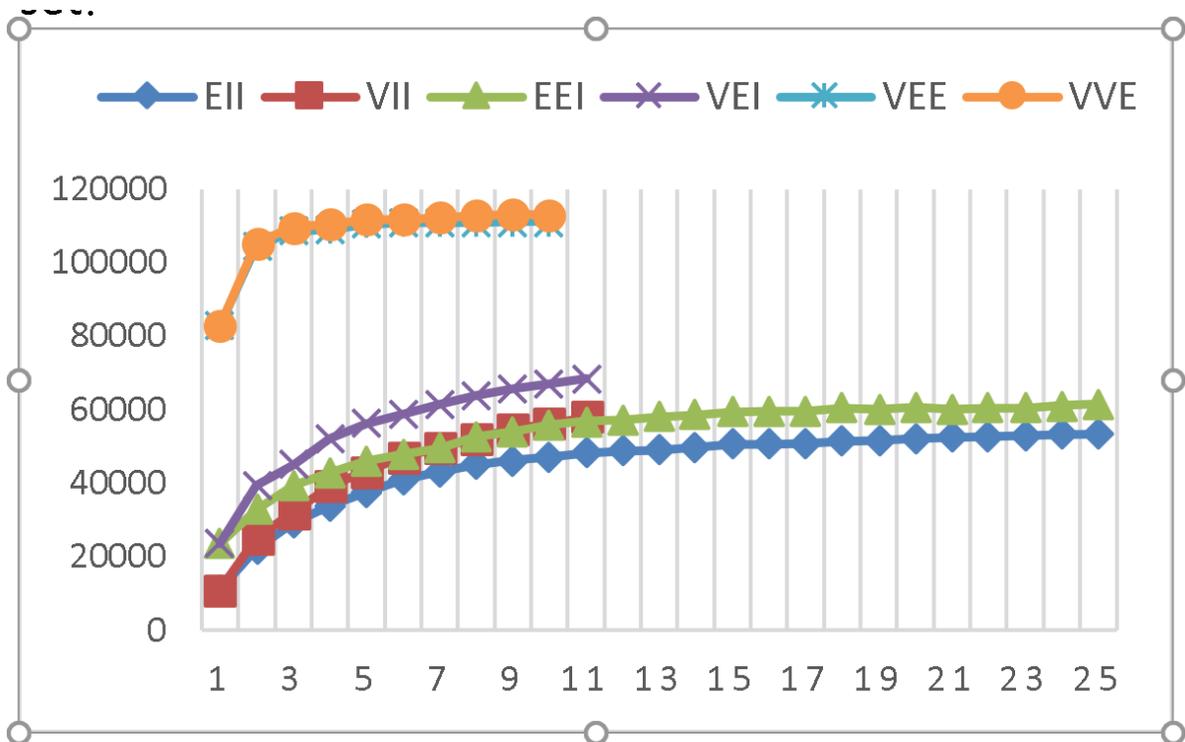
DISIT Firenze Wi-Fi: Access Points Clusters Coverage Map  
DISIT - Distributed Systems and Internet Technologies Lab

Firenze - Saturday November 12 2016 19:16:33

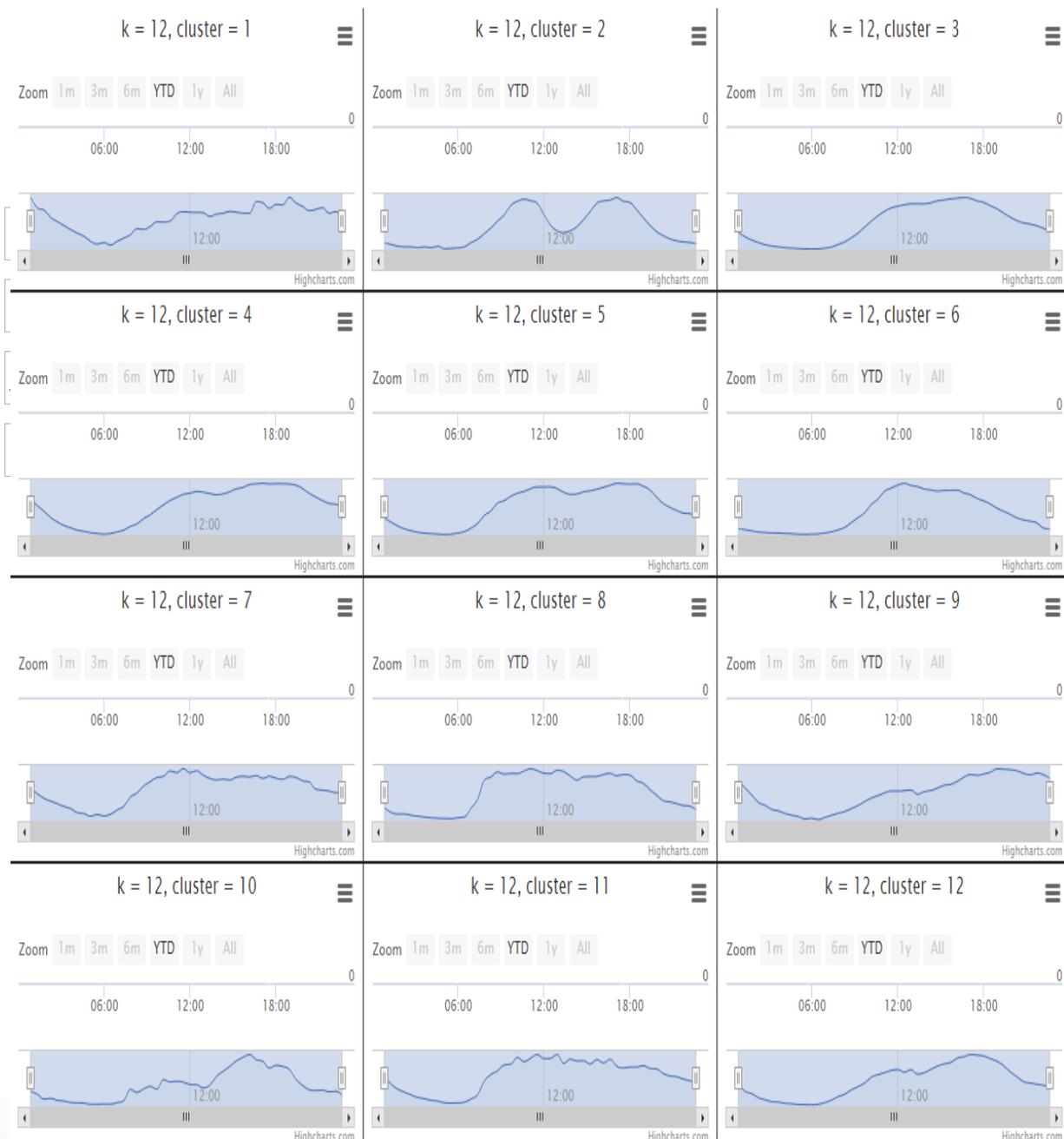
Wi-Fi based

Predicting City Areas Crowd level characterizing Users' Behaviors



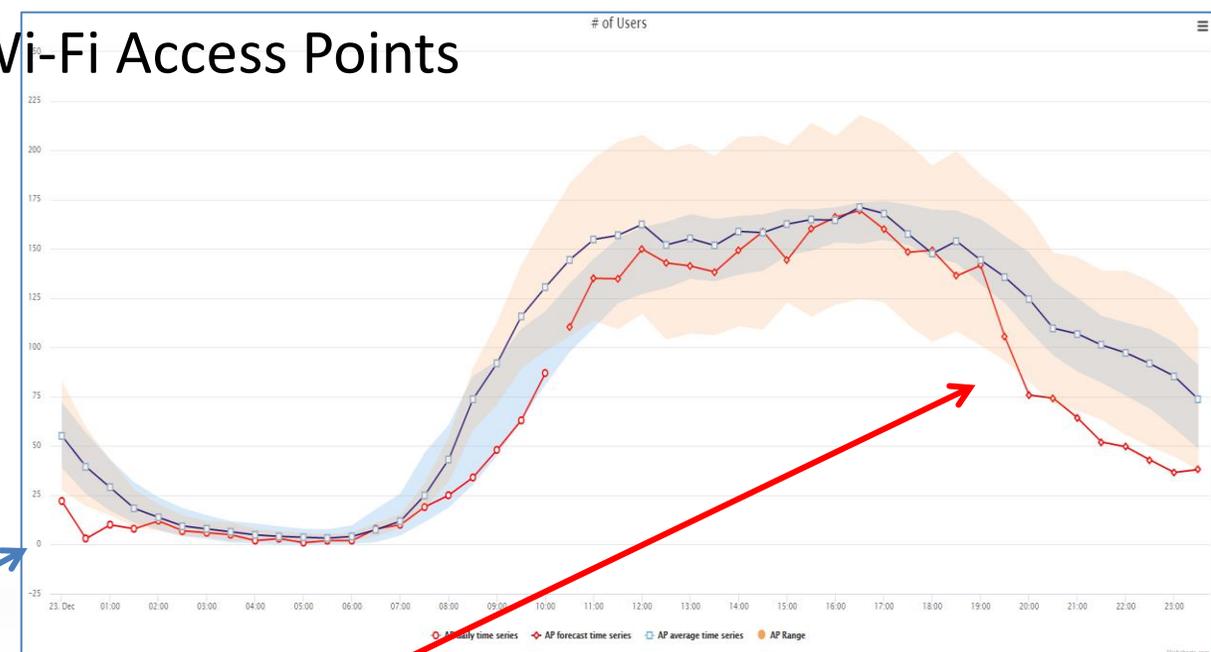
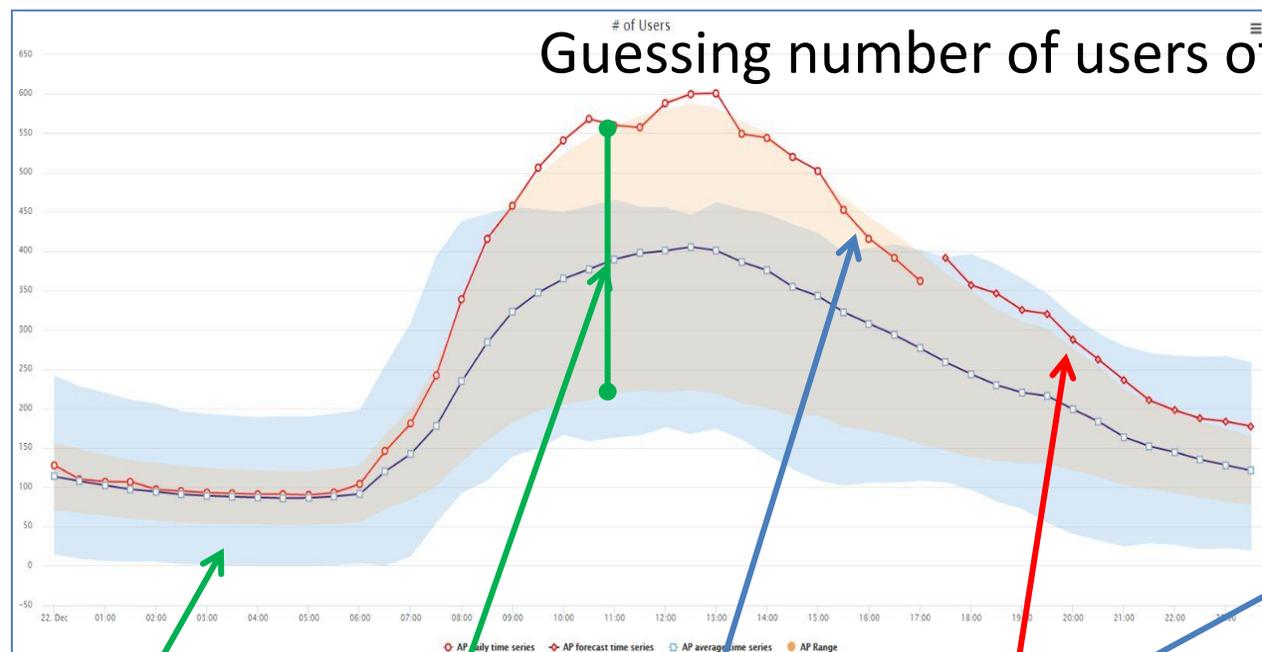


**Figure 14** – Average BIC for mixture models vs K number of cluster, higher values are better, the curves are truncated at the best value for K they found.



# Prediction and Identification of Anomalies

## Guessing number of users of Wi-Fi Access Points



Cluster confidence

AP average and confidence

Actual AP trend for today

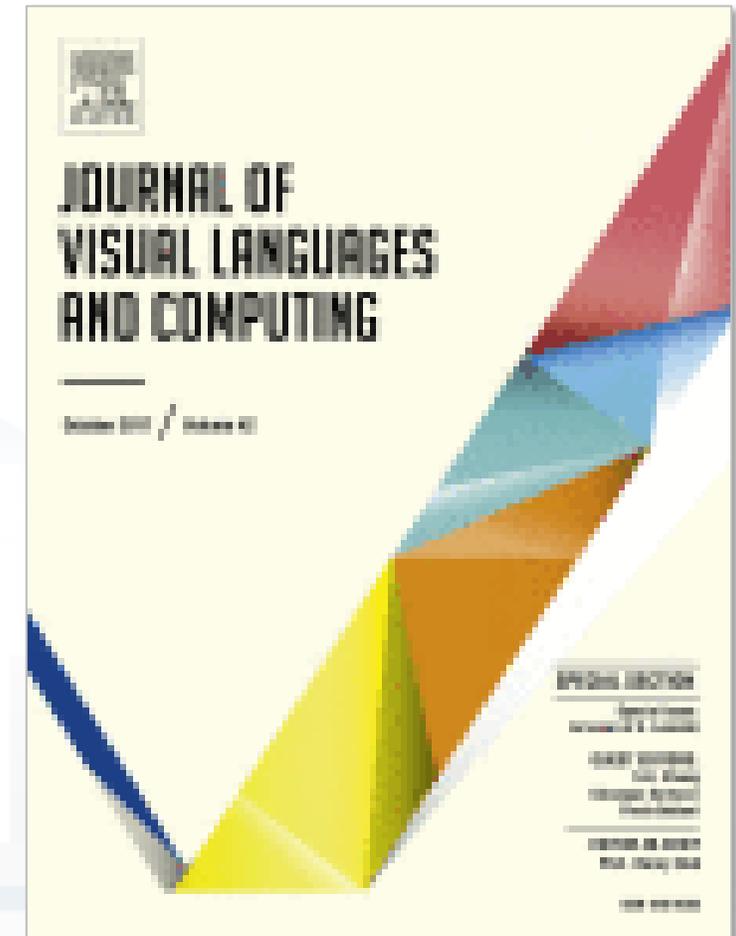
AP prediction for the next time slot in the day on the basis of past weeks

Predictive precision of the 95%

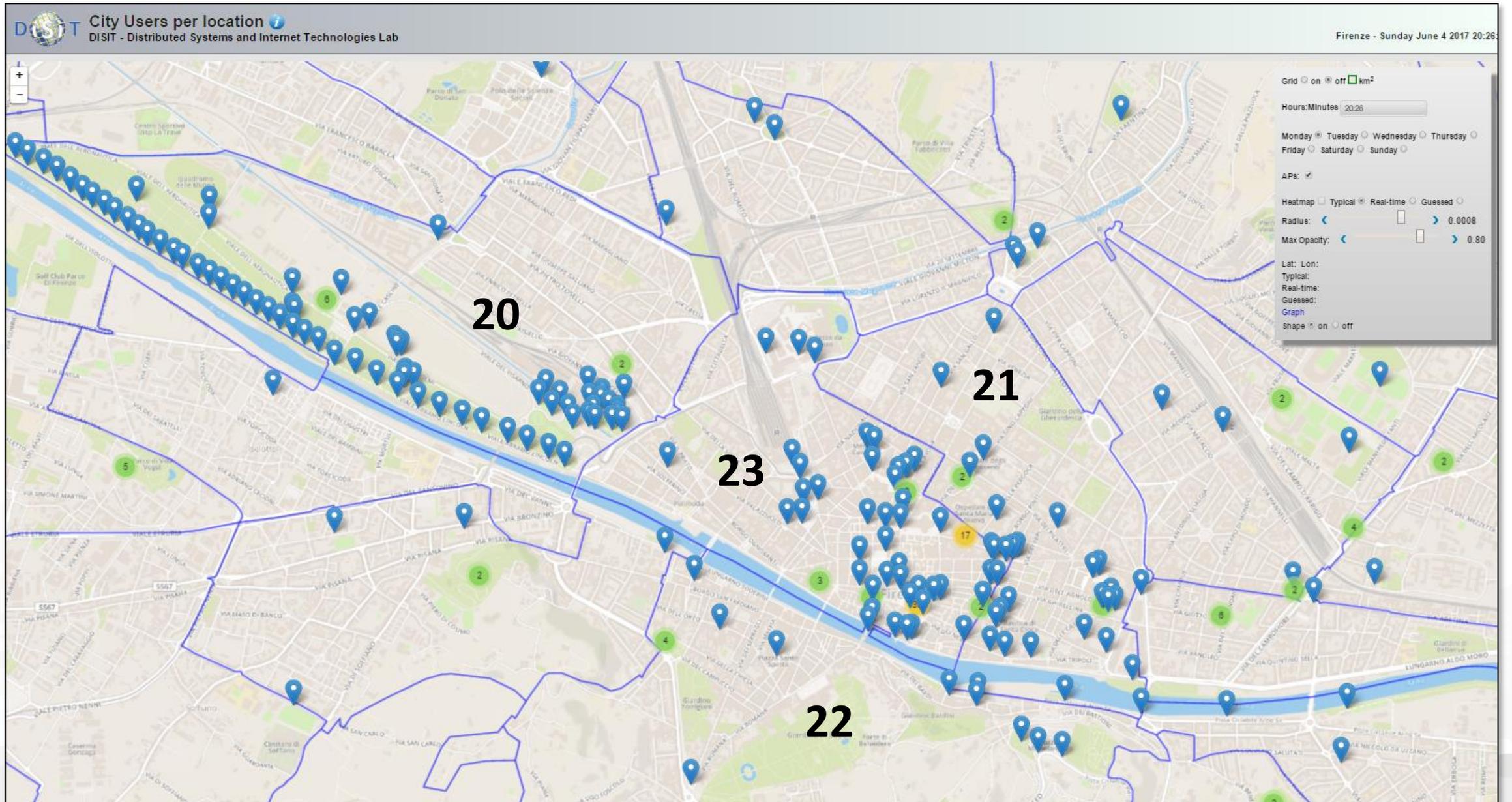


# User Behaviour Analysis

- P. Bellini, D. Cenni, P. Nesi, I. Paoli, "Wi-Fi Based City Users' Behaviour Analysis for Smart City", Journal of Visual Language and Computing, Elsevier, 2017. <http://www.sciencedirect.com/science/article/pii/S1045926X17300083>



# Firenze Wi-Fi vs ACE



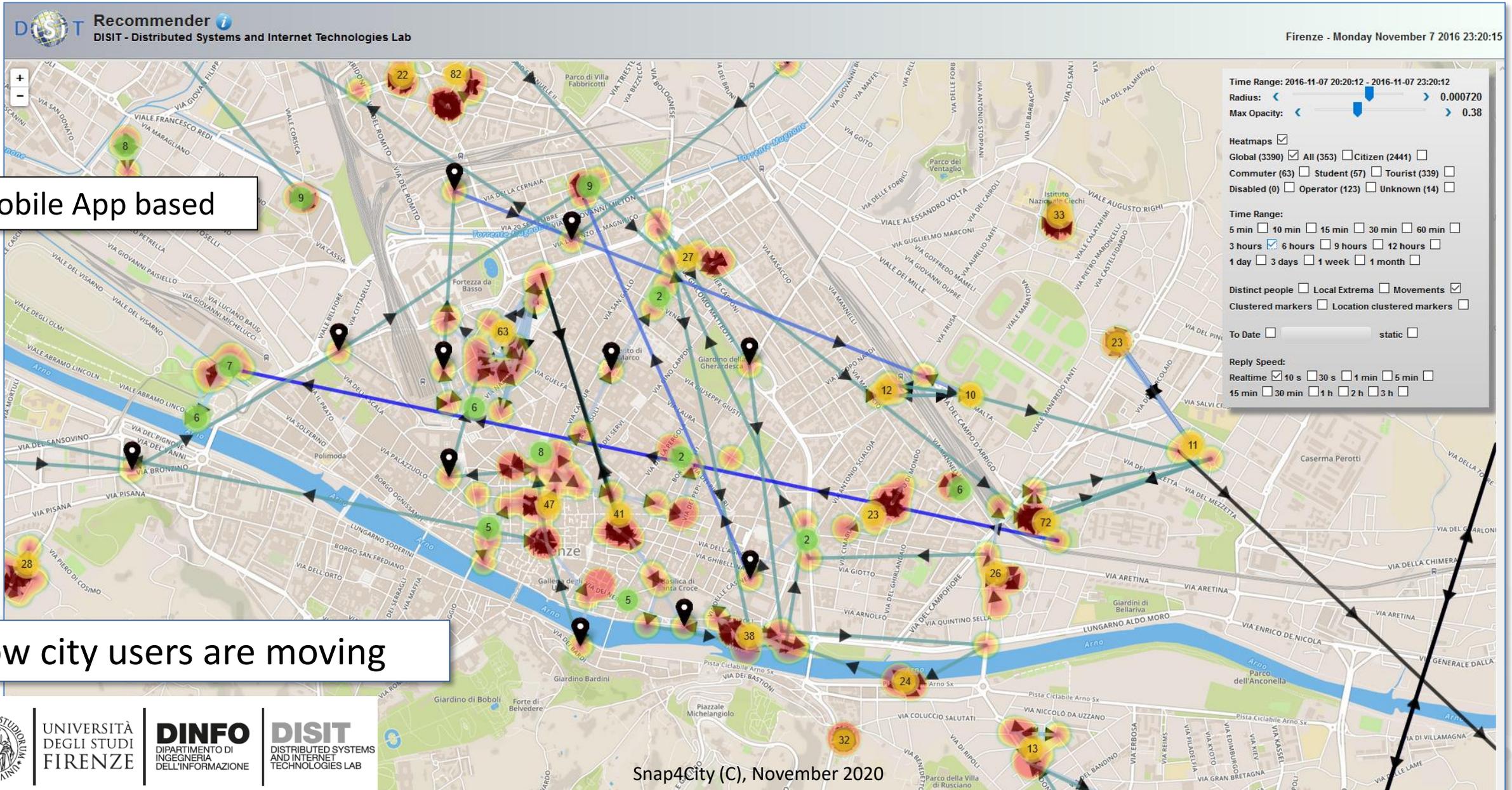
TOP

# *User Behaviour Analysis via Trajectories*



# Anonymous User Behavior Analysis

## Case Study E



UNIVERSITÀ  
DEGLI STUDI  
FIRENZE

**DINFO**  
DIPARTIMENTO DI  
INGEGNERIA  
DELL'INFORMAZIONE

**DISIT**  
DISTRIBUTED SYSTEMS  
AND INTERNET  
TECHNOLOGIES LAB



# Problems of Trajectories from Apps

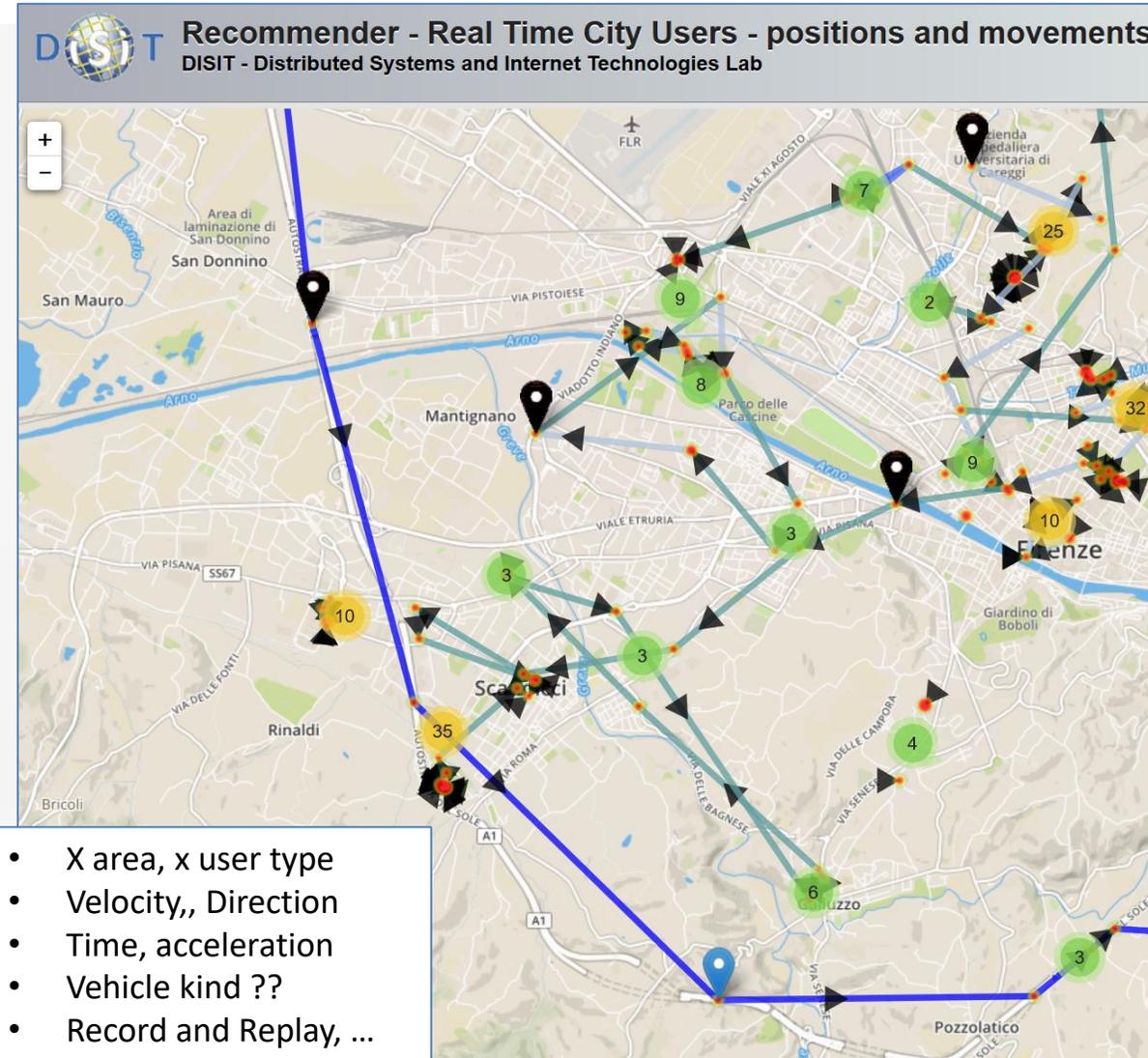
- **From mobile app:**

- Resolving GPS location: GPS, cells, wifi-network, ..mixt
- Noisy, different kind of devices, ..
- Smart algorithm on devices for location acquisition
- Anonymized data, terms of use on mobile

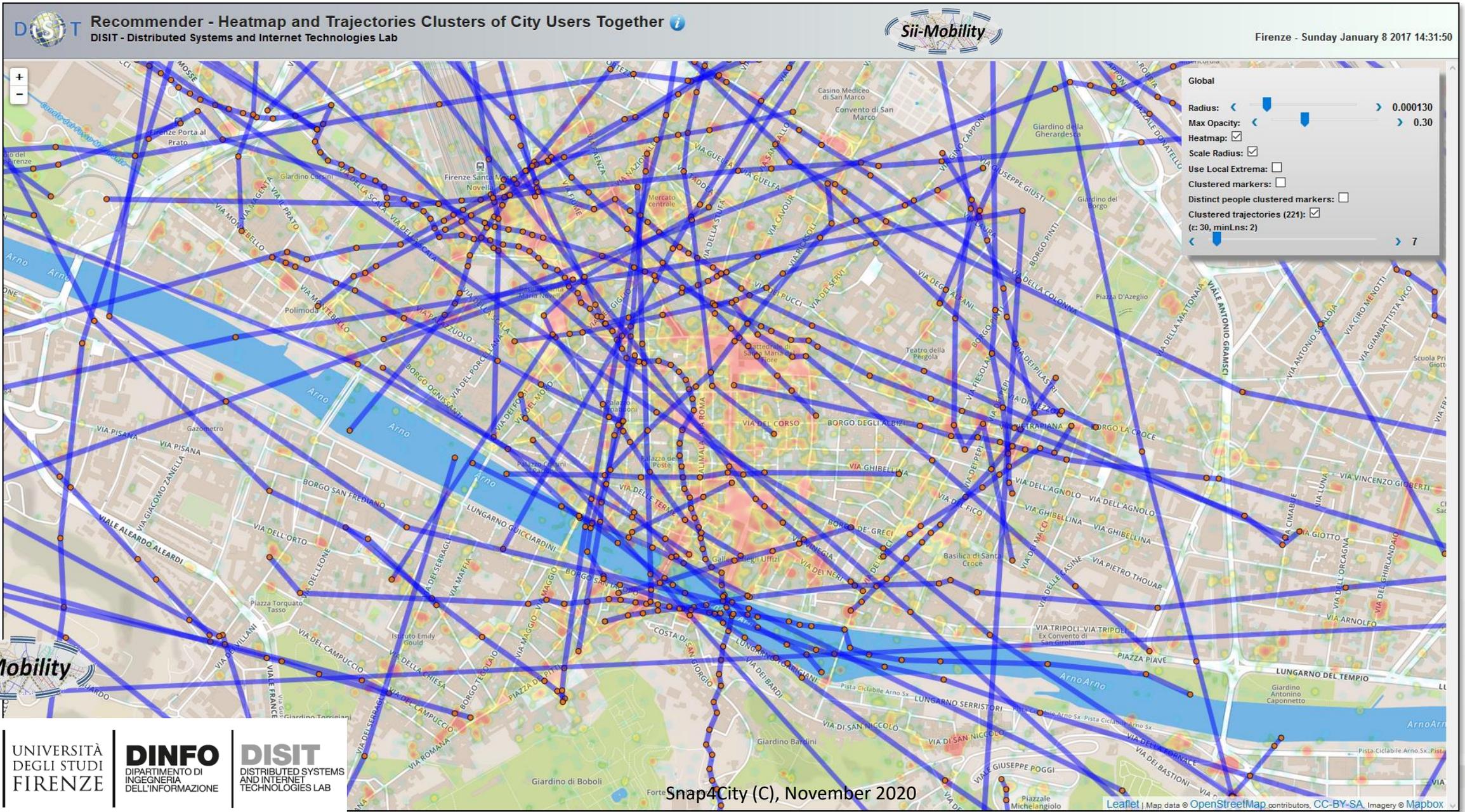
- **Issues and Filtering**

- Gps Accuracy, kind of measure (GPS, mixt)
- Jump in time, space, velocity
- General noise (diff. devices)
- Knowledge of precision map

- **Clustering:** time, space, user kind, etc.



# Heat Map from Mobile: users as sensors

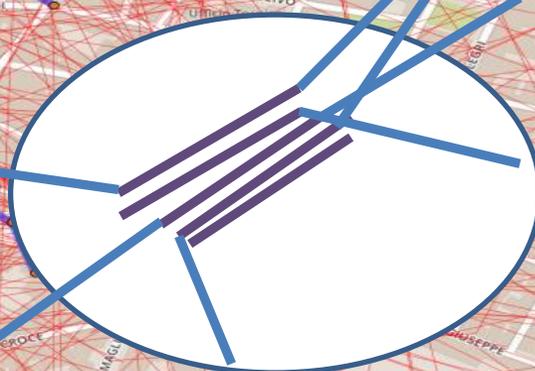
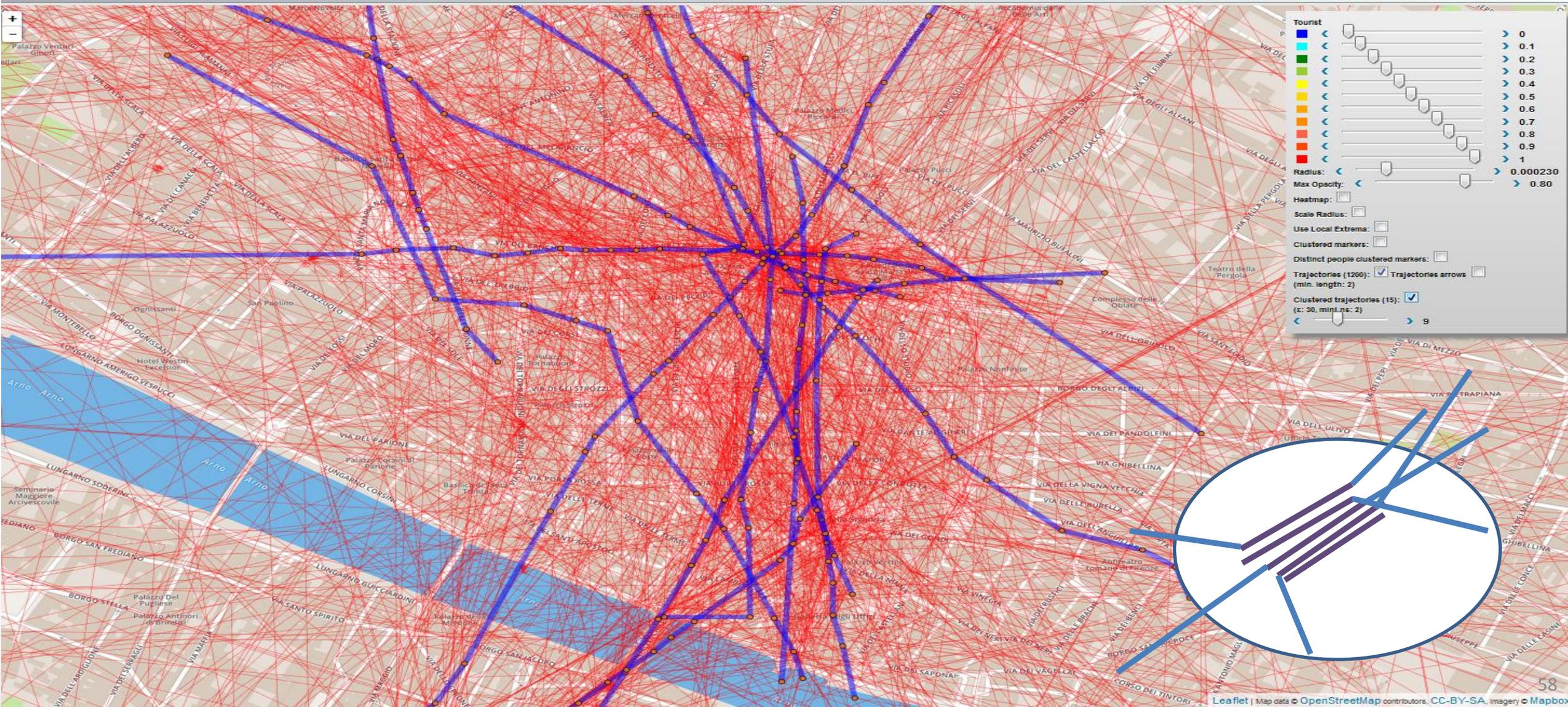




# Cluster di Trajectories



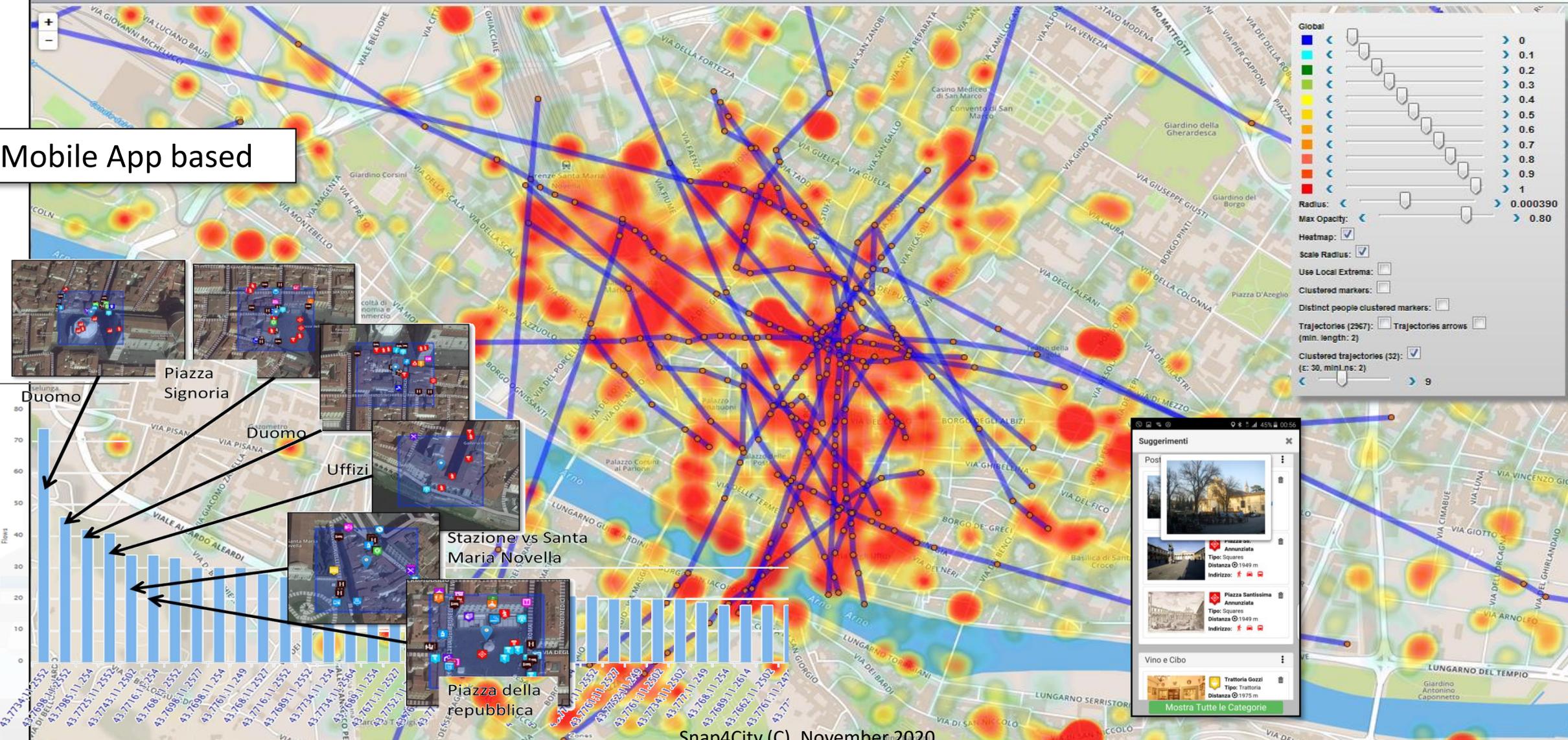
DISIT Personal Recommender  
DISIT - Distributed Systems and Internet Technology Lab



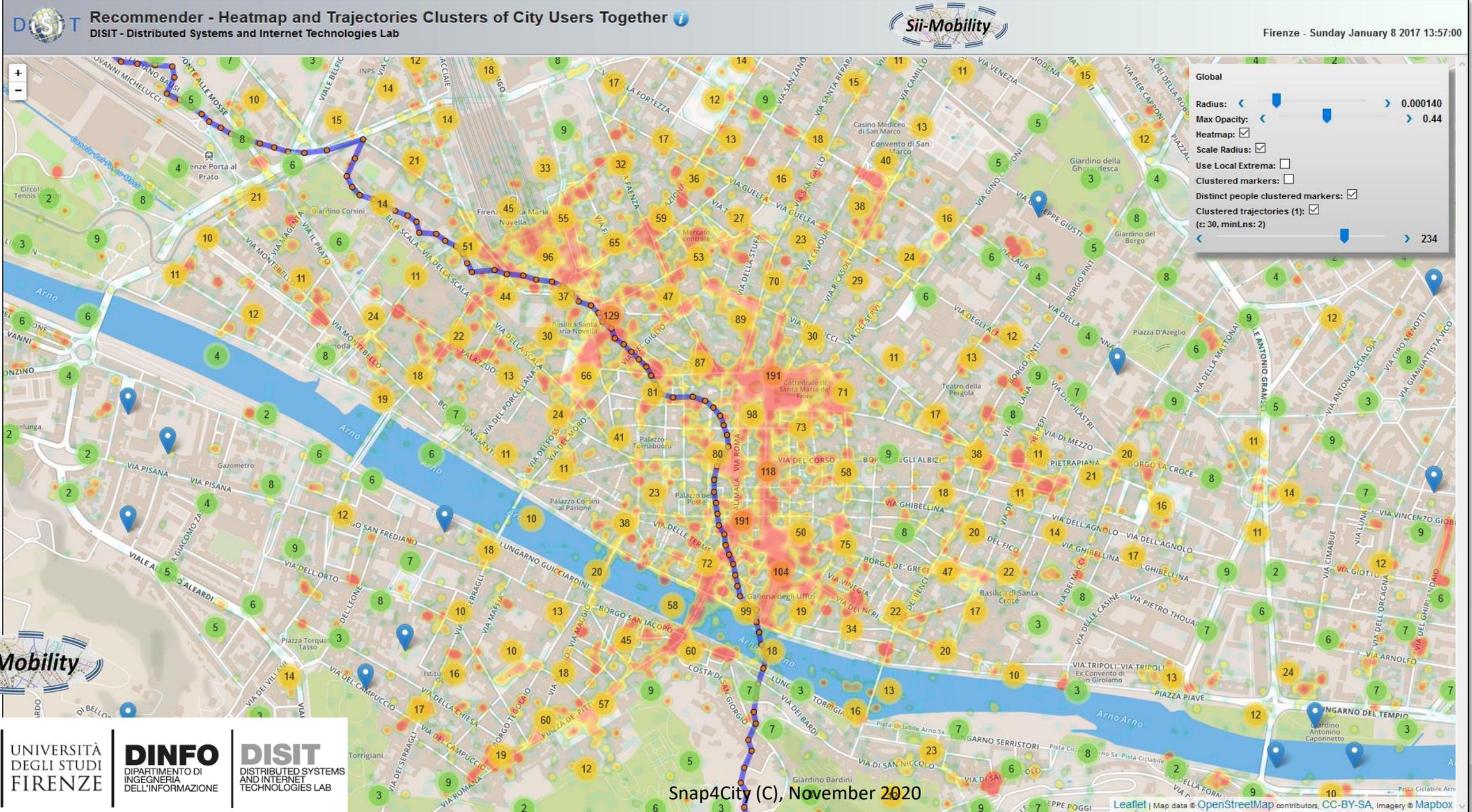
# User Behavior Analyzer

DISIT Personal Recommender  
DISIT - Distributed Systems and Internet Technology Lab

Mobile App based



# Heat Map from Mobile: users as sensors



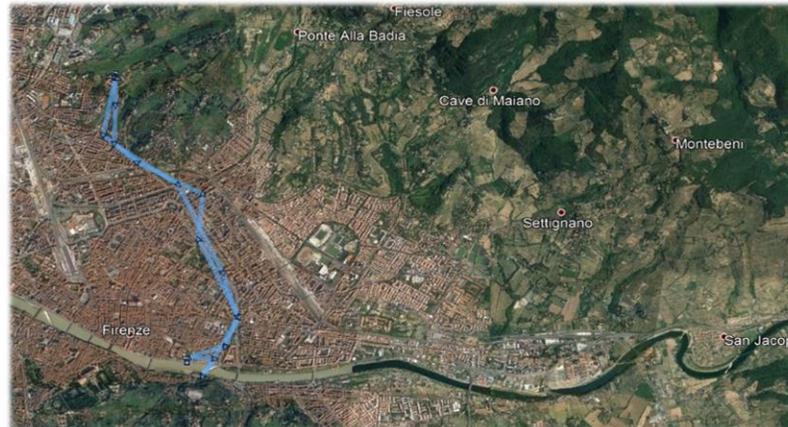
# Recognition of City Users' Transportation means



# Automated Classification of Users' Transportation Modality in Real Conditions

## Variables taken into account:

- **Day/Time Baseline and GPS:**
- **Accelerometer**
- **Proximity**
- **Temporal window**



## Four combinations of the different categories of data:

1. Baseline features and distance feature
2. Baseline, distance feature and accelerometer features
3. Baseline, distance feature and temporal window features
4. Baseline, distance, accelerometer, temporal features together

## Dataset:

- 30K observations
- 25 variables
- 38 different users
- 30 different kinds of devices
- 4 classes (Stationary, Walking, Private Transport, Public Transport)

Note that, *each user have used the mean of transport of his/her own preference.*

When the mode of transport is changed, the user was asked to notify the change to the App for creating the learning set and for validation.

# Automated Classification of Users' Transportation Modality in Real Conditions

## Note that:

- **Large discontinuities samples of data** (from sensors and sporadic communications to the central computation modules)
- Relevant **differences due to the different kind of mobile phone features in terms of sensors and precision.**

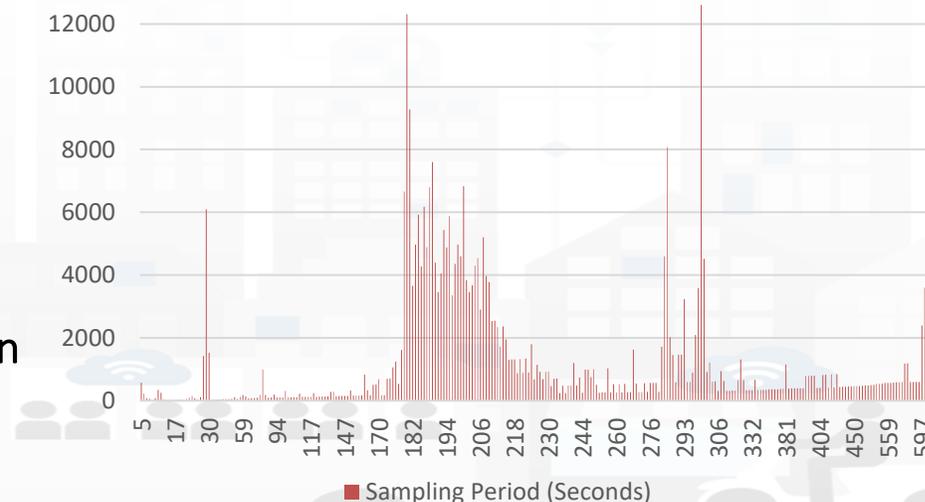
In the state of the art experiments the devices have been asked to keep the application running in foreground to get more precise GPS data, the device in a proper position/orientation during the usage and to use specific devices.

In the proposed solution *no restrictions on the modality of mobile device usage have been imposed.*



- Most of the data was collected in the background because the phones were kept in pocket or bag.
- There is a non-conformity in the Sampling Period frequency distribution of the collected data.

In details, the frequency average is equal to 180 seconds and the variance is equal to 13240 seconds.



# Automated Classification of Users' Transportation Modality in Real Conditions

## One-Step machine learning approach:

- *Random Forest (RF)*
- *Extremely Randomized Trees (Extra-Trees)*
- *Extreme Gradient Boosting procedure (XGBoost)*

Classifier Models	Accuracy	Precision	Recall	F <sub>1</sub> score
Extreme Gradient Boosting	0.947	0.773	0.828	0.800
Random Forest	0.942	0.774	0.869	0.819
Extra-Trees	0.953	0.827	0.869	<b>0.847</b>

Super Learner Binary Classification Models Combination	Accuracy	Precision	Recall	F <sub>1</sub> score
	0.960	0.865	0.857	<b>0.861</b>

Extra Trees Model	Stay	Walk	Private Transport	Public Transport
Sensitivity	0.978	<b>0.731</b>	0.869	0.917
Specificity	0.901	0.988	0.987	0.996
Pos Pred Value	0.977	0.770	0.827	0.936
Neg Pred Value	0.904	0.985	0.990	0.994
Balanced Accuracy	0.940	0.859	0.928	0.956
Super Learner Model	Stay	Walk	Private Transport	Public Transport
Sensitivity	0.990	0.662	0.857	0.927
Specificity	0.892	0.993	0.990	0.996
Pos Pred Value	0.975	0.831	0.865	0.953
Neg Pred Value	0.955	0.982	0.989	0.994
Balanced Accuracy	0.941	0.828	0.924	0.961

- **Super Learner approach:** identification of the multi-class problem into binary classification sub-problems to estimate the risk on future data and select the optimal learner based on the One-Step machine learning approach candidates.

- Four binary classification models have been constructed:
  1. *stationary vs walking, private transport, public transport*
  2. *walking vs stationary, private transport, public transport*
  3. *private transport vs stationary, walking, public transport*
  4. *public transport vs stationary, walking, private transport*

❖ In **Super Learner**, Binary Classification Models results have been combined on the highest probability estimation.

# Automated Classification of Users' Transportation Modality in Real Conditions

## Two-Steps Hierarchical approach:

combination of the **Extra-Tree** multi-class classification and the **Super learner** algorithm.

- **First Step:** Extra-Tree multi-class classifier *to select the two transportation means with higher probability* - 4 different training models.

A **threshold** has been used to decide which class can be considered directly correct at the first step: *if the probability of the class is higher respect the considered threshold (0.90), the transportation modality is regarded correct without proceeding to the second step.*

- **Second Step:** Super learner approach *to discriminate between the two transportation means selected in the first step* - 24 different training models  
(6 transportation modality pairs combinations per 4 categories combinations)

Two-Steps Hierarchical Approach		Predicted			
		Stay	Walk	Private Transport	Public Transport
Actual	Stay	<b>0.98</b>	0.30	0.09	0.03
	Walk	0.01	<b>0.60</b>	0.02	0.01
	Private Transport	0.01	0.07	<b>0.87</b>	0.07
	Public Transport	0.00	0.03	0.01	<b>0.89</b>

Accuracy = **0.940**  
Precision = 0.786  
Recall = 0.869

# Traffic Flow Prediction

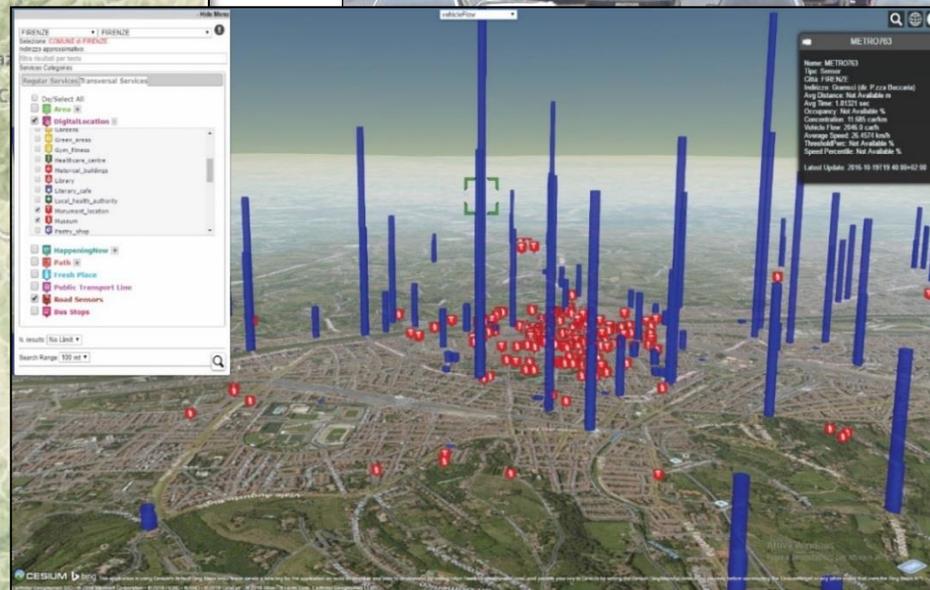
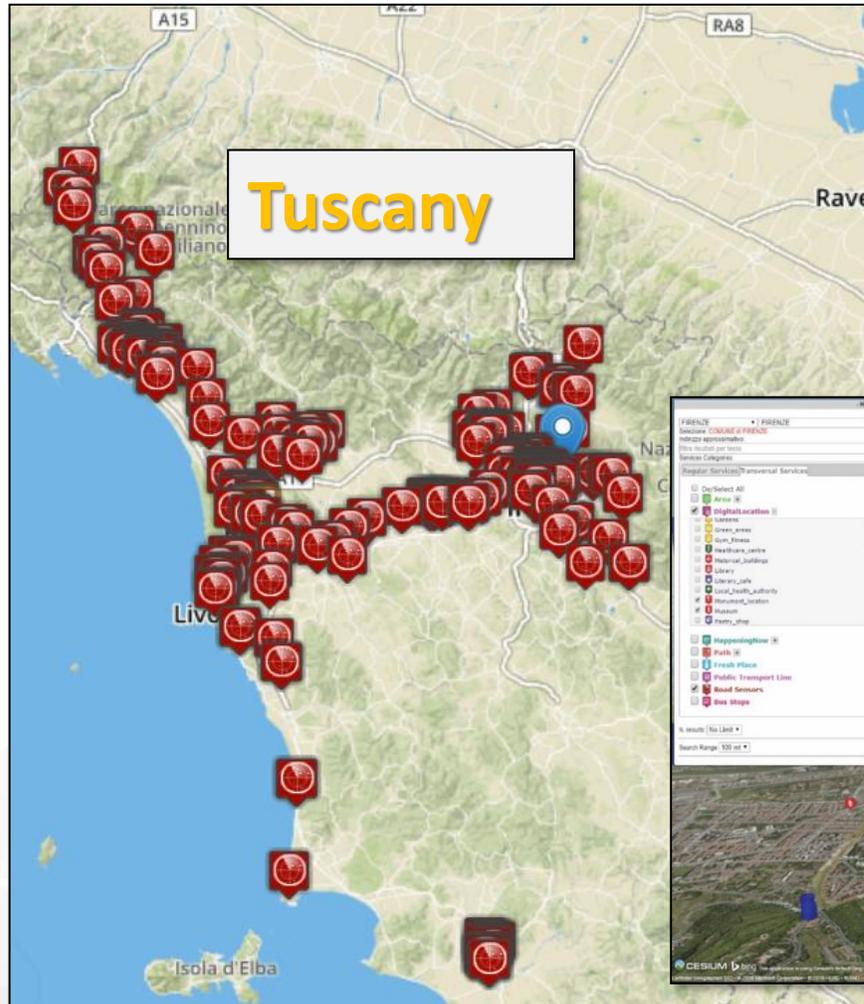


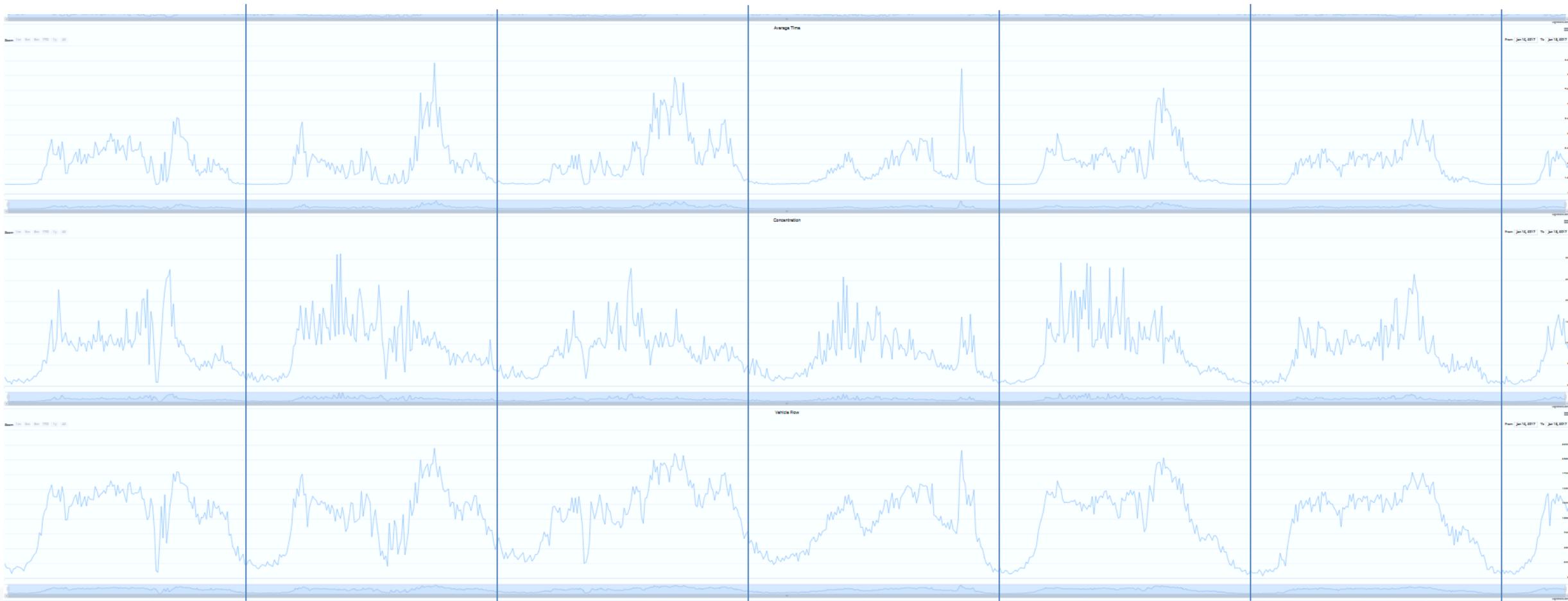


# Traffic Flow Tools

Spire and Virtual Spires (cameras), Bluetooth, ...

Specifically located: along, around, on gates, on x...





- Day by day traffic flow data from 3 sensors

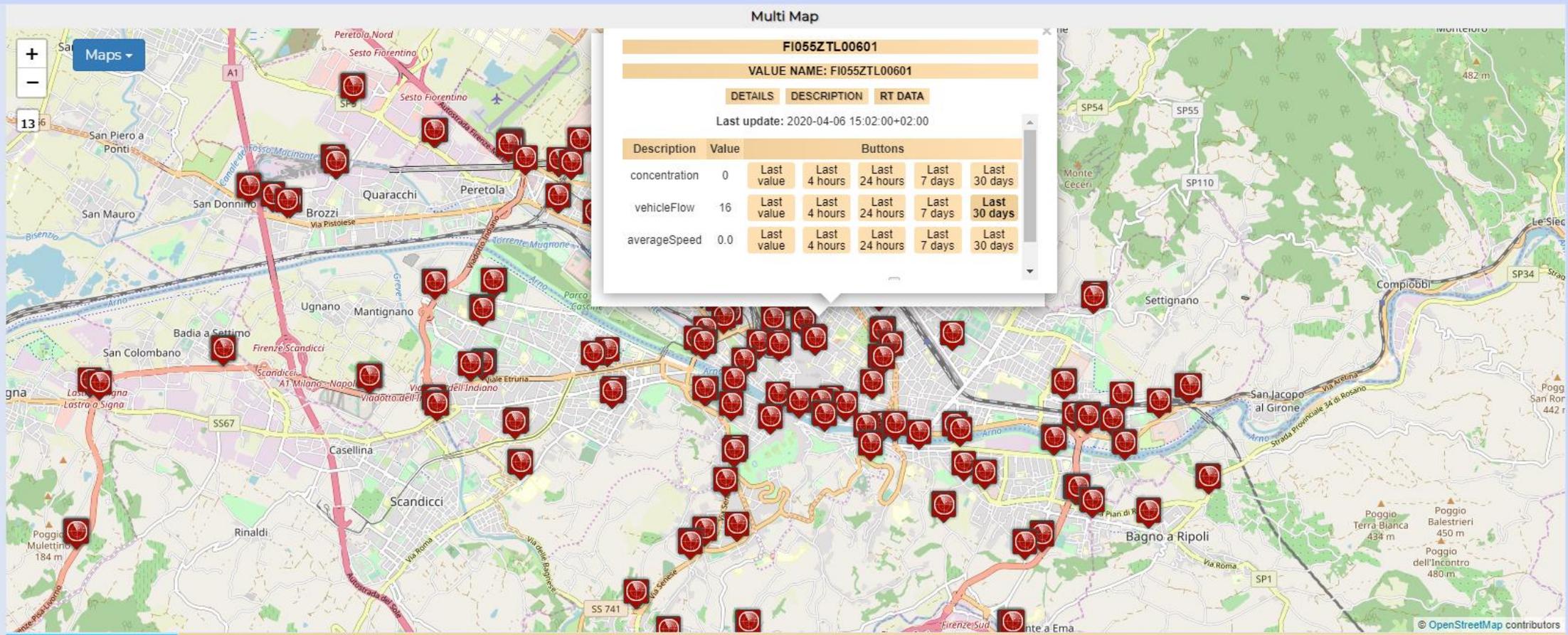
# Firenze - Trafair - AirQuality Heatmaps



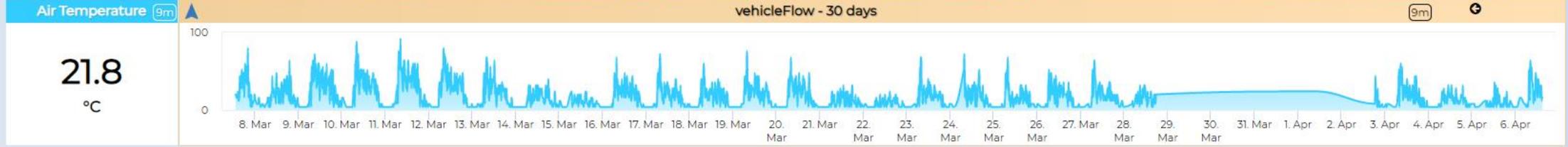
This dashboard contains data derived from actual sensors and predictive values under validation

Mon 6 Apr 15:12:27

- Air Quality Sensors
- Weather Sensors
- PM10 Heatmap
- PM2.5 Heatmap
- CO Heatmap
- CO2 Heatmap
- O3 Heatmap
- NO2 Heatmap
- Europ. AQI Heatmap
- Air Humidity Heatmap
- Air Temp. Heatmap
- Wind Speed Heatmap
- Gral Pred. HM NOX (3m)
- Gral Pred. HM NOX (6m)
- Traffic Sensors
- Traffic Flow
- Cycling Paths
- Accident Heatmap
- Accident Heatmap 2
- Only HRes Anym. Gral
- Green Areas
- Schools



Air quality trends



<https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MTUzMg==>

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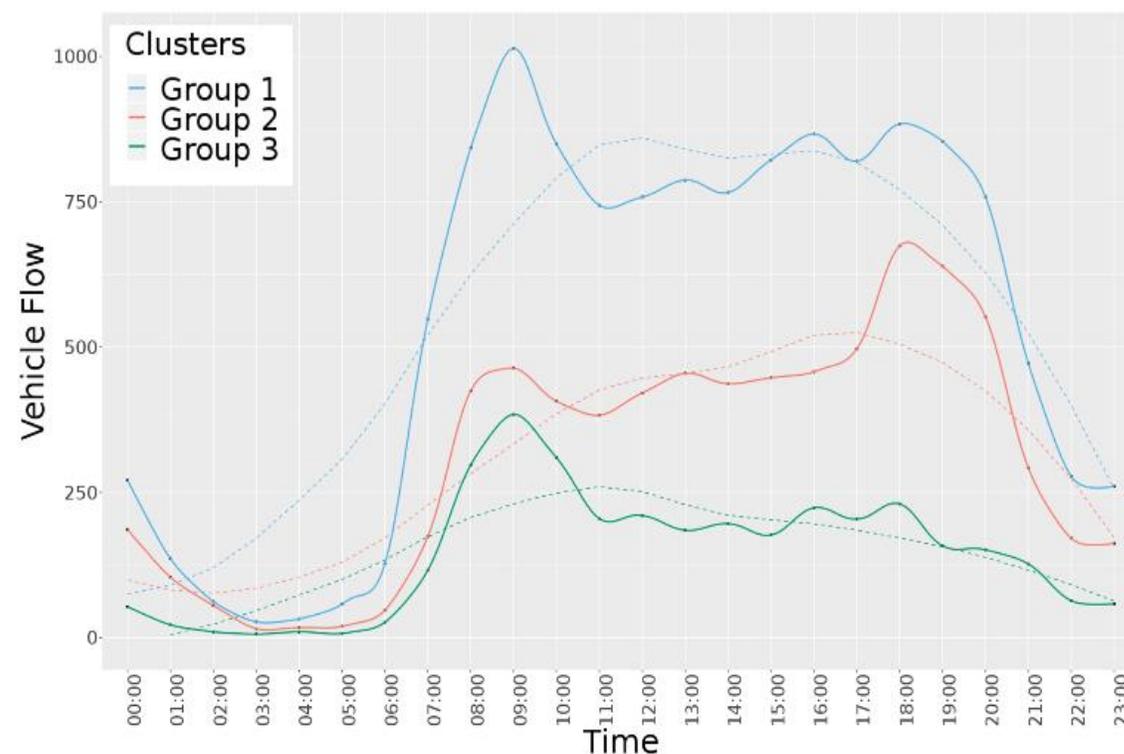
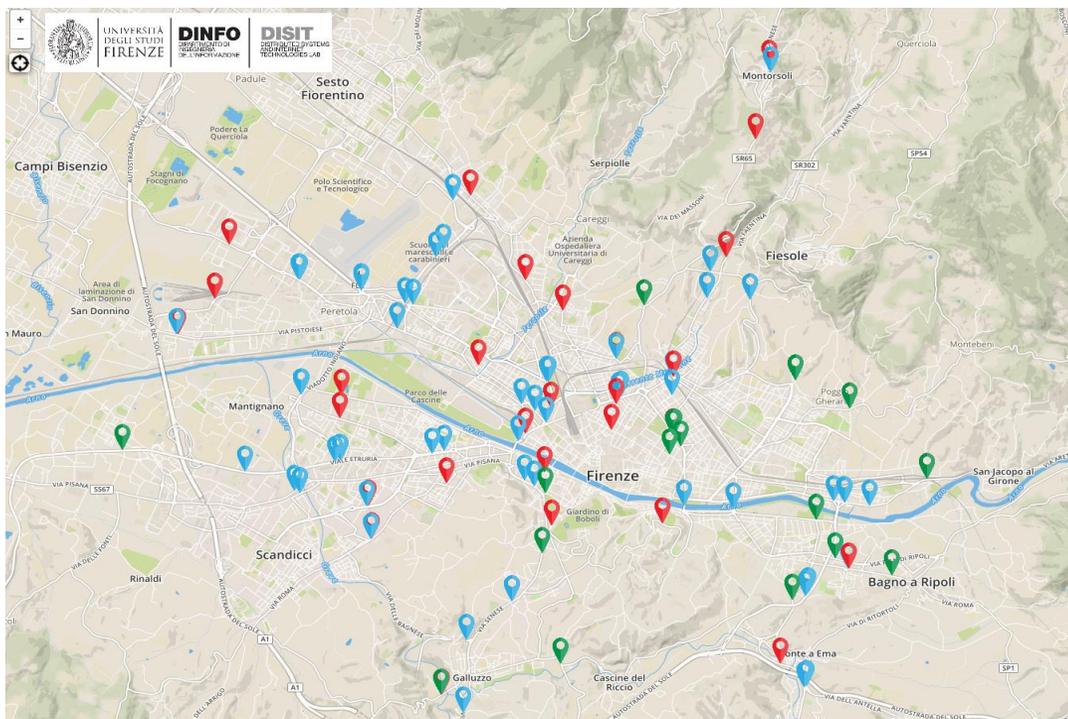




# Traffic Data Analysis

Map of the traffic sensors location per cluster in Florence municipality

Hourly median vehicle flow trends per cluster





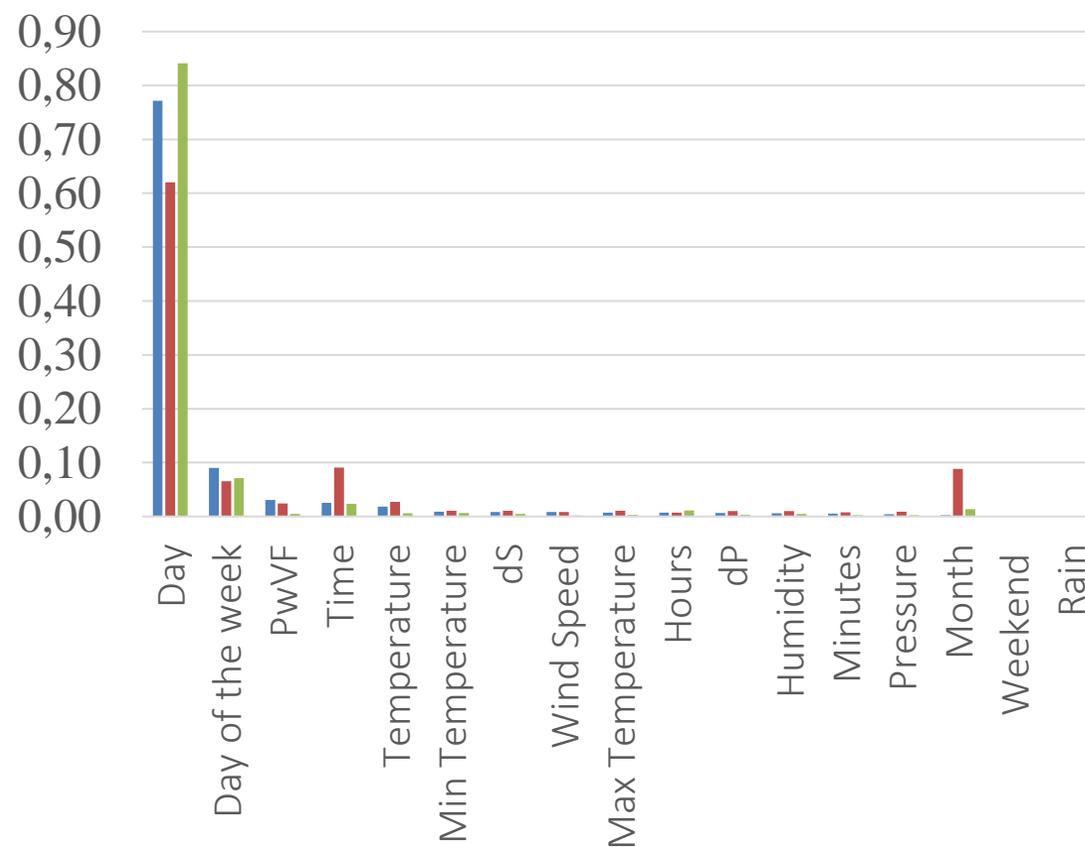
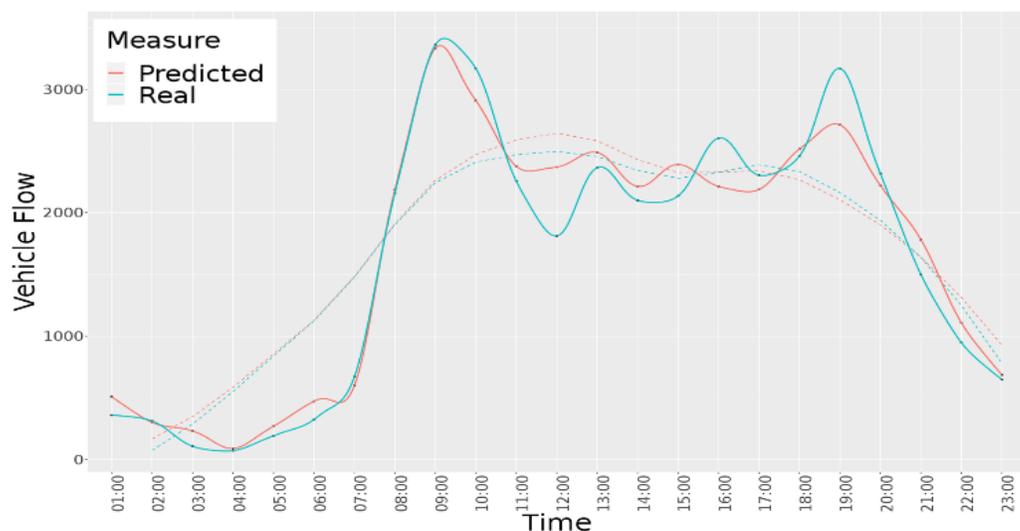
# Traffic Data Analysis

XGBoost Model Results  $R^2$  RMSE MASE

Sensors of Group 1 0.95 215 0.89

Sensors of Group 2 0.91 178 0.82

Sensors of Group 3 0.86 127 0.92



TOP

# Traffic Flow Reconstruction from Traffic Sensors Data





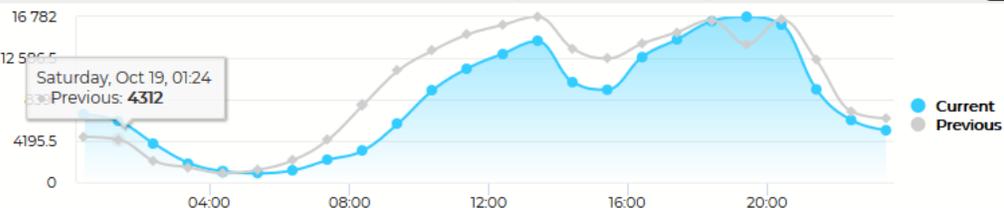
# Traffic Flow Monitoring - Firenze

Sun 20 Oct 23:37:24

# IN FLOW 9m

5302

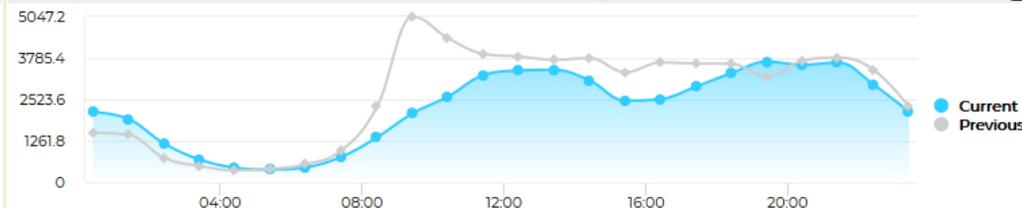
Firenze IN Traffic Flow (number of vehicles)



ZTL in 9m

2149

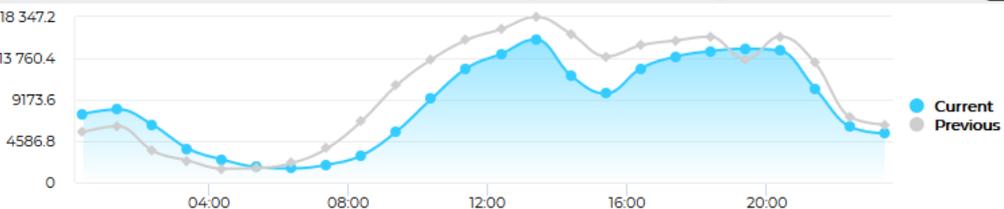
ZTL in Traffic Flow daily trend



# OUT FLOW 9m

5448

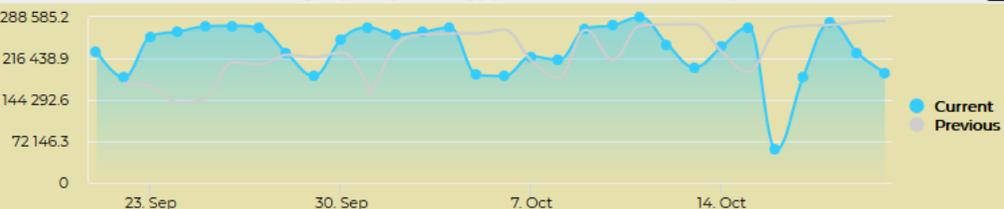
Firenze OUT Traffic Flow (number of vehicles)



Inc Daily Inp... 9m

191840

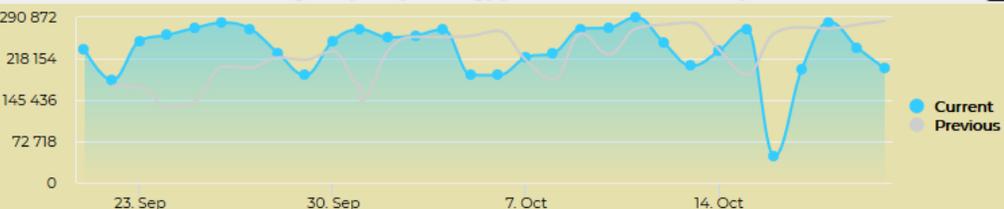
Daily Inputs (monthly) (last value is incremental)



Inc Daily Ou... 9m

201019

Daily Outputs (monthly) (last value is incremental)

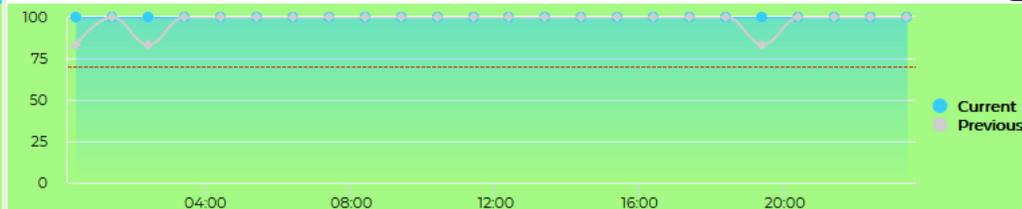


Current Time - ...

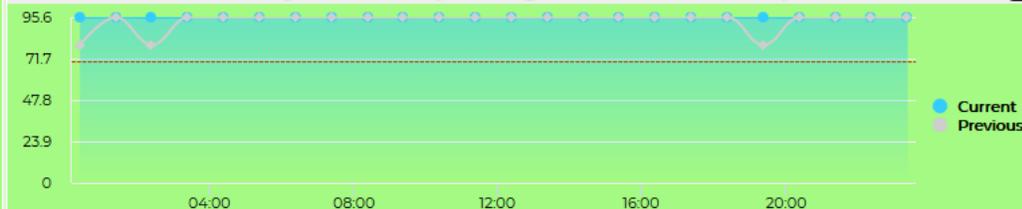
20/10/2019

23:37:25

Quality of Measure in terms of percentage of expected measures considered



Quality of Measure in percentage - ZTL in time trend compare



<https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MTc2MQ==>

On sunday

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2018-02-01T00:10:00

Last sensors measure  
2018-02-01T00:10:00

- Free street
- Fluid traffic
- Heavy traffic
- Very heavy
- Sensor position

# Traffic Flow Reconstruction

Firenze  
FiPiLi  
Pisa  
Modena

real time



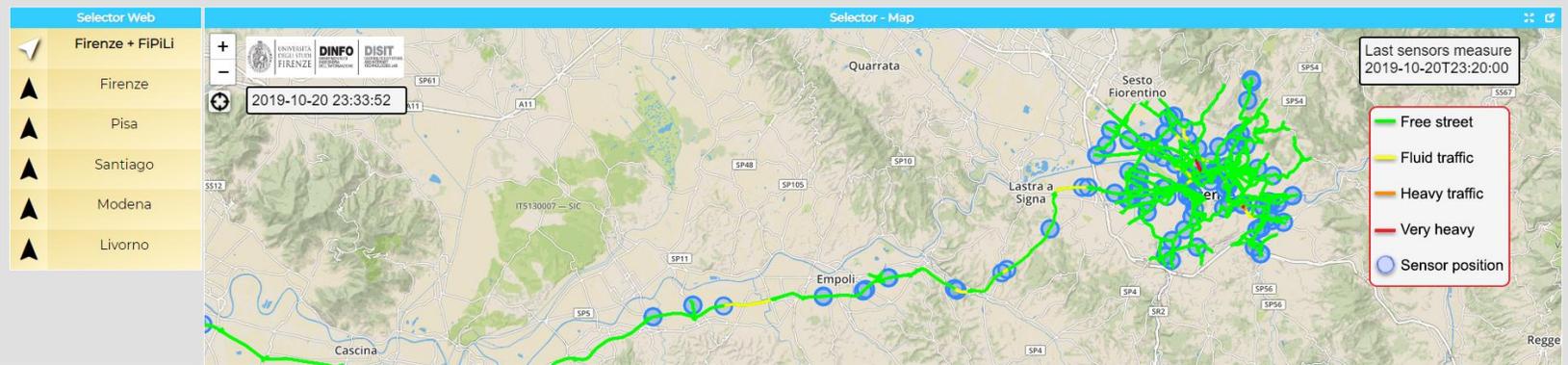
UNIVERSITÀ  
DEGLI STUDI  
FIRENZE

**DINFO**  
DIPARTIMENTO DI  
INGEGNERIA  
DELL'INFORMAZIONE

**DISIT**  
DISTRIBUTED SYSTEMS  
AND INTERNET  
TECHNOLOGIES LAB

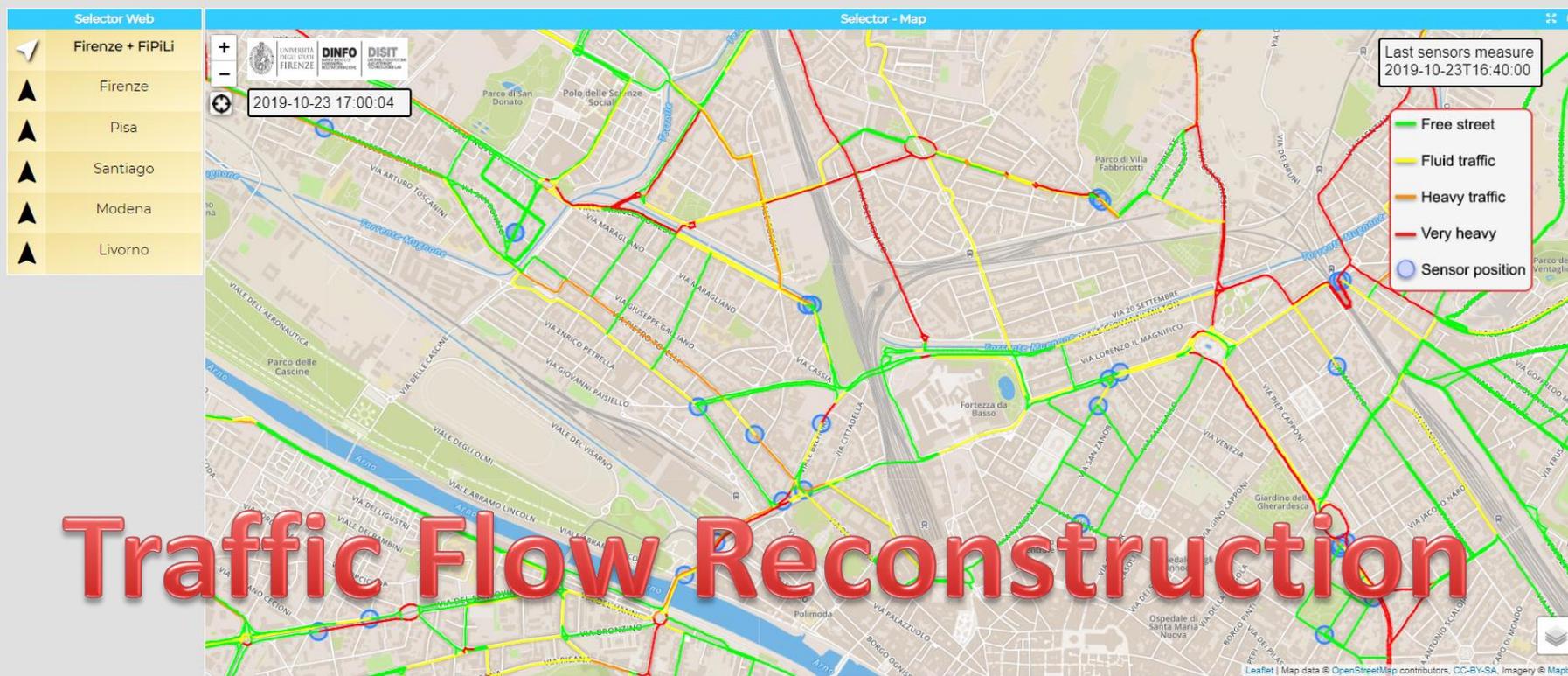
# Traffic Flow Reconstruction for the cities

Sun 20 Oct 23:33:53



# Traffic Flow Reconstruction for the cities

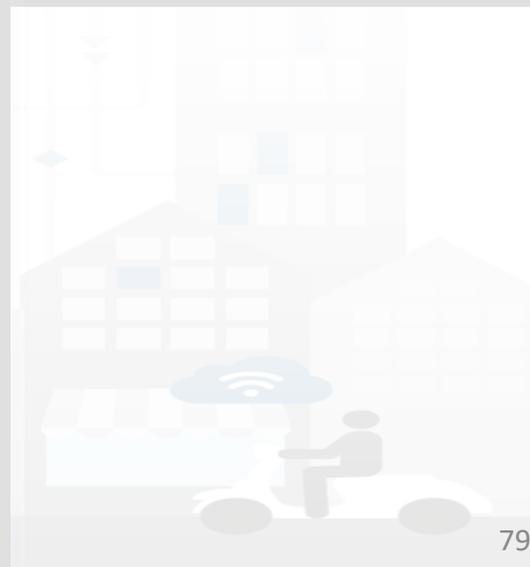
Wed 23 Oct 17:00:03



# Traffic Flow Reconstruction

<https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MTc5NQ==>

Snap4City (C), November 2020







# Toscana Traffico

Thu 1 Nov 14:15:47

**Traffic Events** 9m

**TEMPORARY TRAFFIC LIGHTS**  
 05/11/2018 00:00:00 5

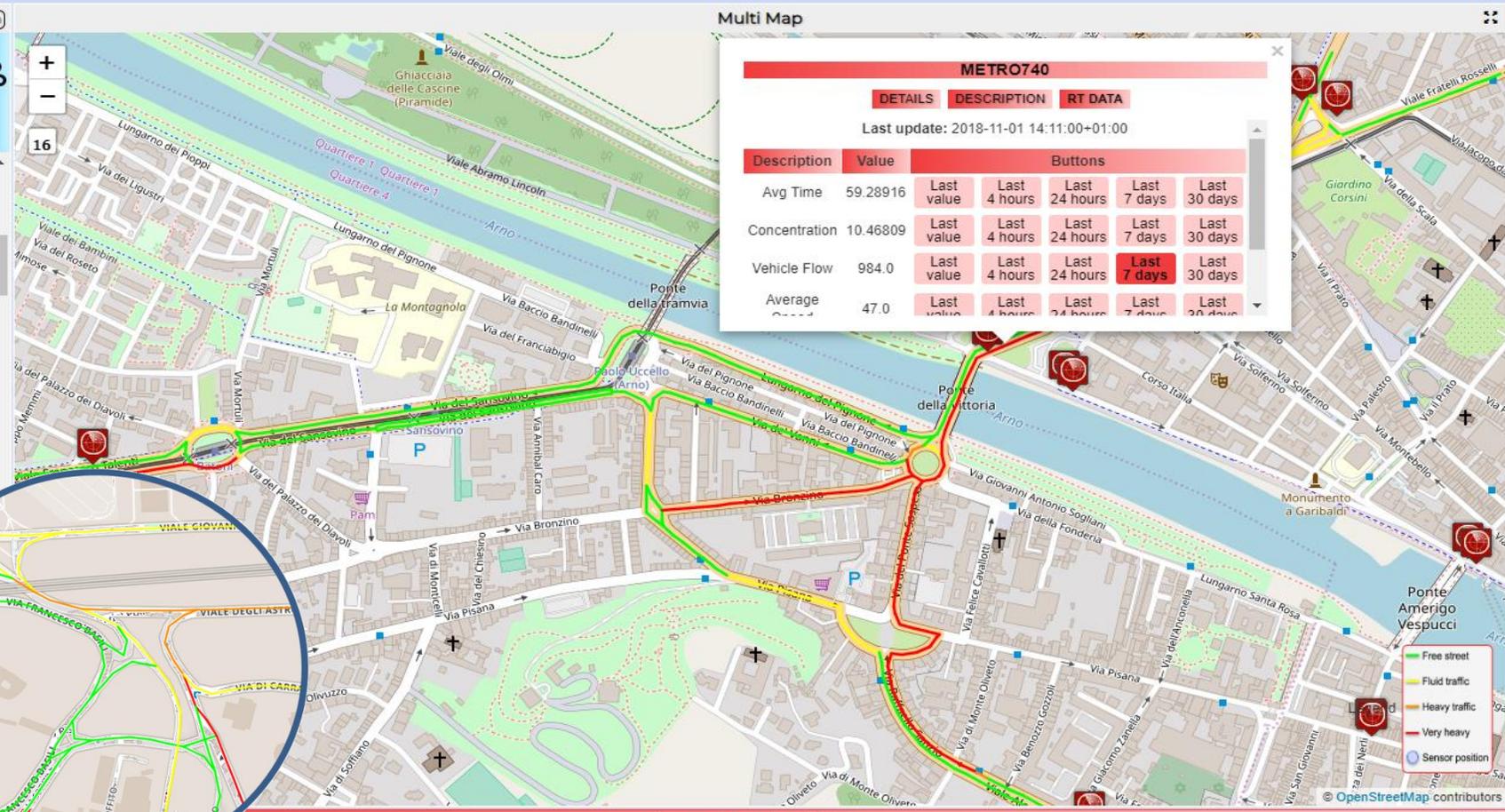
ORD. 2018-002375 - ISTITUZIONE DI SENSO UNICO ALTERNATO REGOLATO DA IMPIANTO SEMAFORICO MOBILE E/O MOVIERI, OLTRE ALLA LOCALIZZATA LIMITAZIONE DI VELOCITA' A 30 KM/H IN PROSSIMITA' DEL CANTIERE, PER IL RESTRINGIMENTO DELLA CARREGGIATA, SULLA S.P. N.56 'DEL BROLLO E POGGIO ALLA CROCE' AL KM 16+600 CIRCA, IN LOCALITA' CAPANNUCCIA E SULLA S.P. N.34 'DI ROSANO', PER INTERVENTI PUNTUALI, DAL KM 3+440 AL KM 5+500 CIRCA, IN LOCALITA' VALLINA, NEL COMUNE DI BAGNO A RIPOLI (FI), DAL GIORNO 05/11/2018 AL GIORNO 16/11/2018 CON ORARIO 08:00/17:00.

**TEMPORARY TRAFFIC LIGHTS**  
 05/11/2018 00:00:00 5

ORD. 2018-002375 - ISTITUZIONE DI SENSO UNICO ALTERNATO REGOLATO DA IMPIANTO SEMAFORICO MOBILE E/O MOVIERI, OLTRE ALLA LOCALIZZATA LIMITAZIONE DI VELOCITA' A 30 KM/H IN PROSSIMITA' DEL CANTIERE, PER IL RESTRINGIMENTO DELLA CARREGGIATA, SULLA S.P. N.56 'DEL BROLLO E POGGIO ALLA CROCE' AL KM 16+600 CIRCA, IN LOCALITA' CAPANNUCCIA E SULLA S.P. N.34 'DI ROSANO', PER INTERVENTI PUNTUALI, DAL KM 3+440 AL KM 5+500 CIRCA, IN LOCALITA' VALLINA, NEL COMUNE DI BAGNO A RIPOLI (FI), DAL GIORNO 05/11/2018 AL GIORNO 16/11/2018 CON ORARIO 08:00/17:00.

**TEMPORARY TRAFFIC LIGHTS**  
 05/11/2018 00:00:00 5

ORD. 2018-002375 - ISTITUZIONE DI SENSO UNICO ALTERNATO REGOLATO DA IMPIANTO SEMAFORICO MOBILE E/O MOVIERI, OLTRE ALLA LOCALIZZATA LIMITAZIONE DI VELOCITA' A 30 KM/H IN PROSSIMITA' DEL CANTIERE, PER IL RESTRINGIMENTO DELLA CARREGGIATA, SULLA S.P. N.56 'DEL BROLLO E POGGIO ALLA CROCE' AL KM 16+600 CIRCA, IN LOCALITA' CAPANNUCCIA E SULLA S.P. N.34 'DI ROSANO', PER INTERVENTI PUNTUALI, DAL KM 3+440 AL KM 5+500 CIRCA, IN LOCALITA' VALLINA, NEL COMUNE DI BAGNO A RIPOLI (FI), DAL GIORNO 05/11/2018 AL GIORNO 16/11/2018 CON ORARIO 08:00/17:00.



**METRO740**

DETAILS DESCRIPTION RT DATA

Last update: 2018-11-01 14:11:00+01:00

Description	Value	Buttons				
Avg Time	59.28916	Last value	Last 4 hours	Last 24 hours	Last 7 days	Last 30 days
Concentration	10.46809	Last value	Last 4 hours	Last 24 hours	Last 7 days	Last 30 days
Vehicle Flow	984.0	Last value	Last 4 hours	Last 24 hours	Last 7 days	Last 30 days
Average Speed	47.0	Last value	Last 4 hours	Last 24 hours	Last 7 days	Last 30 days



**Selector**

- Air Quality
- Bus Stops
- Cycle Paths Geometry
- Cycle Paths Pins
- Hot places heatmap
- Meteo Stations
- Parkings
- Recharging Stations - Normal
- Recharging Stations - Fast
- Traffic Sensors
- Traffic Flow Density

**Florence Events** 9m

- CAMBIO DELLA GUARDIA A PALAZZO VECCHIO
- PER GRANDI E PUCCINI
- QUANTUOR EBENE, ALEXANDER LONGUICH
- "GLI STRUMENTI DI GALILEO" - A TUTTA SCIENZA!

<https://main.snap4city.org/view/index.php?iddashboard=MTE5MQ==>



## Mathematical model

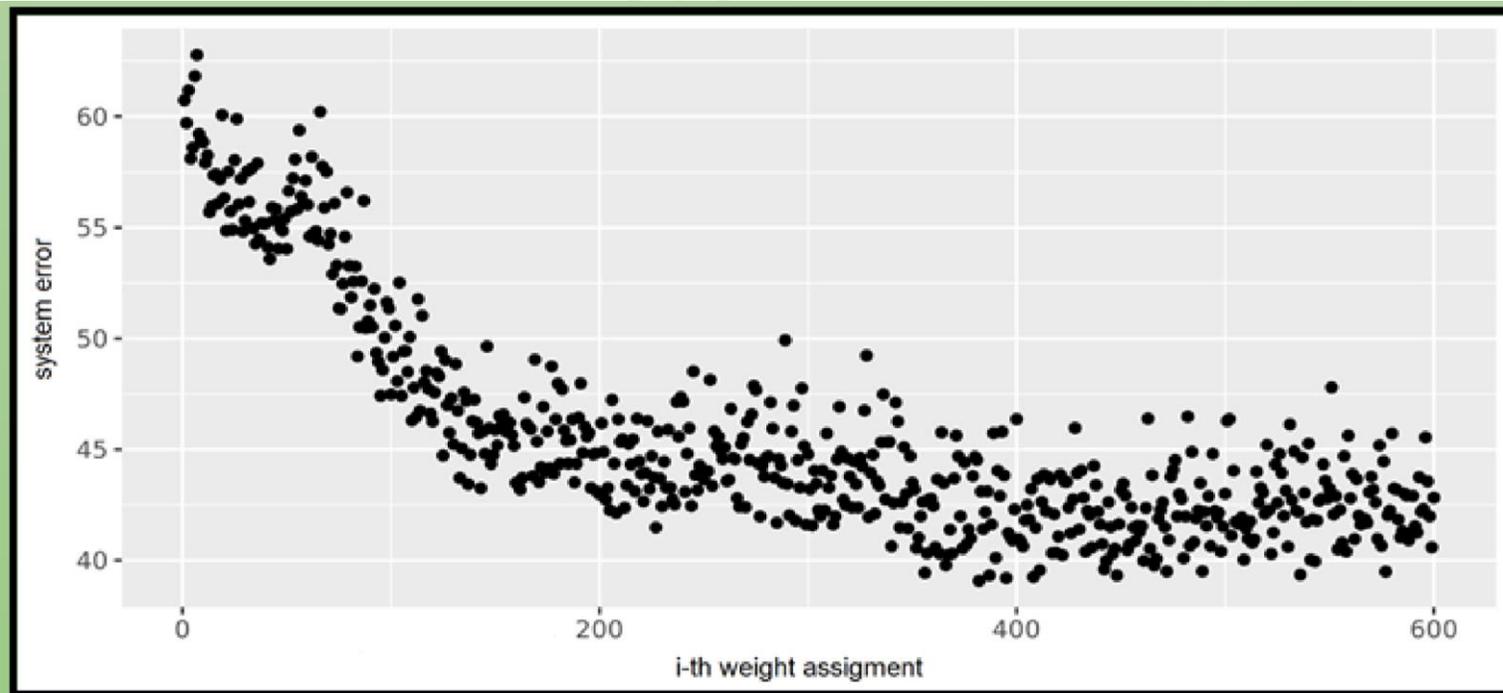
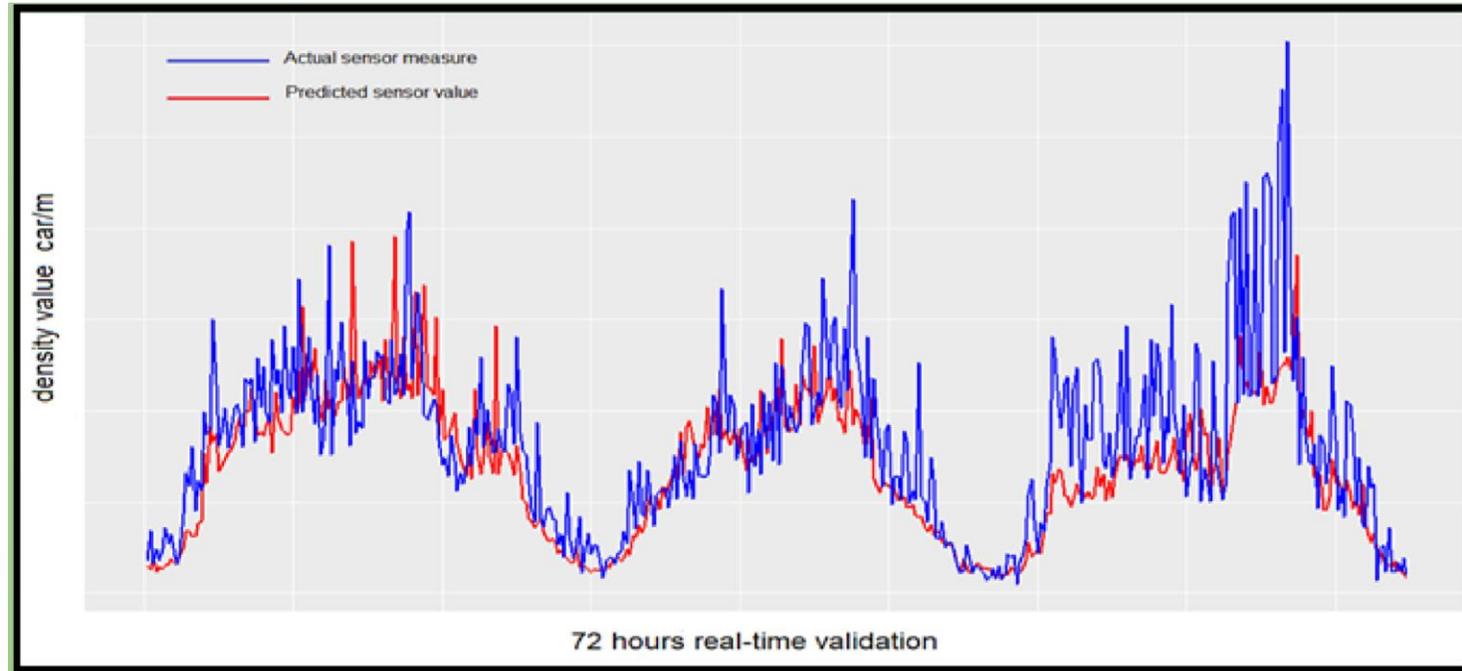
The vehicular traffic flow is propagated in the city graph according to a fluid dynamics model which is based on the conservation law of the vehicles. In a single road, it is described by the following partial differential equation:

$$\frac{\partial \rho(t, x)}{\partial t} + \frac{\partial f(\rho(t, x))}{\partial x} = 0$$

where  $\rho(t, x)$  denotes the vehicular density and the function  $f(\rho(t, x))$  is the vehicular flux which is defined as the product  $\rho(t, x)v(t, x)$ , being  $v(t, x)$  the local speed of the vehicles.

A discretization scheme in terms of *finite differences* is considered to obtain a numerical solution of the above equation. The traffic flow is then distributed through the junctions in the city.

# Convergence of learning phase



# Traffic Flow reconstruction, real time



- Stefano Bilotta,  
Paolo Nesi,
- **Traffic flow reconstruction by solving indeterminacy on traffic distribution at junctions,** Future Generation Computer Systems, Volume 114, 2021, Pages 649-660, ISSN 0167-739X,  
<https://doi.org/10.1016/j.future.2020.08.017>.

<https://www.sciencedirect.com/science/article/pii/S0167739X20308359>



# Traffic Flow Reconstruction (self training)

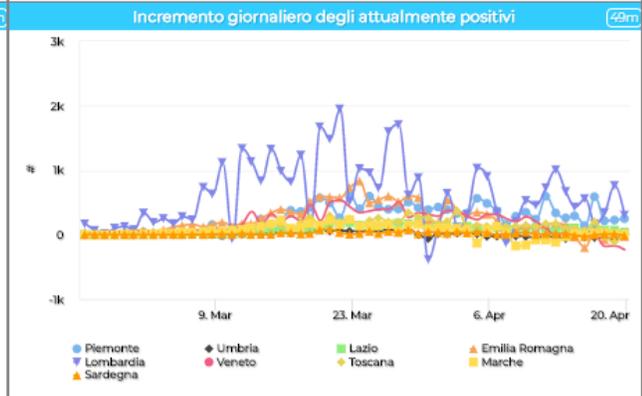
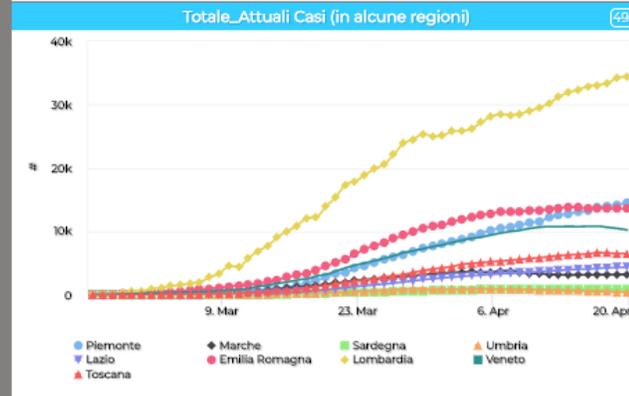
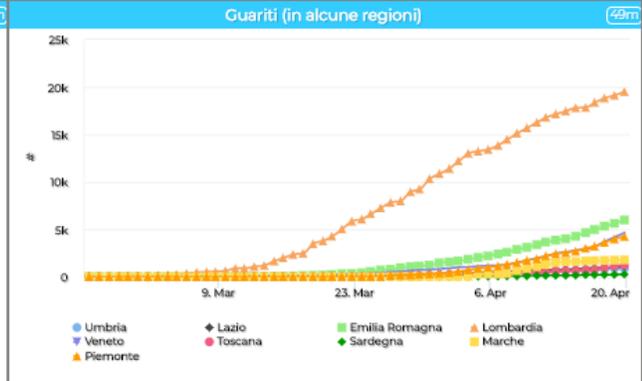
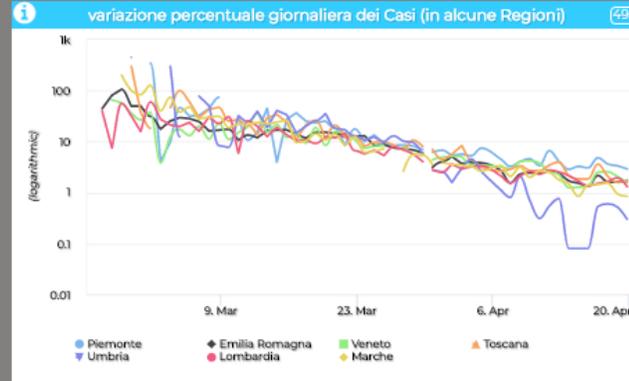
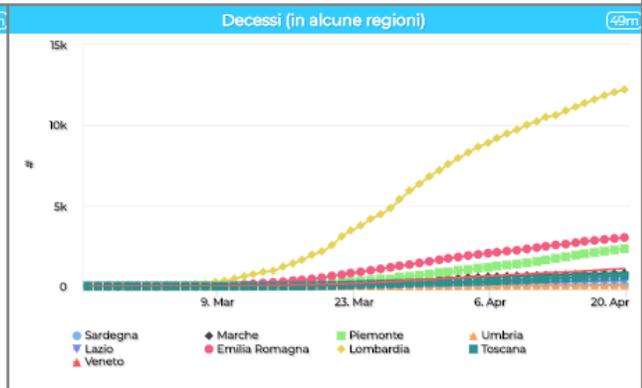
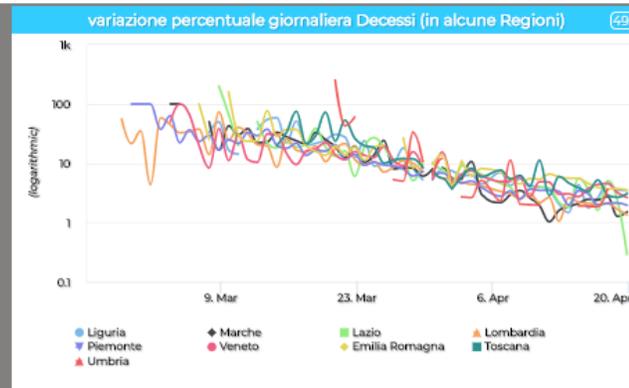
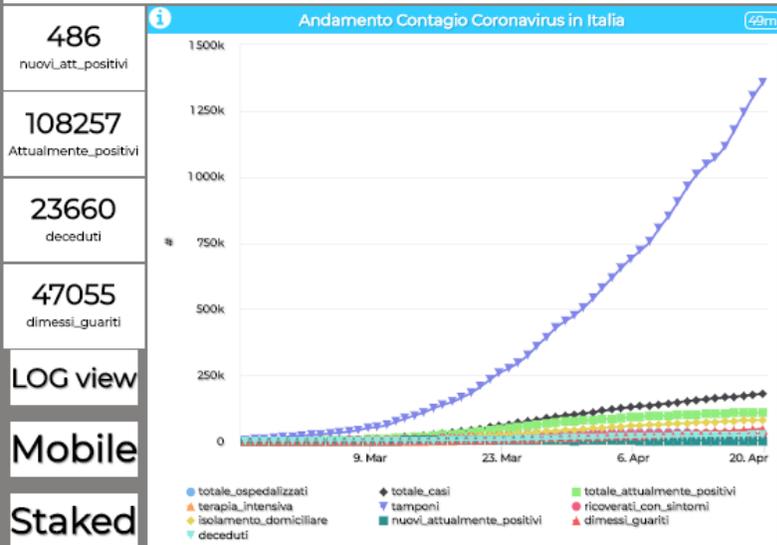
- P. Bellini, S. Bilotta, P. Nesi, M. Paolucci, M. Soderi, "Traffic Flow Reconstruction from Scattered Data", IEEE SMARTCOMP, IEEE international conference on smart computing, 18-20 June, Taormina, Sicily, Italy. 2018
- P. Bellini, S. Bilotta, P. Nesi, M. Paolucci, M. Soderi, "Real-Time Traffic Estimation of Unmonitored Roads", IEEE-DataCom'2018, Athens, 2018

# *COVID-19 vs other data: traffic and environment*



per evidenziare gli andamenti di vostro interesse: eliminare le curve che non interessano selezionandole in legenda.

Alcuni dati in passato non sono pervenuti alla protezione civile



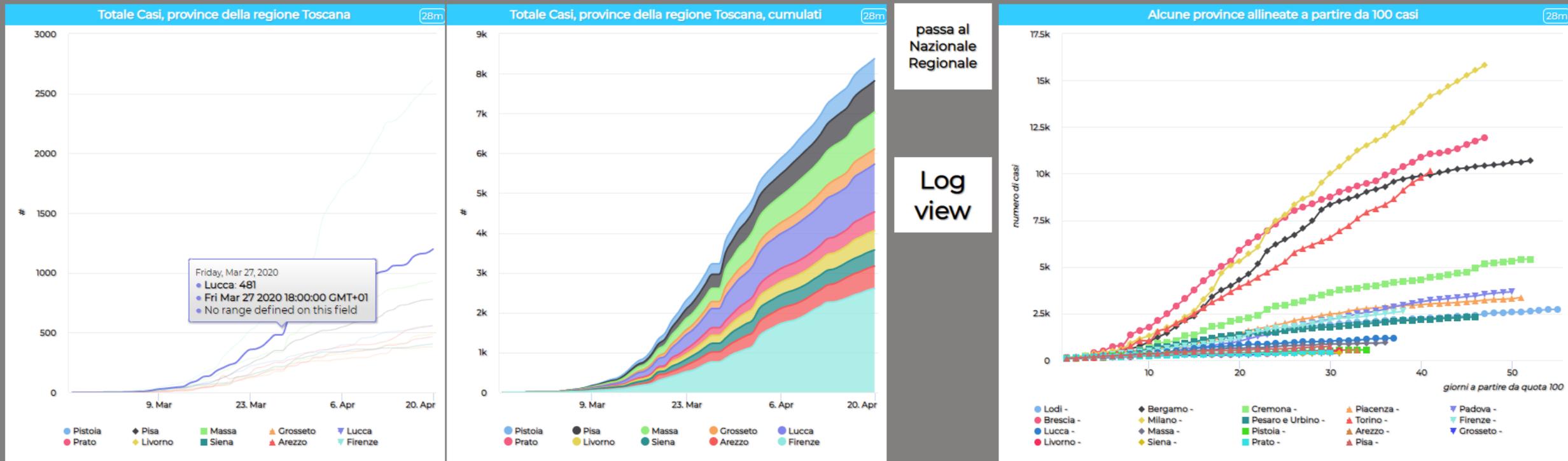
<https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MjU2OQ==>

# Main IT Provinces vs Tuscany Provinces: COVID-19

## Andamento Regione Toscana e Province, COVID-19

Sulla base dei dati della protezione civile, elaborazioni DISITLab

Sun 19 Apr 19:19:56



per evidenziare gli andamenti di vostro interesse: eliminare le curve che non interessano selezionandole in legenda.

Alcuni dati in passato non sono pervenuti alla protezione civile



# Traffic Flow Monitoring - Firenze - Cloned2

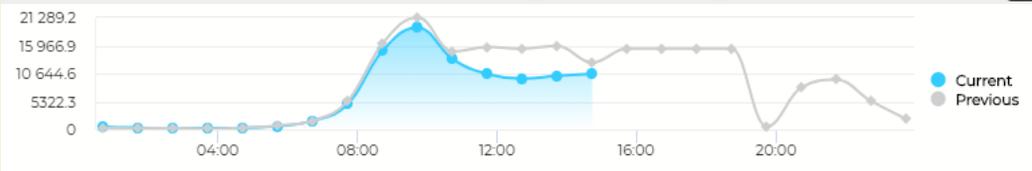
Wed 11 Nov 15:01:32

# IN FLOW 9m

Firenze IN Traffic Flow (number of vehicles)

9m

10549 #ofvehicles

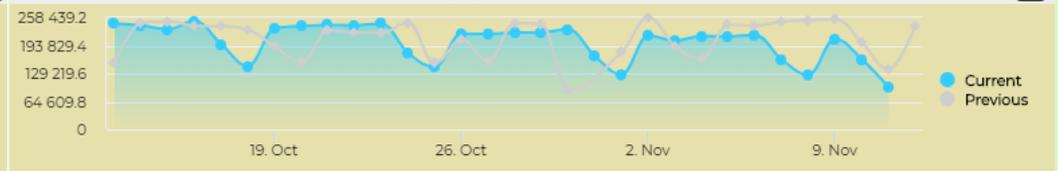


Inc Daily Inp... 9m

Daily Inputs (monthly) (last value is incremental, real time)

9m

97137 #ofvehicles

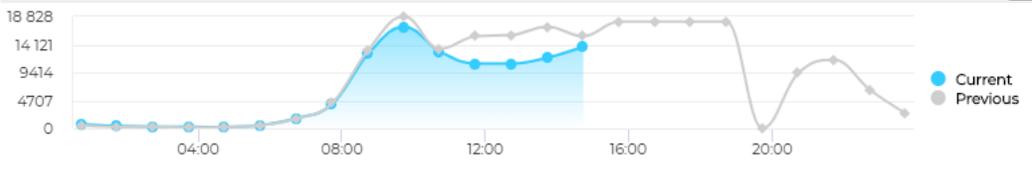


# OUT FLOW 9m

Firenze OUT Traffic Flow (number of vehicles)

9m

13720 #ofvehicles

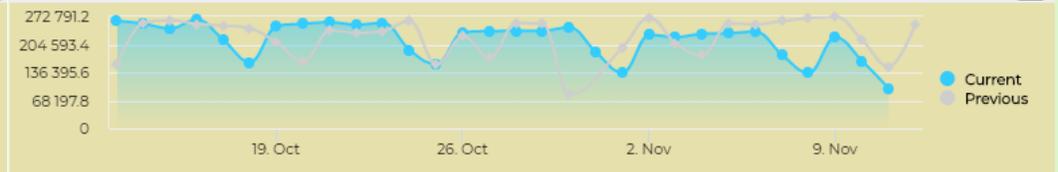


Inc Daily Out... 9m

Daily Outputs (monthly) (last value is incremental real time)

9m

97457 #ofvehicles

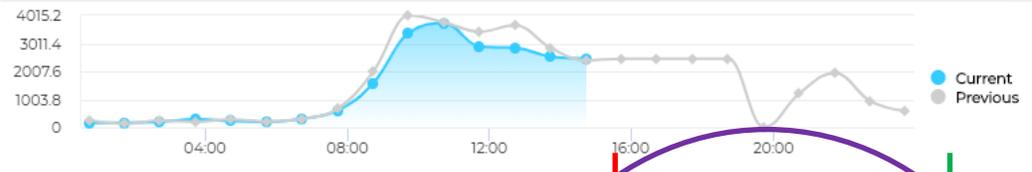


ZTL in 9m

ZTL in Traffic Flow daily trend, entering in ZTL

9m

2468 #ofvehicles



QoS as perc. of measures taken

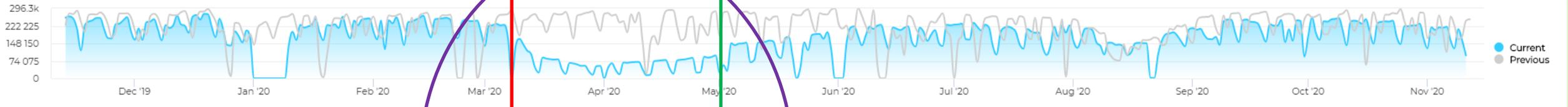
QoS as perc. of measures in ZTL



11/11/2020  
15:01:33

inflow total of the day, yearly

9m



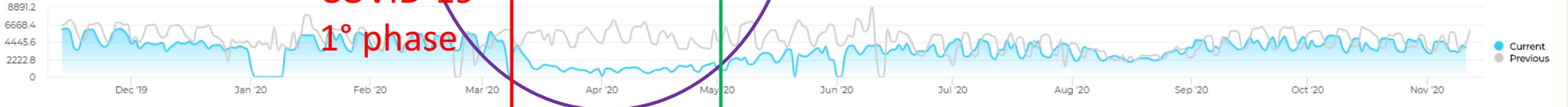
outflow total over the day Yearly

9m



in ZTL yearly compare

9m

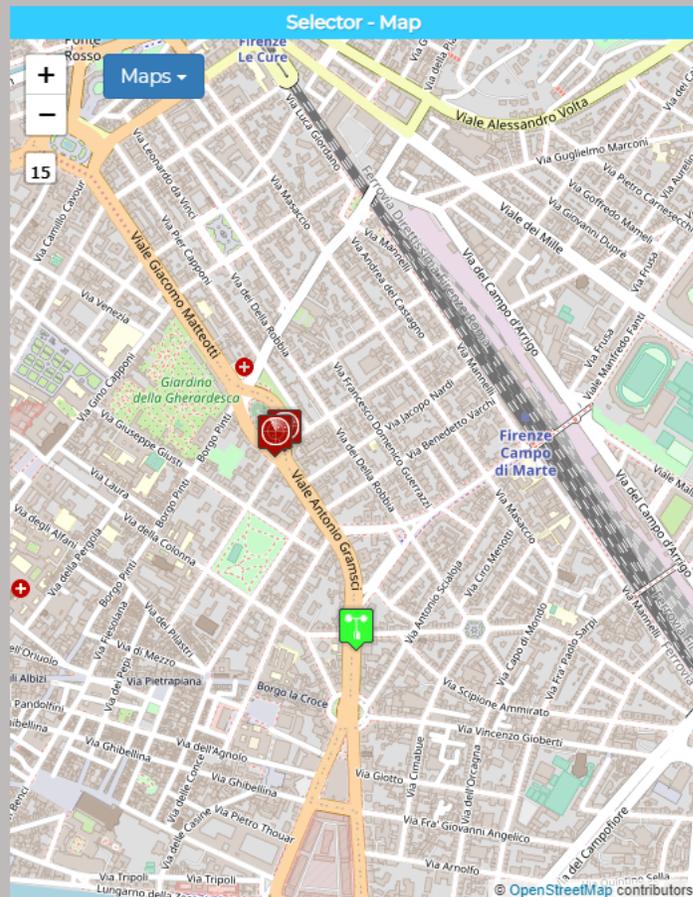


COVID-19  
1° phase

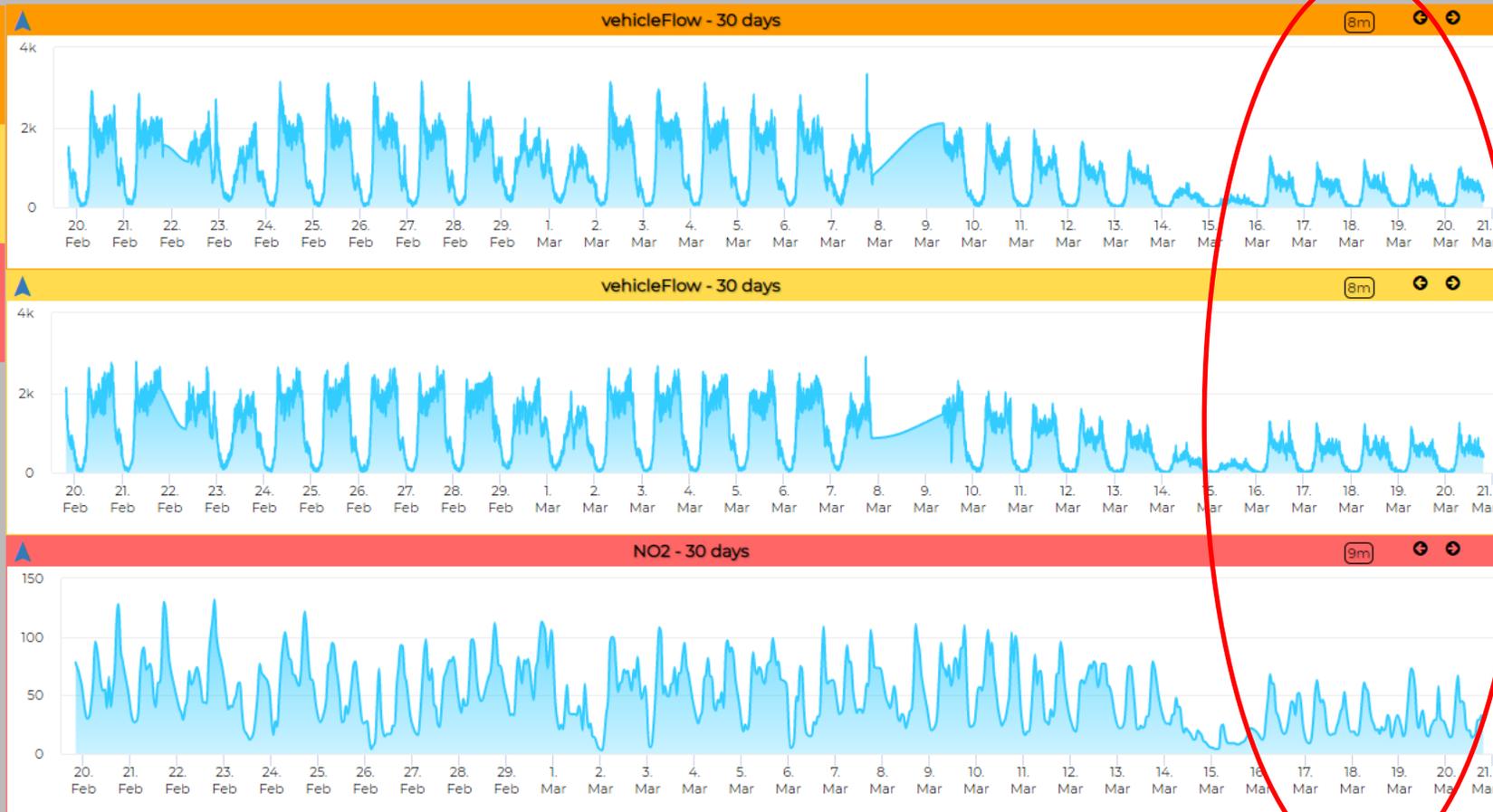
# NOX reduction for COVID

## Monitoraggio Area Gramsci: NO2 vs Traffico

Sun 19 Apr 19:16:42



- 
- 
- 
- InOut traffic Firenze
- NOX Predictions
- Real Time Traffic



# Quality of Public Transport





# Firenze Oggi



Sun 20 Oct 23:35:33

## 26976

Totale utenti WIFI

COLONNINE RICARICA... <sup>9m</sup>

176 INSTALLATE

## 71 % ATTIVE

5.1 % IN USO

**GENERAL METEO** <sup>9m</sup>

**MINIMO BASSO MEDIO ALTO**

**RISCHIO IDRAULICO**

**RISCHIO TEMPORALI**

**RISCHIO IDROGEOLOGICO**

**RISCHIO NEVE**

**RISCHIO GHIACCIO**

**RISCHIO VENTO**

**SITUAZIONE VIABILITA** <sup>55s</sup>

**0 INCIDENTI**

0 CHIUSURE AL TRAFFICO (TOT)

0 CHIUSURE PER CANTIERI

0 PROGR.      0 NON PROG.

0 LIMITAZIONI AL TRAFFICO (TOT)

0 LIMITAZIONI PER CANTIERI

0 NON PROG.      0 PROGR.

**0 TOT. EVENTI SULLA RETE**

<b>SMN</b> <sup>9m</sup>	<b>BINARIO16</b> <sup>9m</sup>	<b>FORTEZZA</b> <sup>9m</sup>
21.6 % occupati su 607 posti	43 % occupati su 165 posti	19.2 % occupati su 521 posti
<b>LEOPOLDA</b> <sup>9m</sup>	<b>CALZA</b> <sup>9m</sup>	<b>S.AMBROGIO</b> <sup>9m</sup>
34 % occupati su 300 posti	39.2 % occupati su 148	21.6 % occupati su 379 posti
<b>PARTERRE</b> <sup>9m</sup>	<b>CAREGGI</b> <sup>9m</sup>	<b>BECCARIA</b> <sup>9m</sup>
31.1 % occupati su 656 posti	4.4 % occupati su 406 posti	23.3 % occupati su 210 posti

### ANALYSIS

Energy

Environment

Mobility

Social

Resilience



<b>Nati Italiani</b> <sup>119m</sup>	<b>Nati stranieri</b> <sup>119m</sup>	<b>Deceduti</b> <sup>119m</sup>	<b>Matrimoni</b> <sup>119m</sup>	<b>Unioni Civili</b> <sup>119m</sup>
164 ultimo mese consolidato	57 ultimo mese	399 ultimo mese	18 ultimi 7 giorni	0 ultimi 7 giorni
<b>Segnalazioni ricevute in attesa</b> <sup>119m</sup>	<b>In Lavorazio...</b> <sup>119m</sup>	<b>Risolte</b> <sup>119m</sup>	<b>Chiuse senza risoluzione...</b> <sup>119m</sup>	
1116 ultimo mese	524	305	285	
<b>Manutenzioni Stradali</b> <sup>59m</sup>	<b>Verde Pubbl...</b> <sup>59m</sup>	<b>Decoro Urbano</b> <sup>59m</sup>	<b>Relitti</b> <sup>59m</sup>	
6 oggi	3	5	0	

**Attesa media alla fermata**

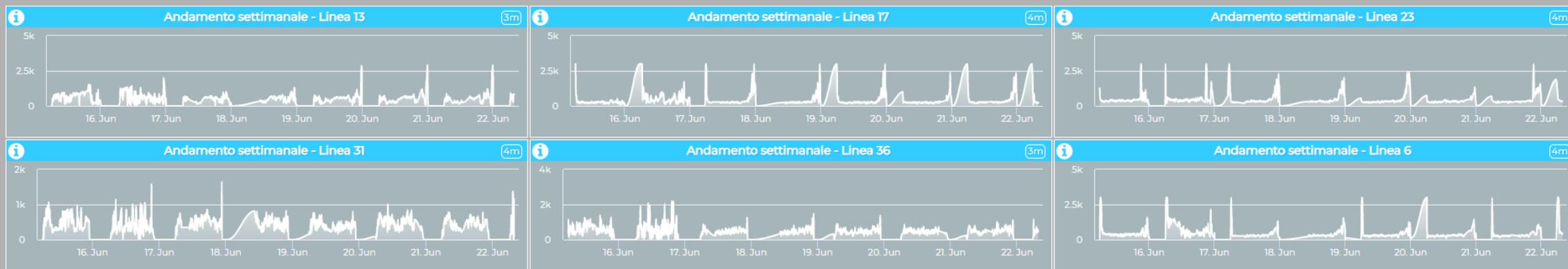
<b>Linea 6</b> <sup>9m</sup>	<b>Linea 13</b> <sup>9m</sup>
3 min	13 min
<b>Linea 17</b> <sup>9m</sup>	<b>Linea 23</b> <sup>9m</sup>
4 min	5 min
<b>Linea 31</b> <sup>9m</sup>	<b>Linea 36</b> <sup>9m</sup>
19 min	2 min

## Florence

# Qualità Trasporto Pubblico - Cloned

Firenze - 6 linee

Sat 22 Jun 07:45:48



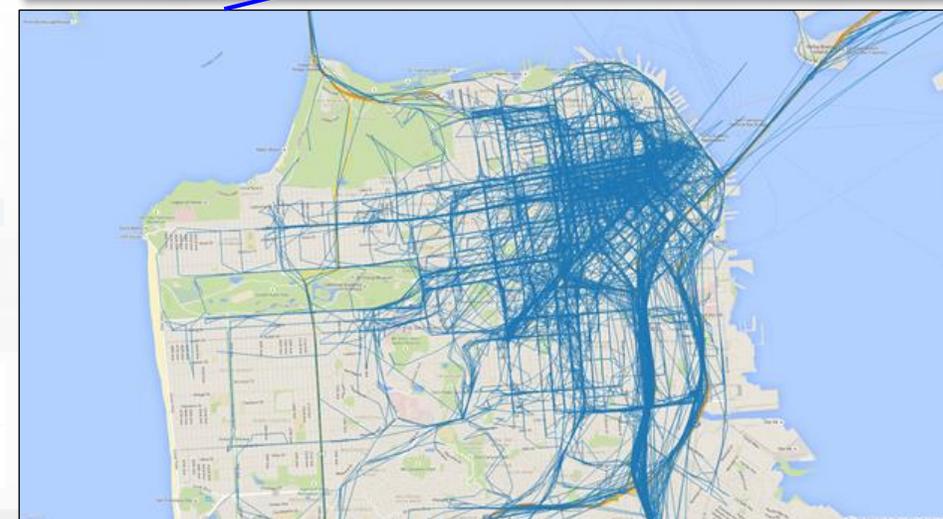
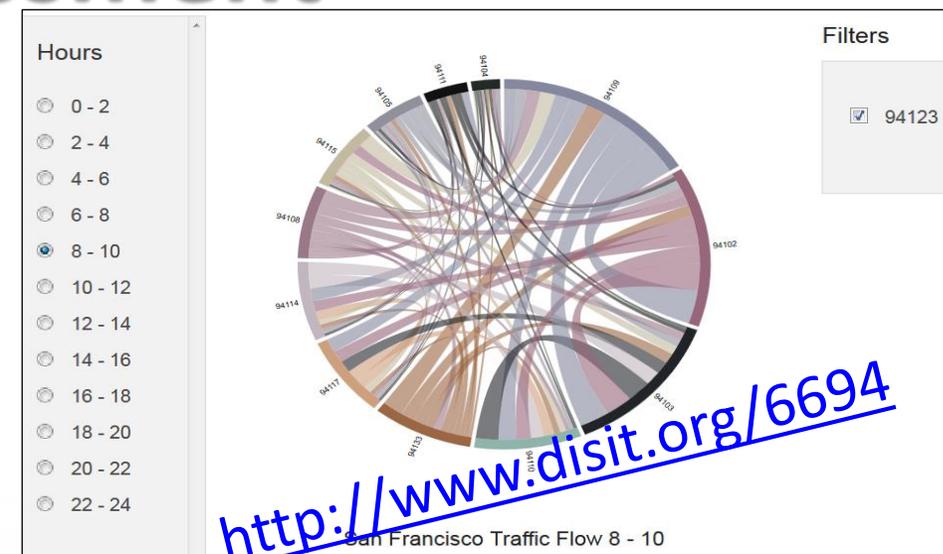
# Origin Destination Matrices





# Traffic and People Flow Assessment

- **Origin Destination Matrix**
  - Specific Sensors, vehicle Kits, mobile App, Wi-Fi Access Points, etc.
  - Data from Taxi in San Francisco
- **Assess people and traffic flows to**
  - improve services
  - predict critical conditions on Crit. Infra.
  - take real time decisions and sending messages in push to population
  - Increase city resilience
  - optimize traffic flow
  - take decision of routing

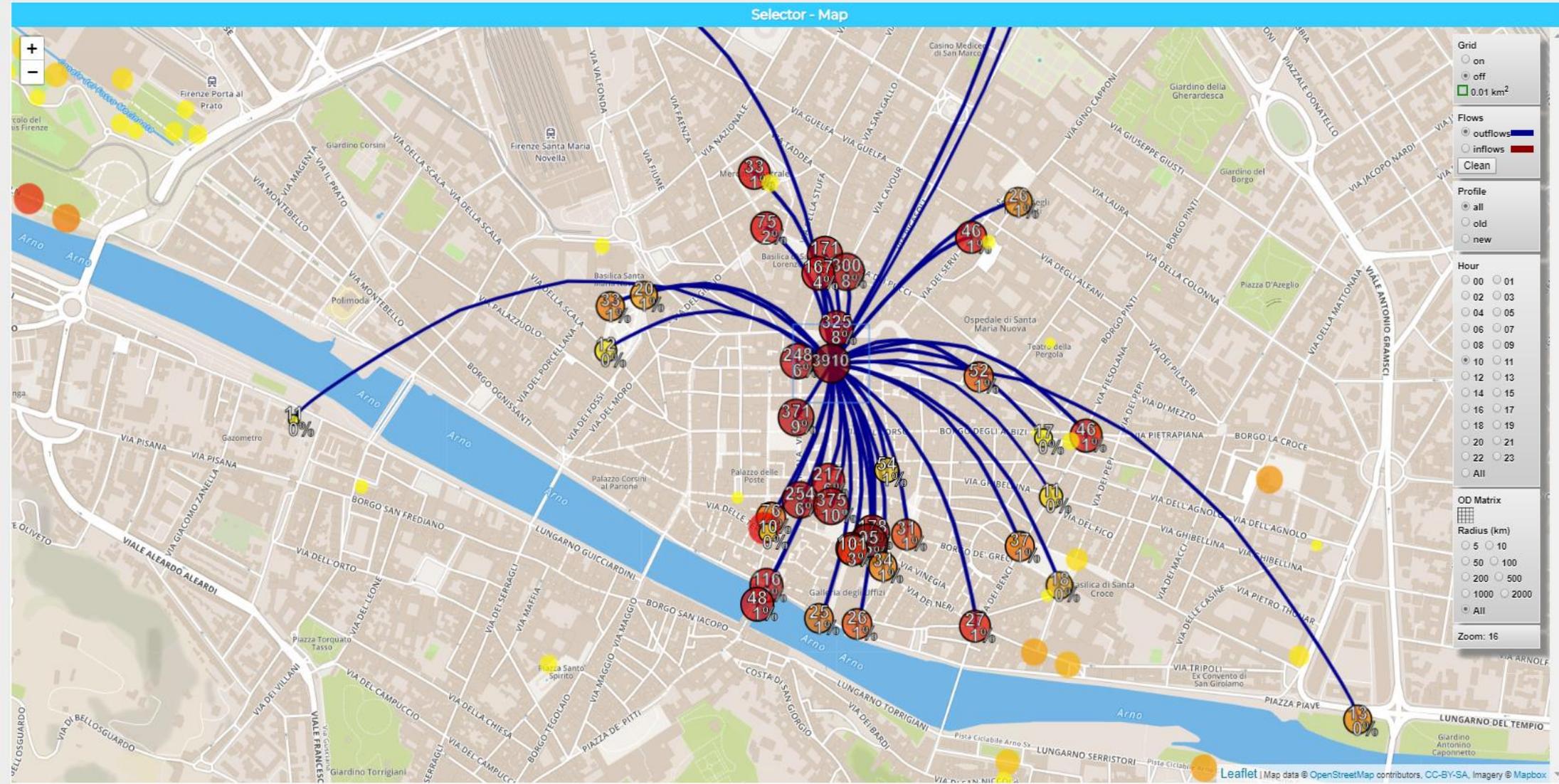






# Life in Toscana: Dashboard

Sun 20 Oct 23:44:05



- Line of Transport
  - Public Transport
  - Travel Plan
  - Traffic Flow FIPILI
  - Air Quality
  - Weather
  - Origin Dest. Matrix
  - Typical Trajectories
  - People Flow WIFI
  - People Flow KM App
  - Cultural Activities
  - Forum Discussion
  - CAM
  - Ponte Vecchio
  - Real Time Busses
- Main

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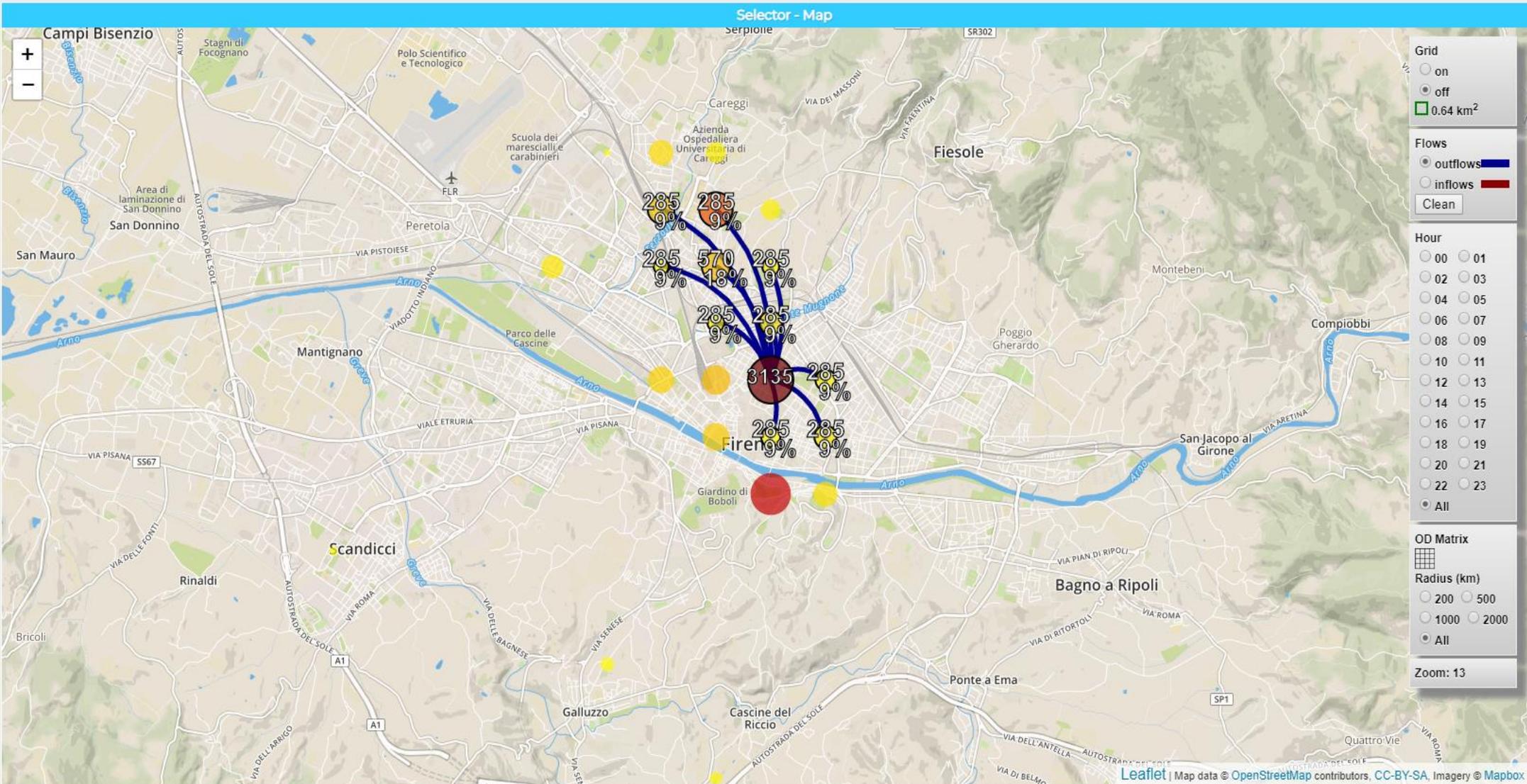


<https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MTC3NA==>

Snap4City (C), November 2020

# Life in Toscana: Dashboard

Sun 20 Oct 23:40:25



- ▲ Line of Transport
- ▲ Public Transport
- ▲ Travel Plan
- ▲ Traffic Flow FIPILI
- ▲ Air Quality
- ▲ Weather
- ▲ Origin Dest. Matrix
- ▲ Typical Trajectories
- ▲ People Flow WIFI
- ▲ People Flow KM App
- ▲ Cultural Activities
- ▲ Forum Discussion
- ▲ CAM
- ▲ Ponte Vecchio
- ▲ Real Time Busses
- ▲ Main

# The Life of Antwerp

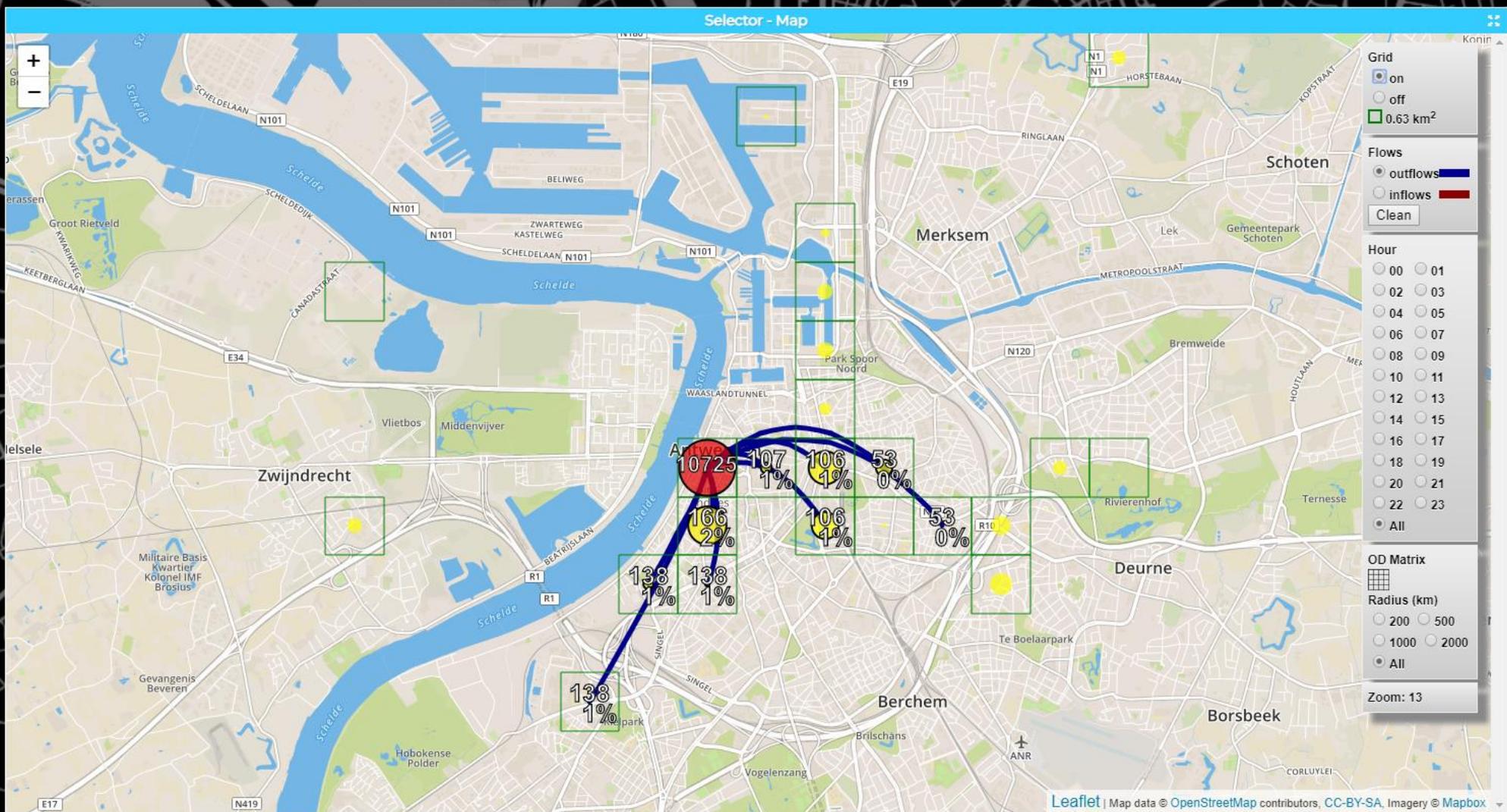
Please note that the data results are not always based on real data.

Sun 20 Oct 23:42:07

- ▲ Shopping: POI
- ▲ Wine and Food: POI
- ▲ Discovery Antwerp
- ▲ Point of Interest
- ▲ 3D view POI
- ▲ Routing on Antwerp
- ▲ Line of Transport
- ▲ Public Transport
- ▲ Safe On Bike
- ▲ Tunnel and Ferry
- ▲ Twitter Vigilance
- ▲ Twitter Vig. Real Time
- ▲ Air Quality
- ▲ Weather
- ▲ Origin Dest. Matrix
- ▲ Typical Trajectories
- ▲ Forum Discussion

Documentation

Survey

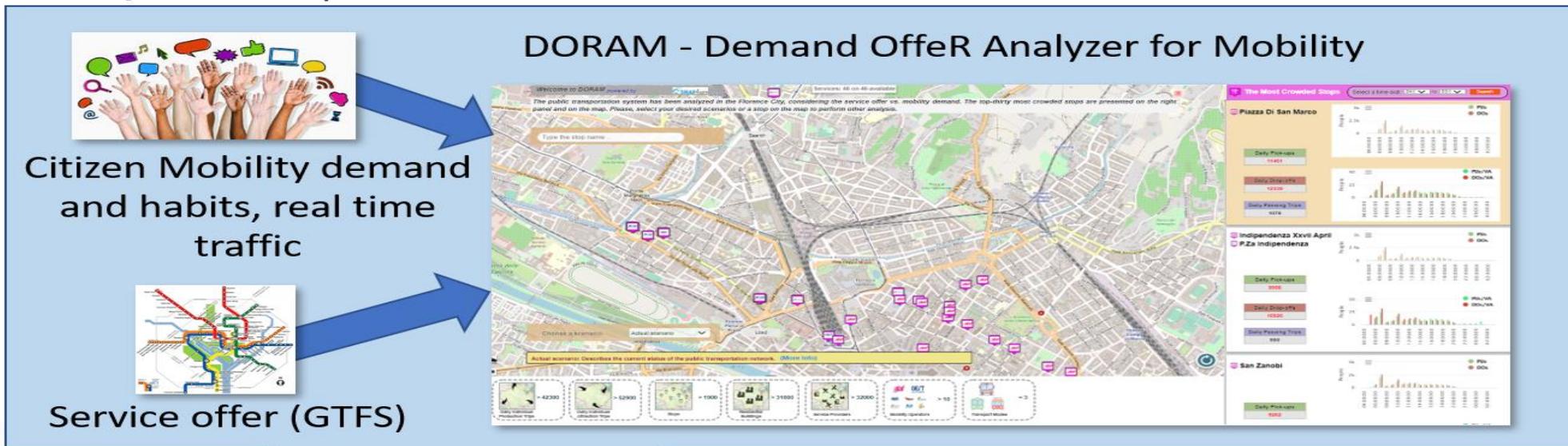


<https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MTcwNg==>

# *Demand of Mobility vs Offer of Transportation*







Citizen Mobility demand and habits, real time traffic



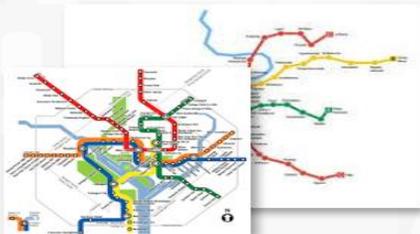
Service offer (GTFS)



City Mobility Operator(s)

analysis of the offer vs demand (DORAM)

Planned Bus/Tram/Train/ etc. stops/trips and timetables (GTFS)

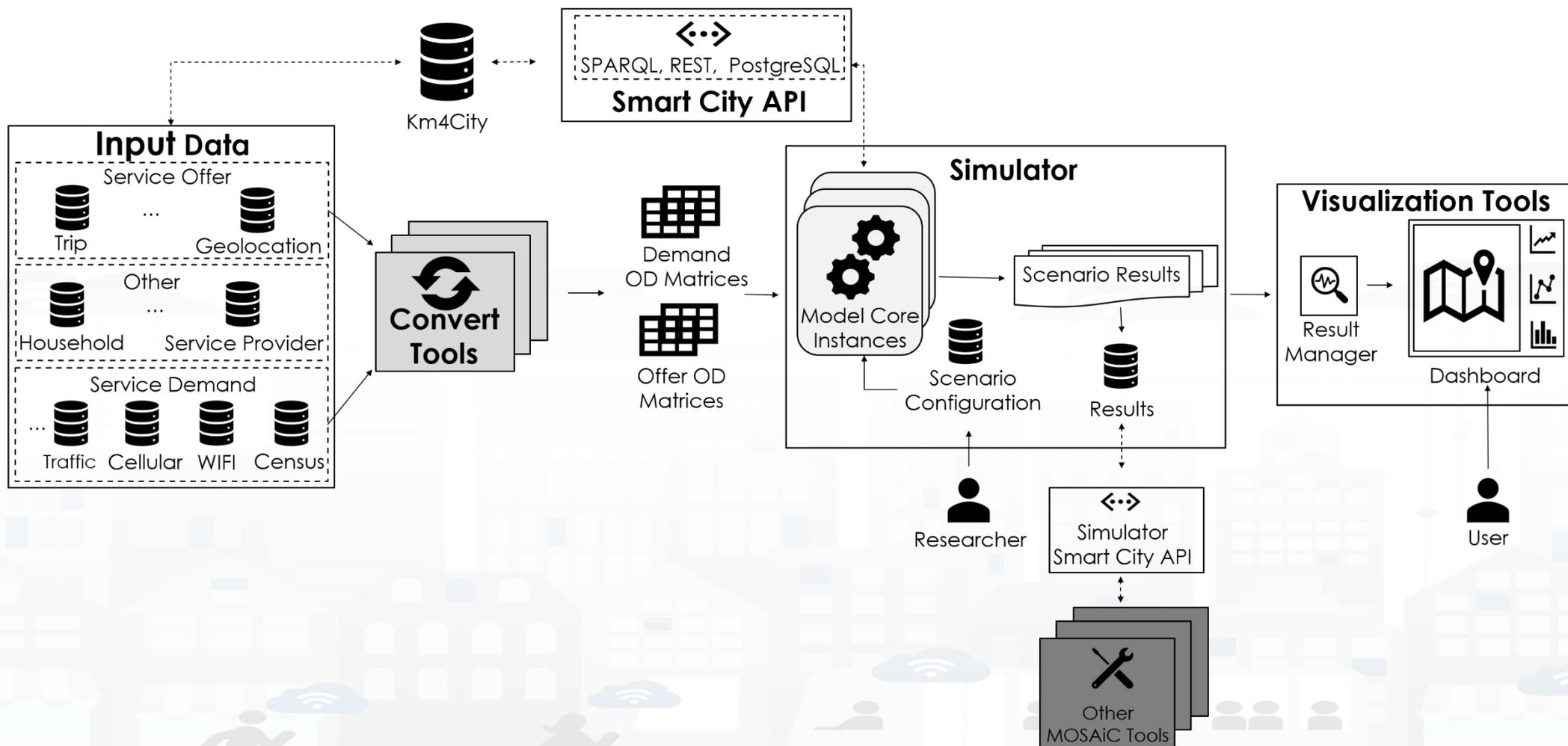


GTFS variation to improve the efficiency of the service





# Demand vs Offer of Mobility Analysis



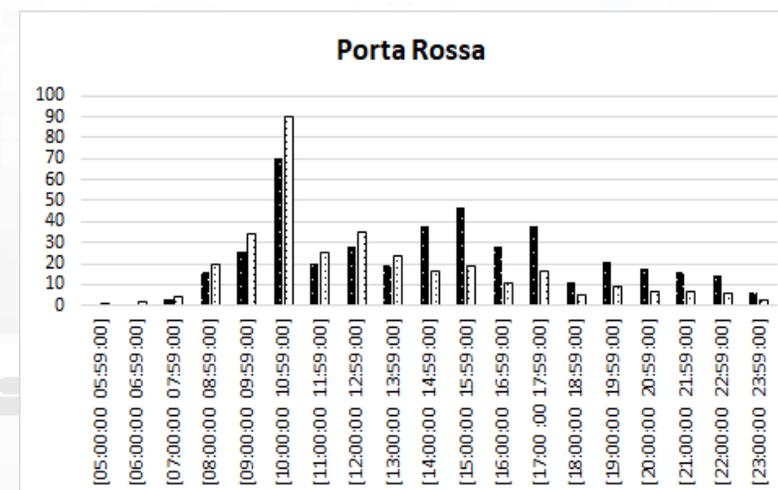
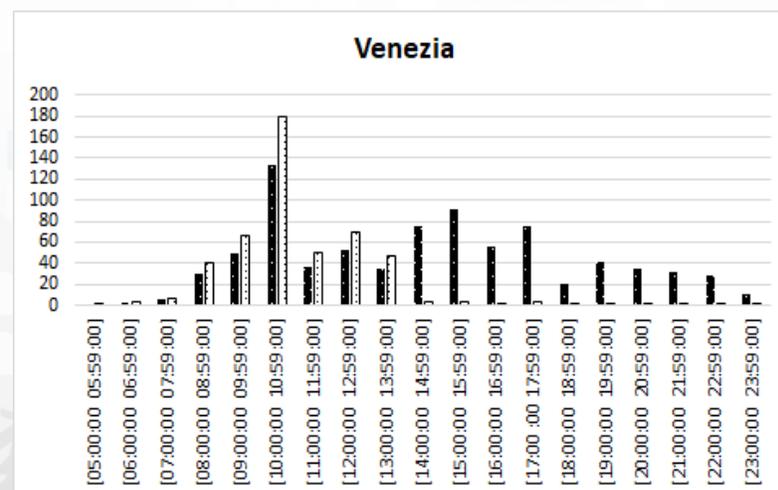
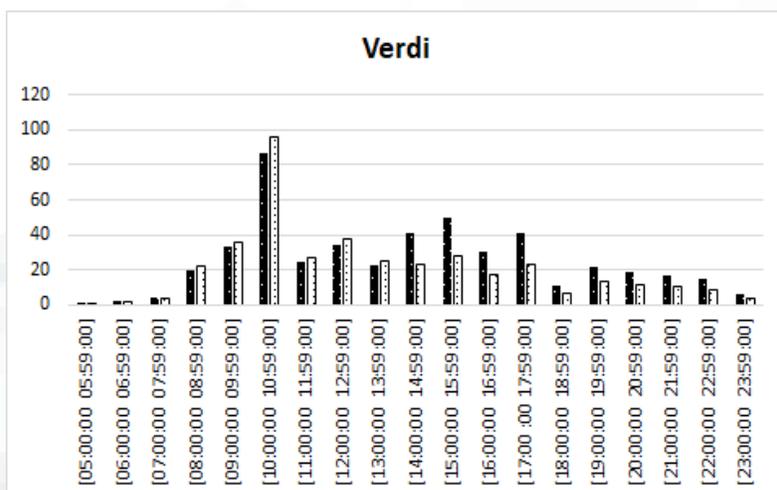
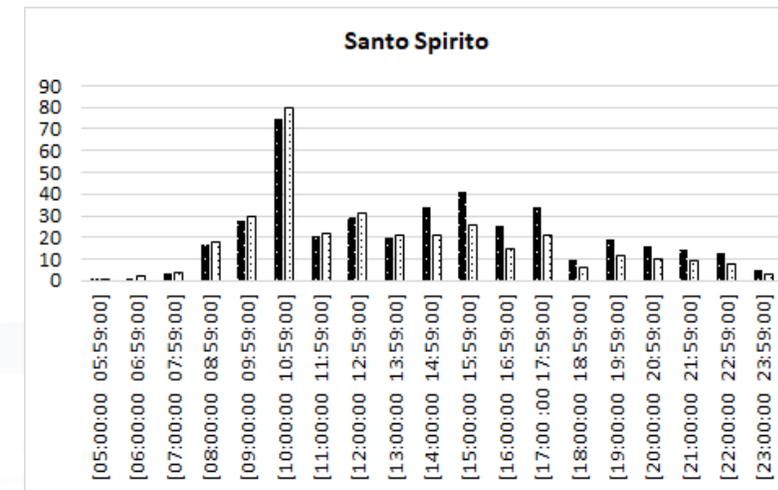
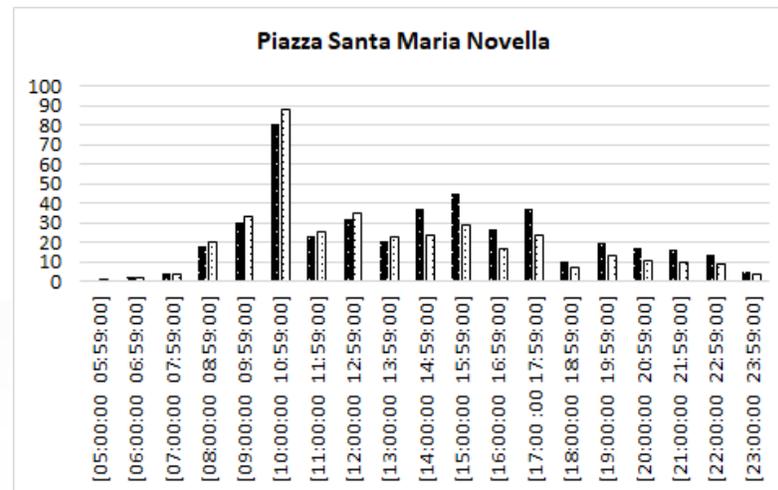
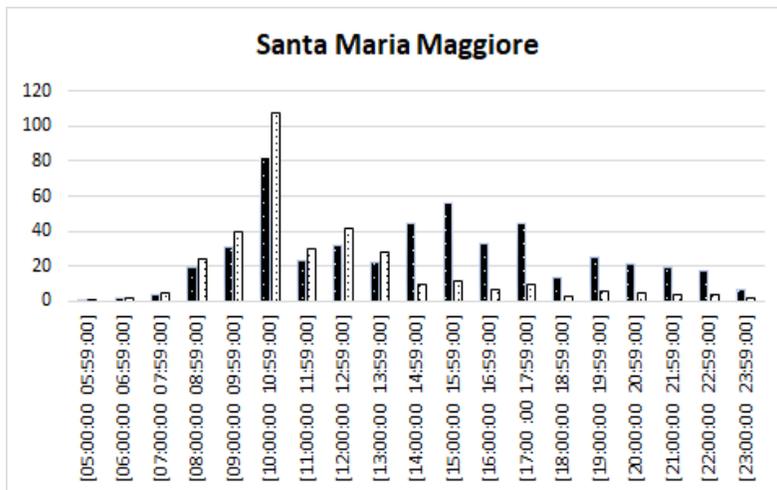


# What can produce the Analysis tool

- Identification of critical Bus Stops over time
- Identification of critical courses of bus lines, over day and week
- Effects of changing the position of Bus Stops, courses and line schedules, bus size, etc.
- Effects of changing the contextual conditions:
  - The opening of shopping centers, cinemas, schools, etc..
  - Seize of the buses

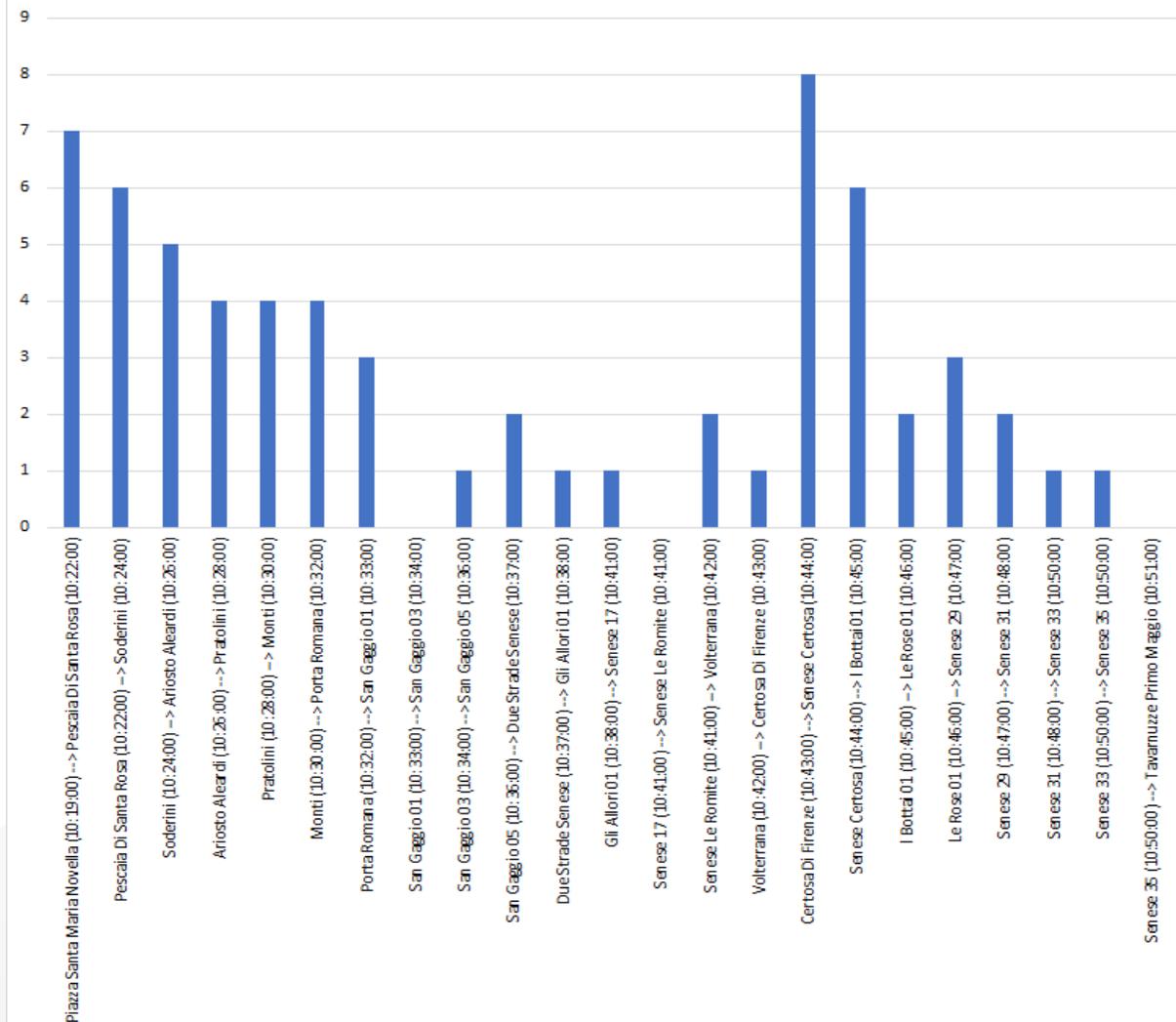


# Pick-ups (black bars) and drop-offs (white bars) for the six selected stops

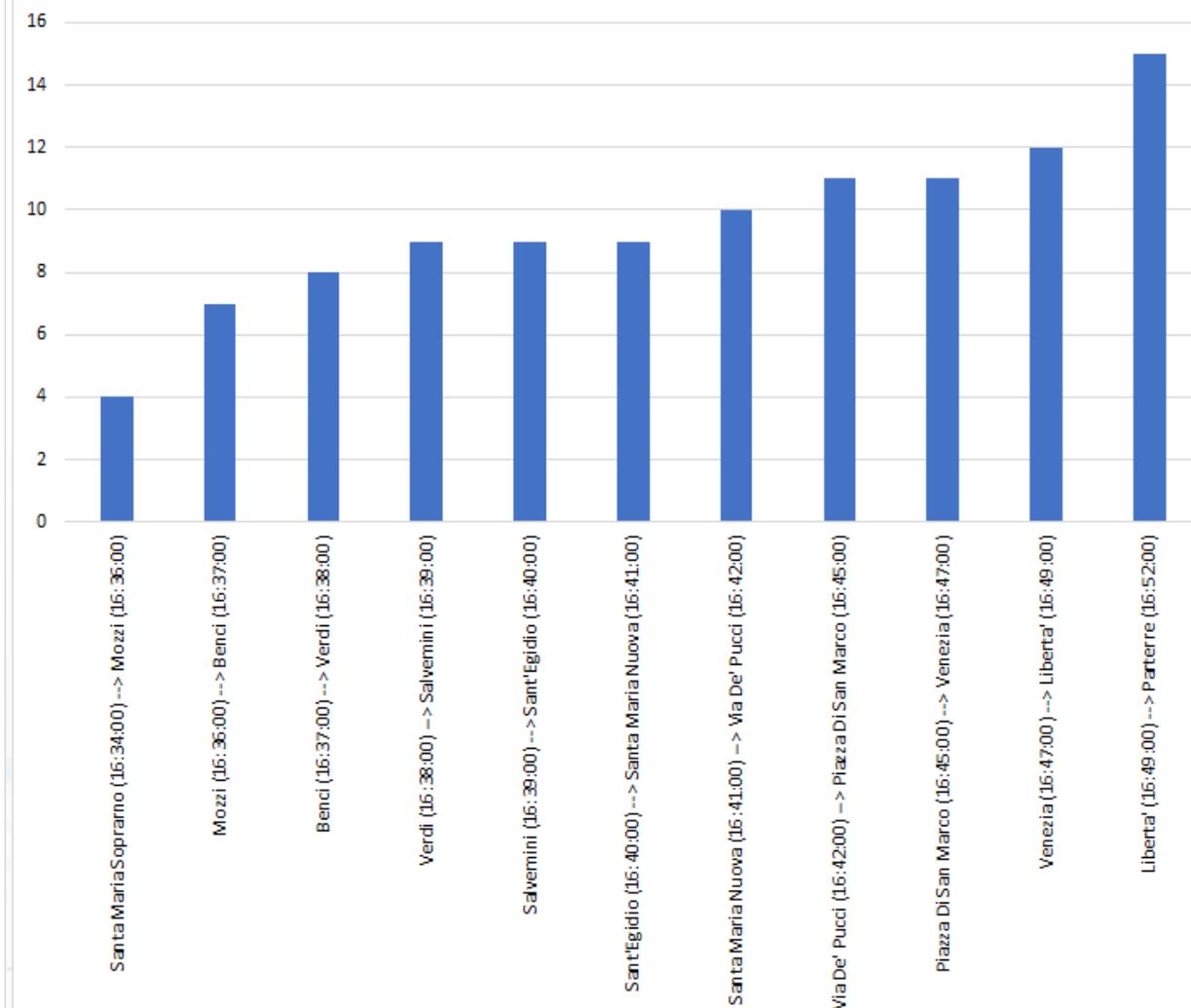




Bus\_ataflinea\_Trip\_2570\_6078641

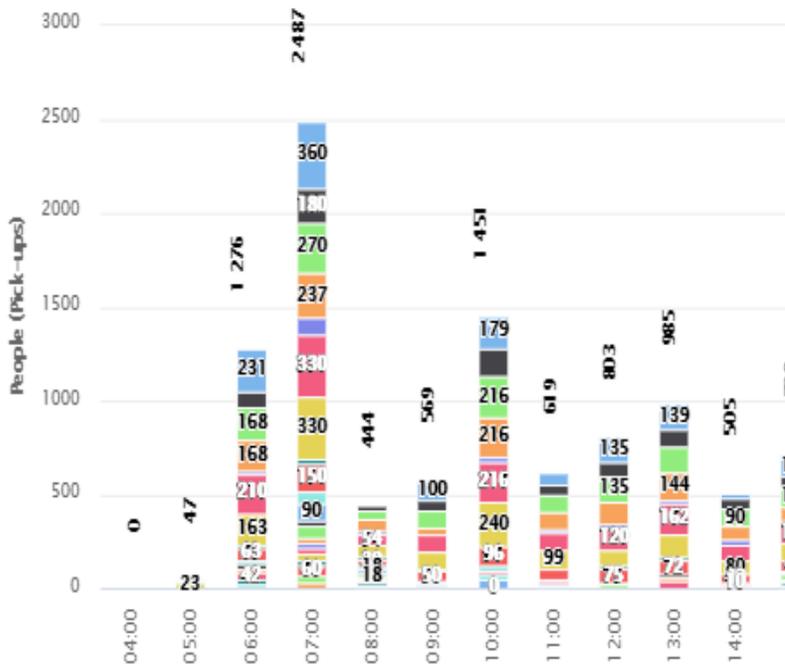


Bus\_ataflinea\_Trip\_2570\_1002616

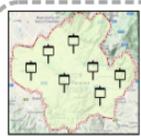


# Bus Stop Analysis: identification of criticalities

Stop(s): *Indipendenza Xxvii Aprile, P.Za Indipendenza*

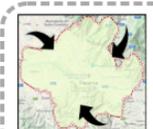
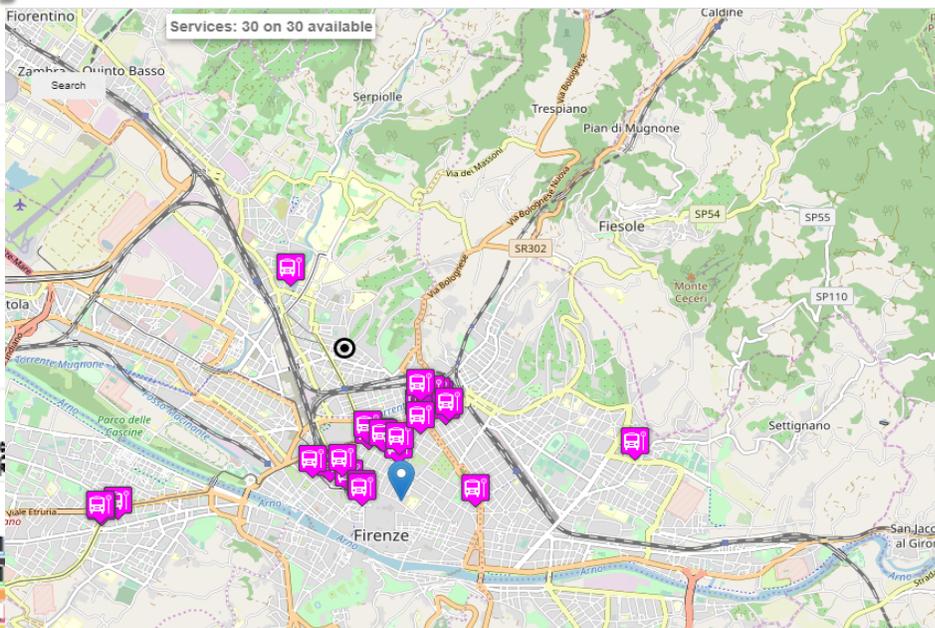


Daily individual  
Production Trips



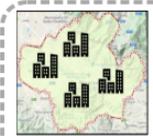
1875

Bus Stops



> 52900

Daily Individual  
Attraction Trips



31070

Residential  
Buildings



21289

Daily bus trips



31059

Service Providers

**The Most Crowded Stops** Select a time slot: 04:00 to 04:59 Search

**Piazza Di San Marco**

Daily Pick-ups: 27301

Daily Drop-offs: 28655

**San Zanobi**

Daily Pick-ups: 26456

Daily Drop-offs: 27620

**Indipendenza Nazionale**

Daily Pick-ups: 24410

Daily Drop-offs: 25971

**Indipendenza Xxvii Aprile**

Daily Pick-ups: 21930

Daily Drop-offs: 24342

**Santa Reparata**

Daily Pick-ups: 19726

Daily Drop-offs: 22190

TOP

# *Modal & Multimodal Routing for Navigation and Travel Planning*







# Routing and Multimodal Routing

## Modes:

- Pedonal, Vehicles
- Public Multimodal
- Multi Point for Delivering
- Constrained: quite, blocked, etc.

## Test it on our:

- Mobile Apps
- MicroApplication
- Dashboard
- ServiceMap service on Tuscany in Snap4City

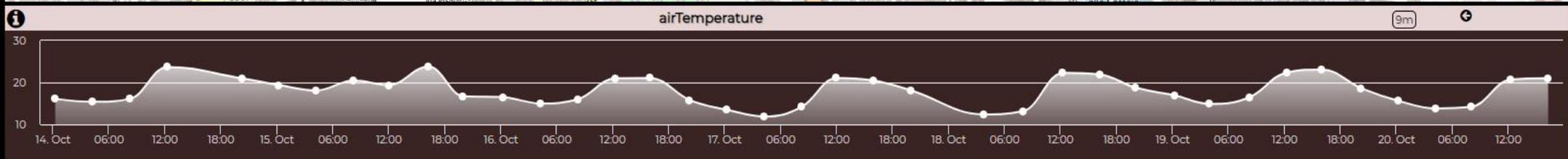
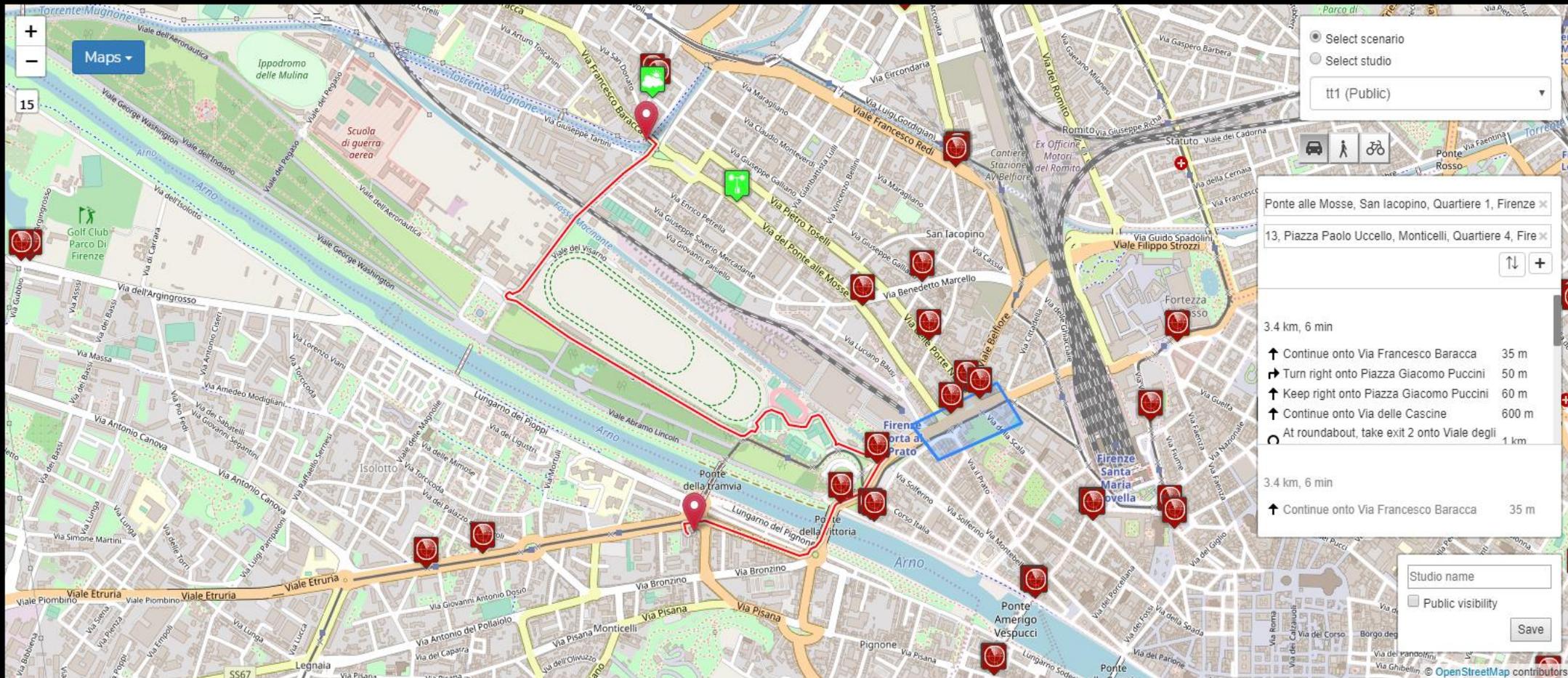
# Mobility and Environment What-IF Analysis

This dashboard contains data derived from actual sensors and predictive values under validation

- Air Quality Sensors
- Weather Sensors
- PM10 Heatmap
- PM2.5 Heatmap
- CO Heatmap
- CO2 Heatmap
- O3 Heatmap
- NO2 Heatmap
- Europ. AQI Heatmap
- Air Humidity Heatmap
- Air Temp. Heatmap
- Wind Speed Heatmap
- Gral Pred. HM NOX (3m)
- Gral Pred. HM NOX (6m)
- Traffic Sensors
- Traffic Flow
- Cycling Paths
- Accident Heatmap
- Only HRes Anym. Gral
- Scenarios
- What-if analysis

Firenze Oggi

Air Temperat... 9m



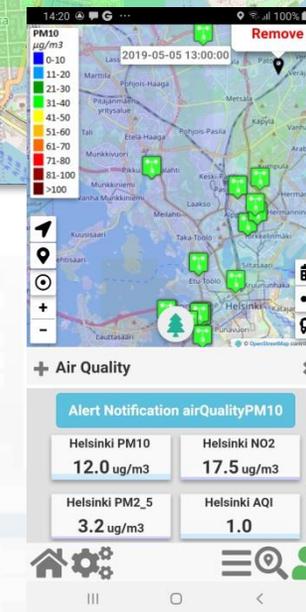
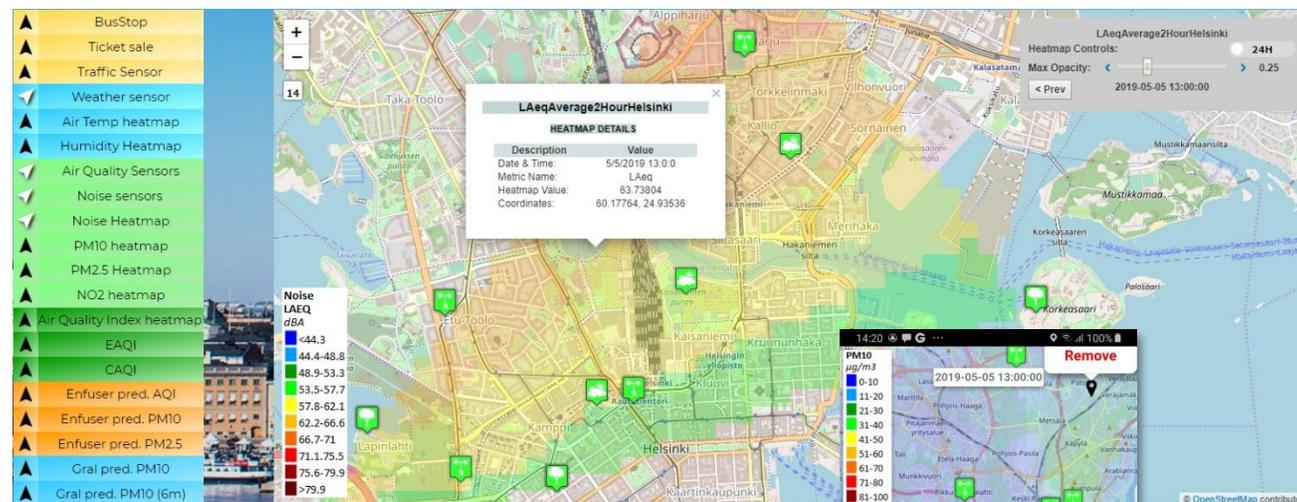
<https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MjE5MA==>

# *Environmental Data: Predictions, Early Warning*



# Data Analytics: Heatmaps

- Over the Gaussian Heatmaps
- Calibrated heatmaps on the basis of Interpolated data for:
  - From 200x200 to 4x4 mt
  - PM10, PM2.5, SO2, NO2, Noise, NO, O3, Enfuser, GRAL,....
  - Any programmed Color map
  - Animations over H24
  - Picking values in any place, values on their position.
  - On Web and Mobile App



# Environmental ENFUSER Predictive Measures

## ENVIRONMENTAL INFORMATION FUSION SERVICE:

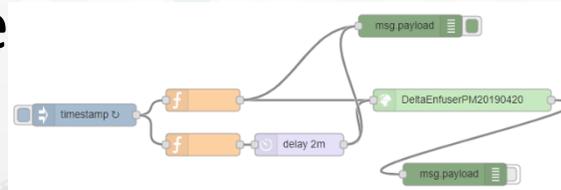
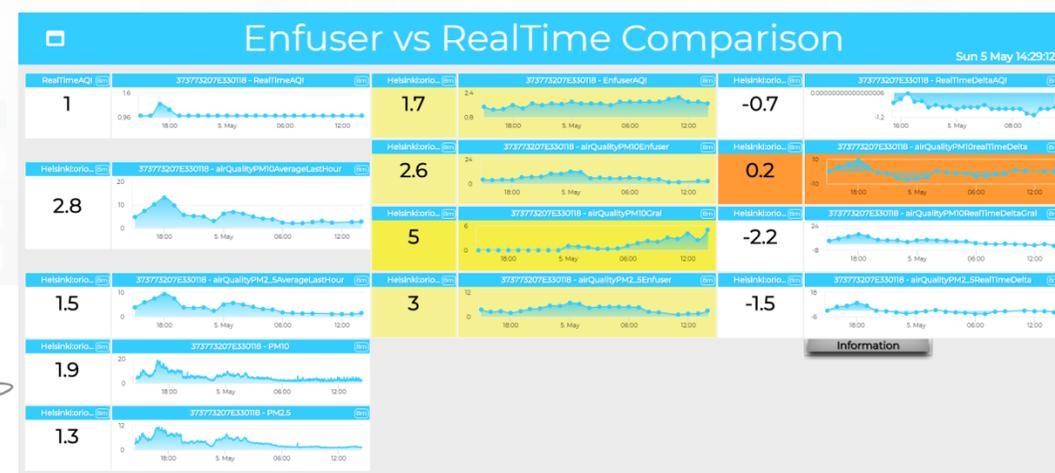
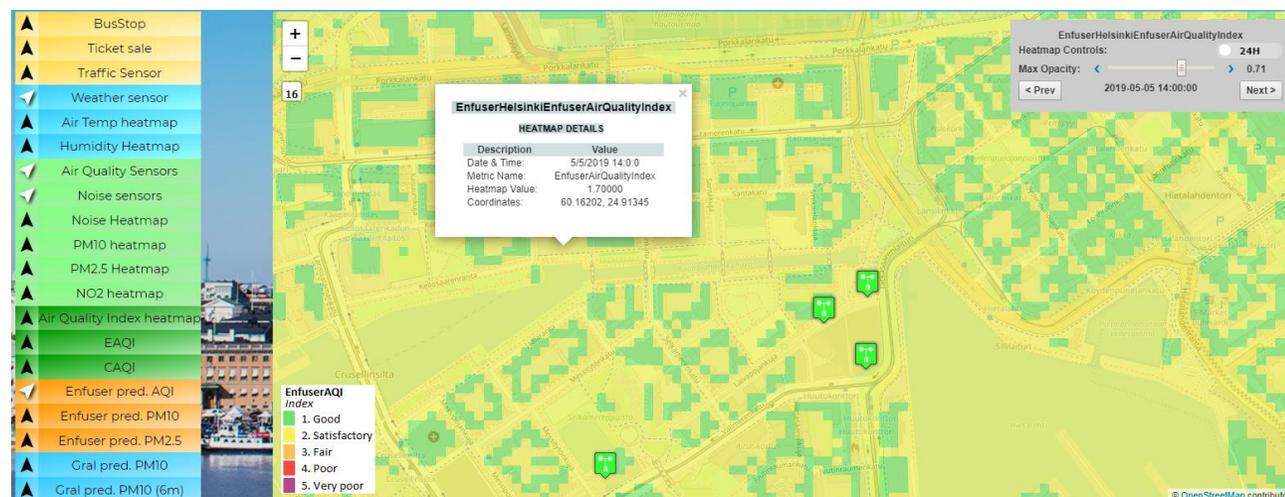
Air quality model that combines *dispersion modelling techniques*, *information fusion algorithms* and *statistical approaches*. The operational modelling system provides both real-time and forecasted, high resolution information on the urban air quality.

- Data gathering, data processing for Piking
- API for accessing data of Heatmaps in real time



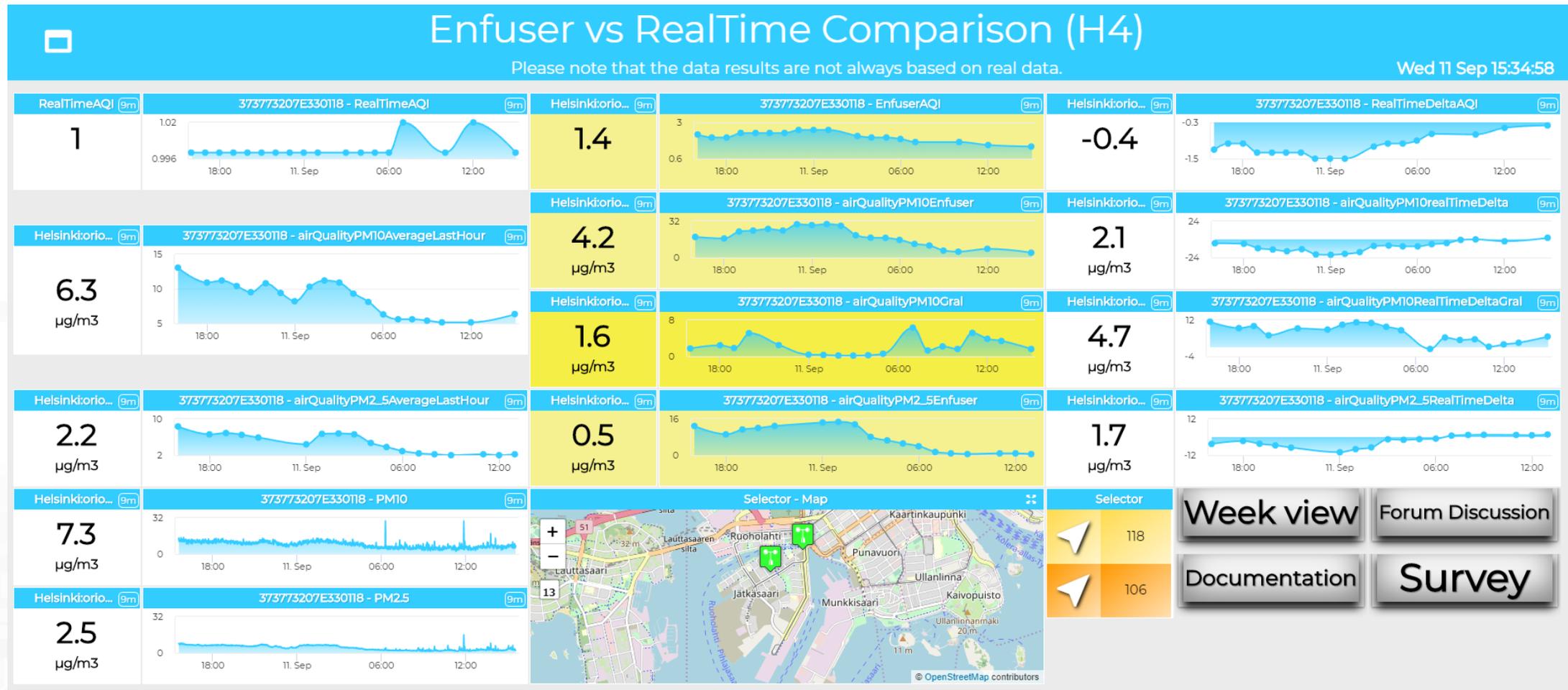
# Data Analytics: Enfuser predictions

- **Enfuser predictions: AQI, PM10, PM2.5**
  - Data gathering, data processing for Piking
  - Delta Estimation Predictions vs Actual: on 12 points/sensors via R-Studio and IOT App
  - API for accessing data of Heatmaps in real time



# Comparative Dashboard

❖ *Delta Estimation Predictions vs Actual* on 12 points/sensors via R-Studio and IOT App



<https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MTczMg==>

# Data Analytics: AQI estimations

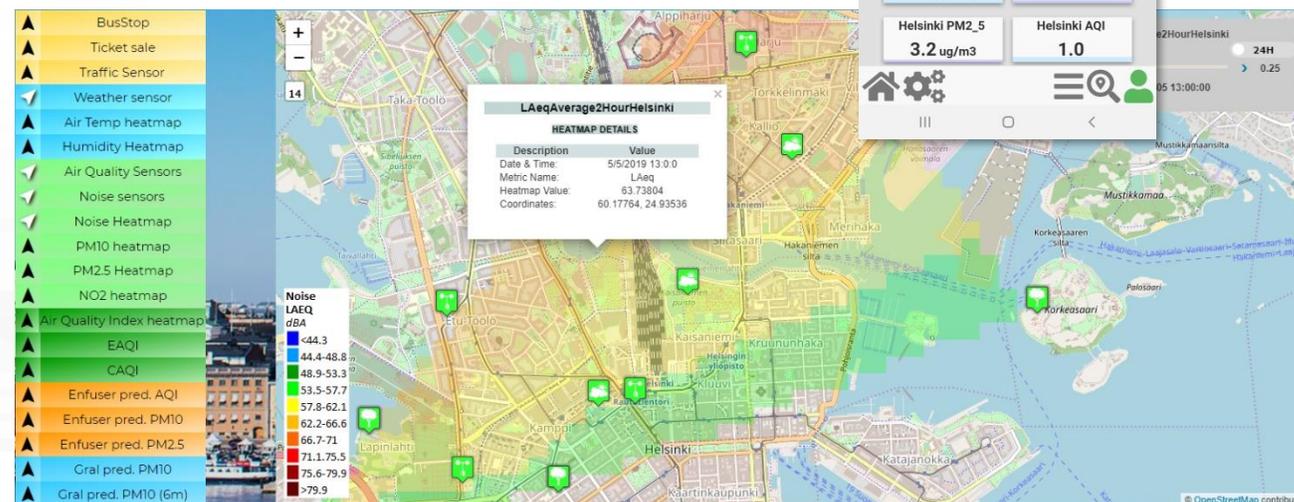
- **Legenda of Environmental data:**
  - <https://www.snap4city.org/435>
- **AQI estimation via Rstudio and IOT App:**
  - EAQI, European Air Quality Index
  - Enfuser AQI for Delta,
  - CAQI
  - Their corresponding Heatmaps

✓	Air Quality Sensors
✓	Noise sensors
✓	Noise Heatmap
▲	PM10 heatmap
▲	PM2.5 Heatmap
▲	NO2 heatmap
▲	Air Quality Index heatmap
▲	EAQI
▲	CAQI
▲	Enfuser pred. AQI
▲	Enfuser pred. PM10
▲	Enfuser pred. PM2.5
▲	Gral pred. PM10
▲	Gral pred. PM10 (6m)

# Environmental Heatmaps

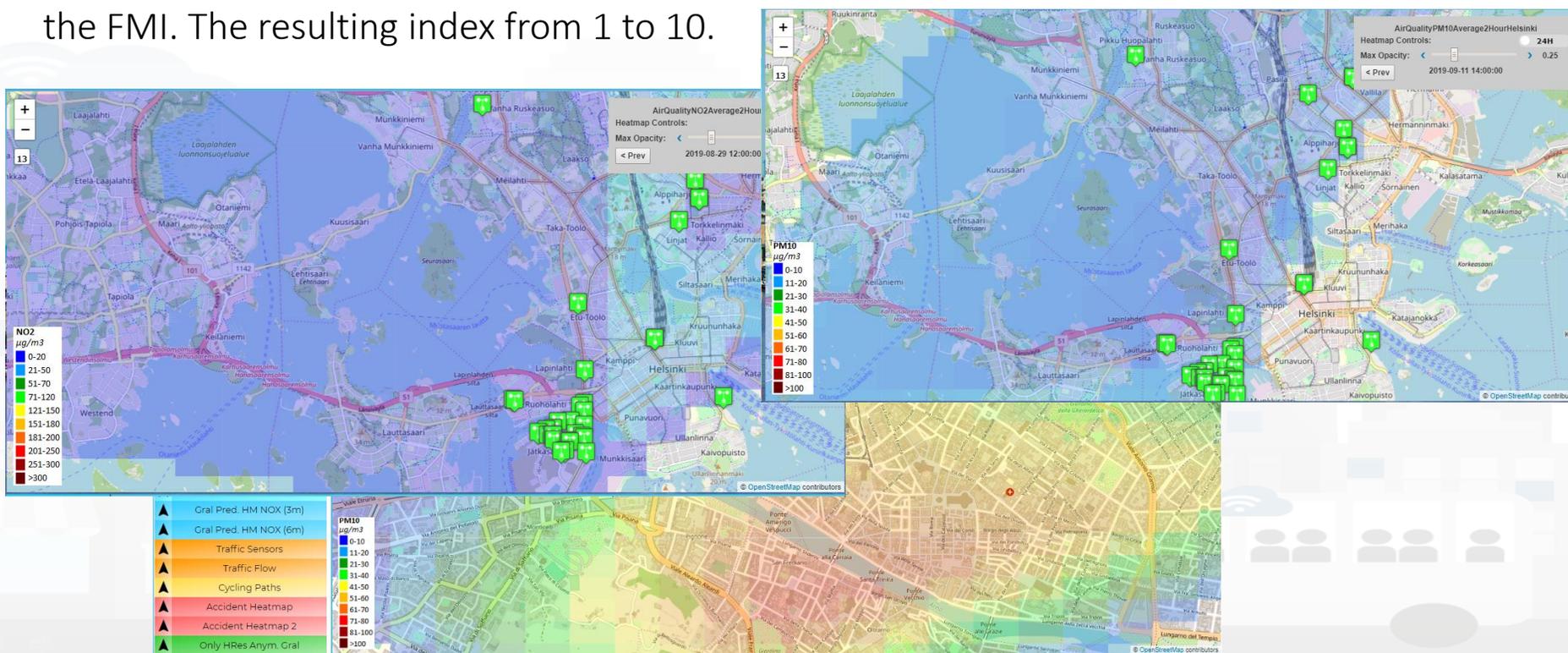
Calibrated heatmaps based on Interpolated data:

- **Real time** measures (PM<sub>10</sub>, PM<sub>2,5</sub>, NO<sub>2</sub>, SO<sub>2</sub>, Noise, NO, O<sub>3</sub>, AQI,..)
- **Predictive** measures (ENFUSER, GRAL)
- From **200x200** to **4x4** m
- Hourly concentration
- Any programmed Color map
- Animations over H24
- Picking values in any place
- On Web and Mobile App



# Environmental Real Time Measures

- **Noise:** real time noise levels (measured in dBA).
- **PM<sub>10</sub>:** real time pollutant levels in air in terms of PM<sub>10</sub> (measured in  $\mu\text{g}/\text{m}^3$ ) particles.
- **PM<sub>2,5</sub>:** real time pollutant levels in air in terms of PM<sub>2.5</sub> (measured in  $\mu\text{g}/\text{m}^3$ ) particles
- **NO<sub>2</sub>:** real time pollutant levels in air in terms of nitrogen dioxide (measured in  $\mu\text{g}/\text{m}^3$ ).
- **Air Quality Index (AQI):** real time air quality index of the Helsinki area, provided by the FMI. The resulting index from 1 to 10.



- ▲ BusStop
- ▲ Ticket sale
- ▲ Traffic Sensor
- ▲ Weather sensor
- ▲ Air Temp heatmap
- ▲ Humidity Heatmap
- ▼ Air Quality Sensors
- ▲ Noise sensors
- ▲ Noise Heatmap
- ▼ PM10 heatmap
- ▲ PM2.5 Heatmap
- ▲ NO2 heatmap
- ▲ Air Quality Index HeatM.
- ▲ EAQI HeatM.
- ▲ CAQI HeatM.
- ▲ Enfuser pred. AQI
- ▲ Enfuser pred. PM10
- ▲ Enfuser pred. PM2.5
- ▲ Gral pred. PM10
- ▲ Gral pred. PM10 (6m)
- ▲ PM10 Jätkäsaari
- ▲ PM2.5 Jätkäsaari
- ▲ EAQI Jätkäsaari
- ▲ Appreciated POIs

# AQI Indexes estimation via R studio and IOT App

## European Air Quality Index **EAQI**

<http://airindex.eea.europa.eu/>

Pollutant	Index level (based on pollutant concentrations in $\mu\text{g}/\text{m}^3$ )				
	Good	Fair	Moderate	Poor	Very poor
Particles less than 2.5 $\mu\text{m}$ (PM <sub>2.5</sub> )	0-10	10-20	20-25	25-50	50-800
Particles less than 10 $\mu\text{m}$ (PM <sub>10</sub> )	0-20	20-35	35-50	50-100	100-1200
Nitrogen dioxide (NO <sub>2</sub> )	0-40	40-100	100-200	200-400	400-1000
Ozone (O <sub>3</sub> )	0-80	80-120	120-180	180-240	240-600
Sulphur dioxide (SO <sub>2</sub> )	0-100	100-200	200-350	350-500	500-1250

Measurements of up to five key pollutants supported by modelled data determine the index level that describes *the current air quality situation at each monitoring station*.

The index corresponds to the **poorest level** for any of five pollutants according to the following scheme.

## Legend of Environmental data:

<https://www.snap4city.org/435>

## Common Air Quality Index **CAQI**

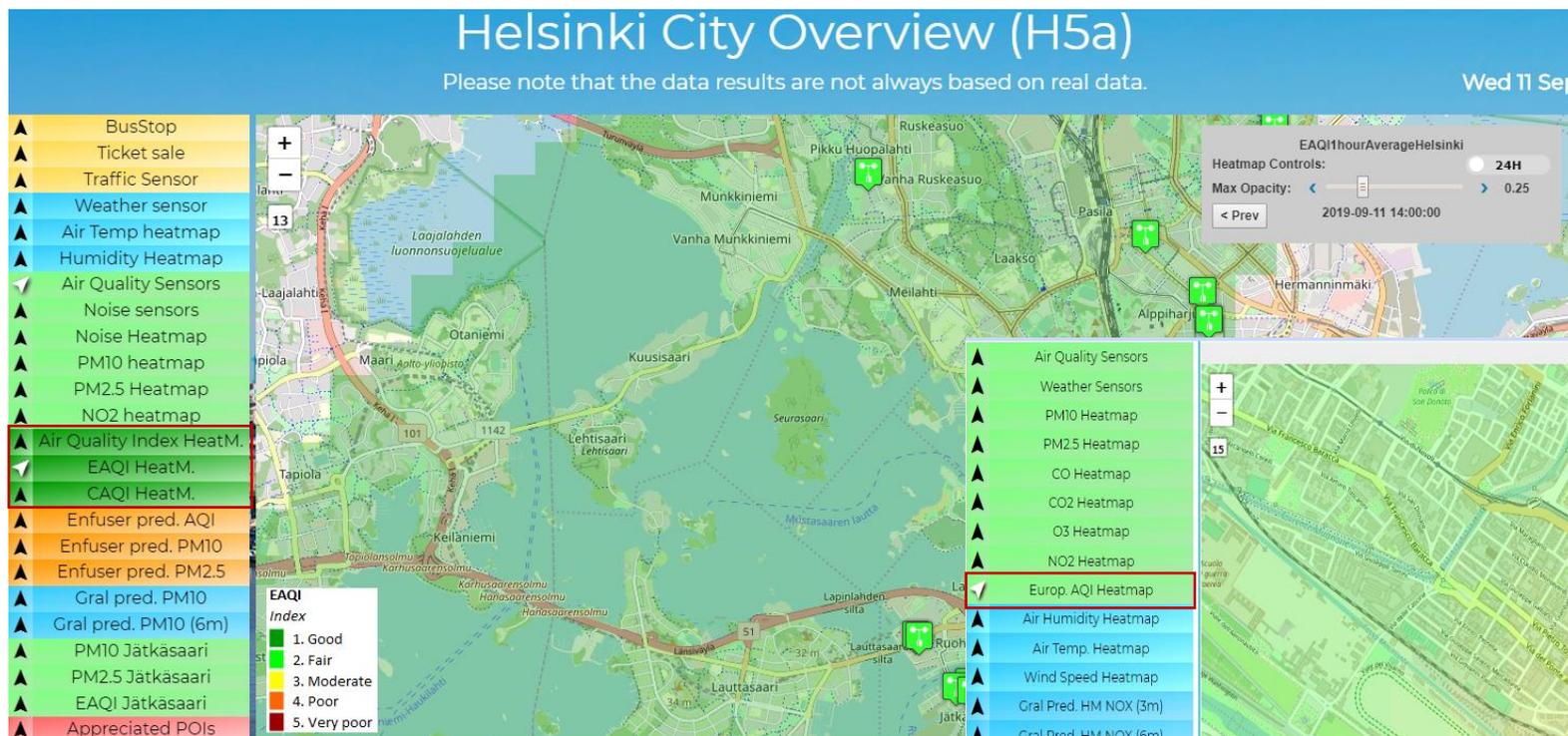
<http://www.airqualitynow.eu>

Qualitative name	Index or sub-index	Pollutant (hourly) density in $\mu\text{g}/\text{m}^3$			
		NO <sub>2</sub>	PM <sub>10</sub>	O <sub>3</sub>	PM <sub>2.5</sub> (optional)
Very low	0-25	0-50	0-25	0-60	0-15
Low	25-50	50-100	25-50	60-120	15-30
Medium	50-75	100-200	50-90	120-180	30-55
High	75-100	200-400	90-180	180-240	55-110
Very high	>100	>400	>180	>240	>110

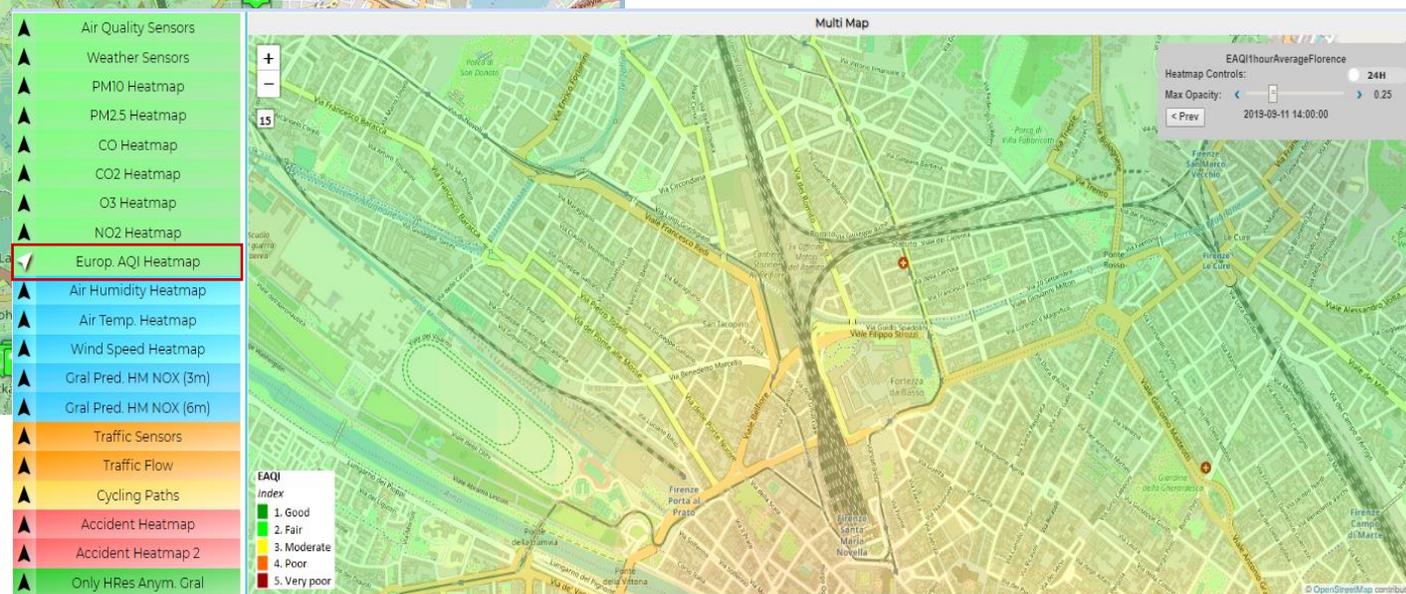
The index is defined away from roads (a "background" index). **CAQI** is computed on the basis of NO<sub>2</sub>, PM<sub>2.5</sub>, PM<sub>10</sub> and O<sub>3</sub>.

# AQI Indexes estimation Heatmaps

Hourly pollutant concentration



<https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MTQwNg==>



<https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MTUzMg==>

# Environmental Data Predictions: GRAL

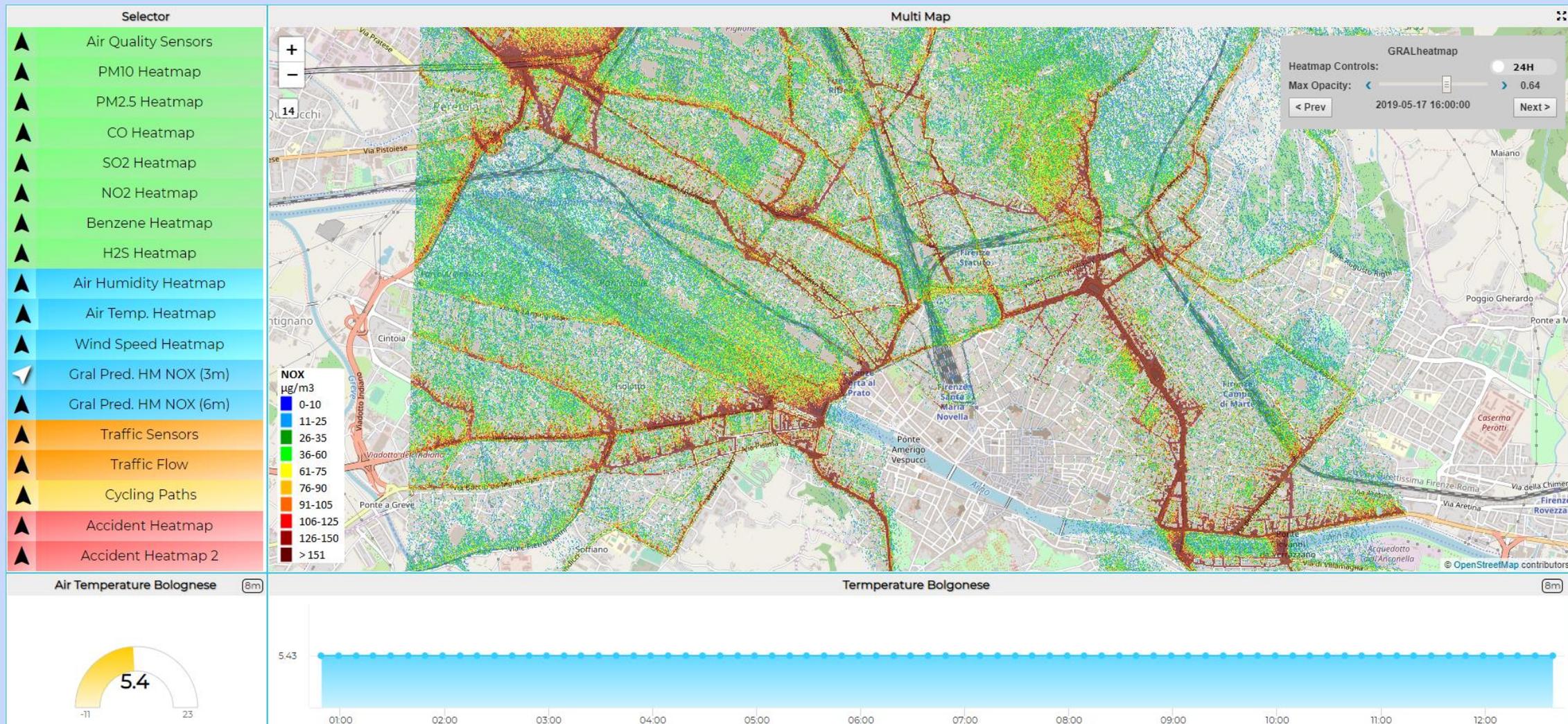
- **GRAL predictions: PM10, NOX, ....**
  - Comparison wrt real time values in actual value of Sensors
  - Graz Lagrangian Model.
- GRAL model takes into account:
  - pollution sources (for example the vehicles, their distribution on the streets, the about of pollution they produce according to their distribution over time and space, etc.),
  - structure of the city (streets and shape 3D of the buildings),
  - weather forecast (wind intensity and direction), etc.
- GRAL can be applied on NOX, PM10, PM2.5, ... or any other particles



# Heatmap Firenze - trafair

different data

Fri 17 May 12:49:34



<https://main.snap4city.org/view/index.php?iddashboard=MTUzMg==>

# Environmental Devices hosted by Citizens



## My Sensor 373773207E330118 - Helsinki - H3

Please note that the data results are not always based on real data.

Sun 3 Nov 23:39:19

### Values from Your Sensor

Helsinki:orio... (8m)	Real Time AQI	1.044
Helsinki:orio... (8m)	Real Time PM10	1.5 $\mu\text{g}/\text{m}^3$
Helsinki:orio... (8m)	Average Last Hour PM10	4.5 $\mu\text{g}/\text{m}^3$
Helsinki:orio... (8m)	Real Time PM2.5	1 $\mu\text{g}/\text{m}^3$
Helsinki:orio... (8m)	Average Last Hour PM2.5	0.9 $\mu\text{g}/\text{m}^3$
Helsinki:orio... (8m)	Sensor reliability	0.5

**PM2.5  $\mu\text{g}/\text{m}^3$**

- 0-5
- 6-10
- 11-15
- 16-25
- 26-35
- 36-40
- 41-50
- 51-60
- 61-70
- >70

### Weather sensor Helsinki Kalsaniemi - airTemperature

temperature (8m)

0.4

Temperature

- Weather Sensors
- Air Quality Sensors
- Air Temperature H
- Air Humidity H
- PM10, Real Time
- PM2.5 Real Time
- NO2 Real Time
- Noise Real Time
- Enfuser Prediction PM10
- Enfuser Prediction PM2.5
- Enfuser Prediction AQI
- Helsinki AQI
- European AQI
- POI
- PM10 Jatkasaari
- PM2.5 Jatkasaari
- EAQI Jatkasaari
- Documentation
- Forum Discussion
- Survey

# Environmental Data Network and Automated Analysis and Representation

## Goal:

- Real time aggregation, integration, assessment of data independently on the number of sensors, on their position.
- Real time analysis and representation of environmental data automatically in dedicated Dashboards on Snap4City platform.

The **target** has been to:

- Provide *informative view of the city users* regarding Environmental data via some mobile App.
- Provide detailed information about the Environmental data to *city officials for decision making*, as *comparison between predictions and real time* in specific point of the city.

Data have been collected from:

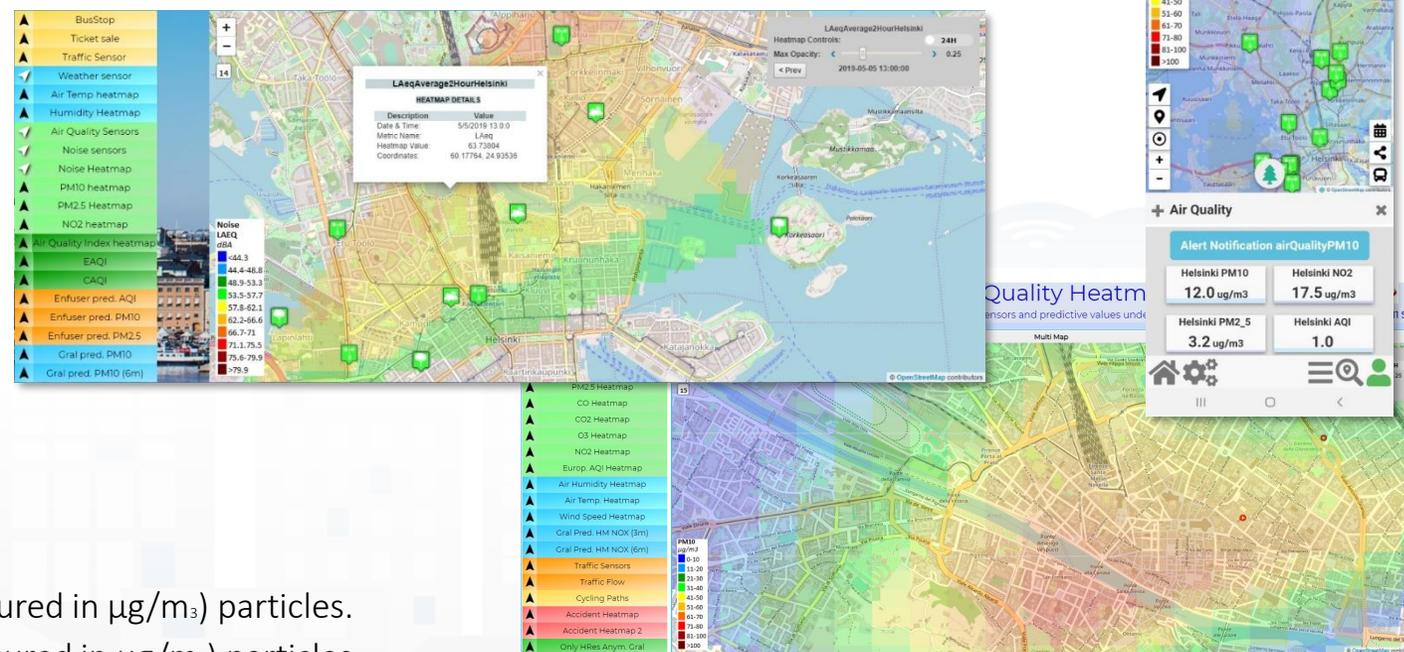
- IOT Brokers included *IOT Devices hosted by city users*.
- Data Providers.



# Environmental Data Network and Automated Analysis and Representation

Bivariate interpolation onto a grid for irregularly spaced input data.

- Resolution from 200x200 to 4x4 m
- Hourly concentration
- Any programmed Color map
- Animations over H24
- Picking values in any place, values on their position
- On Web and Mobile App



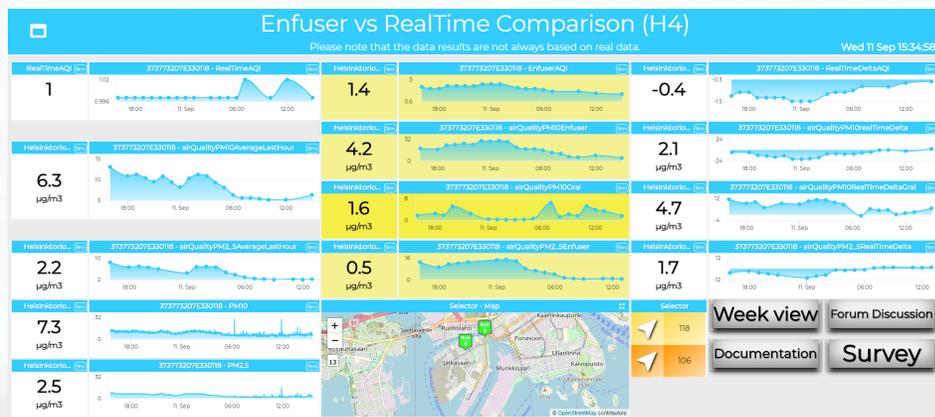
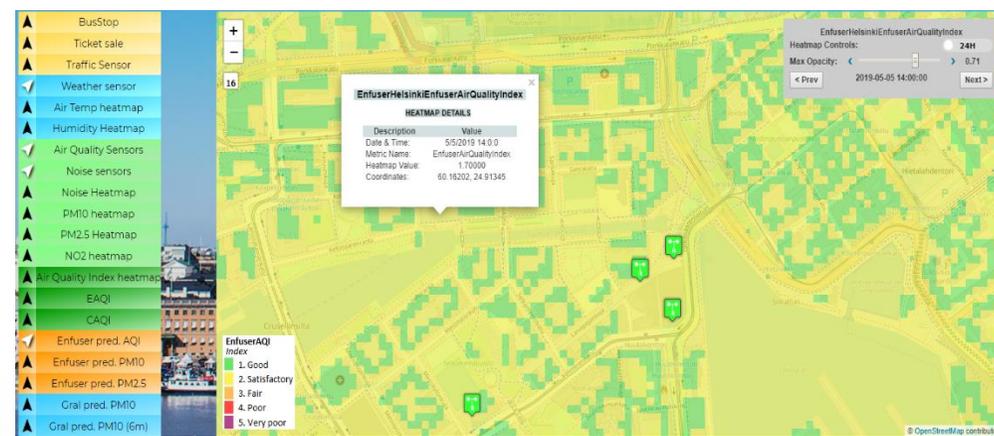
## Environmental Real Time Measures:

- **Noise:** real time noise levels (measured in dBA).
- **PM<sub>10</sub>:** real time pollutant levels in air in terms of PM<sub>10</sub> (measured in  $\mu\text{g}/\text{m}_3$ ) particles.
- **PM<sub>2.5</sub>:** real time pollutant levels in air in terms of PM<sub>2.5</sub> (measured in  $\mu\text{g}/\text{m}_3$ ) particles.
- **NO<sub>2</sub>:** real time pollutant levels in air in terms of nitrogen dioxide (measured in  $\mu\text{g}/\text{m}_3$ ).
- **Air Quality Index (AQI):** real time air quality index of the area, provided by the FMI. The resulting index from 1 to 10.
- **European Air Quality Index (EAQI):** measurements of up to five key pollutants supported by modelled data determine the index level that describes the current air quality situation at each monitoring station.
- **Common Air Quality Index (CAQI):** is defined away from roads (a "background" index). CAQI is computed on the basis of NO<sub>2</sub>, PM<sub>2.5</sub>, PM<sub>10</sub> and O<sub>3</sub>.

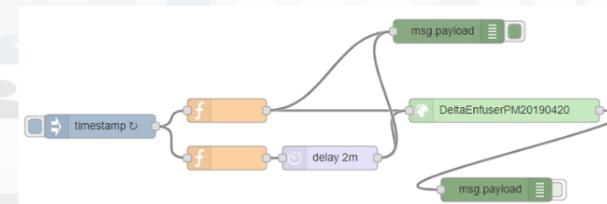
# Environmental Data Network and Automated Analysis and Representation

## Environmental Predictive Measures:

- **Enfuser pred. AQI**: heatmap of Air Quality Index hourly Enfuser predictions, every 12 mt. the Heatmap Controls widget you can see the forecast.
- **Enfuser pred. PM<sub>10</sub>** : heatmap of PM<sub>10</sub> particles hourly Enfuser predictions every 12mt in  $\mu\text{g}/\text{m}^3$ .
- **Enfuser pred. PM<sub>2,5</sub>** heatmap of PM<sub>2,5</sub> particles hourly Enfuser predictions every 12mt in  $\mu\text{g}/\text{m}^3$ .
- **Gral pred. PM<sub>10</sub> (h 3m)**: heatmap of PM<sub>10</sub> particles hourly predictions in  $\mu\text{g}/\text{m}^3$  measured 3 meters on the ground and computed using Gral model every 4mt.
- **Gral pred. PM<sub>10</sub> (h 6m)**: heatmap of PM<sub>10</sub> particles hourly predictions in  $\mu\text{g}/\text{m}^3$  measured 6 meters on the ground and computed using Gral model every 4mt.



- Data gathering, data processing for Piking
- **API** for accessing data of Heatmaps in real time
- **Delta Estimation Predictions vs Actual**: on 12 points/sensors via R-Studio and IOT App

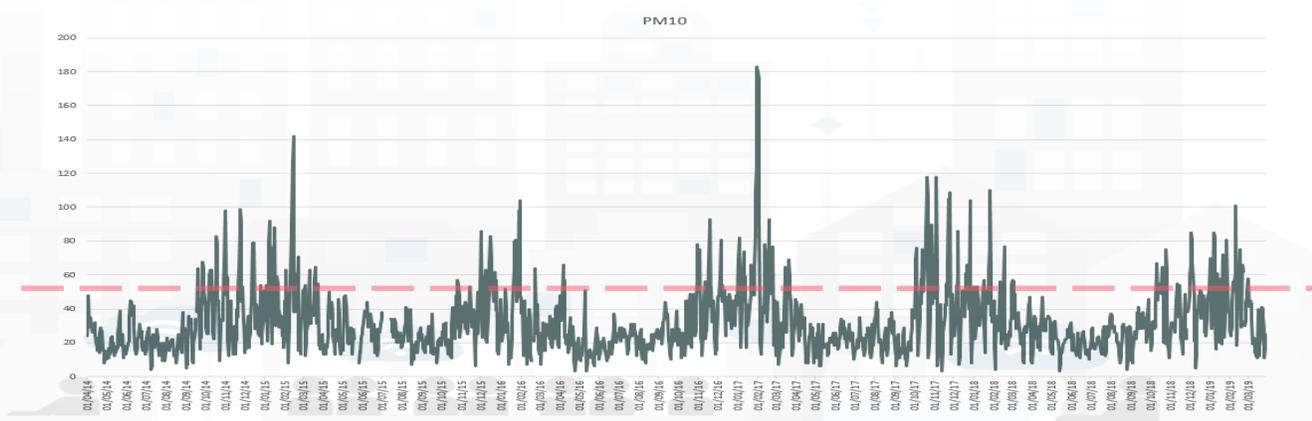




# Predicting Air Quality

- European Air Quality Directive
- Predicting critical days
  - PM10 with an accuracy of more than 90% and precision of 85%;
  - PM2.5 with an accuracy of 90% and precision greater than the 95%.
- Simulating Long terms values
  - For long terms predictions

Air Quality Directive				WHOguidelines	
Pollutant	Averaging period	Objective and legal nature and concentration	Comments	Concentration	Comments
PM <sub>2.5</sub>	One day			25 µg/m <sup>3</sup> (*)	99 <sup>th</sup> percentile (3 days/year)
PM <sub>2.5</sub>	Calendar year	Target value, 25 µg/m <sup>3</sup>	The target value has become a limit value since 1 January 2015	10 µg/m <sup>3</sup>	
PM <sub>10</sub>	One day	Limit value, 50 µg/m <sup>3</sup>	Not to be exceeded on more than 35 days per year.	50 µg/m <sup>3</sup> (*)	99 <sup>th</sup> percentile (3 days/year)
PM <sub>10</sub>	Calendar year	Limit value, 40 µg/m <sup>3</sup> (*)		20 µg/m <sup>3</sup>	
O <sub>3</sub>	Maximum daily 8-hour mean	Target value, 120 µg/m <sup>3</sup>	Not to be exceeded on more than 25 days per year, averaged over three years	100 µg/m <sup>3</sup>	
NO <sub>2</sub>	One hour	Limit value, 200 µg/m <sup>3</sup> (*)	Not to be exceeded more than 18 times a calendar year	200 µg/m <sup>3</sup> (*)	
NO <sub>2</sub>	Calendar year	Limit value, 40 µg/m <sup>3</sup>		40 µg/m <sup>3</sup>	

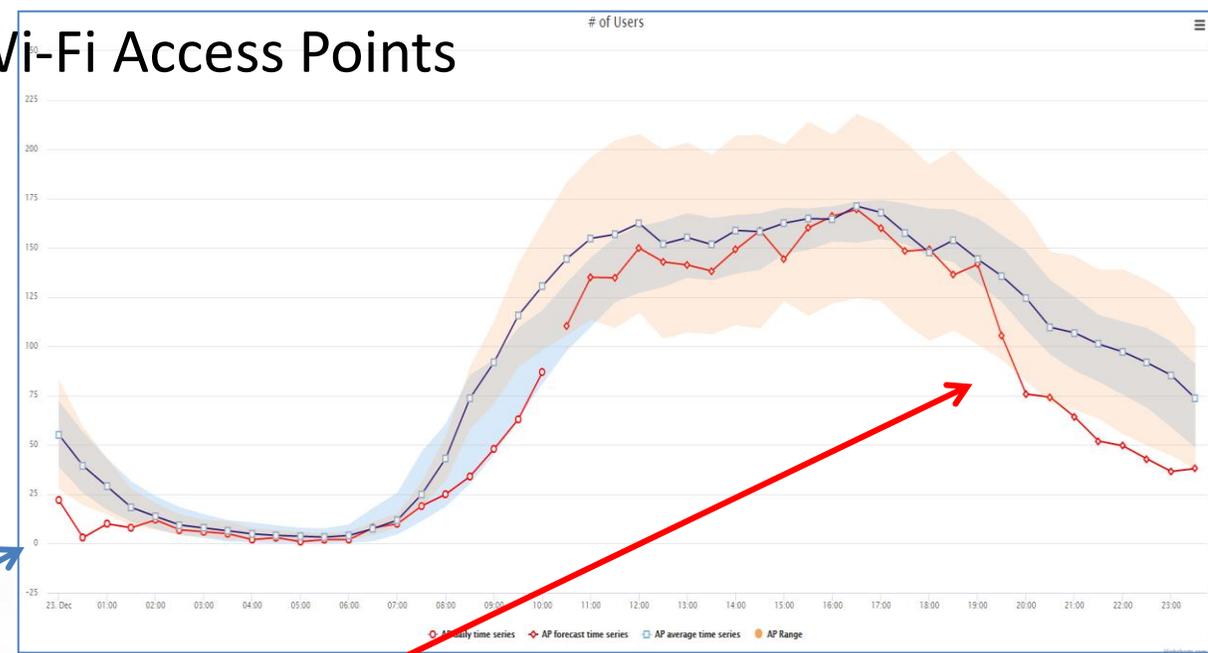
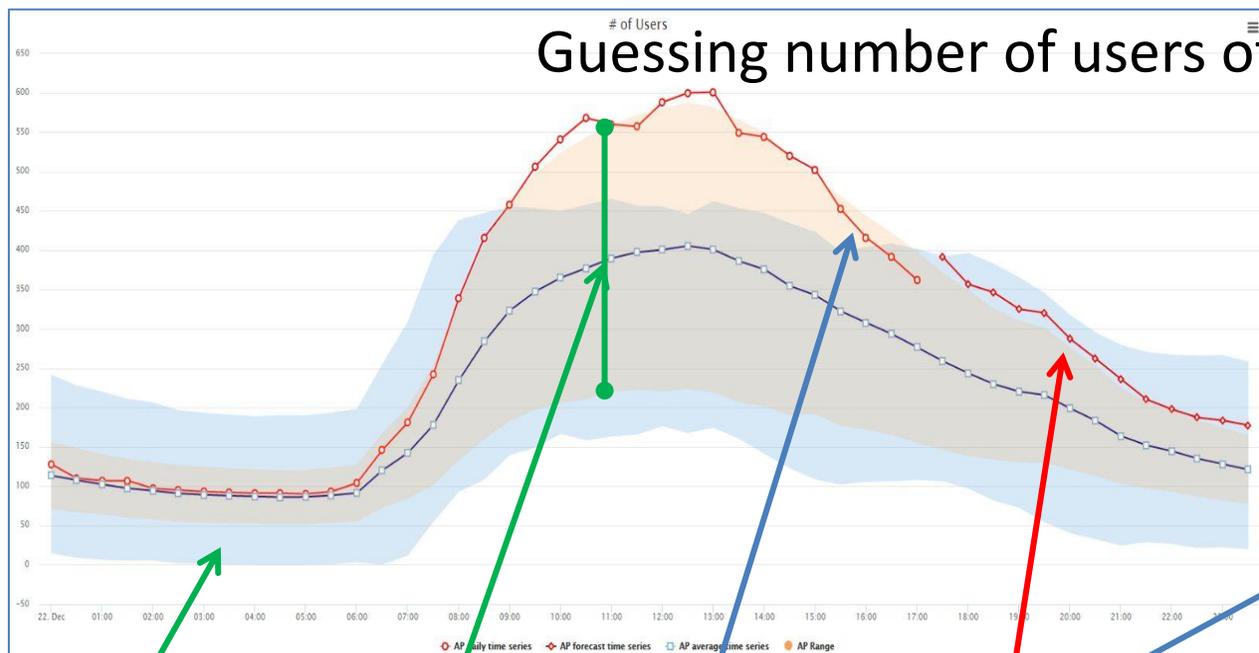


# Anomaly Detection



# Prediction and Identification of Anomalies

## Guessing number of users of Wi-Fi Access Points



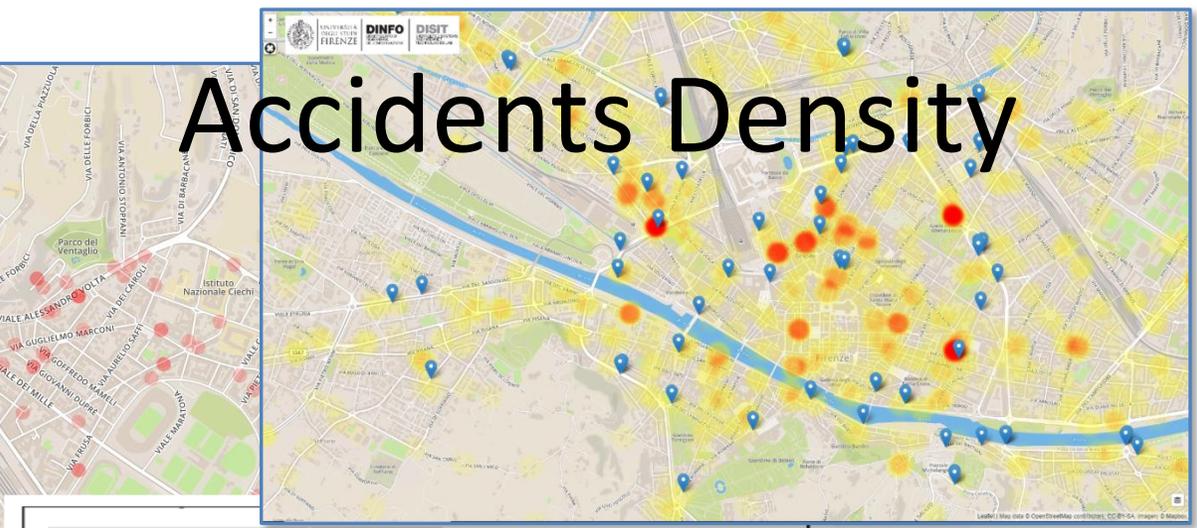
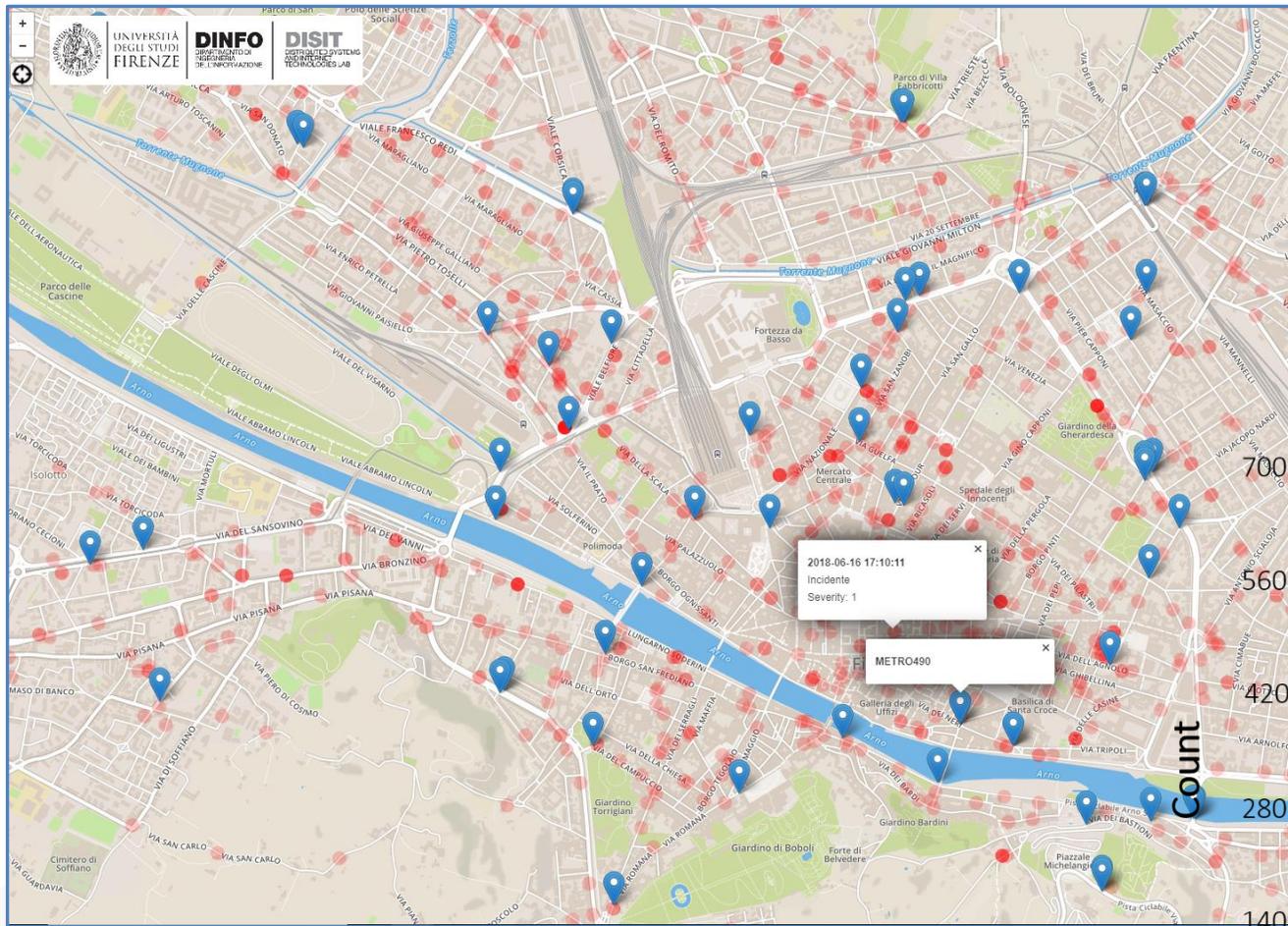
Cluster confidence

AP average and confidence

Actual AP trend for today

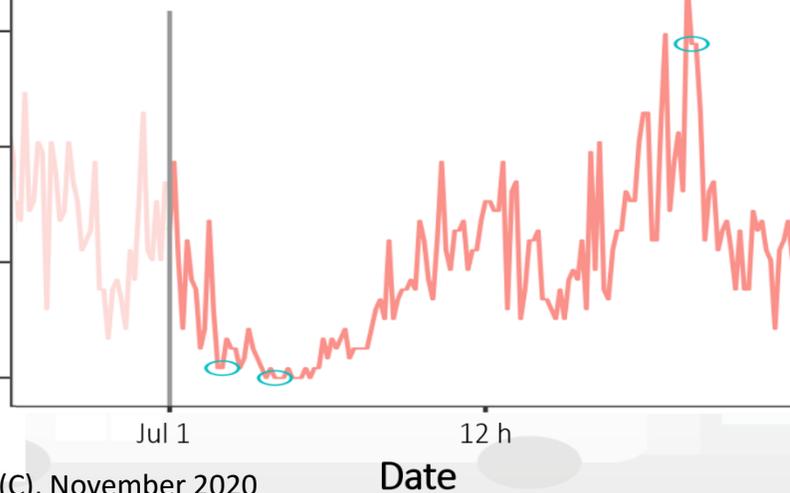
AP prediction for the next time slot in the day on the basis of past weeks

Predictive precision of the 95%



## Accidents Density

Date and Time	Anomaly
2018-07-01 02:00:00	12
2018-07-01 04:00:00	0
2018-07-01 19:40:00	480
2018-07-01 19:50:00	408



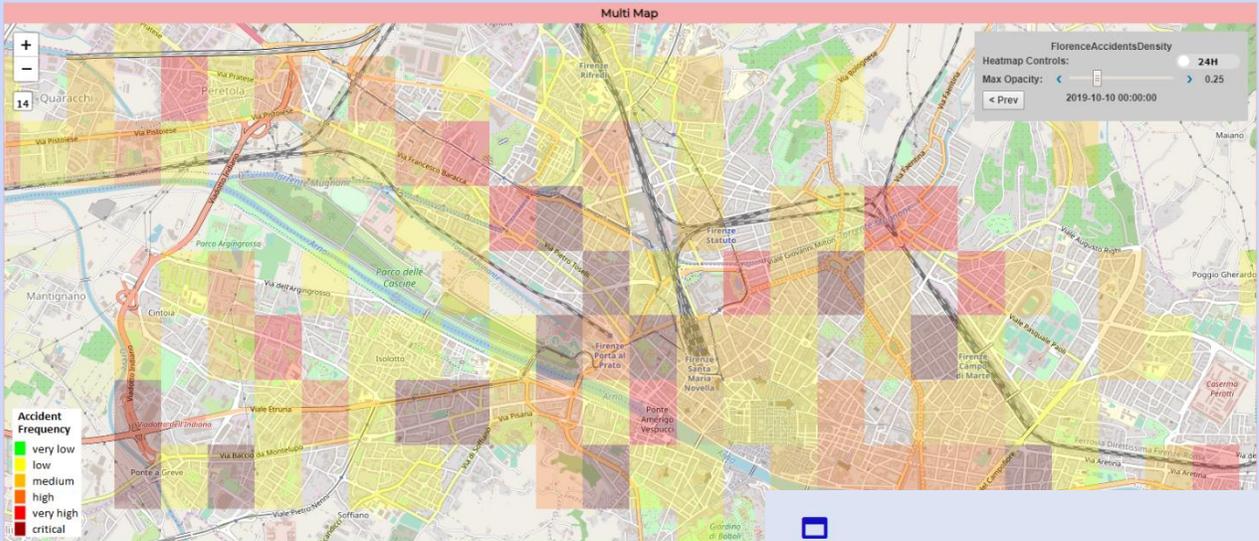
## Accidents vs Traffic

# What-IF analysis test

This dashboard contains data derived from actual sensors and predictive values under validation



- ▲ Air Quality Sensors
- ▲ Weather Sensors
- ▲ PM10 Heatmap
- ▲ PM2.5 Heatmap
- ▲ CO Heatmap
- ▲ CO2 Heatmap
- ▲ O3 Heatmap
- ▲ NO2 Heatmap
- ▲ Europ. AQI Heatmap
- ▲ Air Humidity Heatmap
- ▲ Air Temp. Heatmap
- ▲ Wind Speed Heatmap
- ▲ Gral Pred. HM NOX (3m)
- ▲ Gral Pred. HM NOX (6m)
- ▲ Traffic Sensors
- ▲ Traffic Flow
- ▲ Cycling Paths
- ▲ Accident Heatmap
- ▲ Accident Heatmap 2
- ▲ Only HRes Anym. Gral
- ▲ Scenario
- ▲ What-IF



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<https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MjE4Nw==>

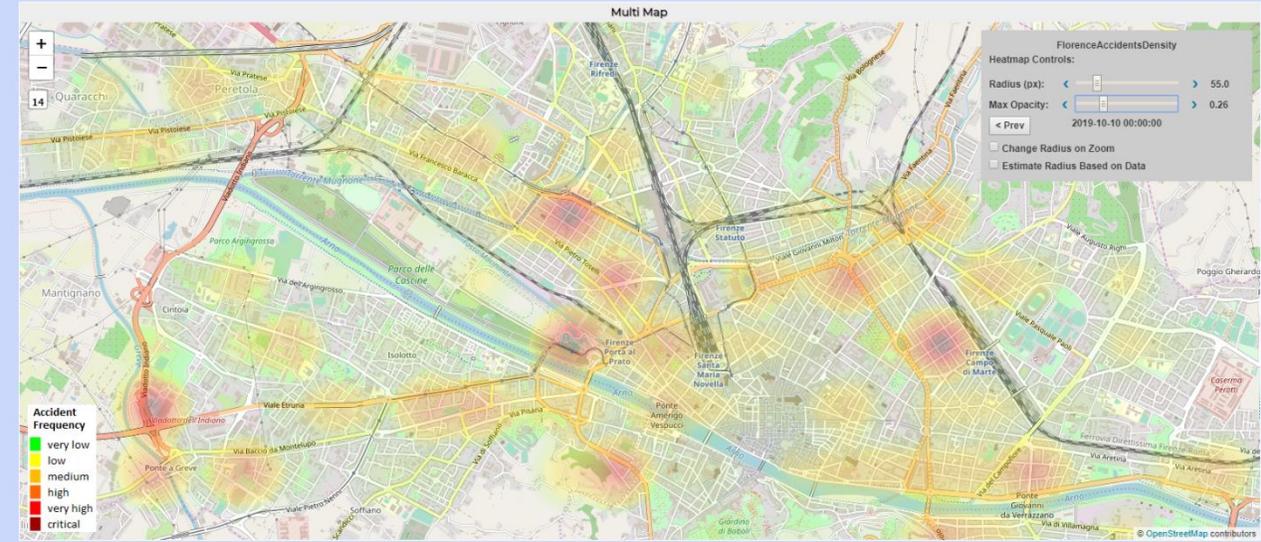


- ▲ Air Quality Sensors
- ▲ Weather Sensors
- ▲ PM10 Heatmap
- ▲ PM2.5 Heatmap
- ▲ CO Heatmap
- ▲ CO2 Heatmap
- ▲ O3 Heatmap
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- ▲ What-IF



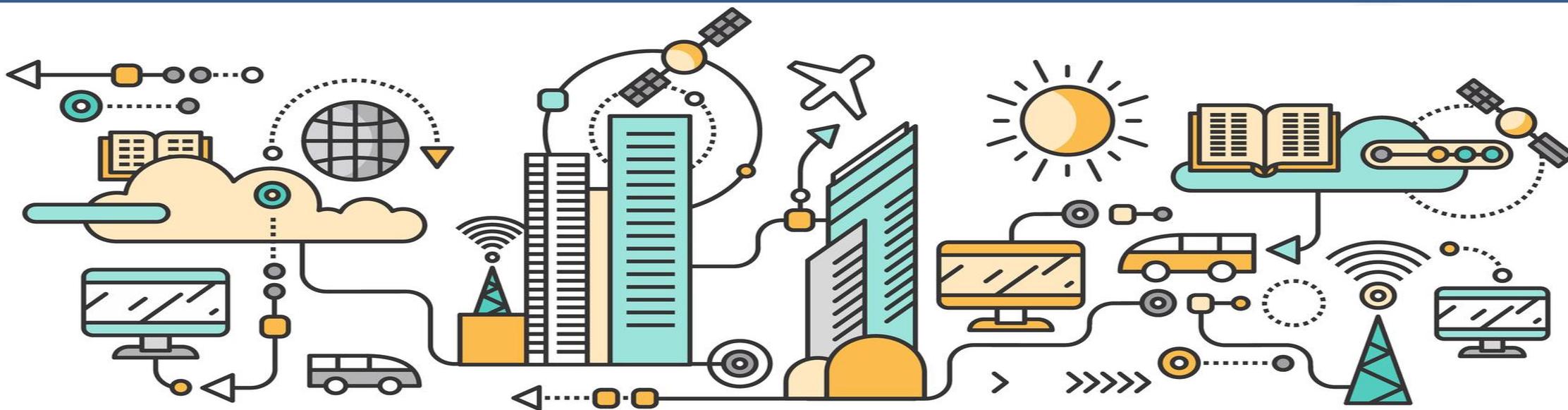
# What-IF analysis test

This dashboard contains data derived from actual sensors and predictive values under validation



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# WHAT-IF Analysis



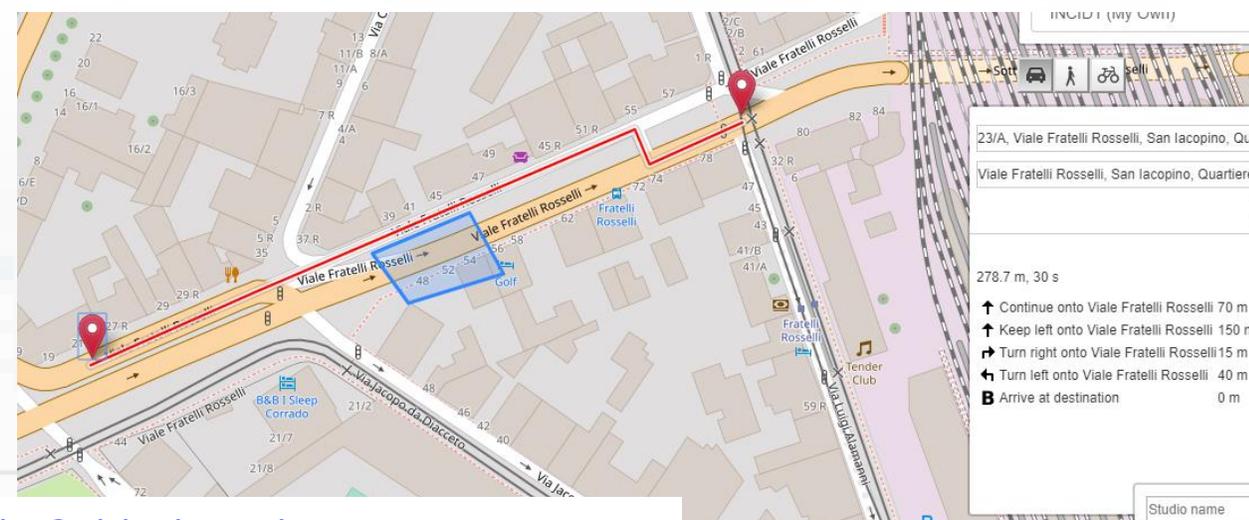
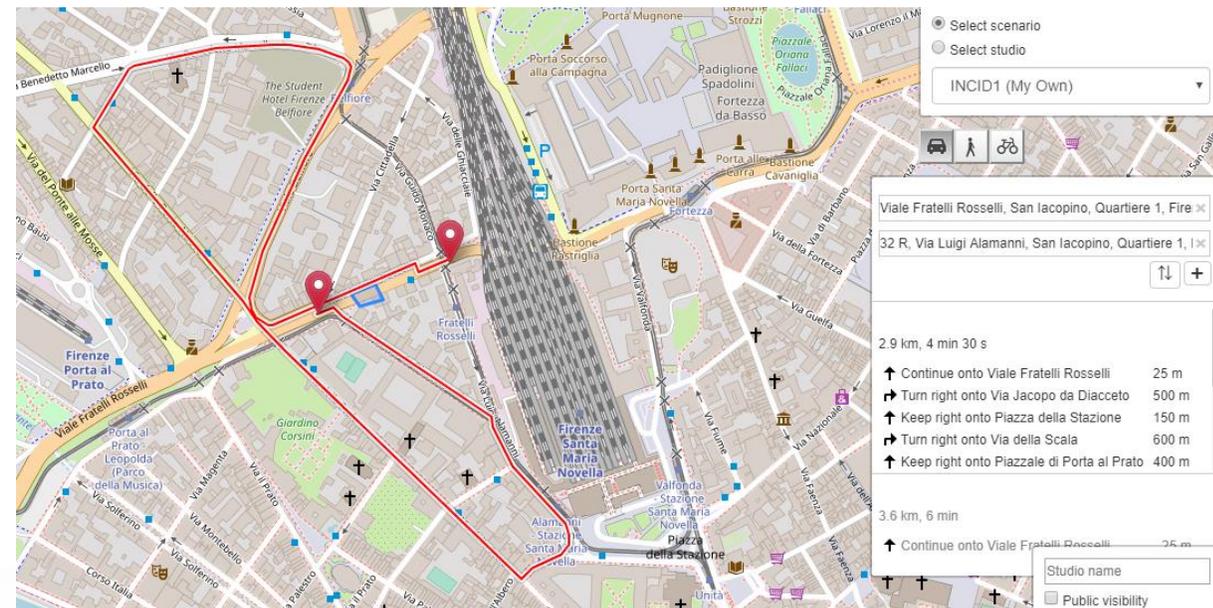


Accidents and elements blocking Points and Shapes taken into account for:

- Routing
- Traffic Flow reconstruction
- Evacuation paths
- Rescue team paths

Assessment on the basis of changes:

- Mobility demand assessment
- Mobility Offer assessment





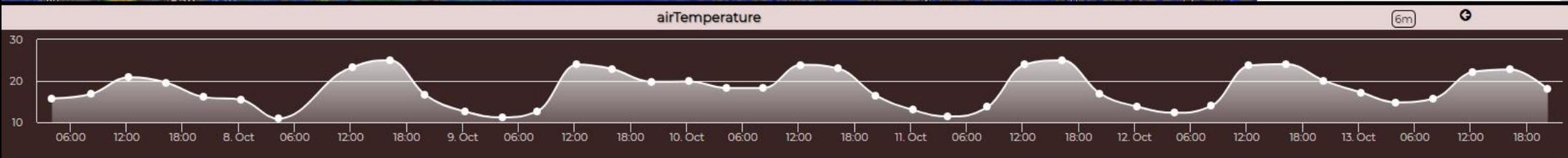
# Mobility and Environment What-IF Analysis

This dashboard contains data derived from actual sensors and predictive values under validation

- Air Quality Sensors
- Weather Sensors
- PM10 Heatmap
- PM25 Heatmap
- CO Heatmap
- CO2 Heatmap
- O3 Heatmap
- NO2 Heatmap
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- Gral Pred. HM NOX (6m)
- Traffic Sensors
- Traffic Flow
- Cycling Paths
- Accident Heatmap
- Only HRes Anym. Gral
- Scenarios
- What-if analysis

Firenze Oggi

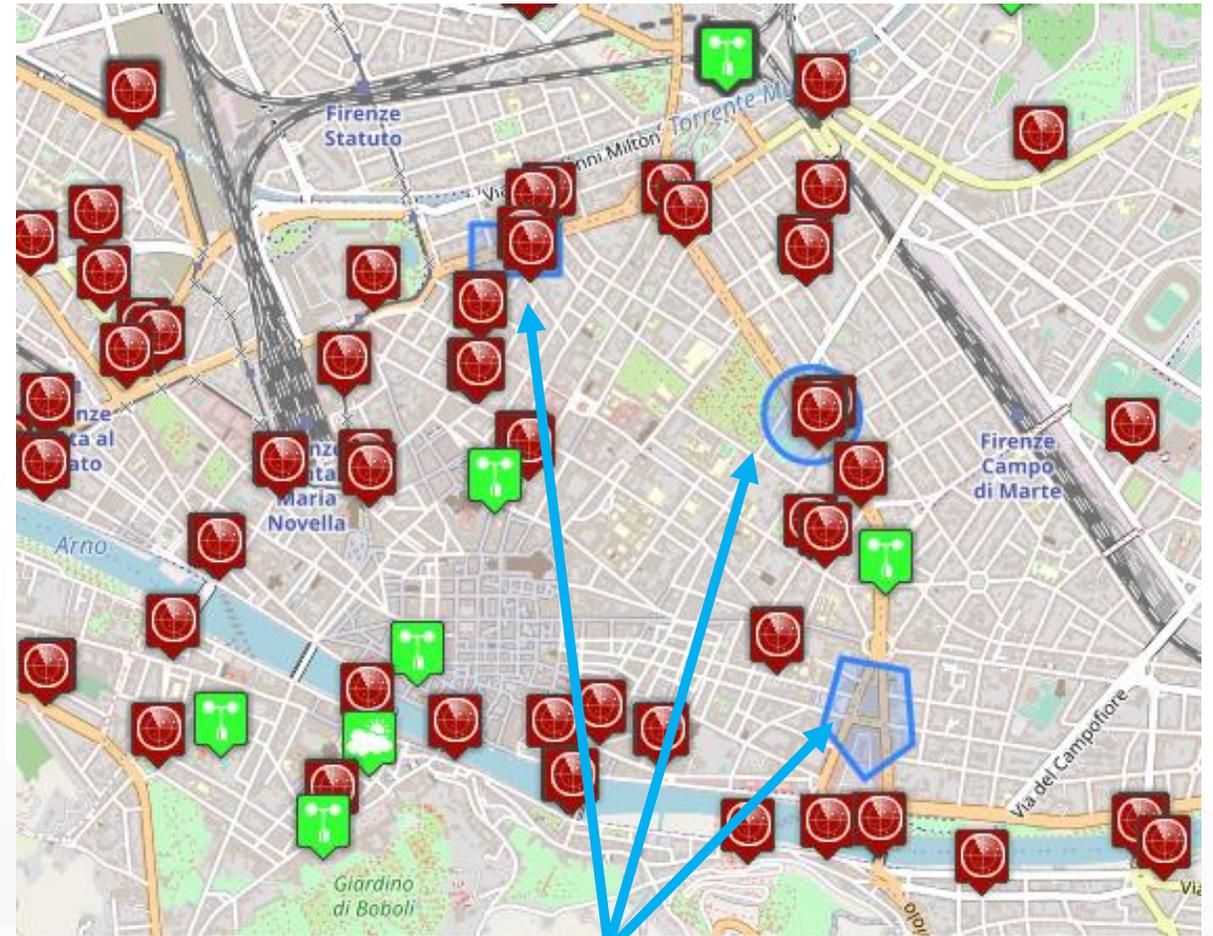
Air Temperat... (6m)



<https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MjE5MA==>

# What-If Analysis Concepts

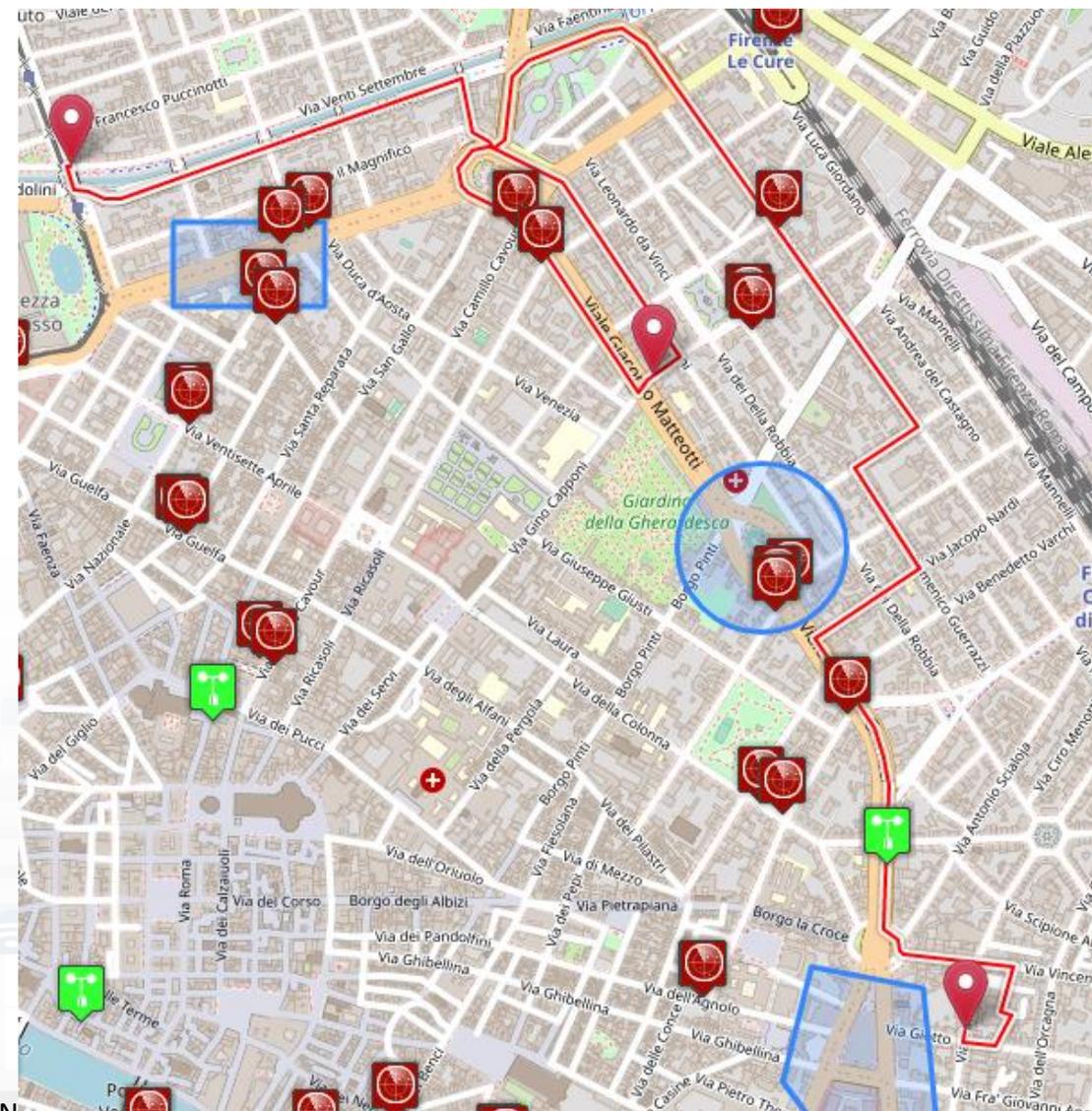
- What is going to happen at Services if certain conditions/cases are going to occur
- Formalize: Conditions/cases, Services
- Scenarios of Cases+Services Vs Solutions are Studios
- You can define, save, load:
  - Scenarios and Studios



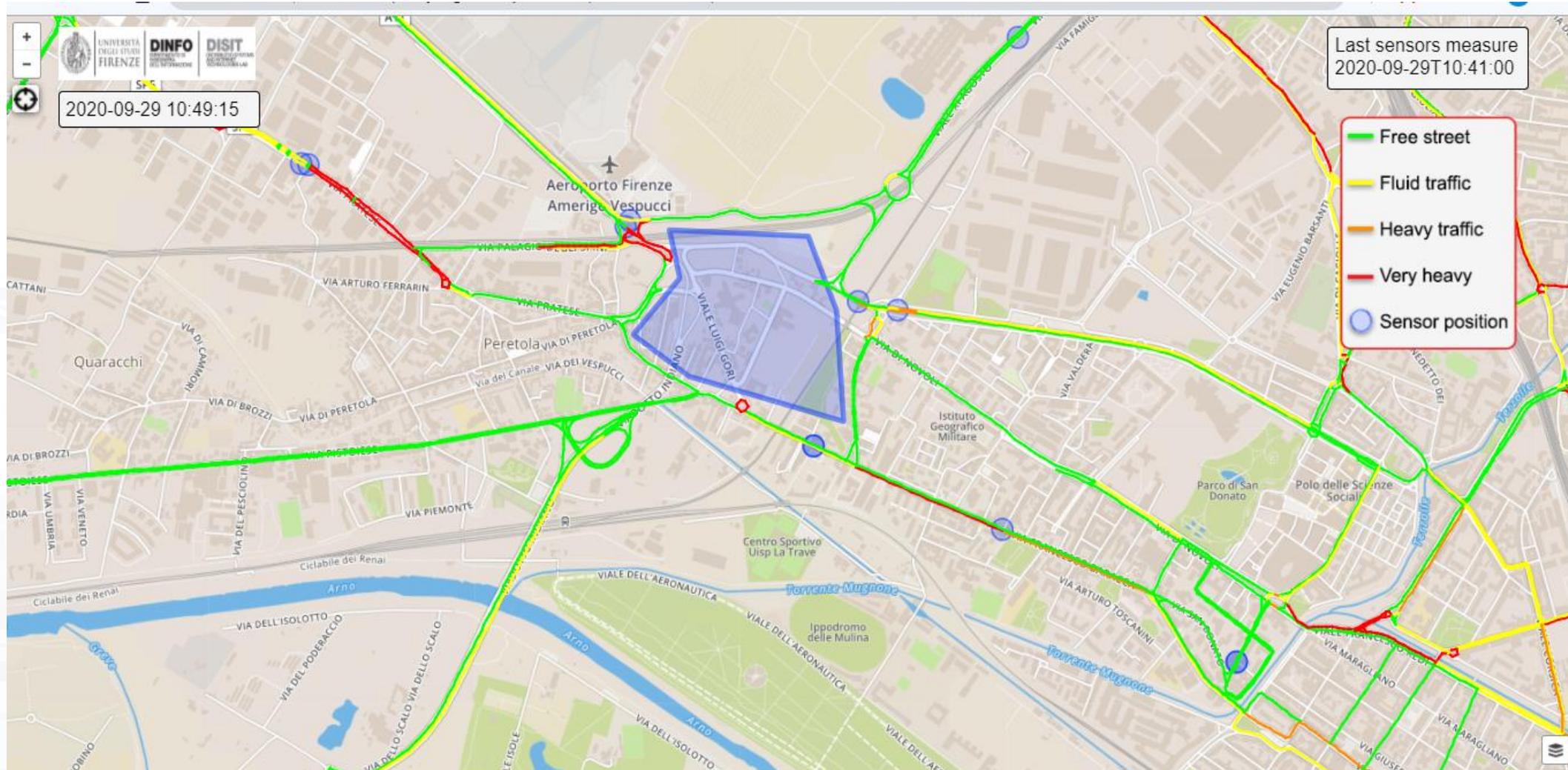
**Scenario**

# Impact on Routing

- Scenario with multiple shapes
- Conditional Routing
  - avoiding areas or
  - reducing traffic in those areas
  - Multiple stop points



# Computation of Traffic Flow Evolution



### ESB

**Alarms**

- TEST - ALLUVIONE MUGNONE MAJOR 07/08/2017 12:45:54
- ALLUVIONE ARNO COVERCIANO CRITICAL 15/08/2017 15:47:31
- ALLUVIONE ARNO VIA PETRIOLO MAJOR 07/08/2017 18:48:11
- TEST - SCONTRI ALLO STADIO CRITICAL 15/08/2017 09:50:04

**Traffic events**

- SEVERE ACCIDENT SERIOUS ACCIDENT(S) 21/08/2017 11:24:01
- ROAD WORKS ROADWORKS 21/08/2017 11:24:10
- ORD 2017-001302 - SP NA\*17 A?ALTO VALDARNO??1ST... RESTRICTIONS 13/08/2017 00:00:00
- INTERVENTO URGENTE PUBBLICACQUA CLOSED AHEAD 20/08/2017 10:00:00

**Evacuation plans**

- PLAN N.1497283867 IN\_PROGRESS 12/08/2017 - 11:37:47 PATHS: 3
- PLAN N.2000000000 PROPOSED 18/08/2017 - 09:42:08 PATHS: 2
- PLAN N.1497604404 PROPOSED 18/08/2017 - 11:08:47 PATHS: 1

**Tram position**

- TRAM/1 21/08/2017 11:32:27
- TRAM/2 21/08/2017 11:32:31

**Network Analysis**

- FM0485 (NORMALIZED) NODE BETWEENNESS 1.0000
- FM0496 (NORMALIZED) NODE BETWEENNESS 0.8091
- FM0500 (NORMALIZED) NODE BETWEENNESS 0.7878
- FM2276 (NORMALIZED) NODE BETWEENNESS 0.7858
- FM0497 (NORMALIZED) NODE BETWEENNESS 0.7825
- FM0701

### Environment

**PROTEZIONE CIVILE**

RISCHIO IDRAULICO: NULLO BASSO MEDIO ALTO

RISCHIO TEMPORALI

RISCHIO IDROGEOLOGICO

RISCHIO NEVE

RISCHIO GHIACCIO

RISCHIO VENTO

RISCHIO MAREGGIATE

Anemomet... 22 C°

221

Temperatu... 24 C°

Umidità 20 %

Pluv. Flore... 24 mm

Hydromete... 20 m.s.z.l.

Hydromete... 24 m.s.z.l.

Hydromete... 24 m.s.z.l.

Hydromete... 24 m.s.z.l.

### Mobility

Bus Lines Status

ULTIMO AGGIORNAMENTO: 2016-08-04 23:59:03

Underpass Viale Mariti Aperto

Underpass Viale Talenti closed

Underpass Fortezza Aperto

Parterre Pa... 76.2%

SMN 65.7%

Fortezza Fi... 37.2%

Mercato Ce... 65.4%

Fortezza Fi... 62.8%

Mercato Ce... 34.6%

### Resources

Planned events

- 1966 - 2016 - LA BELLEZZA SALVATA - PROROGATA FINO AL 2016-12-01 to 2017-07-02
- 2017-02-15 to 2017-06-23
- 2017-02-15 to 2017-09-29

Ambulance... 20 num.

Ambulance... 33 num.

Voluntiers 33 num.

Firenze main first aids status

Priority	Red code	Yellow code	Green code	Blue code	White code
PS SANTA MARIA NUOVA	1	7	14	1	0
PS SAN GIOVANNI DI DIO TORRESGALLE	2	10	24	2	0
PS AD CAREGGI	10	27	31	10	2
PS SANTA MARIA ANNUNZIATA	2	9	22	4	0

Parking availability (%) 28:2

### Resources

Planned events

- 1966 - 2016 - LA BELLEZZA SALVATA - PROROGATA FINO AL 2016-12-01 to 2017-07-02
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Parking availability (%) 28:2

### TV-RT Firenze

Twitter Vigilance Real Time Dashboard

Last crawling: 2017-06-21 12:44:30

Channel active from 2016-06-27 to 2017-06-21 12:35:00

Sentiment trends in channel Firenze

Zoom 1H 2H 6H 12H 1D 1W 1M Y

Most Significant Tweets for Sentiment

Last tweets per channel Firenze

### TV Firenze

Twitter Vigilance Dashboard

Last crawling: 2017-06-21 12:44:49

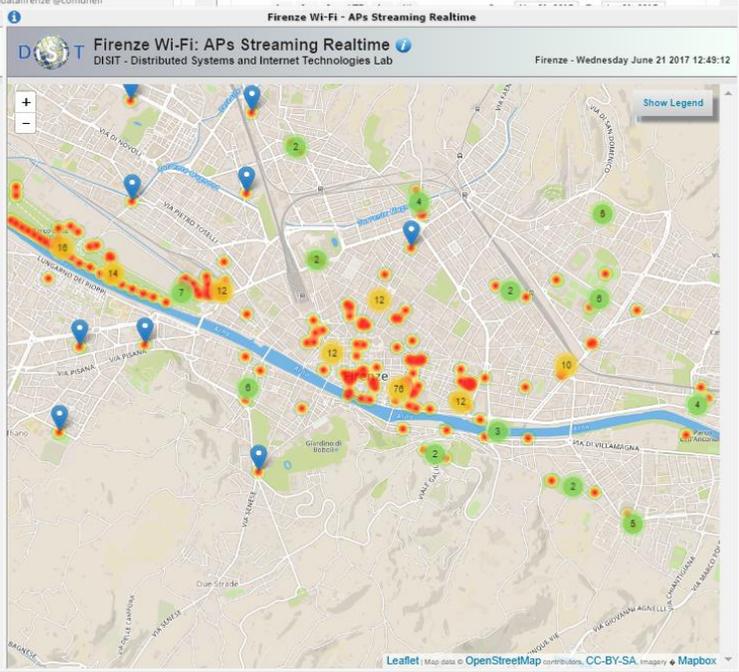
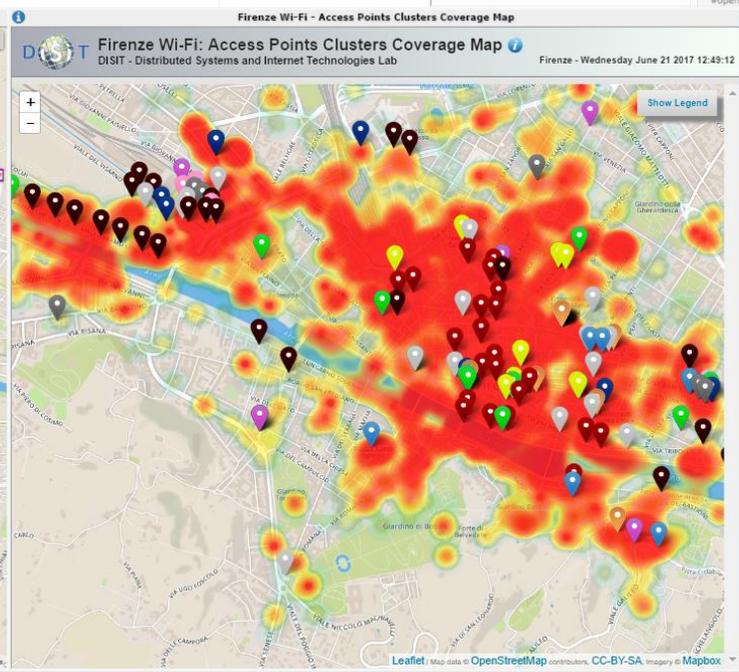
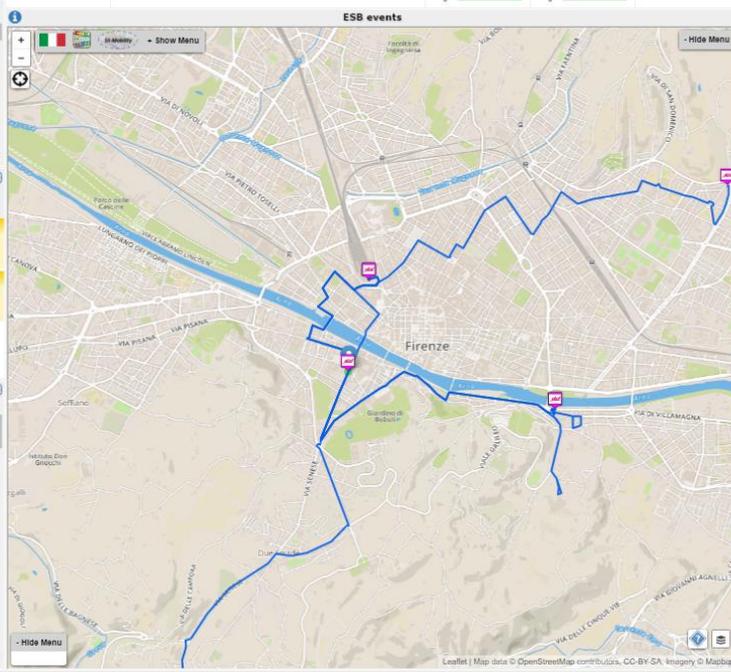
Channel active from 2009-02-27 to today

Data processed from 2015-05-22 to 2017-02-24

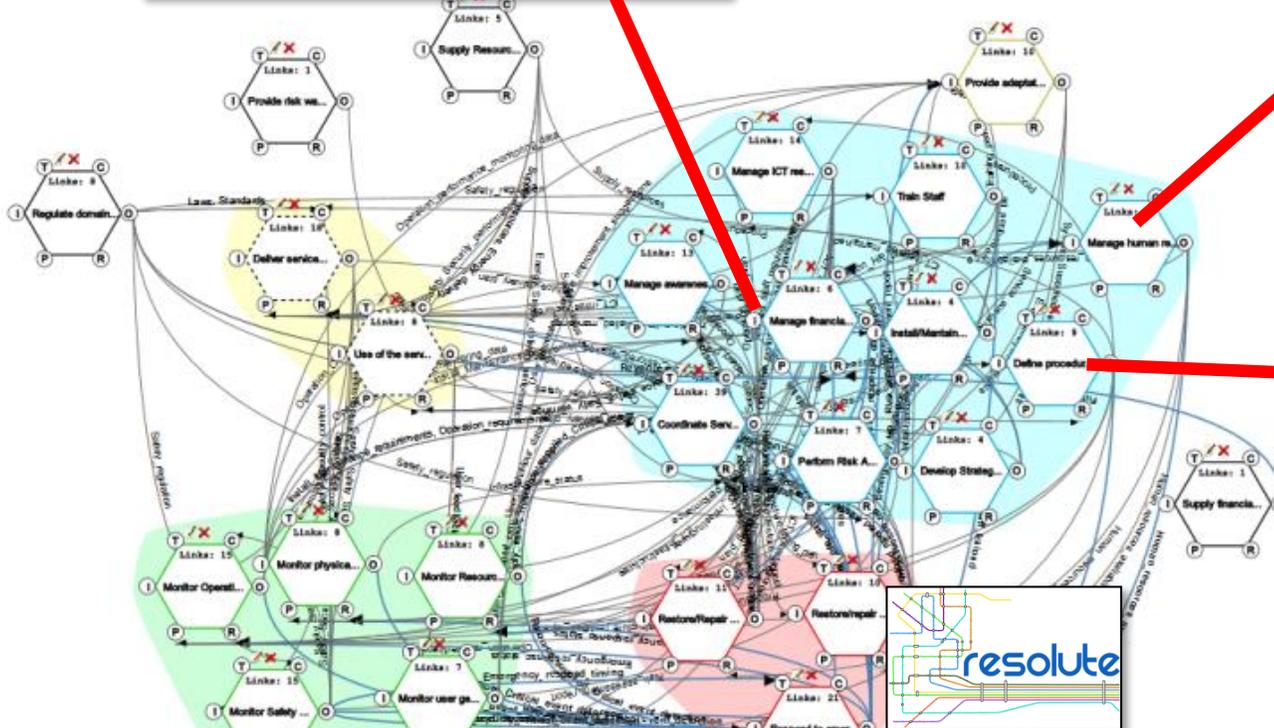
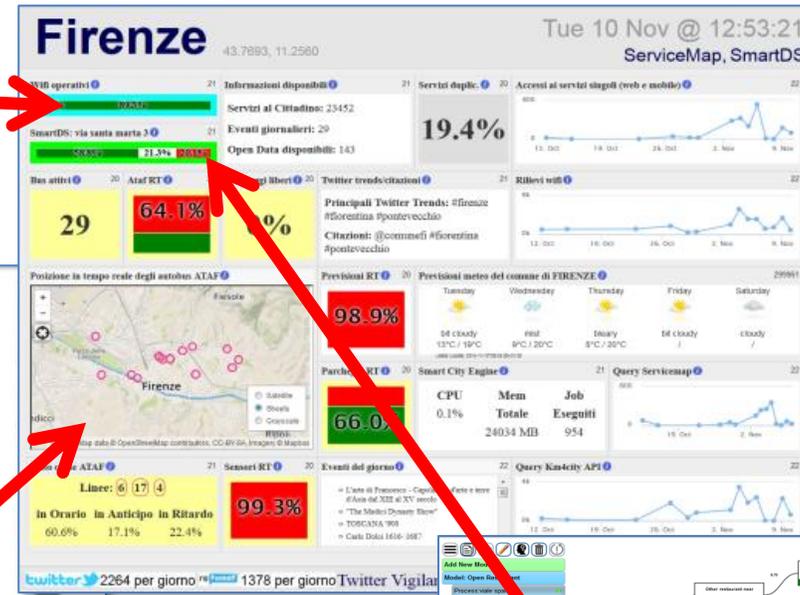
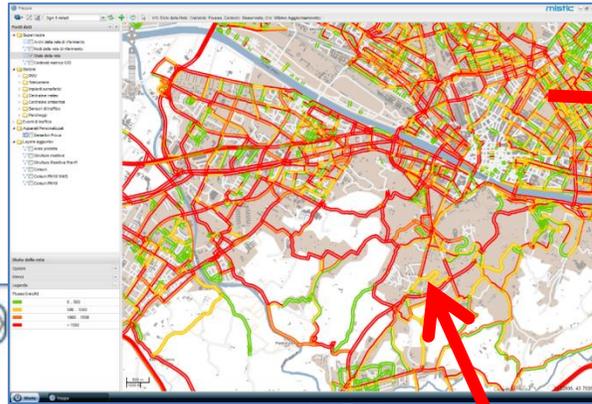
Search related to channel Firenze

Zoom 1m 3m 6m YTD 1y All

Daily number of tweets/retweets for channel: Firenze



# Dashboarding City Resilience

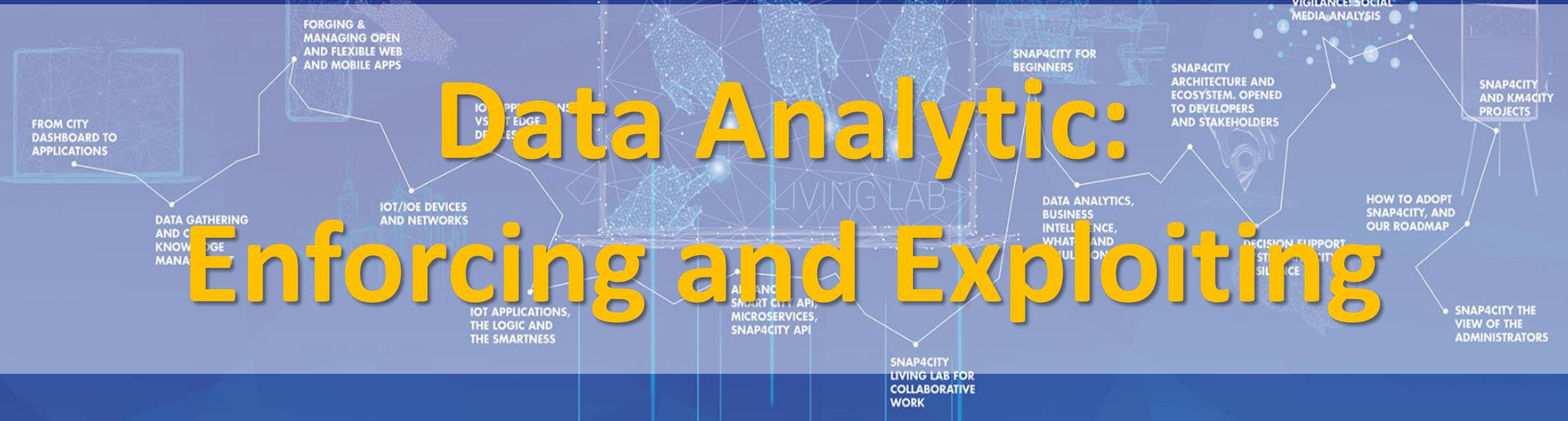


Data and Service Aggregator



TOP

# Data Analytic: Enforcing and Exploiting

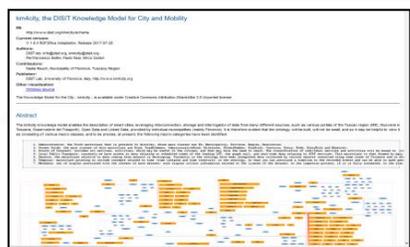
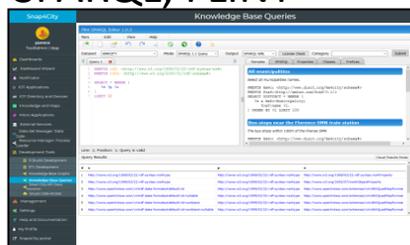


# Data Analytics Dev. in R Studio and/or Tensor Flow

Swagger



SPARQL, FLINT

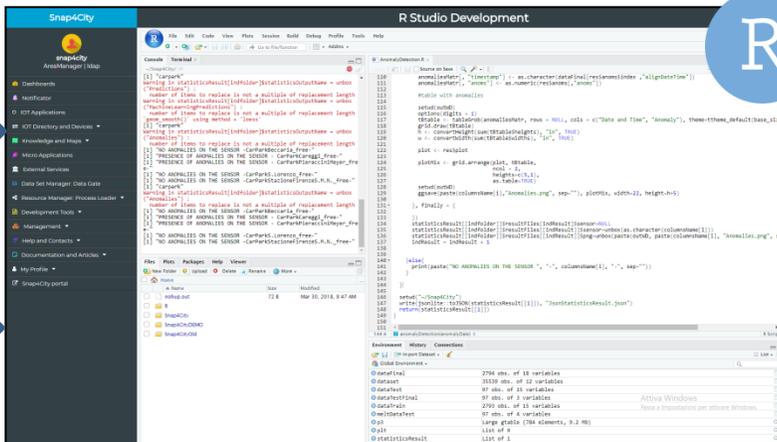
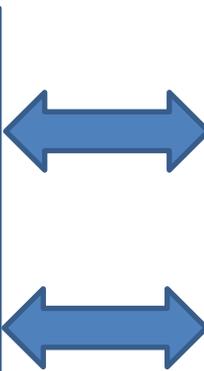


Ontology Schema

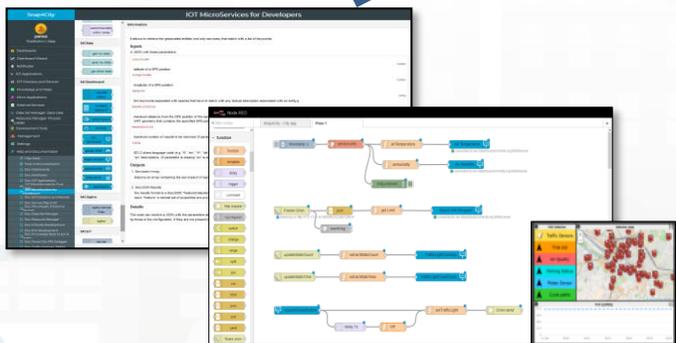


LOG.disit.org

Smart City API from Knowledge Base and other tools



Creating  
MicroServices

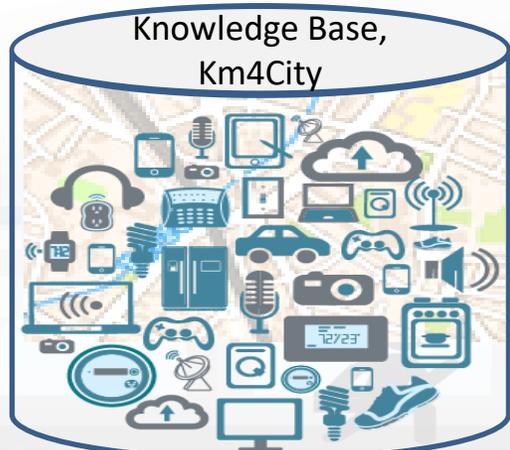


Using them into  
IOT Applications

Saving /  
Sharing  
reusing



Resource Manager



# Developer in R Studio + Tensor Flow

**R Studio Development**

```

110 anomaliesMat[, "timestamp"] <- as.character(dataFinal[res$ansoms$index, "alignDateTime"])
111 anomaliesMat[, "anoms"] <- as.numeric(res$ansoms[, "anoms"])
112
113 #table with anomalies
114
115 setwd(outDir)
116 options(digits = 1)
117 t$Table <- tableGrob(anomaliesMat, rows = NULL, cols = c("Date and Time", "Anomaly"), theme=ttheme_default(base_size=
118 grid.draw(t$Table)
119 h <- convertHeight(sum(t$Table$heights), "in", TRUE)
120 w <- convertWidth(sum(t$Table$widths), "in", TRUE)
121
122 plot <- res$plot
123
124 plotMix <- grid.arrange(plot, t$Table,
125                          ncol = 2,
126                          heights=c(5,1),
127                          as.table=TRUE)
128
129 setwd(outDir)
130 ggsave(paste(columnsName[i], "Anomalies.png"), sep="", plotMix, width=22, height=h*5)
131
132 }, finally = {
133
134 }
135
136 statisticsResult[[indFolder]]$resultFiles[indResult]$sensor=NULL
137 statisticsResult[[indFolder]]$resultFiles[indResult]$sensor=unbox(as.character(columnsName[i]))
138 statisticsResult[[indFolder]]$resultFiles[indResult]$png=unbox(paste(outDir, paste(columnsName[i], "Anomalies.png"), s
139 indResult = indResult + 1
140
141 }else{
142   print(paste("NO ANOMALIES ON THE SENSOR ", "-", columnsName[i], "-", sep=""))
143 }
144
145
146 setwd("~/Snap4City")
147 write(jsonlite::toJSON(statisticsResult[[1]]), "JsonStatisticsResult.json")
148 return(statisticsResult[[1]])
149
150
151

```

**Files** Plots Packages Help Viewer

- Home
- nohup.out
- R
- Snap4City
- Snap4CityDEMO
- Snap4CityOld

**Environment** History Connections

- Global Environment
- dataFinal: 2794 obs. of 18 variables
- dataset: 35539 obs. of 12 variables
- dataTest: 97 obs. of 15 variables
- dataTestFinal: 97 obs. of 3 variables
- dataTrain: 2793 obs. of 15 variables
- meltDataTest: 97 obs. of 4 variables
- p3: Large gtable (784 elements, 9.2 Mb)
- plt: List of 9
- statisticsResult: List of 1

**Files** Plots Packages Help Viewer

- New Folder
- Upload
- Delete
- Rename
- More

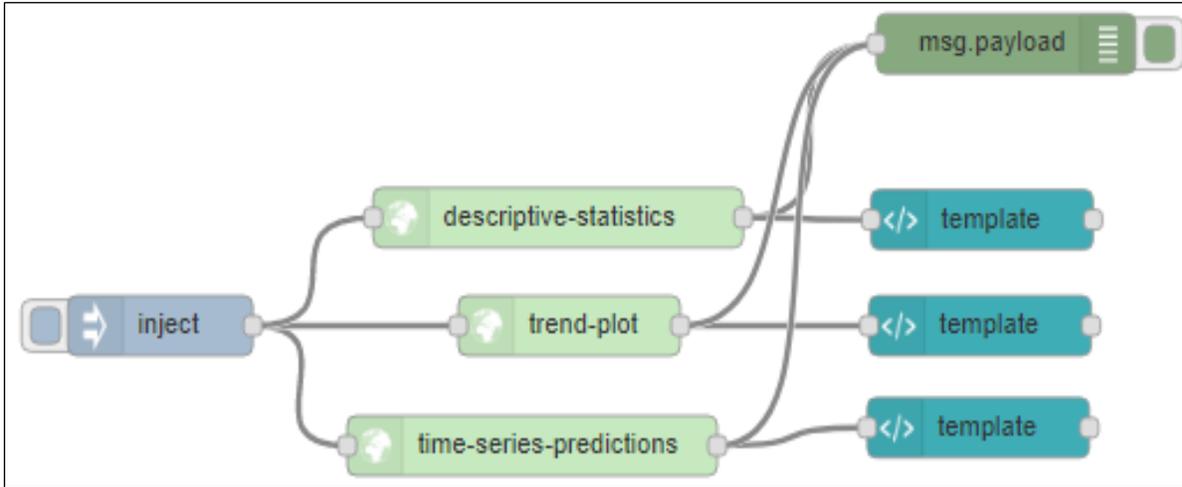
Home > Snap4City > StatisticsOutput

- AverageSpeedDailyTrend.png
- CarParksDailyTrend.png
- CorrelationMatrix.png
- PredictedFreeParking.png
- SensorsMeanPerDayMoment.png
- StatisticsBySensors.png
- StatisticsBySensorsAndDayMoment.png
- VehicleFlowDailyTrend.png

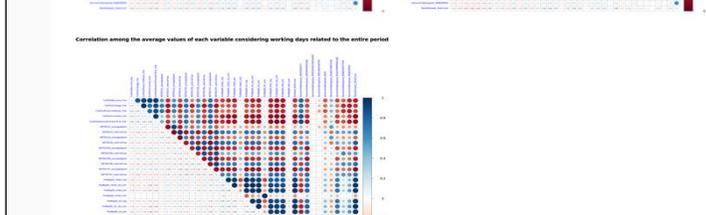
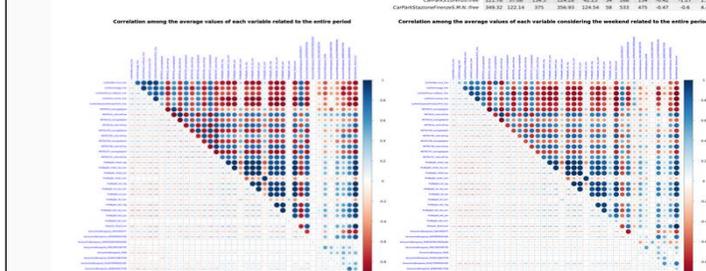
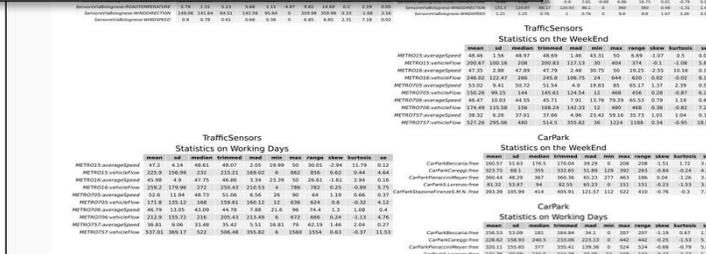
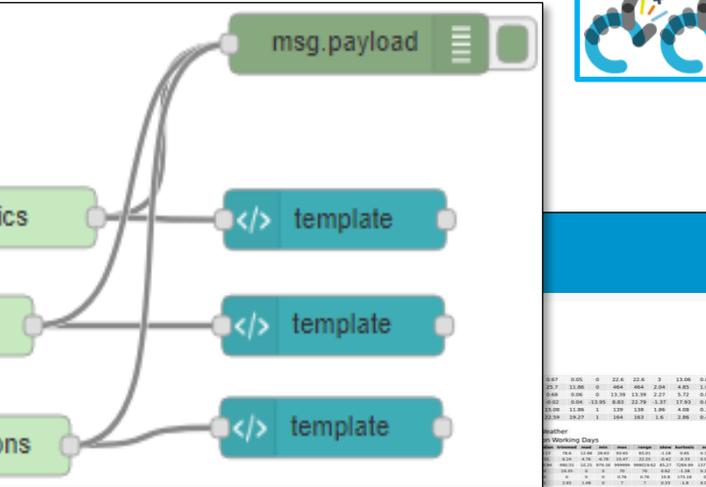
**Click on each .png file to visualize the statistics: a new tab will be opened**



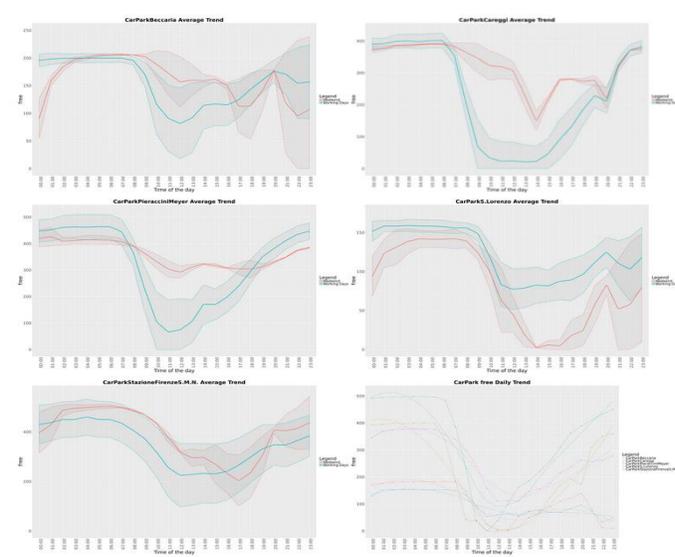
# From R studio data analytics to MicroService



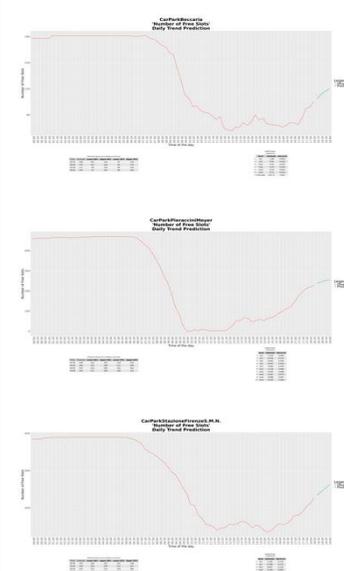
R Studio algorithms are automatically transformed into MicroServices for your IOT Applications



Trend Plot



Time Series Predictions





# Developing in R Studio and/or Tensor Flow

**R Studio Development**

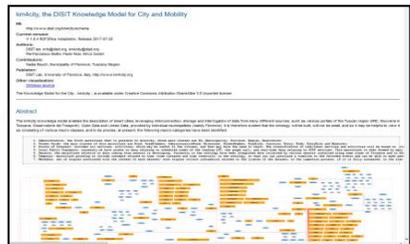
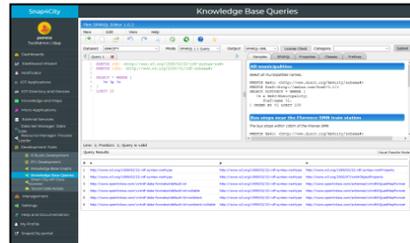
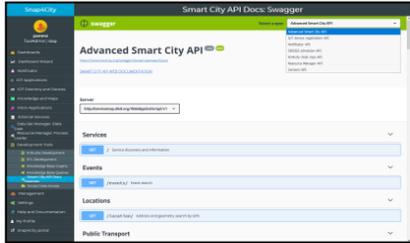
```

110 anomaliesMat[, "timestamp"] <- as.character(dataFinal[res$anoms$index, "alignDateTime"])
111 anomaliesMat[, "anoms"] <- as.numeric(res$anoms[, "anoms"])
112
113 #table with anomalies
114
115 setwd(outND)
116 options(digits = 1)
117 tTable <- tableRob(anomaliesMat, rows = NULL, cols = c("Date and Time", "Anomaly"), theme=theme_default(base_size=12))
118 grid.draw(tTable)
119 h <- convertHeight(sum(tTable$heights), "in", TRUE)
120 w <- convertWidth(sum(tTable$widths), "in", TRUE)
121
122 plot <- res$plot
123
124 plotMx <- grid.arrange(plot, tTable,
125                       ncol = 2,
126                       heights=c(5,1),
127                       as.table=TRUE)
128
129 setwd(outND)
130 ggsave(paste(columnsName[i], "Anomalies.png", sep=""), plotMx, width=22, height=h*5)
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132 }, finally = {
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134   statisticsResult[[indFolder]]$resultFiles[indResult]$sensor=NULL
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136   statisticsResult[[indFolder]]$resultFiles[indResult]$png=unbox(paste(outND, paste(columnsName[i], "Anomalies.png", sep=""), indResult = indResult + 1))
137
138 }
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147 write(jsonlite::toJSON(statisticsResult[[1]]), "jsonStatisticsResult.json")
148 return(statisticsResult[[1]])
149 }
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151 }
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```

# Data Analytics Development in Python, python

Swagger

SPARQL, FLINT

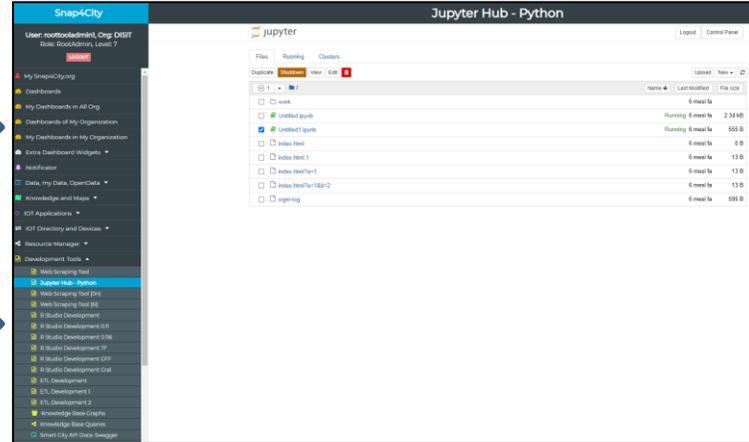
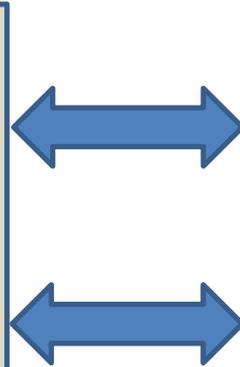


Ontology Schema

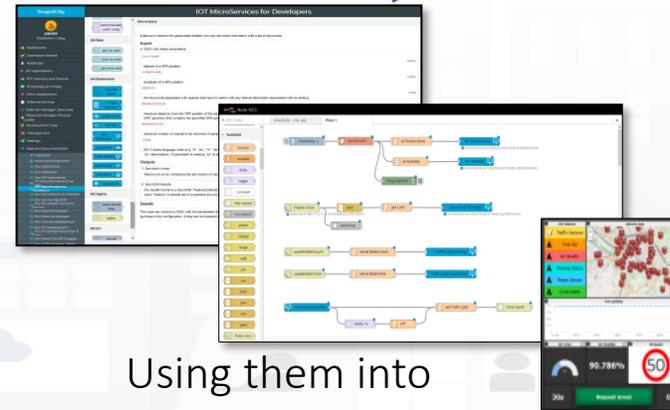
LOG.disit.org



Smart City API from Knowledge Base and other tools



Creating  
Micro Services



Using them into  
IOT Applications

Snap4City (C), November 2020

Coding  
Testing



Saving  
Sharing  
Reusing



Resource Manager



# Python process

- Develop Python code exploiting Flask calls
- Test on local for the Call
- Test on Cloud for API
- Deploy via IOT App



**Edit python-data-analytic node**

Delete Cancel Done

node properties

Name: ScriptBello

Relative Uri: /ScriptBello

Script R: Upload FirstTest3.py

Create Python Data Analytic

info debug dashboa

**Node**

Type: python-data-analytic

ID: \*42d9f1da.63feb\*

show more

**Information**

In order to make the best use of this node, follow the guides:

- [Data Analytic general interactive description](#)
- [Detailed Description](#)
- [Warning, if the script takes longer than 2 minutes to execute, a nodered timeout error may be shown even if](#)

Snap4City

User: p...@disit, Org: DISIT, Role: AssetManager, Level: 3

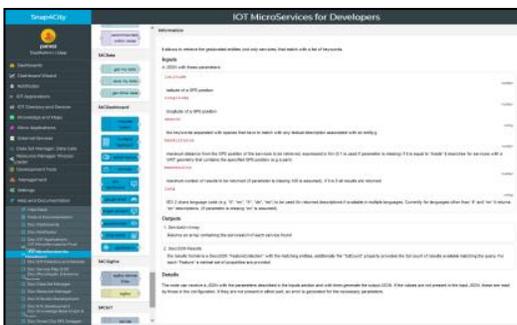
IOT Applications

- IOT Application
- Data Analytic
- IOT Application

# IOT Applications Development

IOT Discovering

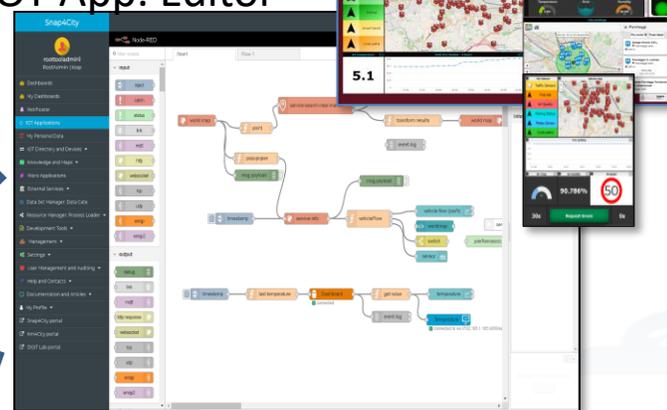
MicroServices collections



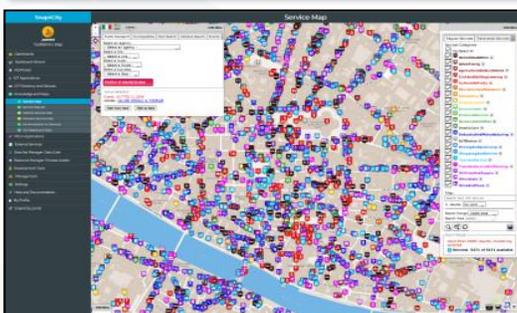
My IOT Applications



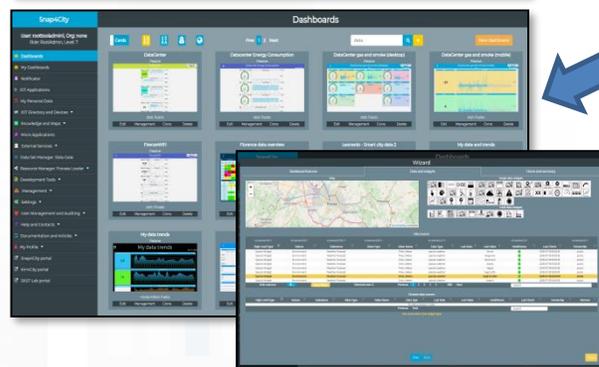
IOT App. Editor



Generating IOT App With Dashboard



ServiceMap Discovery



Dashboard Collection,  
Editor and Wizard

Sharing/saving  
reusing IOT App



Resource Manager



The screenshot shows the Snap4City IOT Applications dashboard. On the left is a navigation sidebar with a 'Logout' button and a menu for 'IOT Applications' which includes options like 'MicroServices for IOT Applications', 'MicroServices from DataAnalytic', and 'IOT MicroServices for Final Users'. The main area is titled 'IOT Applications' and displays a grid of application cards. Each card has a title, a set of icons, and a 'Management' button. The cards shown are: 'coronal', 'coronaR', 'prova APP SVG diretto', 'PythonExample', 'ROMA varie', 'scriptBello', and 'tramline multi'. The 'scriptBello' card is labeled 'Data Analytic' and features a Python logo and gears icon. At the top of the main area, there are sorting options (A-Z, Z-A), pagination (Prev 1 Next), a search filter, and a 'Create new' button.

## More information

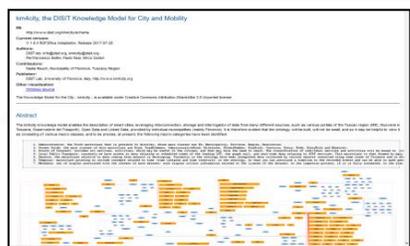
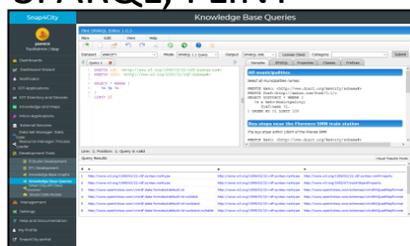
- [HOW TO: develop DataAnalytic in Python and manage them via IOT App](#)

# Data Analytics Dev. in Java

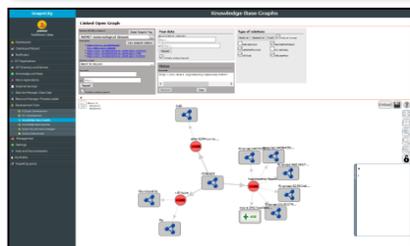
Swagger



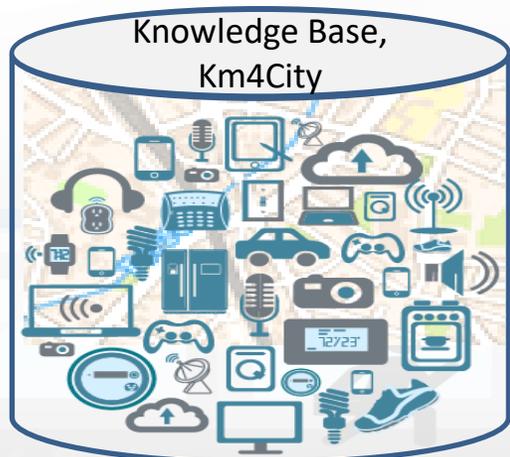
SPARQL, FLINT



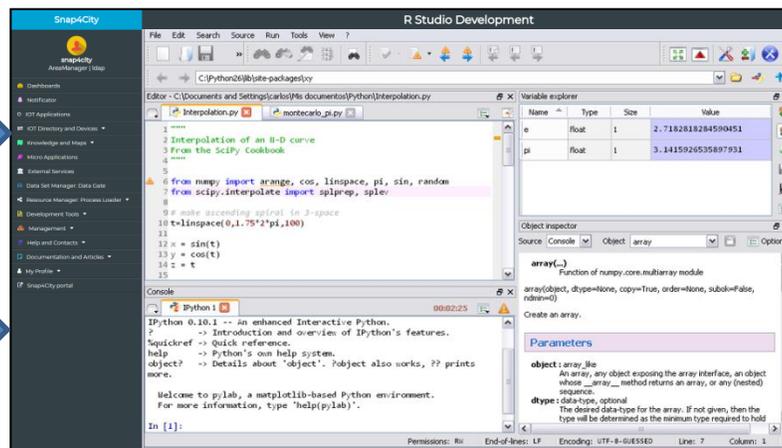
Ontology Schema



LOG.disit.org



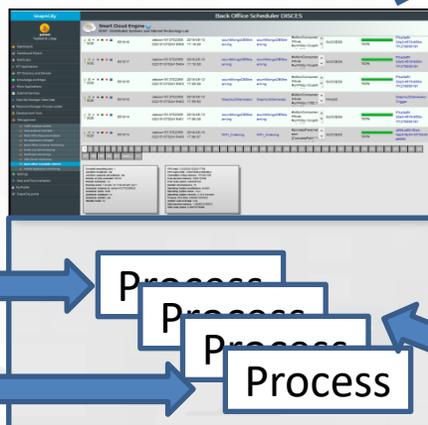
Smart City API from Knowledge Base and other tools



Coding  
Testing

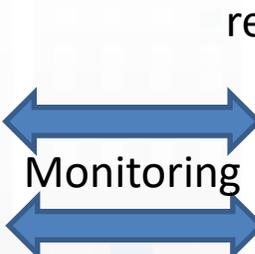


DISCES scheduler



Distributed Back Office

Monitoring



Saving /  
Sharing  
reusing



Resource Manager

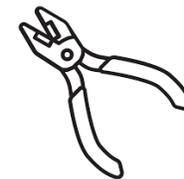


# How to work with R Studio in Snap4City



# How to work with R Studio in Snap4City





# Data Manipulation using R Studio®

1. How to download Real-Time data using APIs
2. How to manipulate data
3. How to create  **Statistics**



# *DEMO*

# *Section 1*

# *Real Time Data Analytics using R Studio. Exploitation in IOT Applications*



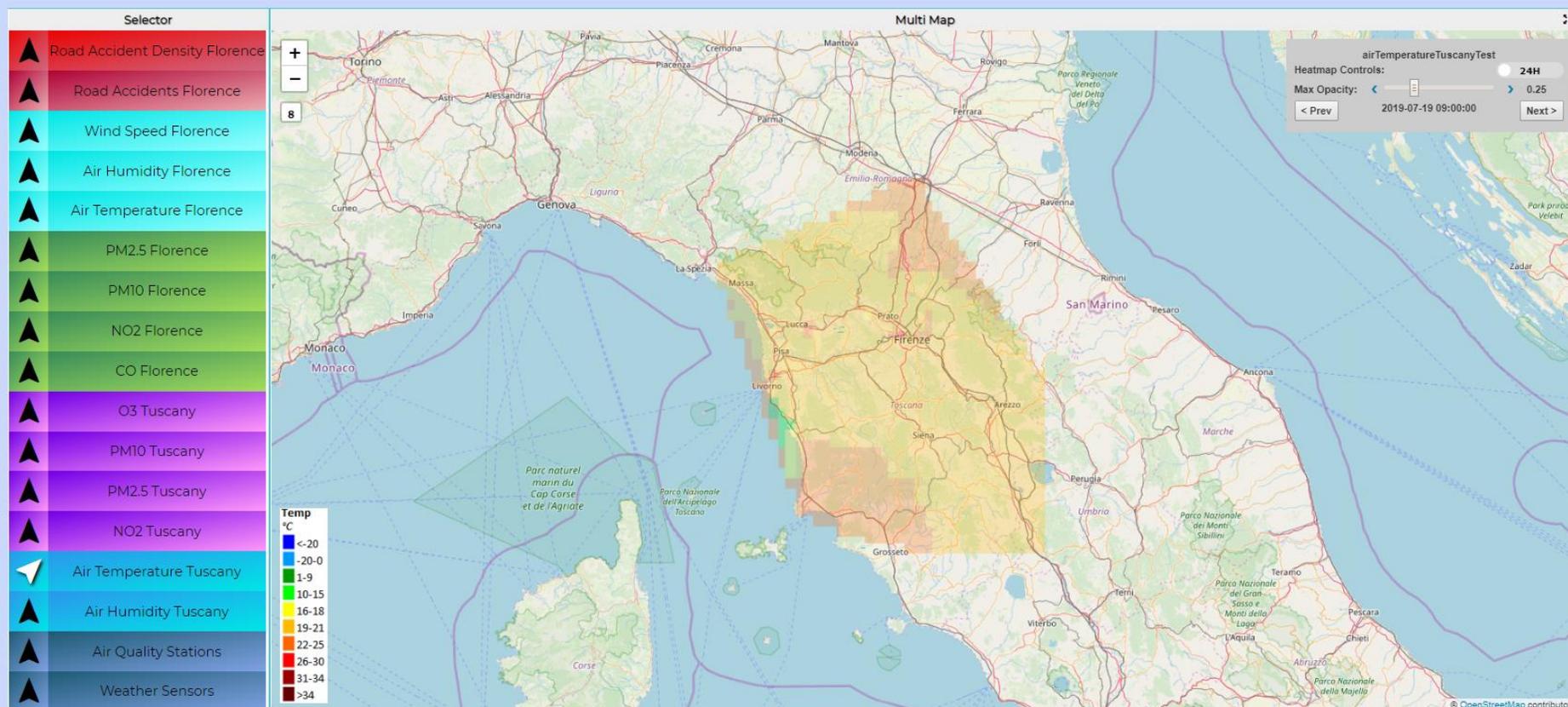


# Heatmap Visualization

## Heatmap Testing Florence/Tuscany

Irene

Fri 19 Jul 12:04:21



<https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MTI2OA==>



# Real Time Data Analytics and Heatmaps creation using R Studio®

1. How to create a *plumberized* R script:
  - How to download Real-Time data using APIs
  - How to save heatmaps using APIs
2. How to create an IOT Application for Real-Time Data Analytics:
  - How to upload the R script and create a plumber instance
3. How to visualize the created heatmap in a dashboard

# Real Time Data Analytics using R Studio

## How to create a *plumberized* R script - 1



**PLUMBER** is an **R** package that generates a web API from the **R** code you already have.

- Step 1 - *Plumberize* the code:



```
#' @get /TuscanyHeatmap  
#' @serializer unboxedJSON
```

- ❖ In order to send a response from R to an API client, the object must be *serialized* into some format that the client can understand (JSON format).

Note that, **@get** and **@serializer** annotations must to be put on the top of the code.

Any comments must not be inserted before the annotations or between them and the R function.

# Real Time Data Analytics using R Studio

## How to create a *plumberized* R script - 2



- Step 2 - Create an R function with the same name of the `@get` parameter:

```
TuscanyHeatmap <- function(sensorCategory, varName, fromDateTime, toDateTime, heatmapName){
```

```
heatmapName = "airTemperatureTuscanyTest"
```

```
sensorCategory = "Weather_sensor"
```

```
varName = "airTemperature"
```

```
toDateTime = "2020-04-14T10:00:00"
```

```
fromDateTime = "2-hour"
```



# Real Time Data Analytics using R Studio

## How to create a *plumberized* R script - 3



- Step 3 - Upload All Service Uris (sensor stations) from service map in the area of interest:

```
query <- paste("https://servicemap.disit.org/WebAppGrafo/api/v1/?selection=  
42.50247797334869;8.19580078125;44.6061127451739;13.4225463867187  
&categories=", sensorCategory,  
"&maxResults=0&maxDists=0.1&format=json", sep="")
```

```
sensorCategoryJson <- fromJSON(query) #jsonlite package
```

```
suri <- sensorCategoryJson$Services$features$properties$serviceUri #serviceUri
```



# Real Time Data Analytics using R Studio

## How to create a *plumberized* R script - 3



[https://servicemap.disit.org/WebAppGrafo/api/v1/?selection=42.67897316354954;9.954032295814045;44.00523270268637;12.063407295814045&categories=Weather\\_sensor&maxResults=0&maxDists=0.1&format=json](https://servicemap.disit.org/WebAppGrafo/api/v1/?selection=42.67897316354954;9.954032295814045;44.00523270268637;12.063407295814045&categories=Weather_sensor&maxResults=0&maxDists=0.1&format=json)



```
"http://www.disit.org/km4city/resource/IBIMET_SMART11"  
"http://www.disit.org/km4city/resource/IBIMET_SMART04"  
"http://www.disit.org/km4city/resource/IBIMET_SMART13"  
"http://www.disit.org/km4city/resource/IBIMET_SMART06"  
"http://www.disit.org/km4city/resource/IBIMET_SMART17"  
"http://www.disit.org/km4city/resource/IBIMET_SMART33"  
"http://www.disit.org/km4city/resource/IBIMET_SMART33"  
"http://www.disit.org/km4city/resource/IBIMET_SMART25"  
"http://www.disit.org/km4city/resource/IBIMET_SMART24"  
"http://www.disit.org/km4city/resource/IBIMET_SMART30"
```

[...]

# Real Time Data Analytics using R Studio

## How to create a *plumberized* R script - 4



- Step 4 - Upload data related to a specific time interval (fromTime/toTime ) for each Service Uri:

```
sensorData <- vector("list", length(suri))  
for (i in 1:length(suri)){  
  temp=c()  
  #api to upload the realtime data  
  api <- paste("https://servicemap.disit.org/WebAppGrafo/api/v1/?serviceUri=",  
              suri[i], "&fromTime=", fromDateTime,  
              "&toTime=", toDateTime, sep="")  
  sensorCategoryData <- fromJSON(api)
```

```
https://servicemap.disit.org/WebAppGrafo/api/v1/?serviceU  
ri="http://www.disit.org/km4city/resource/IBIMET_SMART11"  
&fromTime=2-hour&toTime=2020-04-14T10:00:00
```

# Real Time Data Analytics using R Studio

## How to create a *plumberized* R script - 5



- Step 5 – Data manipulation and data Interpolation...

... After data manipulation and interpolation we obtain something like this:

long	lat	value
11.24686	42.76616	39.87238
11.30287	42.76616	39.54115
11.35888	42.76616	39.20993
11.41489	42.76616	38.87870
11.47090	42.76616	38.54747
11.52691	42.76616	38.21624
11.58292	42.76616	37.88501
[...]		

Interpolated  
values



# Real Time Data Analytics using R Studio

## How to save heatmaps using API - 1

### ■ Step 6 - Create a R list:

```
interpolatedHeatmap=list()
interpolatedHeatmap$attributes=vector("list", dim(interpolatedData)[1])
interpolatedHeatmap$saveStatus=list()

for(i in 1:dim(interpolatedData)[1]) {

  #list
  lat = as.numeric(interpolatedData[i, "lat"])
  long = as.numeric(interpolatedData[i, "long"])
  meanObs = interpolatedData[i, "value"]

  listAttribTemp = list("mapName"=heatmapName, "metricName"= metricName,
    "description"= paste("Average from",fromDateTime,"to",toDateTime,sep=" "),
    "clustered"= 0, "latitude"=lat, "longitude"=long,
    "value"= meanObs, "date"= paste(toDateTime, "Z", sep=""), "org"="DISIT")

  interpolatedHeatmap$attributes[[i]]=listAttribTemp
```

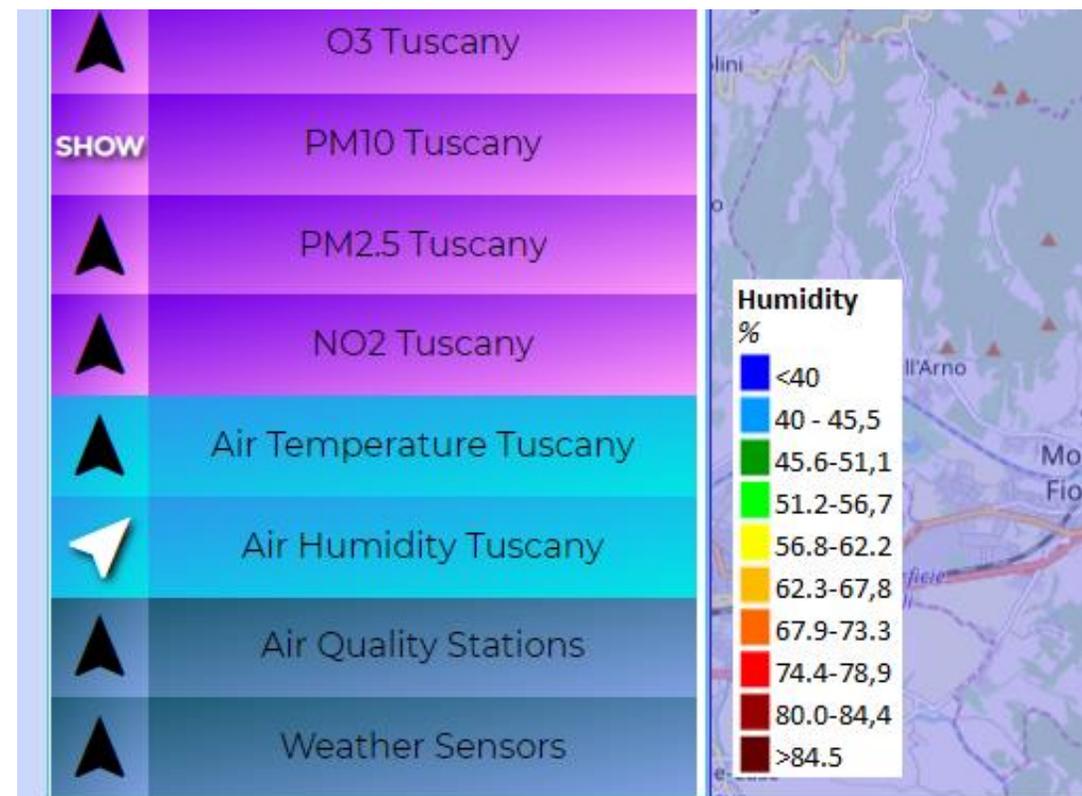
# Real Time Data Analytics using R Studio

## How to save heatmaps using API - 2

Note that, the "**metricName**" identifies the legend for each heatmap and the colour scale to be used.

It corresponds to the *varName* of the R function except for PM10 and PM2.5 measurements:

- "HighDensityPM10"
- "HighDensityPM25"



# Real Time Data Analytics using R Studio

## How to save heatmaps using API - 3

- Step 7 - Transform the R list in a Json and save heatmap data using API:

```
request_body_json <- toJSON(interpolatedHeatmap$attributes, auto_unbox = TRUE, digits = 10)
```

```
resultPOST <- POST(url = "http://snap4city:disit2019@192.168.0.59:8000/insertArray",  
  body = request_body_json,  
  encode = "json", add_headers("Content-Type" = "application/json"))
```

[...]

```
apiFinal <- paste("http://192.168.0.59/setMap.php?mapName=", heatmapName,  
  "&metricName=", metricName,  
  "&date=", paste(toDateTime, "Z", sep=""),  
  "&completed=", completed, sep="")  
resultPOST <- GET(url = apiFinal)
```



# Real Time Data Analytics using R Studio

## How to save heatmaps using API - 4

JSON Array  
Format  
example



```
[  
{  
  "mapName": "airTemperatureTuscany",  
  "metricName": "airTemperature",  
  "description": " Air Temperature heatmap ... ",  
  "clustered": 0,  
  "latitude": 43.1,  
  "longitude": 11.1,  
  "value": 16.5,  
  "date": "2020-04-14T10:00:00Z"  
  "org": "DISIT"  
}, { [...]} ]
```

# IOT App for Real Time Data Analytics

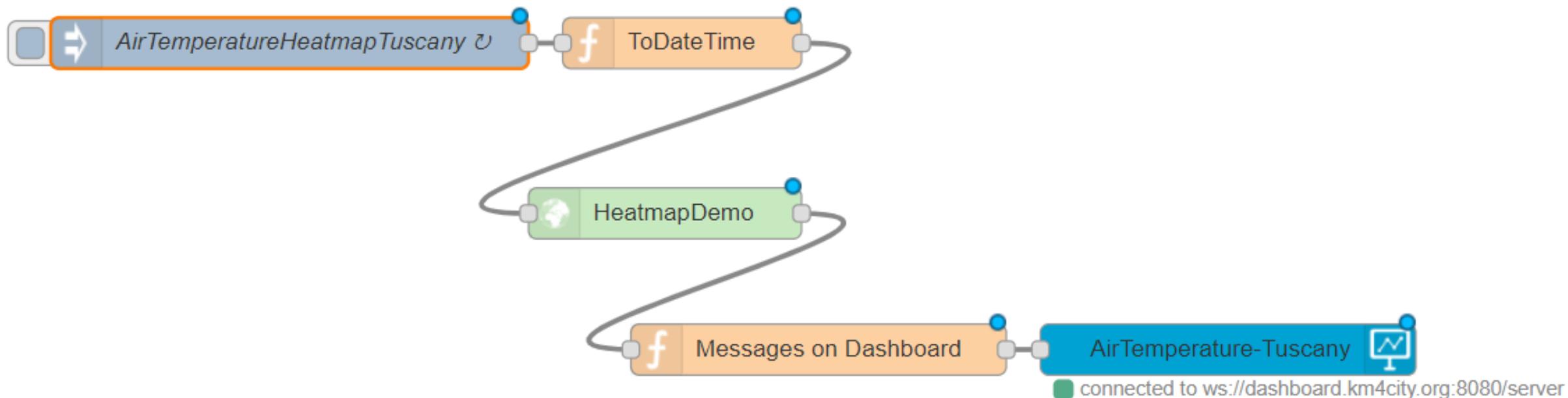
## How to create a Data Analytics IOT Application

### What we need:

-  inject  To insert the R function parameter
-  plumber data analytic  To upload the R script and create a plumber instance
-  function  To visualize strings/numbers/html on a dashboard
-  single content  To execute JavaScript code on output messages

# IOT App for Real Time Data Analytics

## How to create a Data Analytics IOT Application



# IOT App for Real Time Data Analytics

## Nodes Configuration – Inject Node

How to configure the **inject** node:

The screenshot shows the Node-RED interface for configuring an inject node. The node name is "AirTemperatureHeatmapTuscany". The payload is set to a JSON object: {"varName": "airTemperature", "heatmapName": "airTemperatureTuscanyTest", "fromDateTime": "2-hour", "sensorCategory": "Weather\_sensor"}. The repeat interval is set to 2 hours. The "Inject once at start?" checkbox is checked.

The JSON Format of the Payload property has the same notation of the R function parameters:

```
{  "varName": "airTemperature",  
  "heatmapName":  
  "airTemperatureTuscanyTest",  
  "fromDateTime": "2-hour",  
  "sensorCategory": "Weather_sensor"  
}
```

# IOT App for Real Time Data Analytics

## Nodes Configuration – Function Node for Date and Time

- ❖ Before configure the plumber data analytic node is necessary to execute a JavaScript code to dynamically update the date ("toDateTime" parameter):

Name: ToDateTime

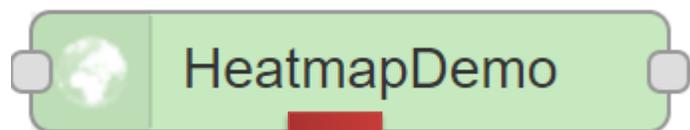
Function

```
1 msg.payload.toDateime
2 new Date(new Date().getTime() +
3 7200000).toISOString().substring(0,13)+(":00:00");
4 return msg;
```

# IOT App for Real Time Data Analytics

## Nodes Configuration – Plumber Data Analytic Node

How to configure the **plumber data analytic** node:



**Edit plumber-data-analytic node**

Delete Cancel Done

node properties

Name HeatmapDemo

Relative Uri /TuscanyHeatmap

Script R Upload TuscanyHeatmap (3).R

Create Plumber Data Analytic

Relative Uri is the same of  
the R `@get` annotation:

```
#' @get /TuscanyHeatmap
```

# IOT App for Real Time Data Analytics

## Nodes Configuration – Function Node for Messages on Dashboard

- ❖ Before configure the single content node is necessary to execute a JavaScript code to visualize the status of the heatmap:

🔧 Function

f Messages on Dashboard

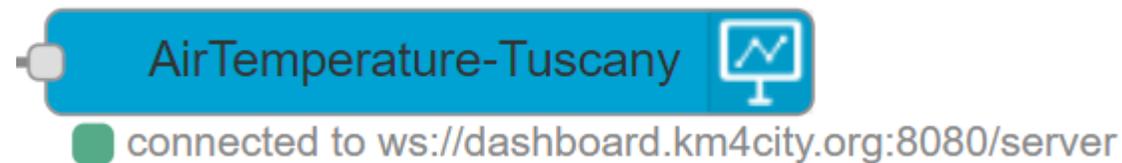
```
1 msg.payload=msg.payload.message+" "+msg.payload.dateTime;
2 if(msg.payload.indexOf("Completed")!= -1){
3     msg.payload ="<span style='color:green;'>" +
i 4     msg.payload + "</span>"
5 } else if (msg.payload.indexOf("No Availabe Data") != -1){
6     msg.payload ="<span style='color:orange;'>" +
i 7     msg.payload + "</span>"
8 }
9 return msg;
```



# IOT App for Real Time Data Analytics

## Nodes Configuration - Single Content Node

How to configure the **single content** node:



Dashboard

Name

Check Data Analytics Tuscany

Create New

Widget

Name

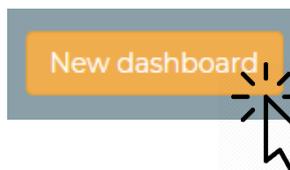
AirTemperature-Tuscany

Edit Dashboard

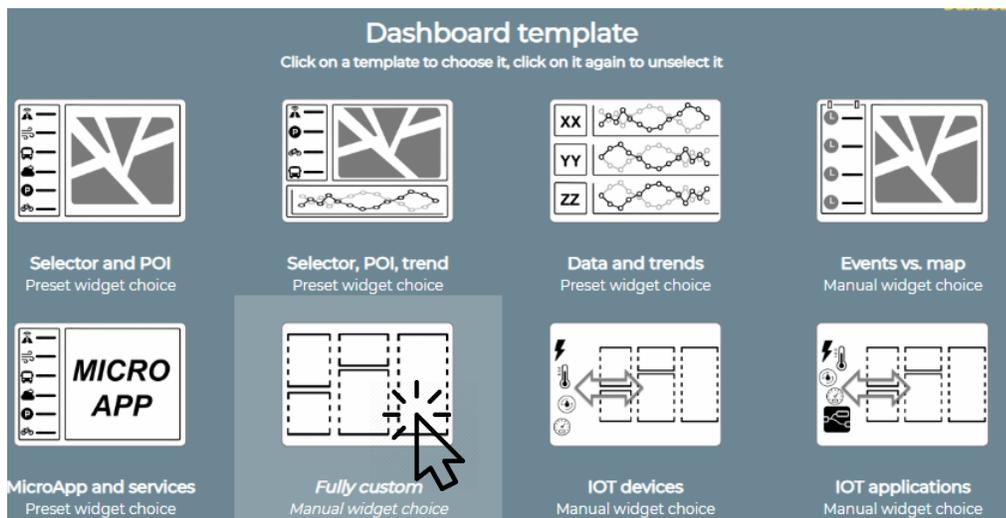
View Dashboard

# Wizarded Heatmap Visualization

1. Create a New Dashboard from Dashboard (Public) 

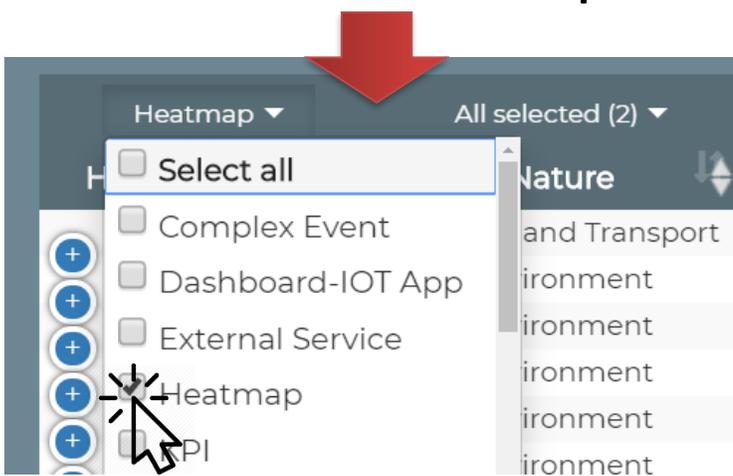


2. Insert a Dashboard Title and select a Dashboard Template

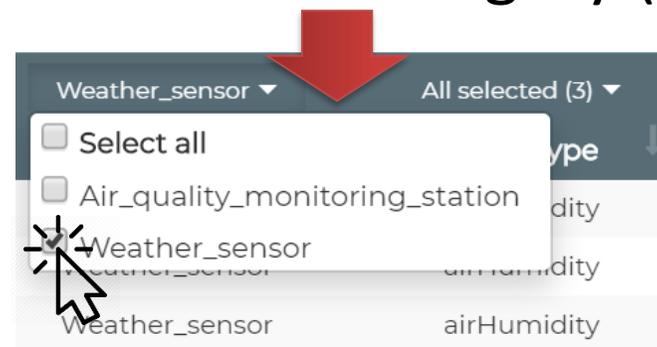


# Wizarded Heatmap Visualization

3. Select the Heatmap box as High-Level-Type



4. Select the Sensor Category (Subnature)



5. Select the measure (Value Type) and the Heatmap Name (Value Name)

Value Type	Value Name	Data Type	Last Date
airHumidity	AirHumidityAverage24HourFlorence	heatmap	2019-04-08 13:27:52
airHumidity	AirHumidityAverage2HourFlorence	heatmap	2019-07-22 13:00:00
airHumidity	airHumidityTuscanyTest	heatmap	2019-07-22 12:00:00

# Manually Heatmap Visualization

6. After the Heatmap selection, select the Multi Data Map button and click on next

7. Select the instantiation button to proceed with items creation

Value Type	Value Name	Data Type
airHumidity	AirHumidityAverage24HourFlorence	heatmap
airHumidity	AirHumidityAverage2HourFlorence	heatmap
airHumidity	airHumidityTuscanyTest	heatmap

**Instantiation**  
Button to proceed with items creation

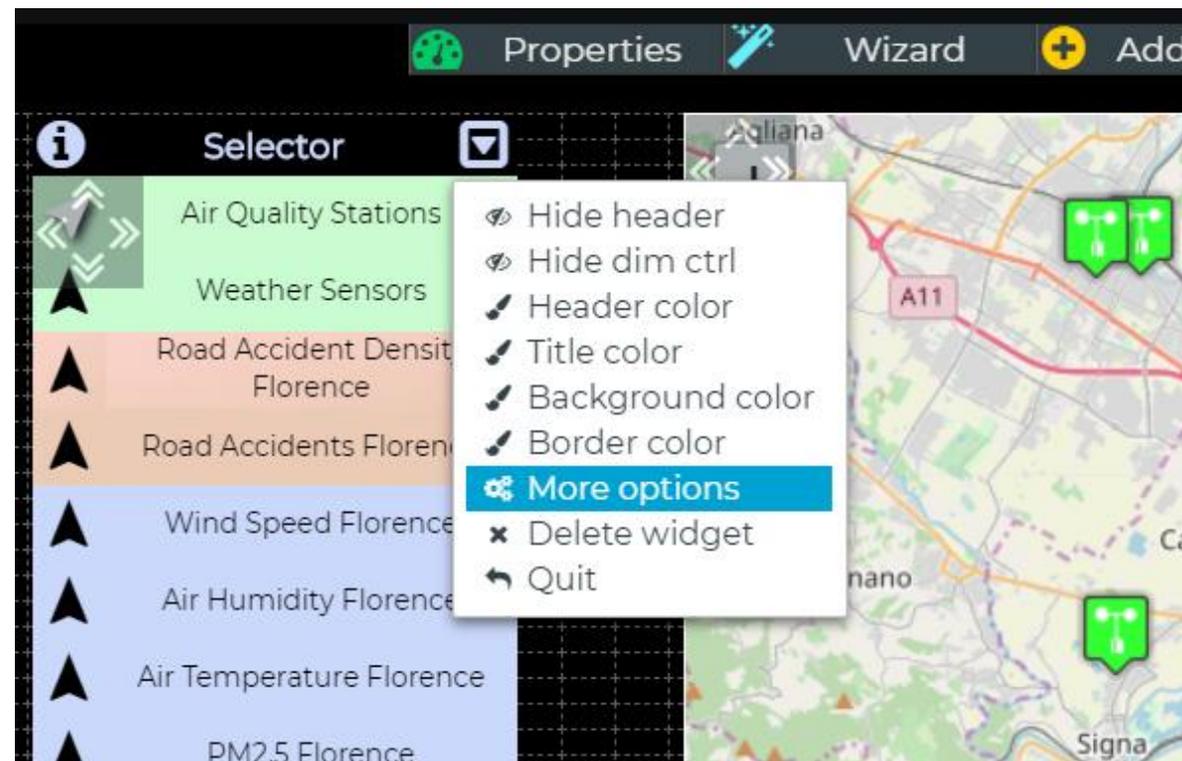
Create dashboard/widgets

# Manually Heatmap Visualization

1. Select a Dashboard and click on Edit



2. Select on More Options to modify the widget properties



# Manually Heatmap Visualization

## 3. Change the Query to visualize the new heatmap

Specific widget properties

Map widgets: Multi Map

Active rows font color: rgba(0,0,0,1)

Default	Symbol mode	Symbol choice	Symbol preview	Description	Query	Color1	Color2	Data widgets
<input type="checkbox"/> No	<input checked="" type="checkbox"/> Auto		▲	Road Accident...	https://he...	rgba(2:	rgba(2:	Nothing se ▾
<input type="checkbox"/> No	<input checked="" type="checkbox"/> Auto		▲	Road Accident...	https://wm...	rgba(17:	rgba(2:	Nothing se ▾
<input type="checkbox"/> No	<input checked="" type="checkbox"/> Auto		▲	Wind Speed FL...	https://wm...	rgba(0,	rgba(15:	Nothing se ▾

<https://wmserver.snap4city.org/geoserver/Snap4City/wms?service=WMS&layers=heatmapName>

<https://wmserver.snap4city.org/geoserver/Snap4City/wms?service=WMS&layers=airTemperatureTuscanyTest>

# Heatmap Visualization

Livorno Firenze Toscana - Air Quality Heatmaps

Thu 9 Apr 14:03:50

This dashboard contains data derived from actual sensors and predictive values under validation

**Selector**

- Air Quality Stations
- Weather Sensors
- Road Accident Density Florence
- Road Accidents Florence
- Wind Speed Florence
- Air Humidity Florence
- Air Temperature Florence
- PM2.5 Florence
- PM10 Florence
- NO2 Florence
- CO Florence
- CO Livorno
- O3 Livorno
- Air Temperature Tuscany
- Air Humidity Tuscany
- Tuscany EAQI

SensoreV1... (9m)

15.9

---

Humidity (9m)

69.9

---

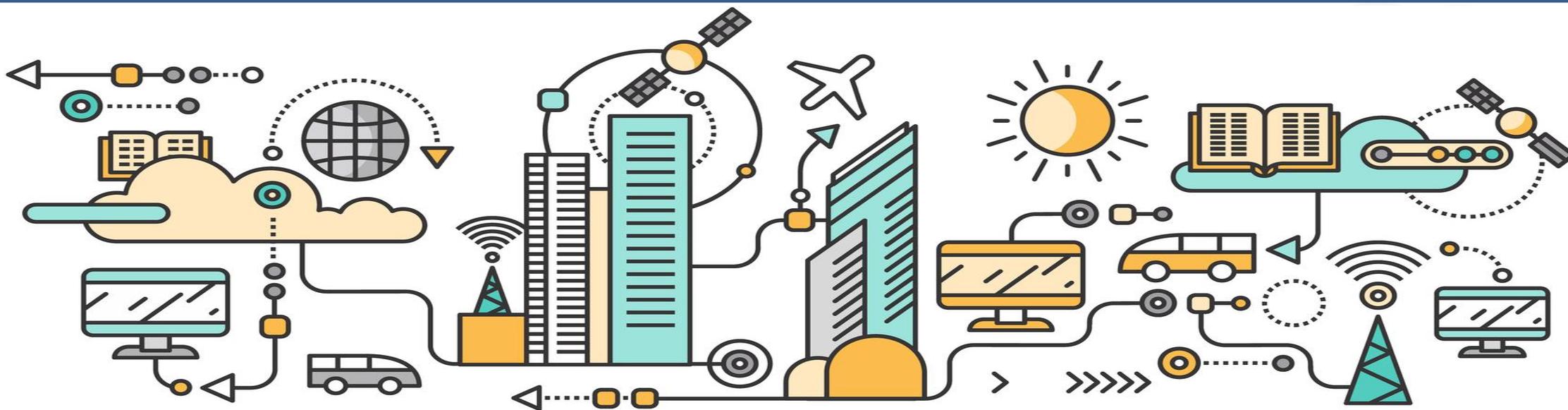
Pressure (9m)

991.3

<https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MTI2OA==>

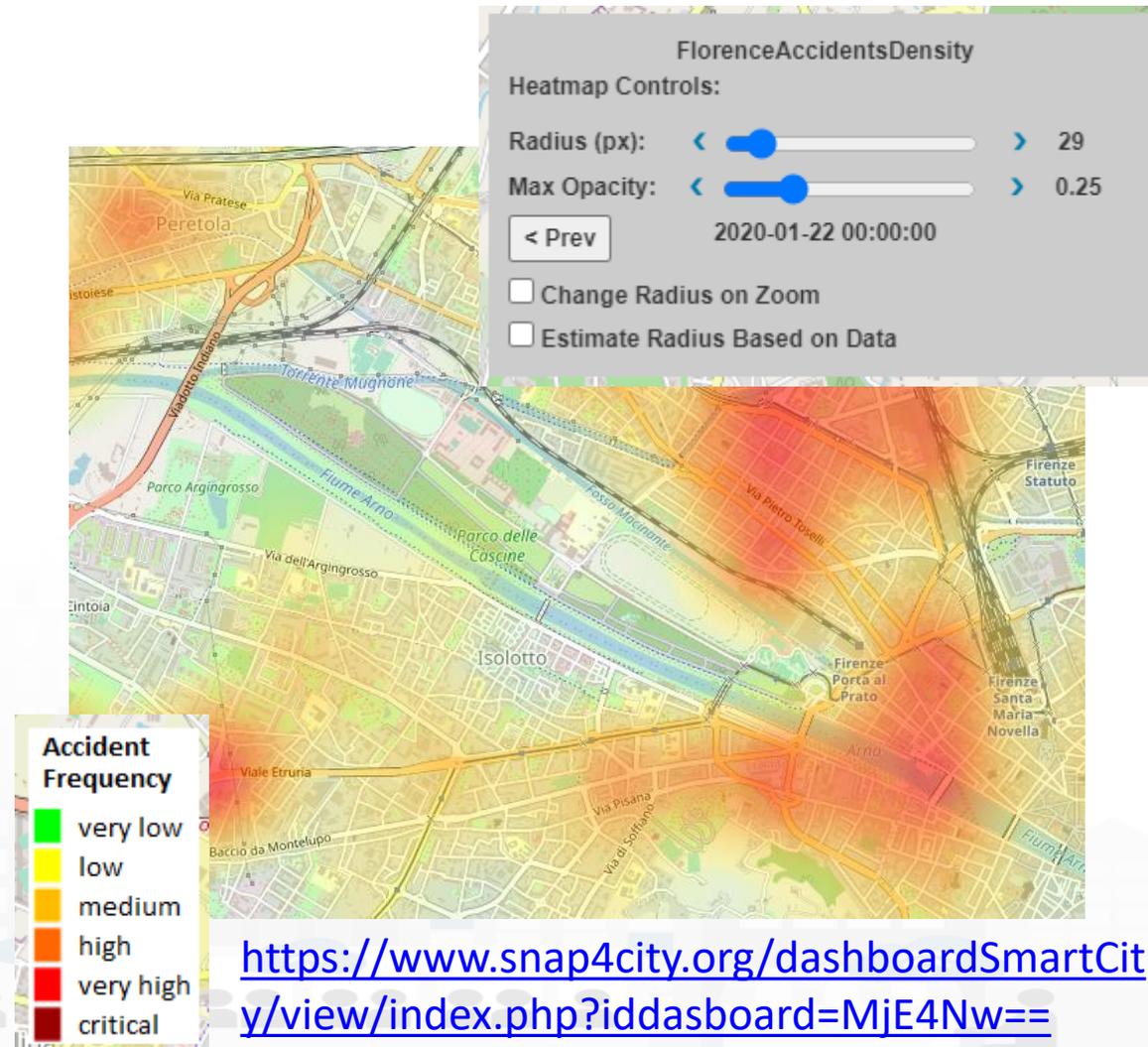
# *Different Heatmap Models*

## *A comparison and features*



# Gaussian vs WMS heatmap settings/calls

- <https://heatmap.snap4city.org/heatmap.php?dataset=15MinIndex HousingIndex>
  - GPS coordinates (points)
  - Metrics to be defined into the Dashboard table
  - Legenda of colormap in PNG to be uploaded if not standard
  - Heatmap non calibrated, created on client. Data provided from Heatmap server, some limitations on the number of points since the heatmap is created on client side
- If data are on Heatmap Server, the data Piker from Heatmap is accessible

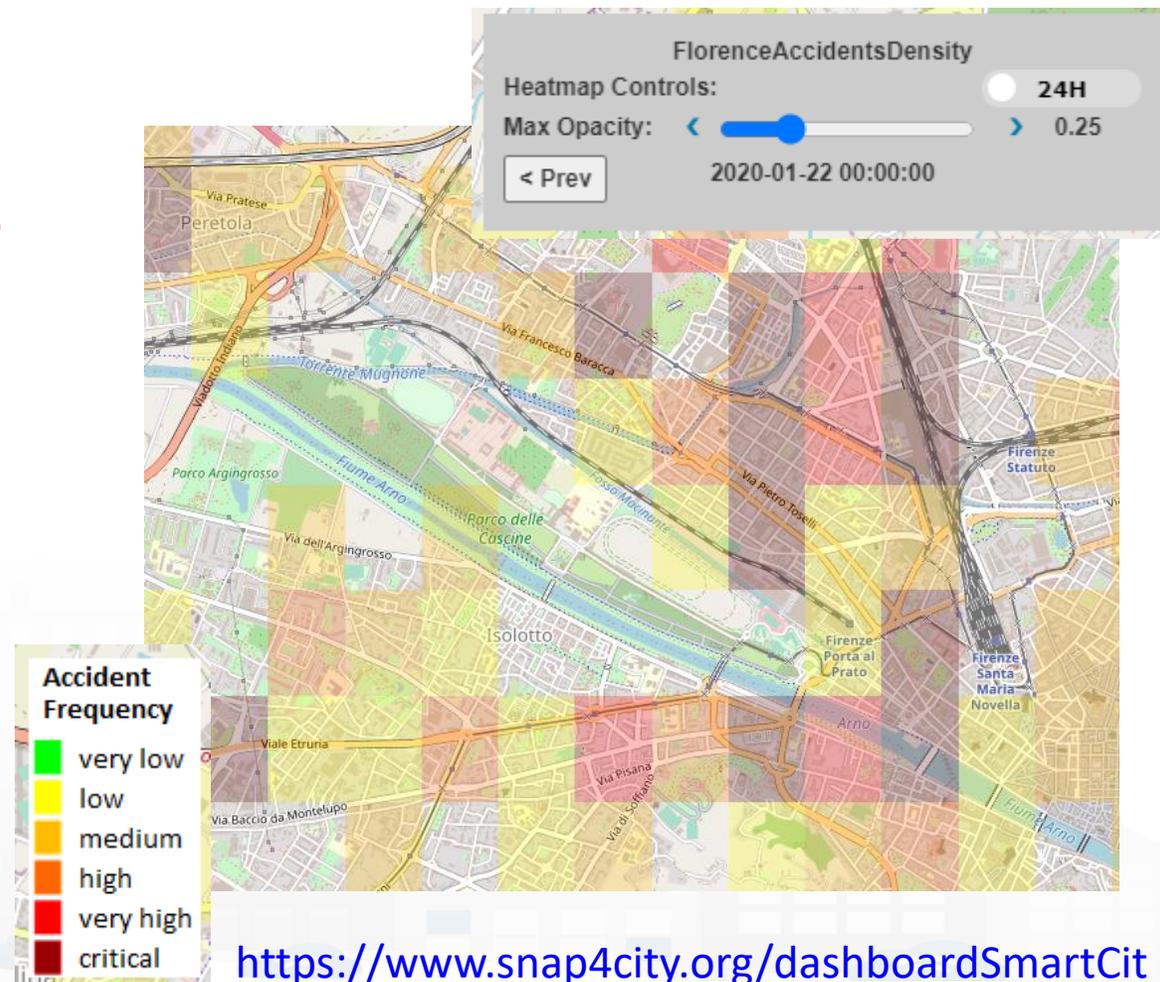


# Gaussian vs WMS heatmap settings/calls

- <https://wmserver.snap4city.org/geoserver/Snap4City/wms?service=WMS&layers=15MinIndex HealthIndex>

X

- UTM coordinates (points, grid size, etc.)
- Legenda of Colormap in PNG to be uploaded if not standard
- Heatmap built as Tiled Images in GeoTIFF and provided from GeoServer
- It is possible to create Heatmap on GeoTiff without loading data on Heatmap Server



<https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MjE4Nw==>



## What-IF analysis Informative

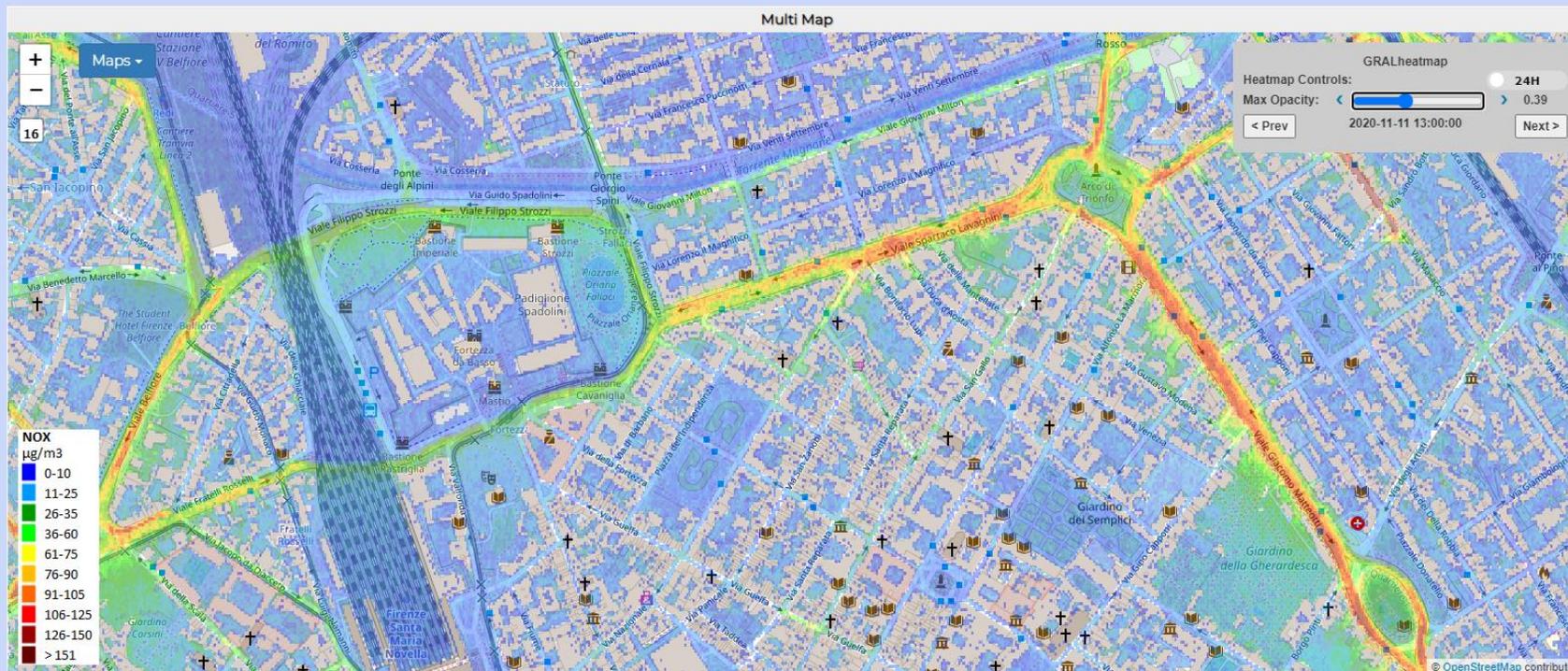
This dashboard contains data derived from actual sensors and predictive values under validation



Wed 11 Nov 13:39:09

- ▲ Air Quality Sensors
- ▲ Weather Sensors
- ▲ PM10 Heatmap
- ▲ PM2.5 Heatmap
- ▲ CO Heatmap
- ▲ CO2 Heatmap
- ▲ O3 Heatmap
- ▲ NO2 Heatmap
- ▲ Europ. AQI Heatmap
- ▲ Air Humidity Heatmap
- ▲ Air Temp. Heatmap
- ▲ Wind Speed Heatmap
- ▲ Gral Pred. HM NOX (3m)
- ▲ Gral Pred. HM NOX (6m)
- ▲ Traffic Sensors
- ▲ Traffic Flow
- ▲ Cycling Paths
- ▲ Accident Heatmap
- ▲ Accident Heatmap 2
- ▲ Only HRes Anym. Gral
- ▲ Scenario
- ▲ What-IF

Air Temperature Bologn... (5m)



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# R studio Development documentation (self training)

<https://www.snap4city.org/dashboardSmartCity/management/iframeApp.php?linkUrl=https%3A%2F%2Fwww.snap4city.org%2Fdrupal%2Fnode%2F25&linkId=25link&pageTitle=Doc:%20R%20Studio%20Development&fromSubmenu=handddocLink>

- [TC7.1. Exploiting data analytics and machine learning in IOT Applications as MicroService](#)
- [TC7.2. R Studio for Analytics, exploiting Tensor Flow](#)
- [TC7.3. Download data from AMMA \(Application and MicroService Monitor and Analyser\), ResDash \(Resource Dashboard\) and DevDash \(Development Dashboard\) tools](#)
- [TC7.4. From R Studio process to MicroService for IOT application, data analytics, machine learning](#)
- [TC7.5. Developing Data Analytics Processes](#)
- [TC7.6. How to get data from API into R studio](#)
- [TC7.7. How to Save resulting data via API from R studio](#)
- [TC7.8. Example of how to CreateLastValuesMean.R](#)
- [TC7.9. CreateHourlyAvgTrendPerDay.R](#)
- [TC7.10. CreateHeatmap.R](#)
- [TC2.31 - Create Data Analytic Flow](#)
- [TC2.32 - Make Your Data Analytic Flow Public](#)

# *Dynamic Heatmap Exploitation on the Front-End Tools*



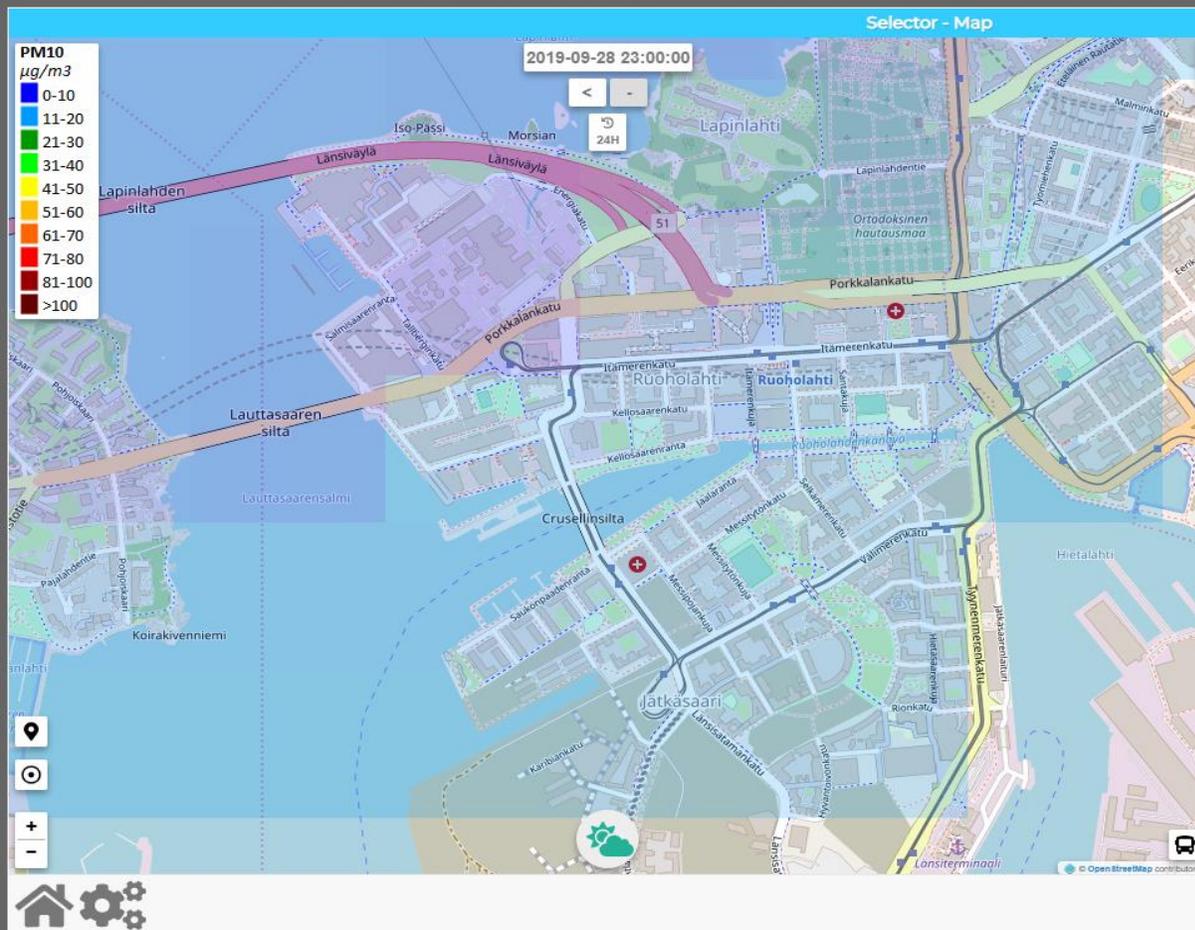
## The Life of Helsinki (H5b)

Please note that the data results are not always based on real data.

Sun 29 Sep 00:42:50

- ▲ Origin Dest. Matrix
- ▲ Typical Trajectories
- ▲ Twitter Vigilance
- ▲ Twitter Vig. Real Time
- ▲ Entertainment Events
- ▲ Shopping: POI
- ▲ Wine and Food: POI
- ▲ Discovery Helsinki
- ▲ Points of Interest
- ▲ 3D view POI
- ▲ Routing on Helsinki
- ▲ Line of Transport
- ▲ Public Transport
- ▲ Air Quality
- ▲ Air Quality Jätkäsaari
- ▲ Weather
- ▲ Forum Discussion

- Documentation
- Survey
- Environment



**Selector - Map**

**+ Ilmanlaatu Heatmap**

**+ Ilmoita PM 10**

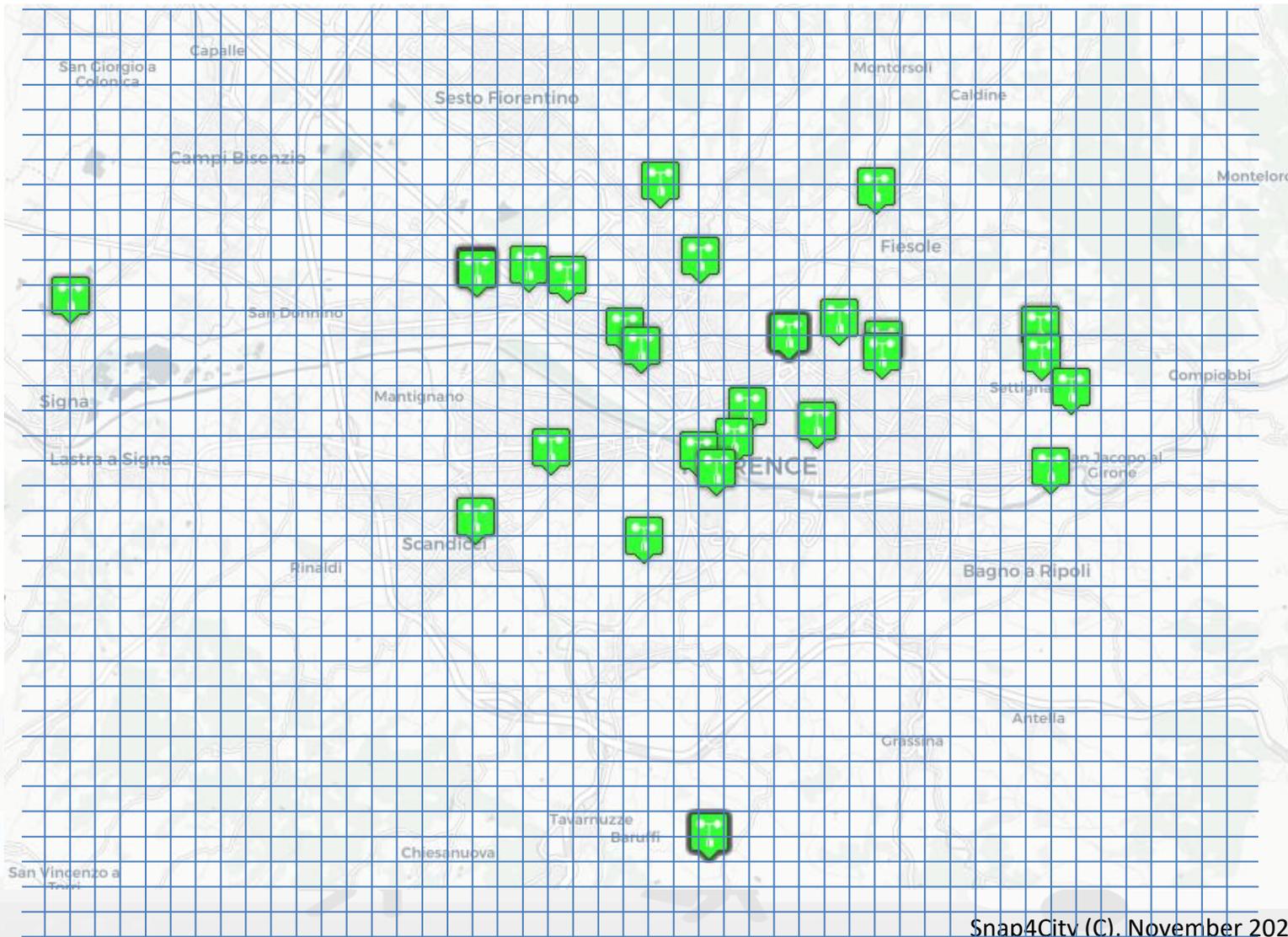
<b>PM 10</b> 9.443 µg/m <sup>3</sup>	<b>PM 2.5</b> 5.855 µg/m <sup>3</sup>
<b>NO2</b> 34.128 µg/m <sup>3</sup>	<b>Helsinki AQI</b> 1.895
<b>LAeq (Noise)</b> 55.831 dbBA	<b>European AQI</b> 1
<b>AQI Enfuser Pred.</b> 1	<b>PM 10 Enfuser Pred.</b> 6.3 µg/m <sup>3</sup>
<b>PM 2.5 Enfuser Pred.</b> 3.7 µg/m <sup>3</sup>	<b>PM 10 GRAL Pred.</b> 1.055 µg/m <sup>3</sup>

**i**



- **Air Quality sensors are**
  - Collected on scattered positions
- **AirQuality Services**
  - AirQuality indicators independent on the sensors' position, in any GPS position of the area
  - **Multiple data:**  $PM_{10}$ ,  $PM_{2.5}$ ,  $CO$ ,  $CO_2$ ,  $SO_2$ ,  $O_3$ ,  $H_2S$ ,  $NO$ ,  $NO_2$ ,  $NO_x$ , air temperature, air humidity, velocity of wind speed, dew point, etc.
- **Applications**
  - Alerting on specific personal GPS locations
  - Constrained routing for: runners, walking with baby, people with pulmonary problems,
  - Control Room Rendering
  - Mobile Phone Rendering, this means to have thousands of users active at the same time, and a reasonable memory consumption in the server.

# The GRID density is never enough

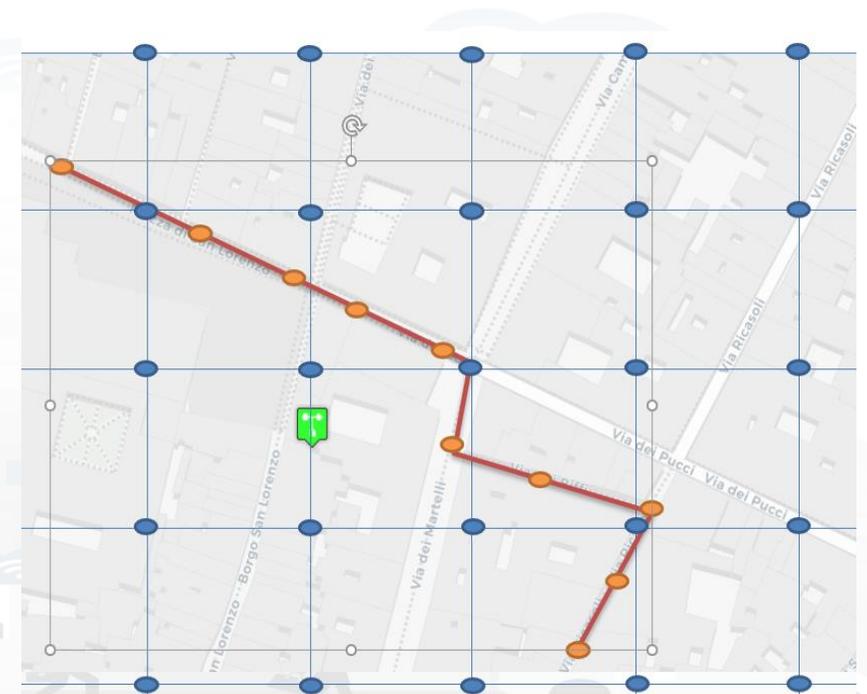


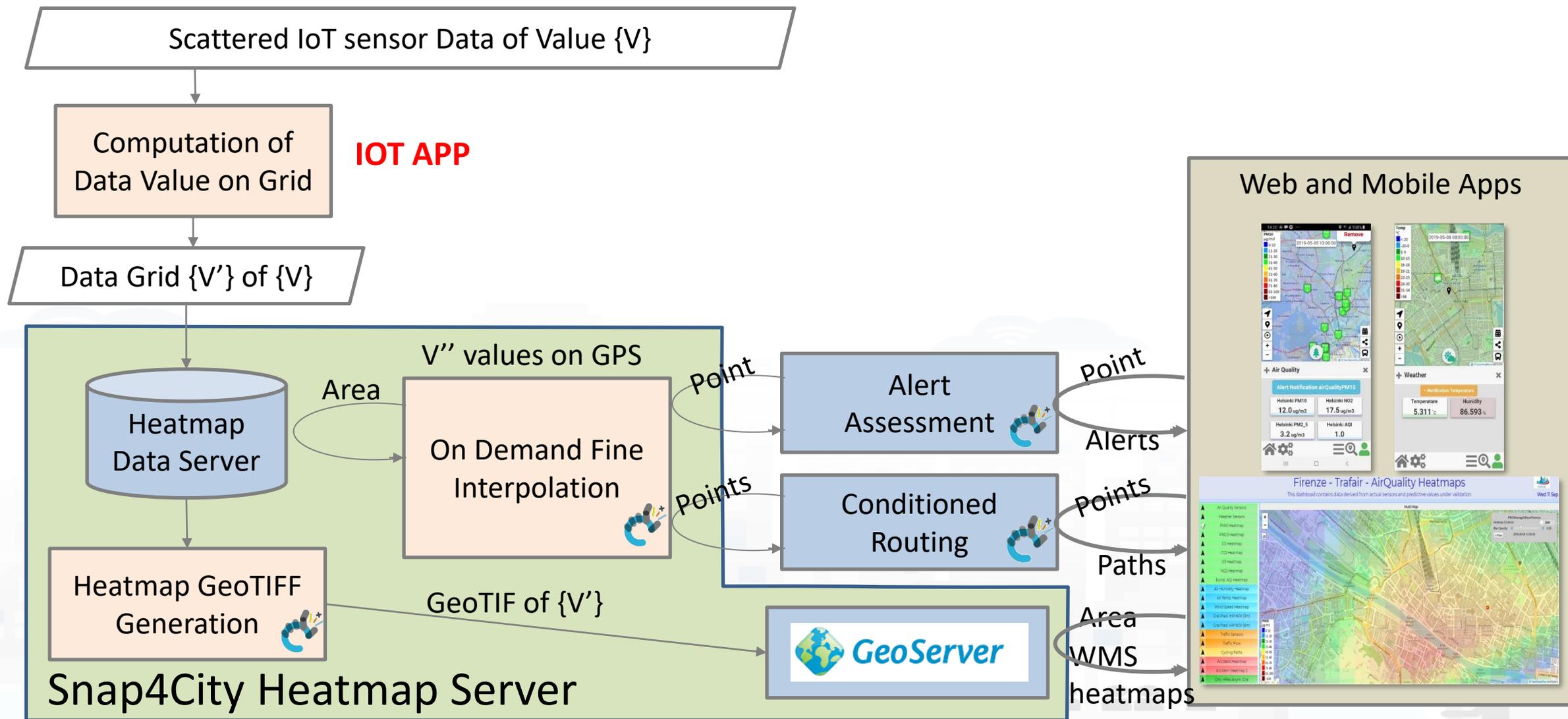
4x4 meters grid is really too expensive

1000x1000 area (small town)

$4 \times 4 \text{ mt} * 10 \text{ variables} * 24 \text{ hours per day}$

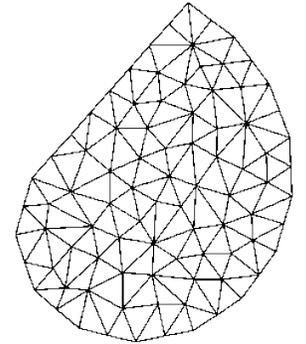
→ 3.8 Billions of data





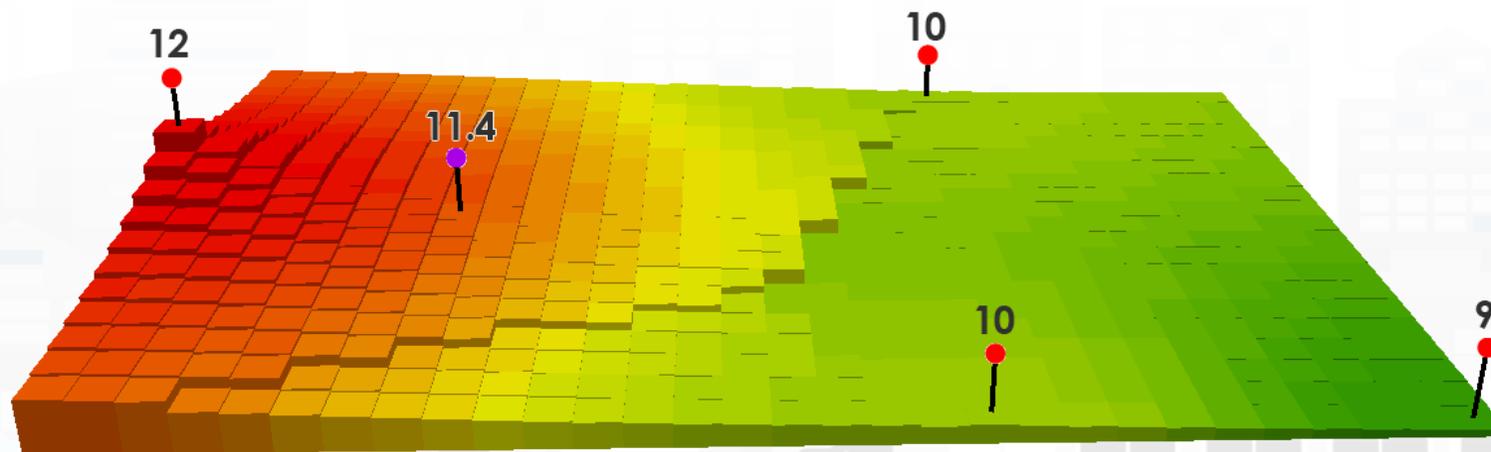
## *Bivariate Interpolation Method [Akima]*

- Steps for irregular data
  - *triangulation* (i.e., partitioning of the area into a number of triangles) of the  $x$ - $y$  plane
  - *selection* of several data points that are closest to each data point (sensor) and are used for estimating the partial derivatives;
  - *organization* of the resulting data with respect to triangle numbers;
  - *estimation* of partial derivatives at each data point;
  - *computation* of the interpolation at each output point.



## Inverse Distance Weighting, IDW Method

- It is a deterministic mathematical method widely used in the geoscience.
  - the interpolated value at the location  $(x, y)$ ;  $z_i$  is the observed value;  $d_i$  is the Euclidean distance between the point  $i$  and the interpolated point; and  $w_i$  is the weight for the point each point  $(x_i, y_i)$  and  $(x, y)$



# Validation via Error Estimation

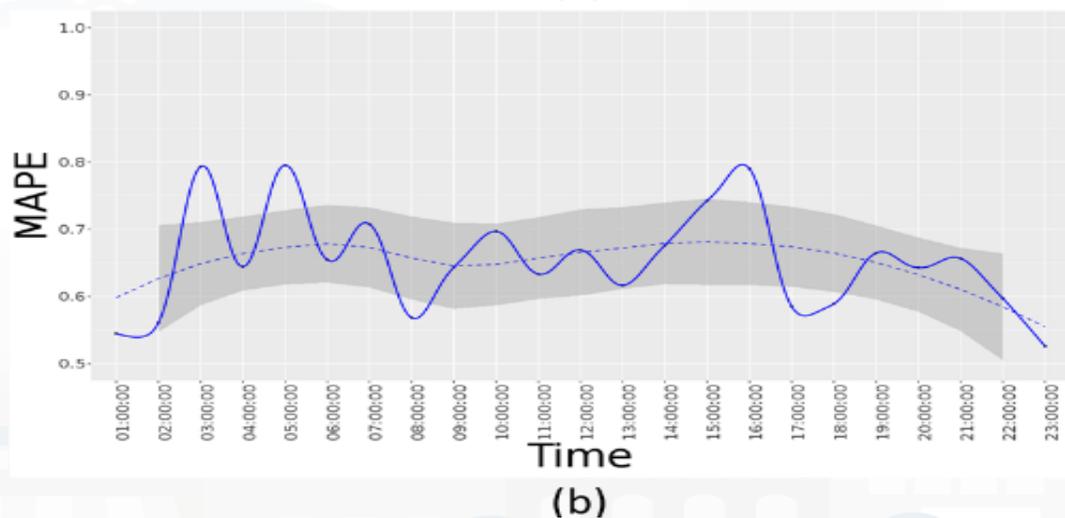
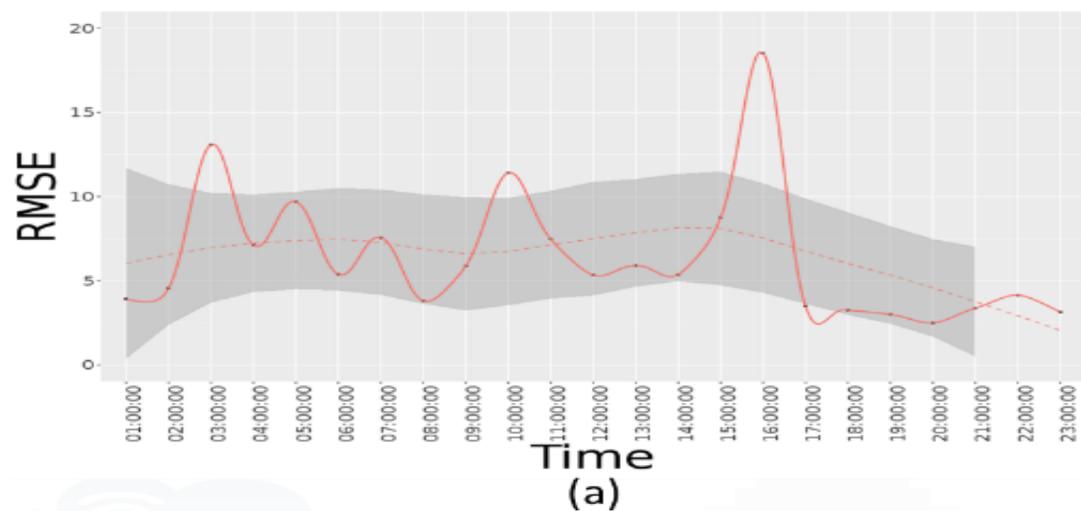
- alternate exclusion of selected air quality sensor in contributing to the model and using the excluded as true value for validation in that point on the basis of the estimation performed exploiting all the others.

Error Measures	Akima	IDW
MAPE	<b>0.69</b>	0.79
RMSE	<b>8.90</b>	12.20
MAPE-we	<b>0.60</b>	0.95
MAPE-wd	<b>0.70</b>	0.93
RMSE-we	<b>8.60</b>	10.70
RMSE-wd	<b>9.70</b>	17.00

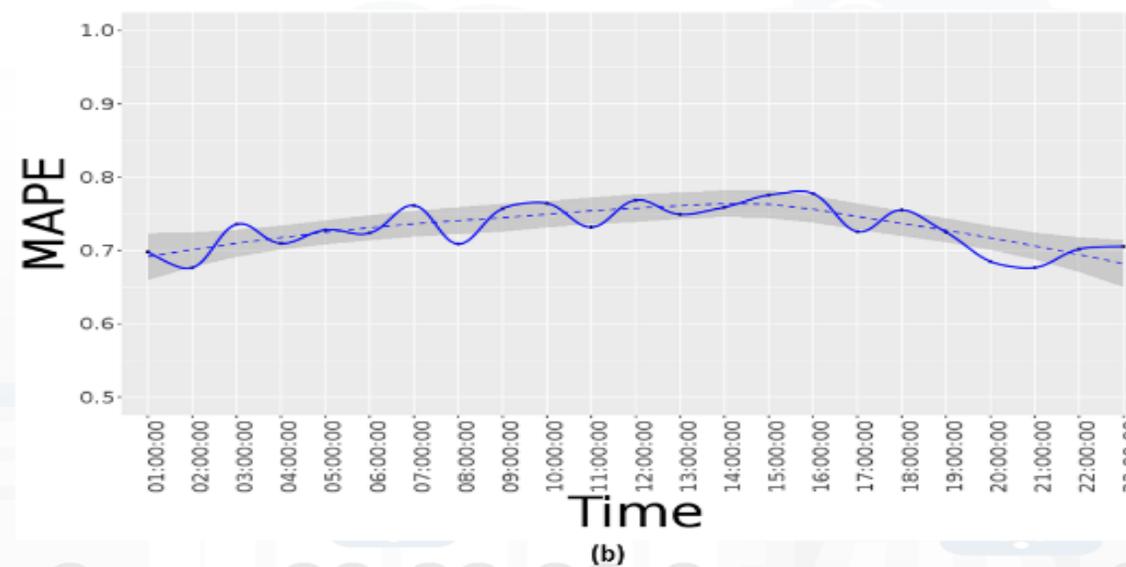
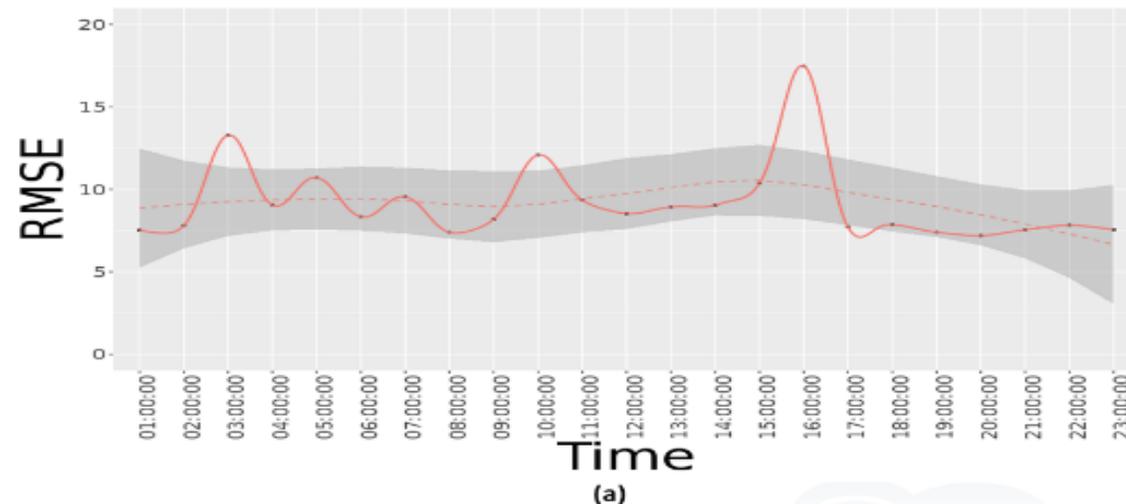
mean absolute percentage error (MAPE)

root mean squared error (RMSE)

# Error Trends



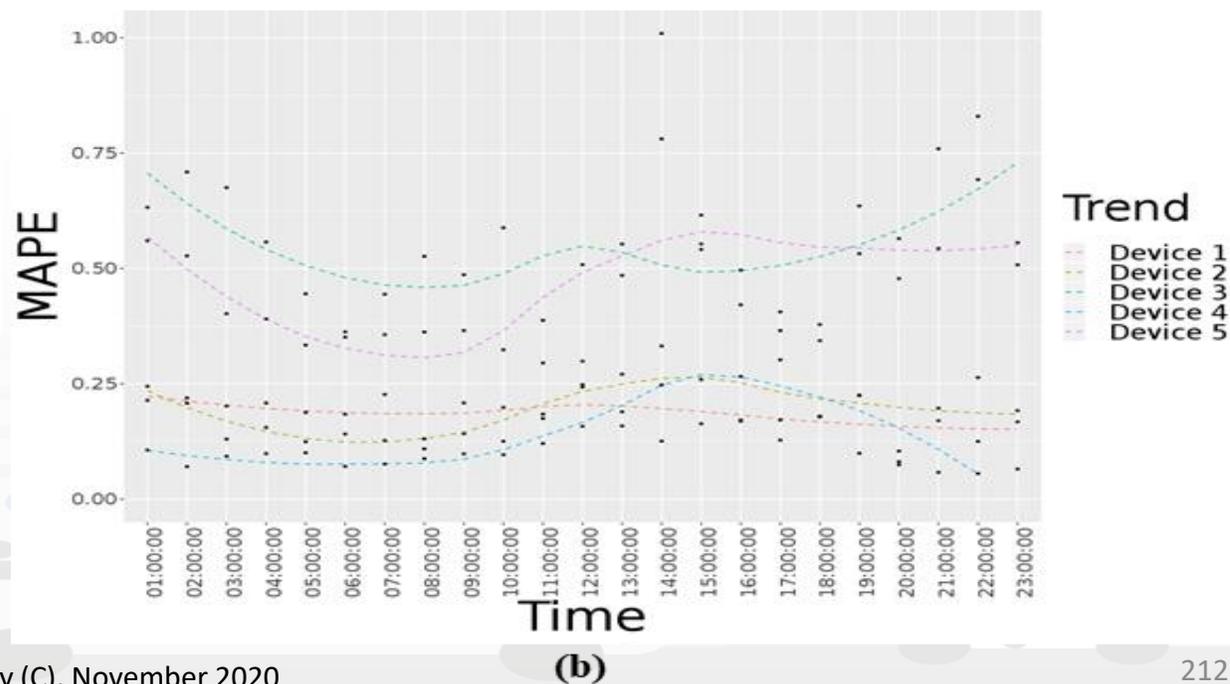
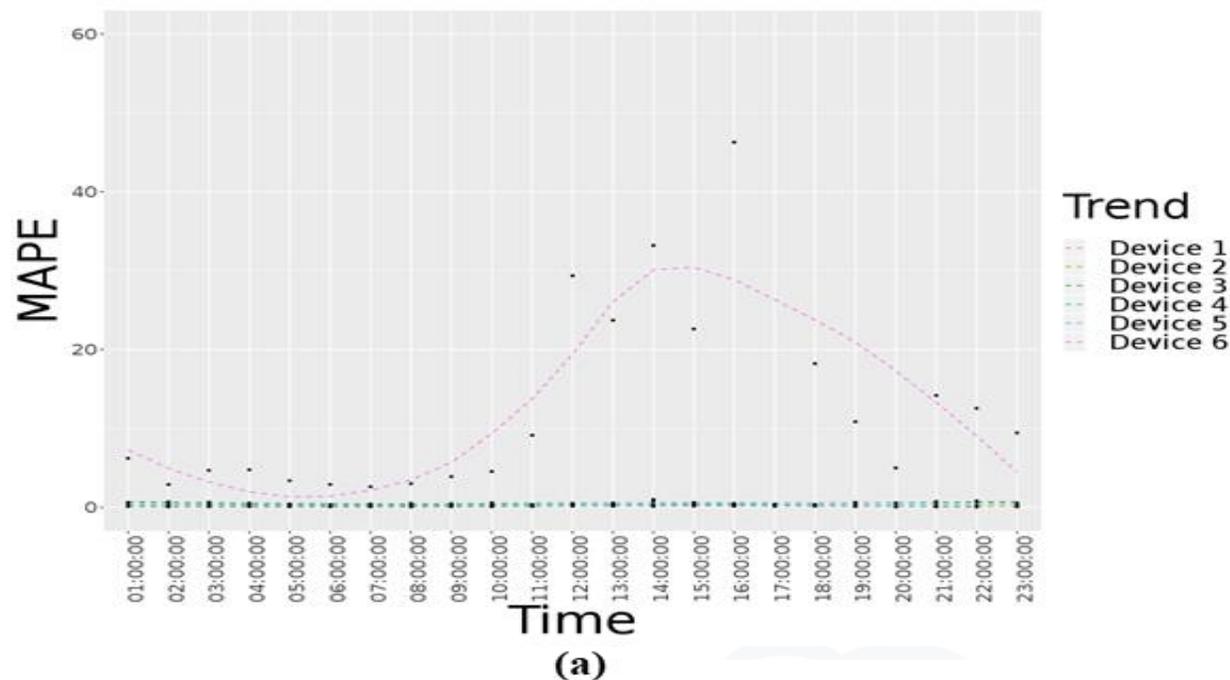
**$PM_{10}$  working days RMSE (a) and MAPE (b) per time slots (Akima Method)**



**$PM_{10}$  working days RMSE (a) and MAPE (b) per time slots (IDW Method)**

# Detecting dysfunction on devices using error detection

- Air Quality  $PM_{10}$  working days interpolation error trends per hour in terms of mean absolute percentage error for
  - (a) six personal devices including the device with a dysfunction;
  - (b) five personal devices



- In order to **satisfy the requirements** reported above:
  - Provide Sensor value in any GPS point, for implementing alerts and other applications (routing), rendering on mobile and control room web pages
- What:
  - Two methods have been implemented
  - A scalable architecture has been defined and implemented to provide these services to several thousands of users
- The selection of the best method has been performed on the basis of and error assessment in which Akima solution has been better ranked.
- The Solution can be also used for detecting eventual dysfunction of specific IOT Devices in the same area, for example for bad positioning, turned off, etc.

# High Density Real-Time Air Quality Derived Services from IoT Networks

- C. Badii, S. Bilotta, D. Cenni, A. Difino, P. Nesi, I. Paoli, M. Paolucci, Sensors, Vol.20, 2020, N.18, ISSN 1424-8220
- DOI 10.3390/s20185435
- <https://www.mdpi.com/1424-8220/20/18/5435/pdf>



*sensors*

an Open Access Journal by MDPI

IMPACT  
FACTOR  
3.275

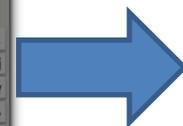
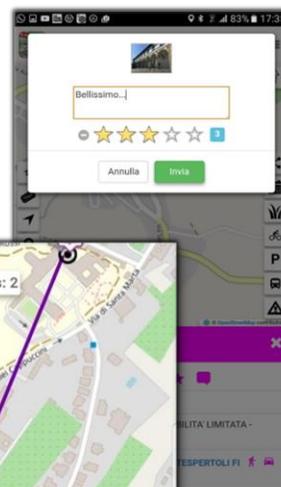
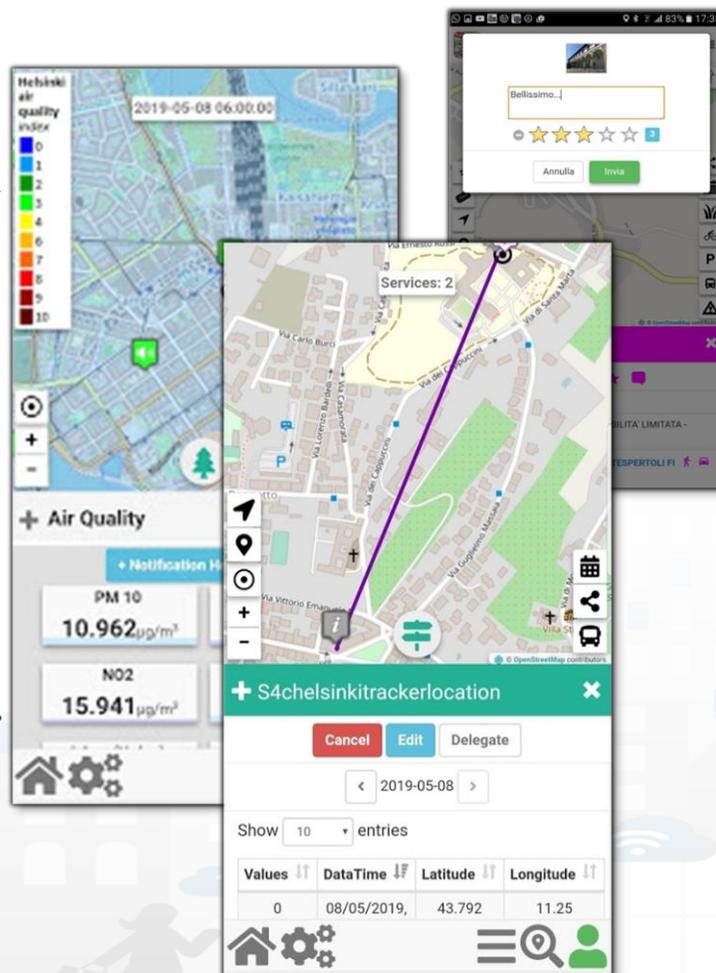
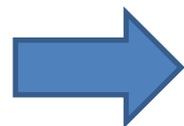


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# The App is a Bidirectional Device

- GPS Positions
- Selections on menus
- Views of POI
- Access to Dashboards
- searched information
- Routing
- Ranks, votes
- Comments
- Images
- Subscriptions to notifications
- ....

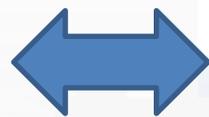


## Derived information

- Trajectories
- Hot Places by click and by move
- Origin destination matrices
- Most interested topics
- Most interested POI
- Delegation and relationships
- Accesses to Dashboards
- **Cumulated Scores from Actions**
- Requested information
- Routing performed
- .....

## Produced information

- Accepted ?
- Performed ?
- ...



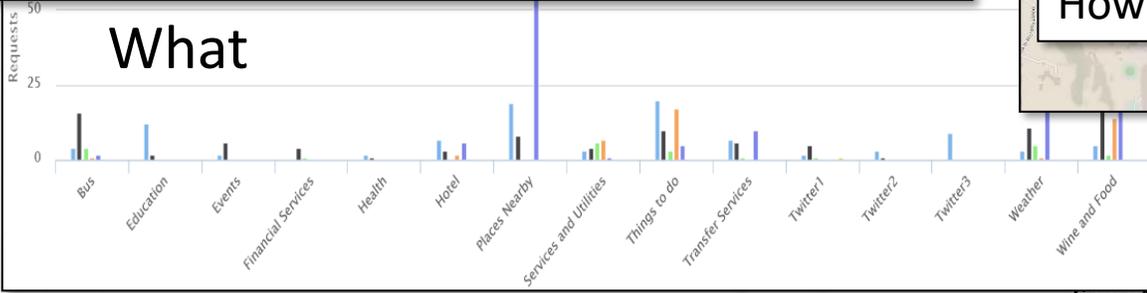
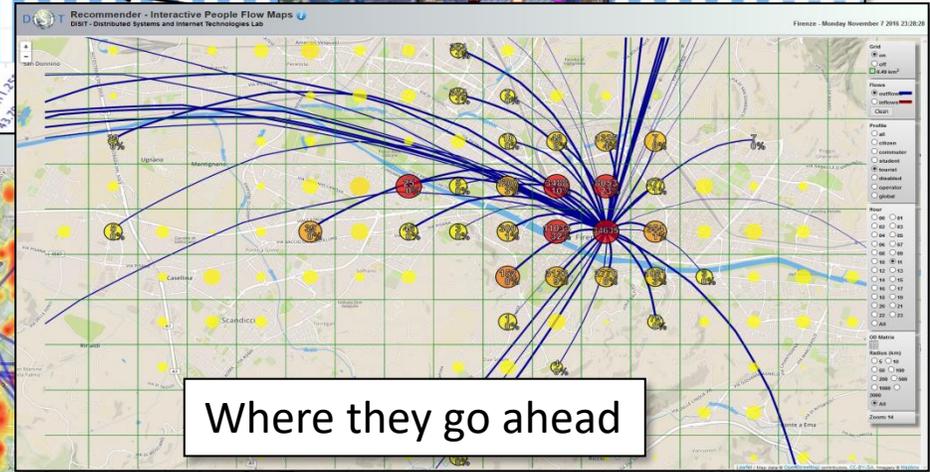
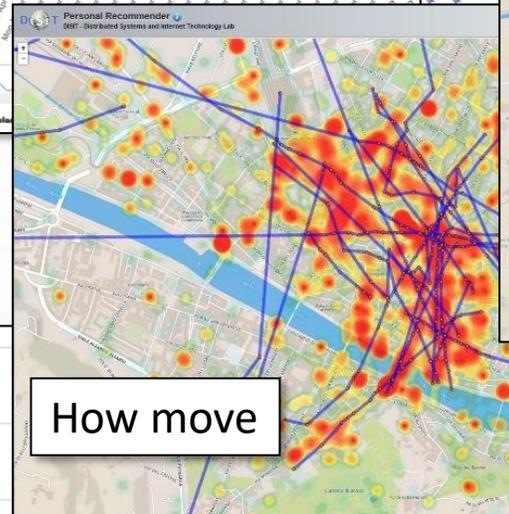
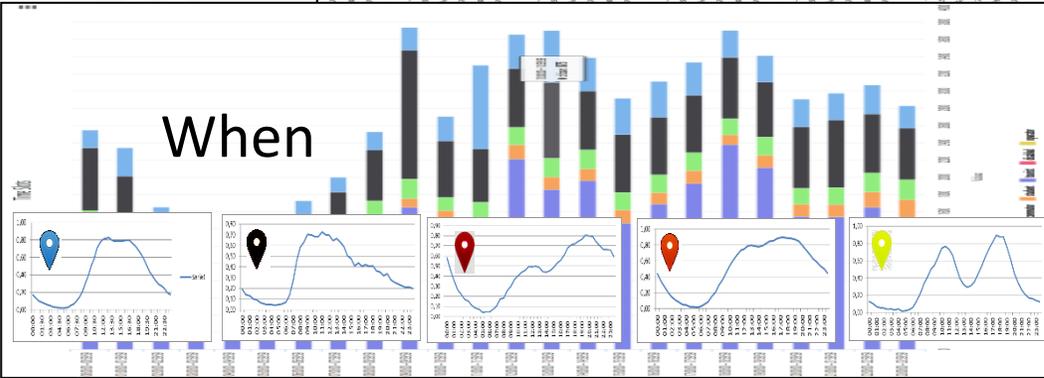
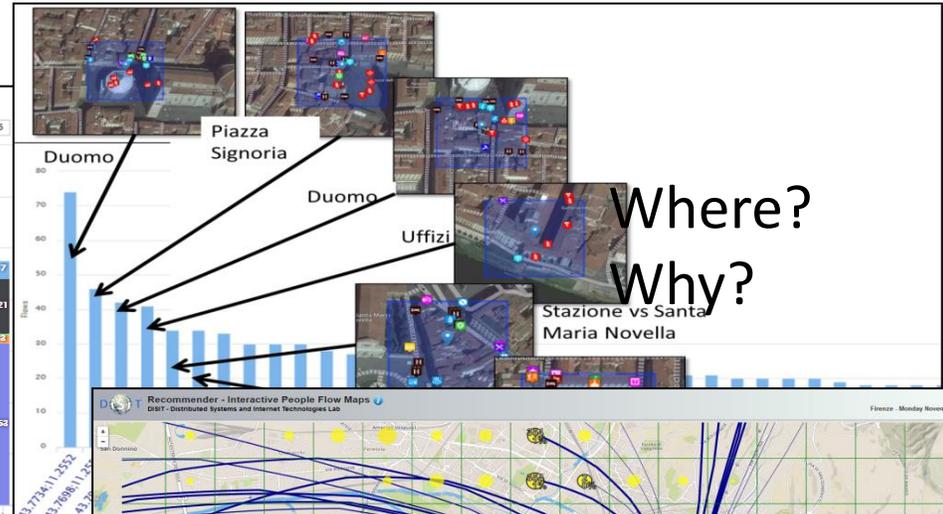
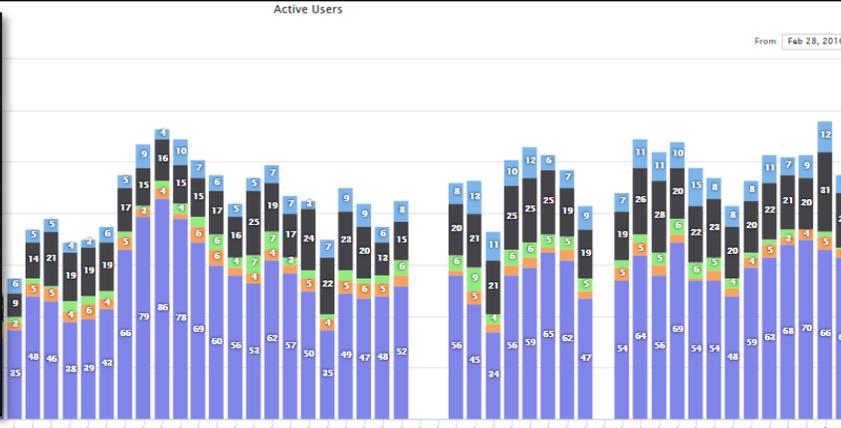
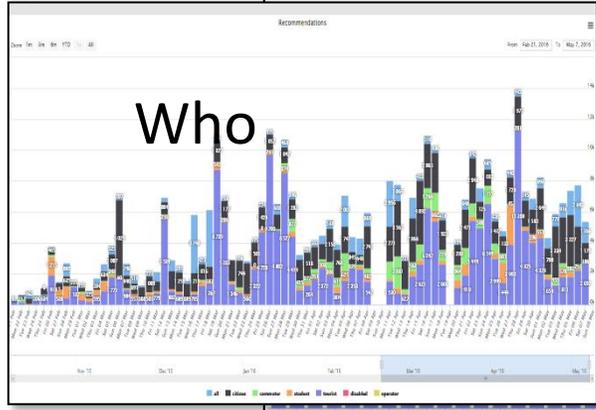
## Produced information

- Suggestions
- Engagements
- Notifications
- ...

Users

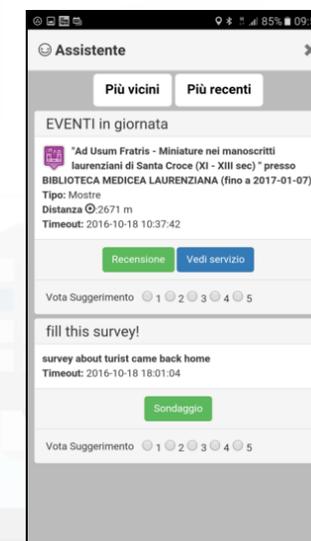
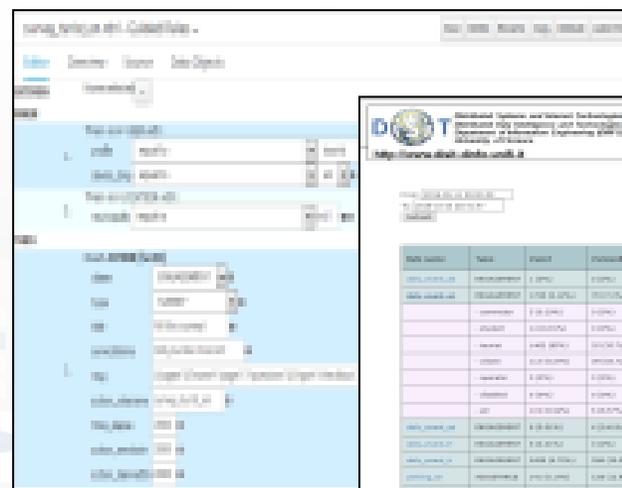
System

# User Behavior Analyser for Collective Profiling

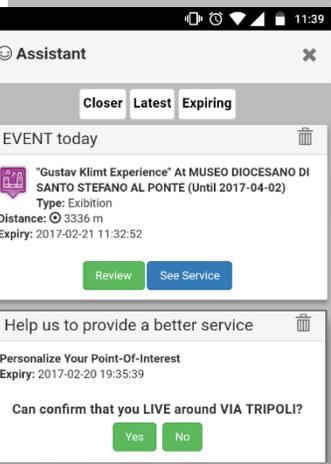
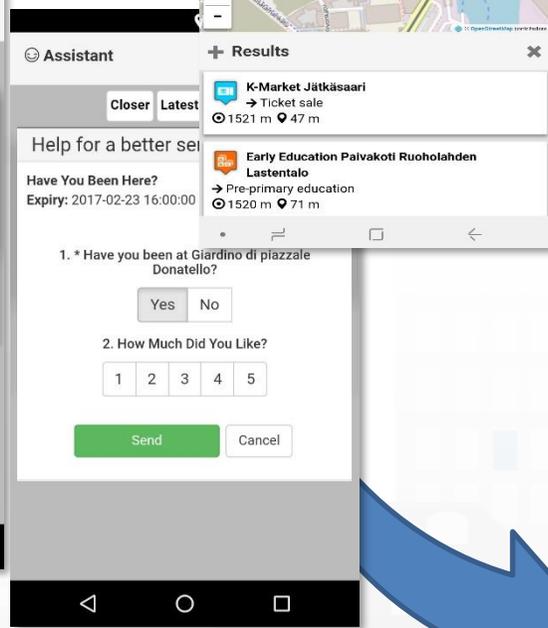
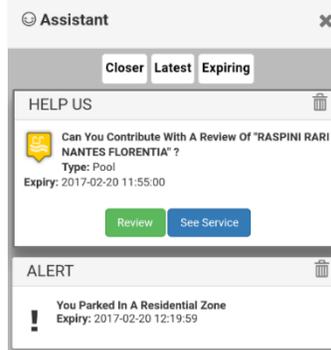
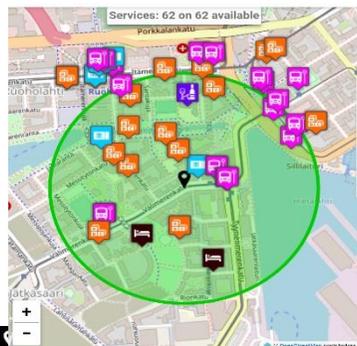
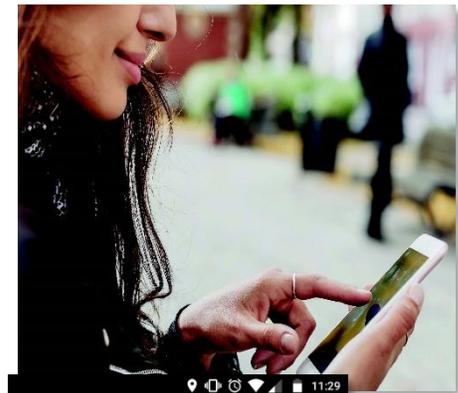


# Profiled Engagements to City Users

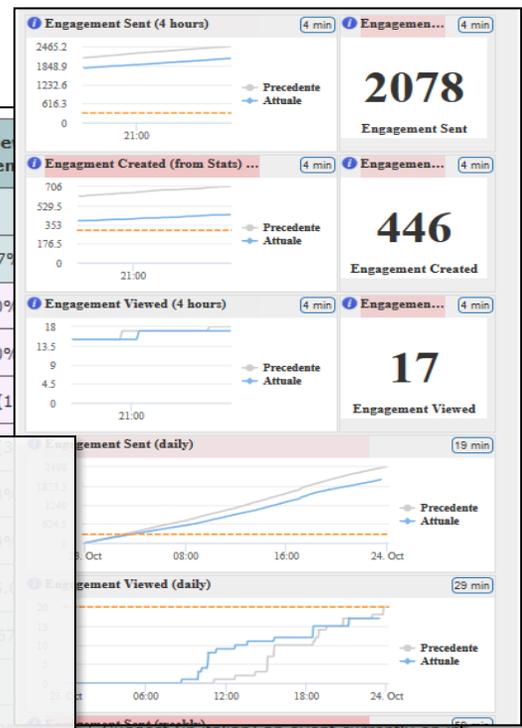
- The users are profiled to learn habits:
  - Personal POI, paths, Mobility habits
- Information and engagements sent to the users are programmed according to the context and user behavior to:
  - Stimulate virtuous habits
  - More sustainable habits
  - More healthy habits, etc.
  - Get feedbacks
  - Provide bonus and prices, .....
  - Send alerts, ....



# Users' Engagement



Rule name	Type	#sent	#viewed	#viewed / #sent
daily_event_de	ENGAGEMENT	1 (0%)	0 (0%)	0%
daily_event_en	ENGAGEMENT	1720 (2.12%)	70 (7.1%)	4.07%
- commuter		5 (0.29%)	0 (0%)	0 (0%)
- student		14 (0.81%)	0 (0%)	0 (0%)
- tourist		1462 (85%)	25 (35.71%)	25 (17.1%)



**Inform**  
Air Quality forecast is not very nice  
You have parked out of your residential parking zone  
The Road cleaning is this night  
The waste in S.Andreas Road is full

**Engage**  
Provide a comment, a score, etc.

**Stimulate / recommend**  
Events in the city, services you may be interested, etc..

**Provide Bonus, rewards if needed**  
you get a bonus since you parked here  
We suggest: leave the car out of the city, this bonus can be used to by a bus ticket

User context

City context

Rules

# Engaging City Users

- **Mobile Applications** can use Advanced Smart City API to collect data about the city usage by the city users via a signed consent
- It can be used for sending engagements to them such as to:
  - **Inform**
    - You have parked out of your residential parking zone
    - The Road cleaning is this night
    - The waste in S.Andreas Road is full
  - **Engage**
    - Please Provide a comment, a score, etc.
  - **Stimulate / recommend**
    - Events in the city, services you may be interested, etc..
  - **Provide Bonus**
    - Since you have parked here you can get 1 Bonus
    - We suggest you to leave the car out of the city, this bonus can be used to buy a bus ticket



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<http://www.disit.org>

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Carnet multicorsa Cap e  
voucher per:

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trasp  
Scari  
guad  
autol  
Per n  
il sito

# Sii smart. Sii-Mobility!

## Scarica, viaggia, vinci!

Dal 15 aprile al 15 luglio scegliere il  
trasporto pubblico ti premia!  
Scarica l'app "Toscana dove, cosa",  
guadagna punti viaggiando in  
autobus e vinci tanti fantastici premi!  
Per maggiori informazioni visita  
il sito [info.sii-mobility.org](http://info.sii-mobility.org)



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TECHNOLOGIES LAB

## In palio per te

Carnet multicorsa Cpt e  
voucher per:



*Ci Prendiamo cura del tuo benessere*



# Sii smart. Sii-Mobility!

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# REWARDING'S RULES



## • ASSISTANCE

- If public transport is detected after bus line suggestion on trajectory usually made on private transport → 10points
  - Why don't you take the bus line 4 in Piazza Marconi to reach your workplace? You save money, you respect the environment and you will be stress free for not worry about parking!
- Once a day, if public transport is detected after suggestion on an alternative bus line availability → 3points
  - Why don't you take the bus line 4 that stop just 50 meters far from you? You save money, you respect the environment and you will be stress free for the traffic jam!
- If public transport is detected for at least 30(?) minutes a day → 1point

## • ENGAGEMENT

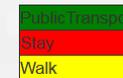
- Survey on commuter and their preferred way of mobility → 1point
  - How many minutes you usually commute to go to work?  
How do you rate the service?
- Feedback on public transport → 1point
  - Which current public transport are you using? Are the service in line with your expectation?
- Comments/Photo/Rate or survey on POI (public transport) → 1point
- Survey on use of the App after N days or for tourist coming home → 1point
- Feedback on PPOI or mobility → 1point

# WALLET / PROFILE

- On homepage
  - How many points have been distributed?
  - How many rewards has been already delivered?
  - How many rewards are still available?
  - How many CO2 has been saved?
  - How many km our users made this week?



PrivateTransport  
Stay



From: 2016-08-01 00:00:00

To: 2017-05-26 11:19:52

Refresh

# CURRENT NUMBERS

- 50 engagement's rules in 5 languages
  - (surveys, feedbacks, suggestions, assistances)
- From 1° September 2016
  - Produced 322.900 engagements on 4270 users
- From 1° July 2017
  - 233 registered users with email (154 via social)

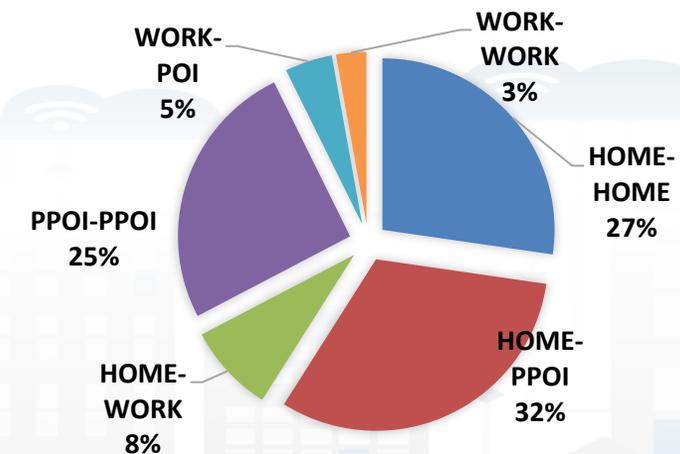
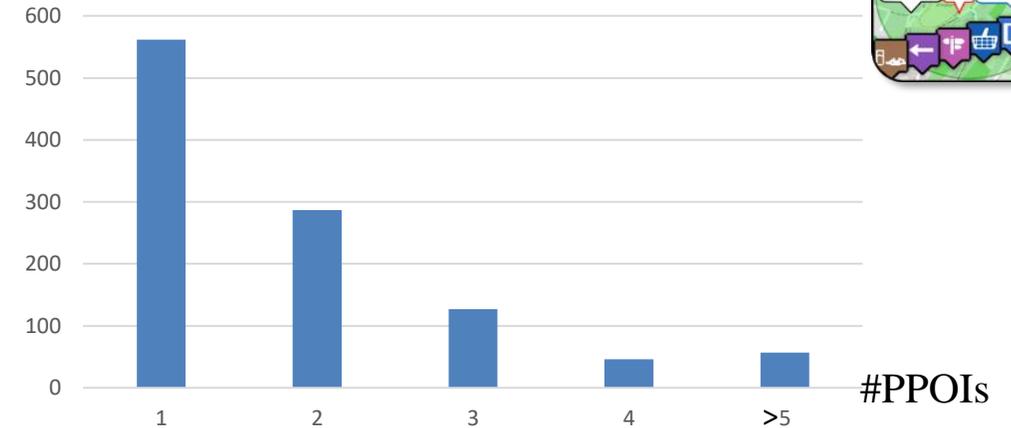
Rule name	Type	#sent	#viewed	#viewed on #sent	#executed	#executed on #viewed	Description
confirm_ppoi_home_de	ENGAGEMENT	4 (0%)	1 (0.03%)	25%	0 (0%)	0%	Ask (in german) a confirmation of the position of user's HOME
confirm_ppoi_home_en	ENGAGEMENT	90 (0.03%)	0 (0%)	0%	0 (0%)	0%	Ask (in english) a confirmation of the position of user's HOME
confirm_ppoi_home_es	ENGAGEMENT	13 (0.01%)	1 (0.03%)	7.69%	1 (1.04%)	100%	Ask (in spanish) a confirmation of the position of user's HOME
confirm_ppoi_home_fr	ENGAGEMENT	1 (0%)	0 (0%)	0%	0 (0%)	0%	Ask (in french) a confirmation of the position of user's HOME
confirm_ppoi_home_it	ENGAGEMENT	1794 (0.69%)	97 (2.97%)	5.41%	16 (16.67%)	16.49%	Ask (in italian) a confirmation of the position of user's HOME
confirm_ppoi_school_it	ENGAGEMENT	45 (0.02%)	1 (0.03%)	2.22%	1 (1.04%)	100%	Ask (in italian) a confirmation of the position of user's SCHOOL
confirm_ppoi_work_en	ENGAGEMENT	15 (0.01%)	0 (0%)	0%	0 (0%)	0%	Ask (in english) a confirmation of the position of user's WORK
confirm_ppoi_work_it	ENGAGEMENT	368 (0.14%)	37 (1.13%)	10.05%	7 (7.29%)	18.92%	Ask (in italian) a confirmation of the position of user's WORK
daily_event_de	ENGAGEMENT	105 (0.04%)	19 (0.58%)	18.1%	0 (0%)	0%	Suggest (in german) an event currently on in Florence
daily_event_en	ENGAGEMENT	2115 (0.81%)	66 (2.02%)	3.12%	0 (0%)	0%	Suggest (in english) an event currently on in Florence
parking_it	ASSISTANCE	659 (0.25%)	75 (2.3%)	11.38%	0 (0%)	0%	Alert (in italian) if the user parked in a residential parking zone
shoot_a_photo_de	ENGAGEMENT	604 (0.23%)	4 (0.12%)	0.66%	0 (0%)	0%	Ask (in german) a contribution for a nearby point-of-interest
shoot_a_photo_en	ENGAGEMENT	11159 (4.29%)	37 (1.13%)	0.33%	0 (0%)	0%	Ask (in english) a contribution for a nearby point-of-interest
shoot_a_photo_es	ENGAGEMENT	2140 (0.82%)	11 (0.34%)	0.51%	1 (1.04%)	9.09%	Ask (in spanish) a contribution for a nearby point-of-interest
shoot_a_photo_fr	ENGAGEMENT	2880 (1.11%)	4 (0.12%)	0.14%	0 (0%)	0%	Ask (in french) a contribution for a nearby point-of-interest
shoot_a_photo_it	ENGAGEMENT	216479 (83.29%)	976 (29.88%)	0.45%	14 (14.58%)	1.43%	Ask (in italian) a contribution for a nearby point-of-interest
spent_time_en	ENGAGEMENT	53 (0.02%)	14 (0.43%)	26.42%	0 (0%)	0%	Ask (in english) a confirmation of the position of user's POI
spent_time_it	ENGAGEMENT	1192 (0.46%)	175 (5.36%)	14.68%	15 (15.63%)	8.57%	Ask (in italian) a confirmation of the position of user's POI
- commuter		24 (2.01%)	2 (1.14%)	8.33%	0 (0%)	0%	
- student		131 (10.99%)	11 (6.29%)	8.4%	2 (13.33%)	18.18%	
- tourist		238 (19.97%)	59 (33.71%)	24.79%	0 (0%)	0%	
- citizen		665 (55.79%)	122 (69.71%)	18.35%	10 (66.67%)	8.2%	
- operator		26 (2.18%)	5 (2.86%)	19.23%	1 (6.67%)	20%	
- all		155 (13%)	23 (13.14%)	14.84%	2 (13.33%)	8.7%	
survey_turist_de	ENGAGEMENT	179 (0.07%)	15 (0.46%)	8.38%	1 (1.04%)	6.67%	Propose (in german) a survey to tourist after they left Florence
survey_turist_en	ENGAGEMENT	966 (0.37%)	13 (0.4%)	1.35%	2 (2.08%)	15.38%	Propose (in english) a survey to tourist after they left Florence
survey_turist_es	ENGAGEMENT	115 (0.04%)	2 (0.06%)	1.74%	0 (0%)	0%	Propose (in spanish) a survey to tourist after they left Florence
survey_turist_fr	ENGAGEMENT	51 (0.02%)	2 (0.06%)	3.92%	0 (0%)	0%	Propose (in french) a survey to tourist after they left Florence
survey_turist_it	ENGAGEMENT	1006 (0.39%)	42 (1.29%)	4.17%	6 (6.25%)	14.29%	Propose (in italian) a survey to tourist after they left Florence



# CURRENT NUMBERS

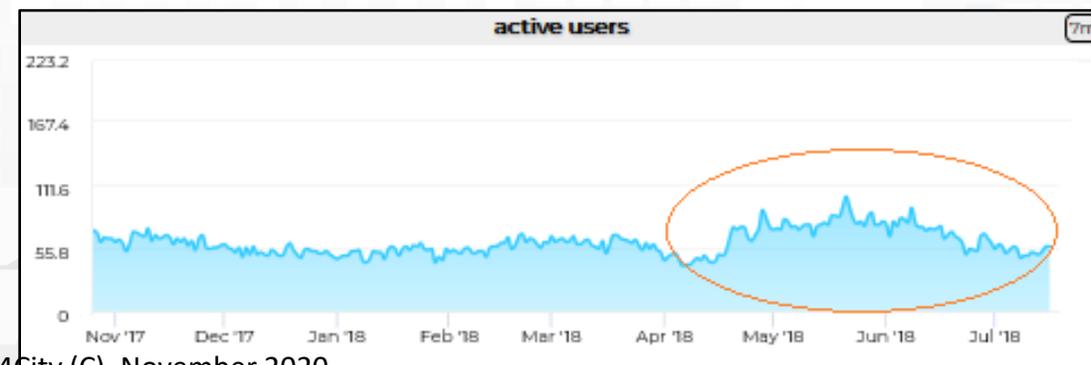
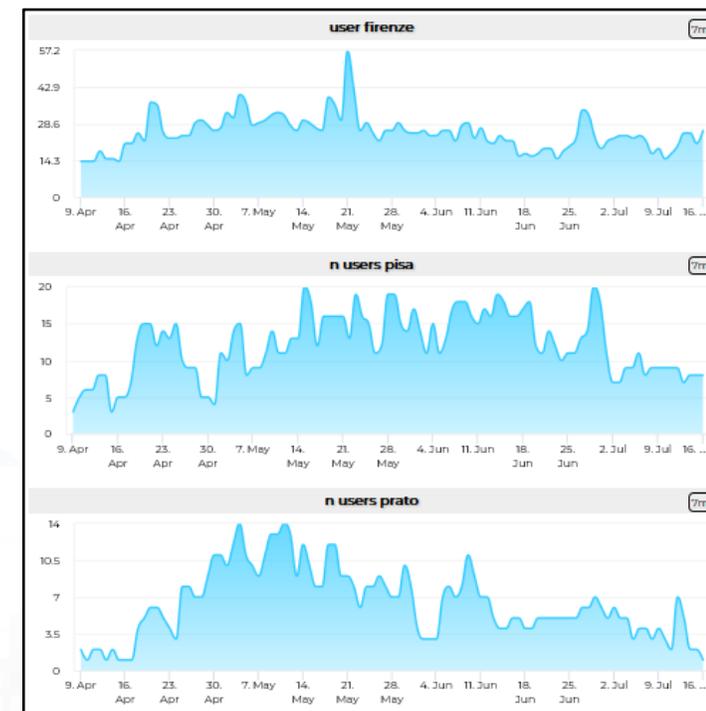
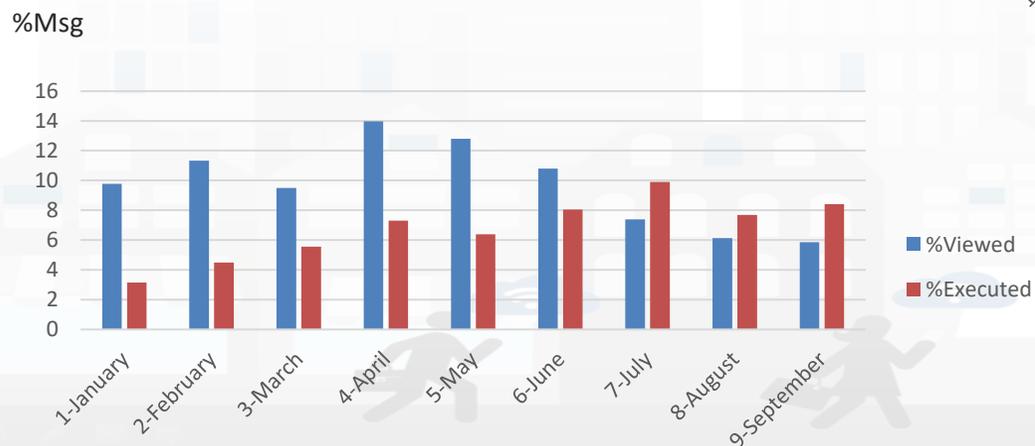
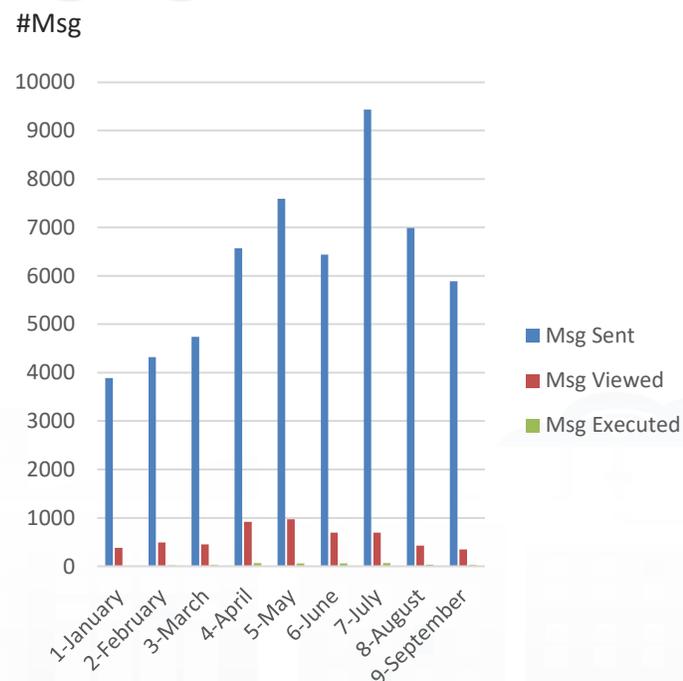
- From 1° September 2016
  - Detected 2108 PPOIs on 1080 users
    - 437 HOME
    - 285 WORK
    - 34 SCHOOL
    - 1350 EXTRA
  - 130 PPOIs are feedbacked
  - 460 survey responses
- From 1° August 2017
  - Built 524 Markov Networks about user's trajectories

Number of users with #PPOIs



# Validation of user Engagement

Months	Msg Sent	Msg Viewed	Msg Executed
1-January	3888	380	12
2-February	4319	489	22
3-March	4739	450	25
4-April	6567	918	67
5-May	7594	972	61
6-June	6437	695	55
7-July	9432	697	69
8-August	6988	429	73
9-September	5885	345	49
Total	55849	5375	433



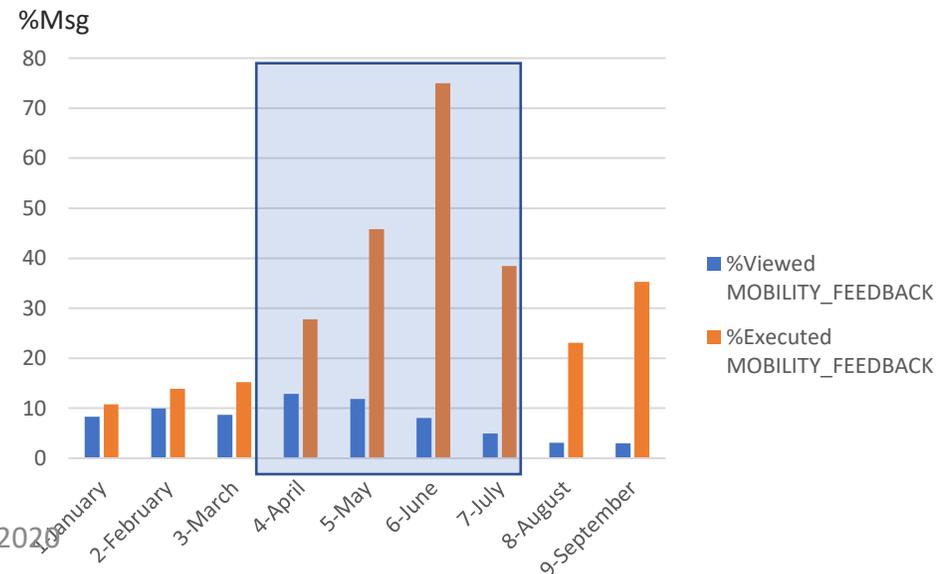
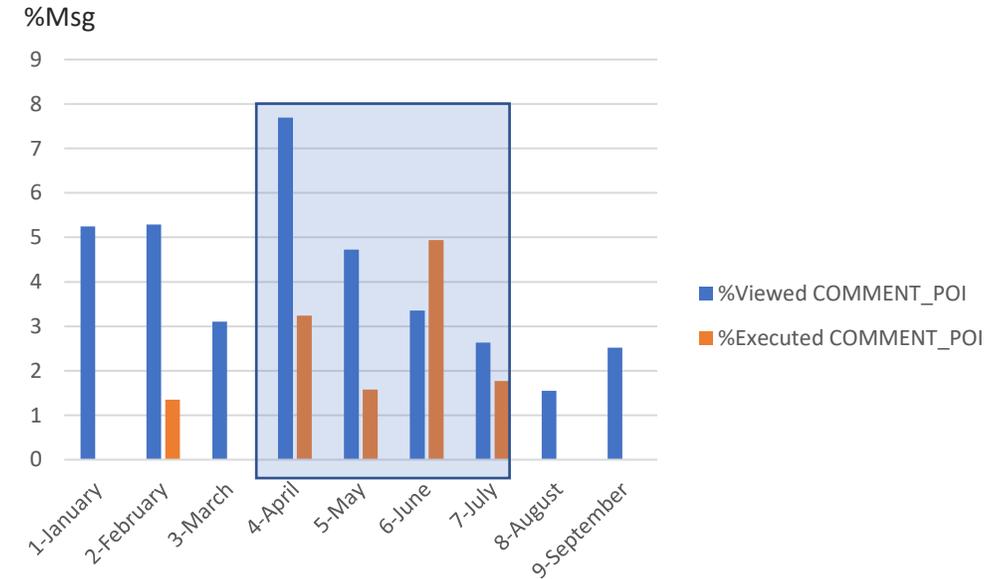
# User Behaviour Analysis



## VALIDATION

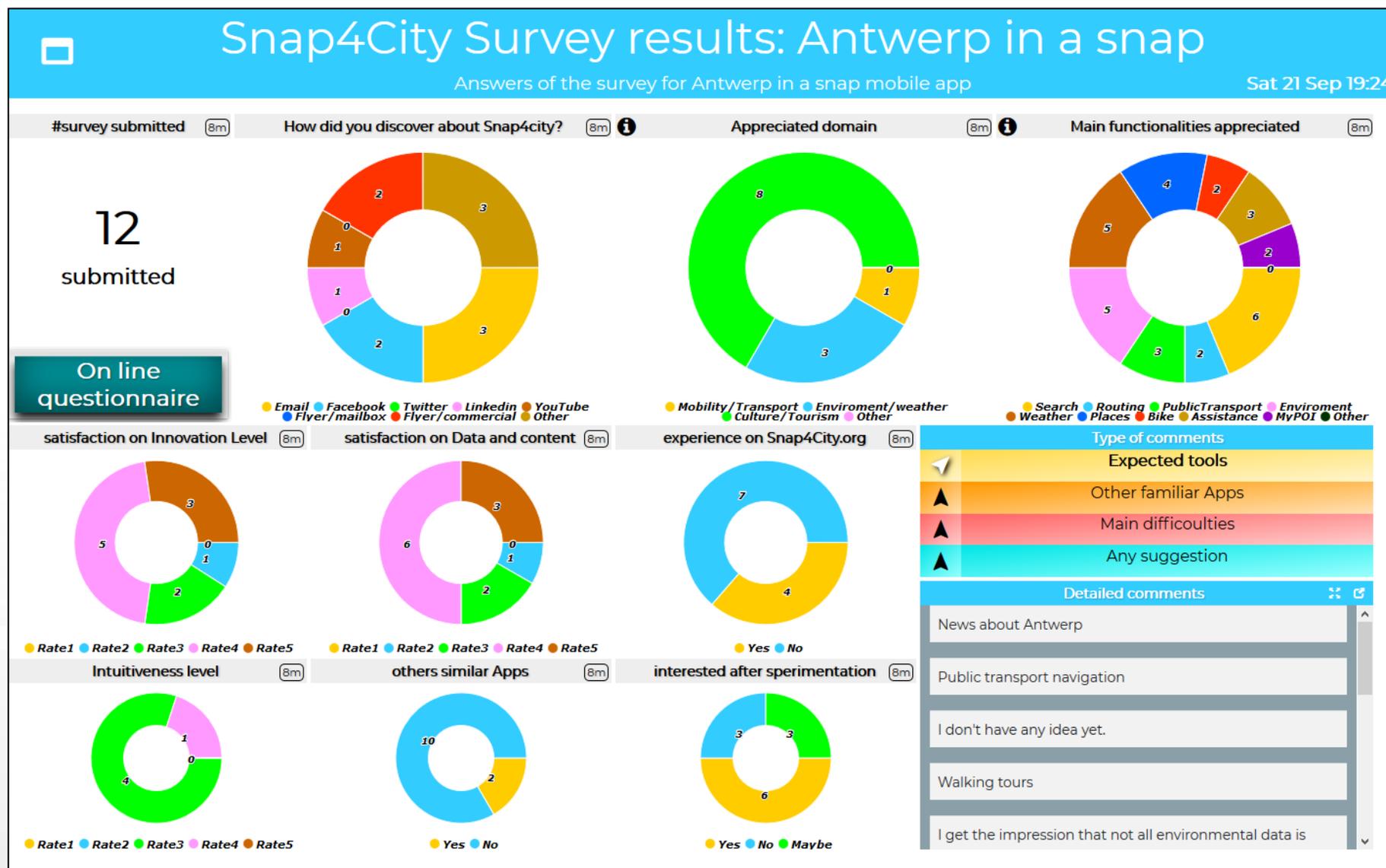
- During the PILOT new rules has been added (30 on a total of 80) and mostly all of them are still online
- COMMENT\_POI: requires more user interaction and not very contextualized (POI proximity) → higher rate of sent, lower rate on execution
- MOBILITY\_FEEDBACK: requires less user iteration and very contextualized (user in MOBILITY) → normal rate of sent, high rate on execution

	Msg Sent	Msg Viewed	Msg Executed
COMMENT_POI	21632	804	15
MOBILITY_FEEDBACK	5378	371	94



<https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MTc2OQ==>

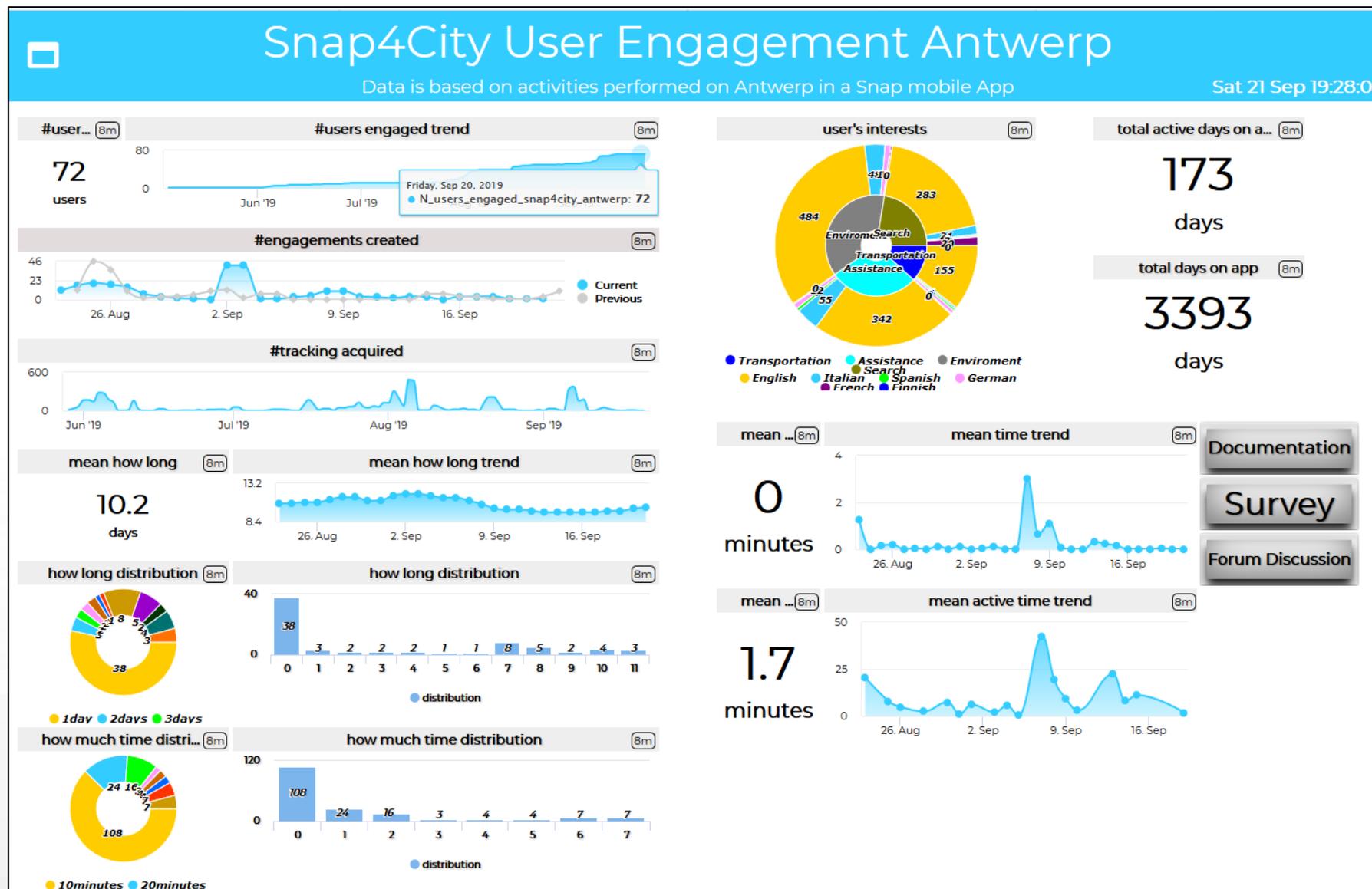
Dashboard  
created to monitor  
in real time the  
answers to the  
survey provided  
on the Mobile  
App directly by the  
Engagement tool



<https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MTc10Q==>

## Dashboard monitoring the Mobile App:

- Collecting the clicks
- Describing the community of users in terms of the profile aspects
- Measuring the time spend, and topics of interest of the users, etc.



TOP

# DECISION SUPPORT SYSTEM AND CITY RESILIENCE

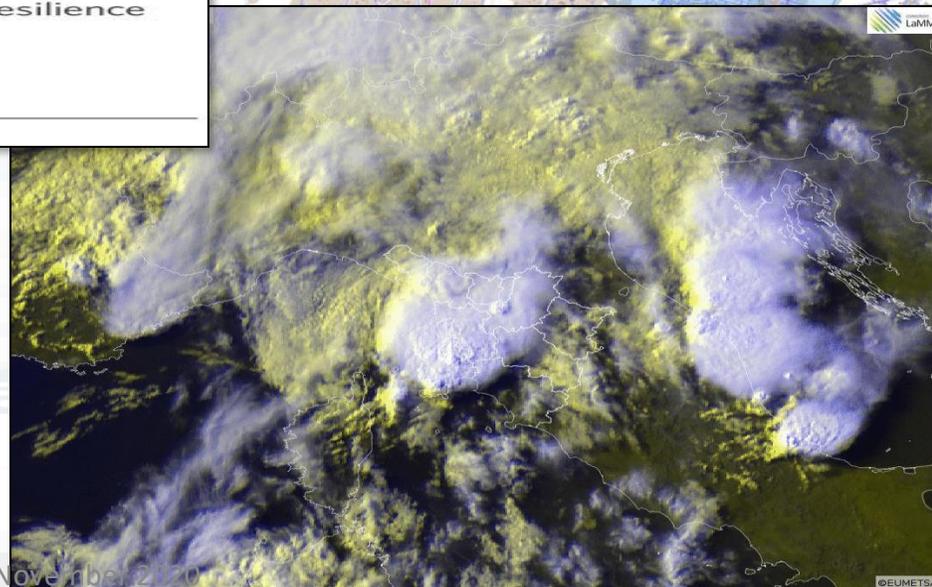
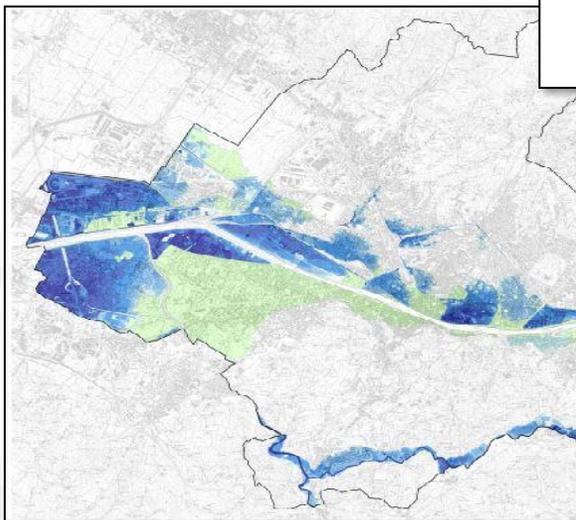
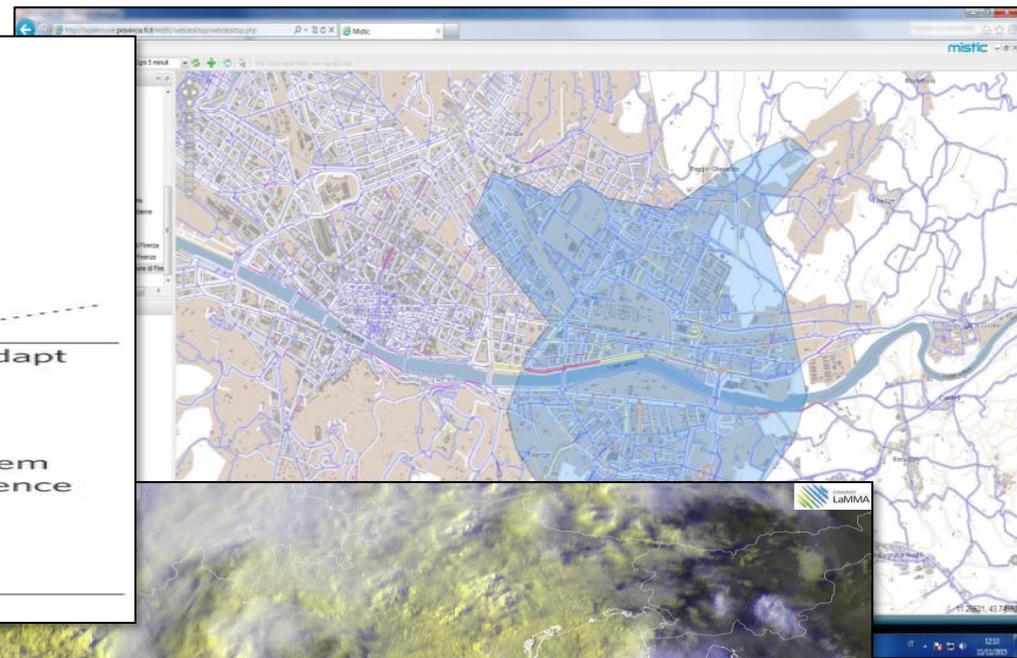
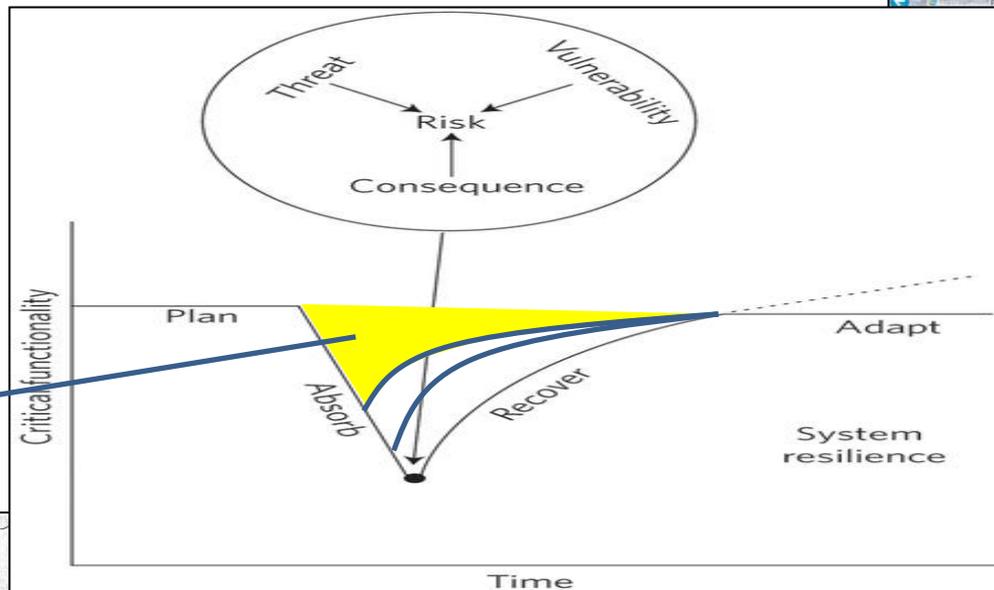




# Early Warning, Detection

**P**repare  
**A**bsorb  
**R**ecover  
**A**dapt

damage



# Early Warning, Detection

## Issue:

- Detection of critical condition
- Not easily detected with other means

**P**repare  
**A**bsorb  
**R**ecover  
**A**dapt

## Impact:

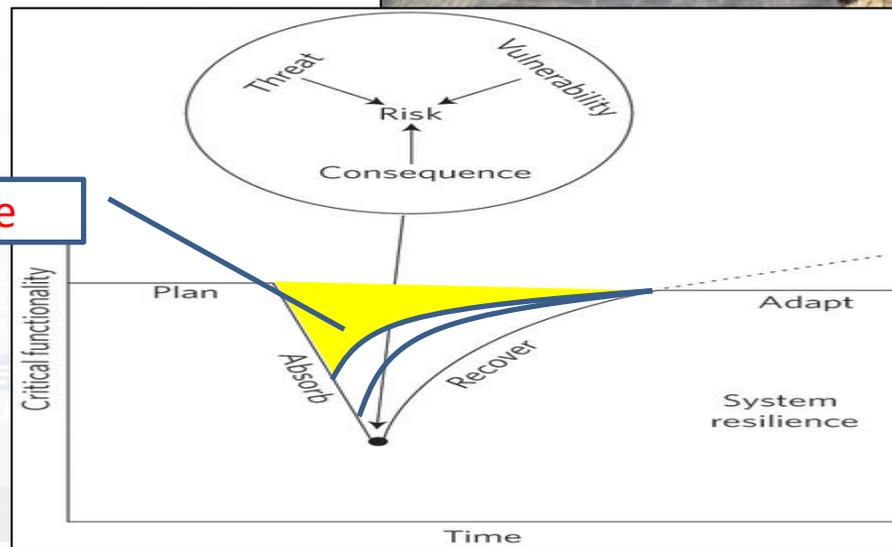
- Early warning, faster reaction
- Increased resilience

## Several metrics related to:

- Volume of retweets
- Sentiment analysis



damage



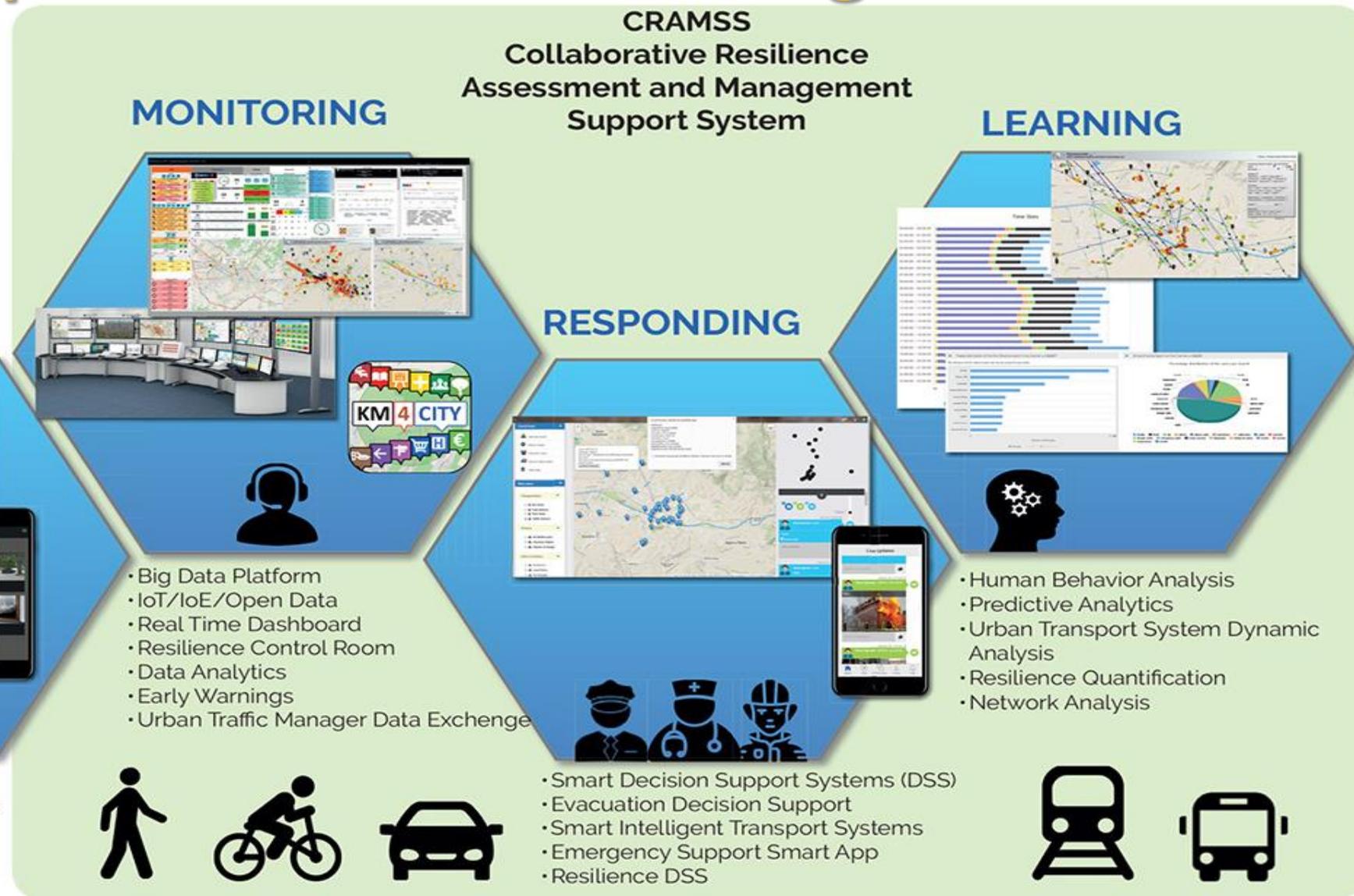
# Main Approach

- Three main layers
- Complex System modeling: function, processes, resources, time, events, etc.
  - Functional Resonance Analysis Method, FRAM
  - Resilience Analysis Grid, RAG
- Decision Support System, DSS
  - System Thinking, Goal Models
  - Risk analysis
  - UTS/ITS decision supports
- Data, big data access and exploitation
  - Data Analytics, Internet of Things, sensors, flows
  - People flow and behavior
  - Social Media



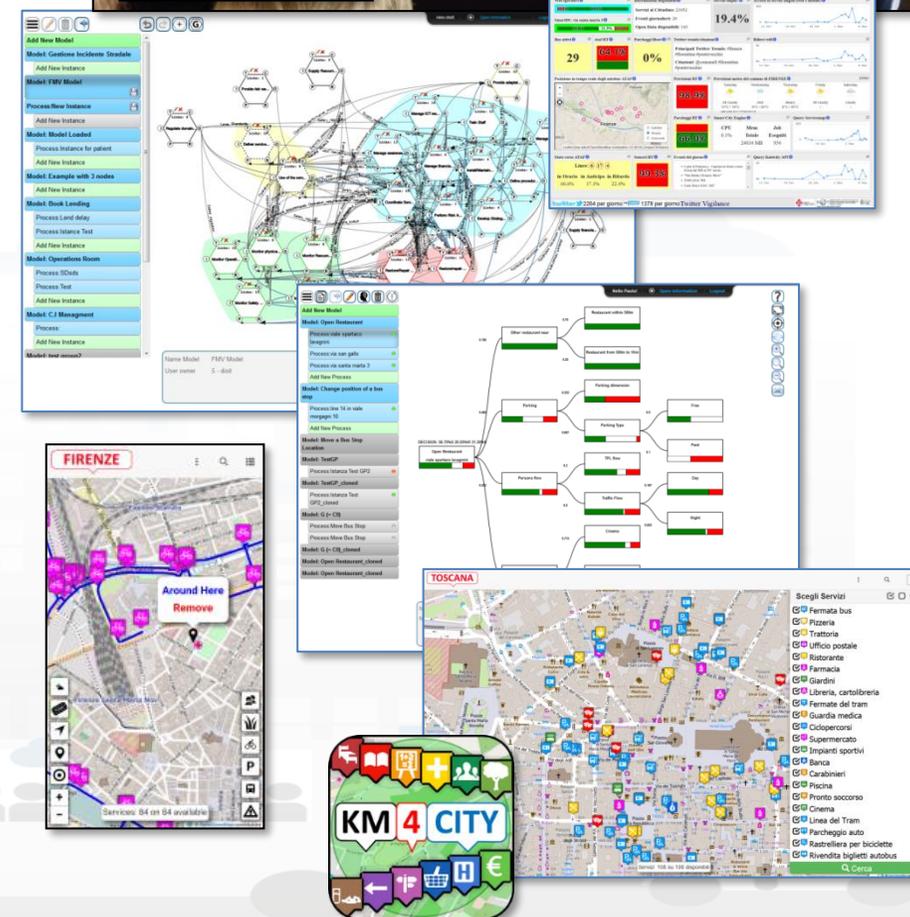
# ERMIG: European Resilience Management Guide

<http://www.resolute-eu.org/>

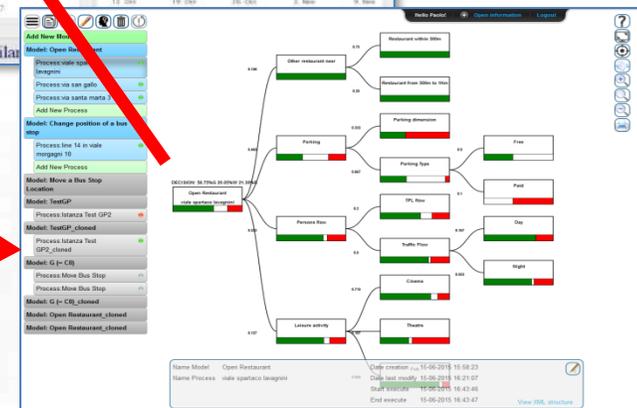
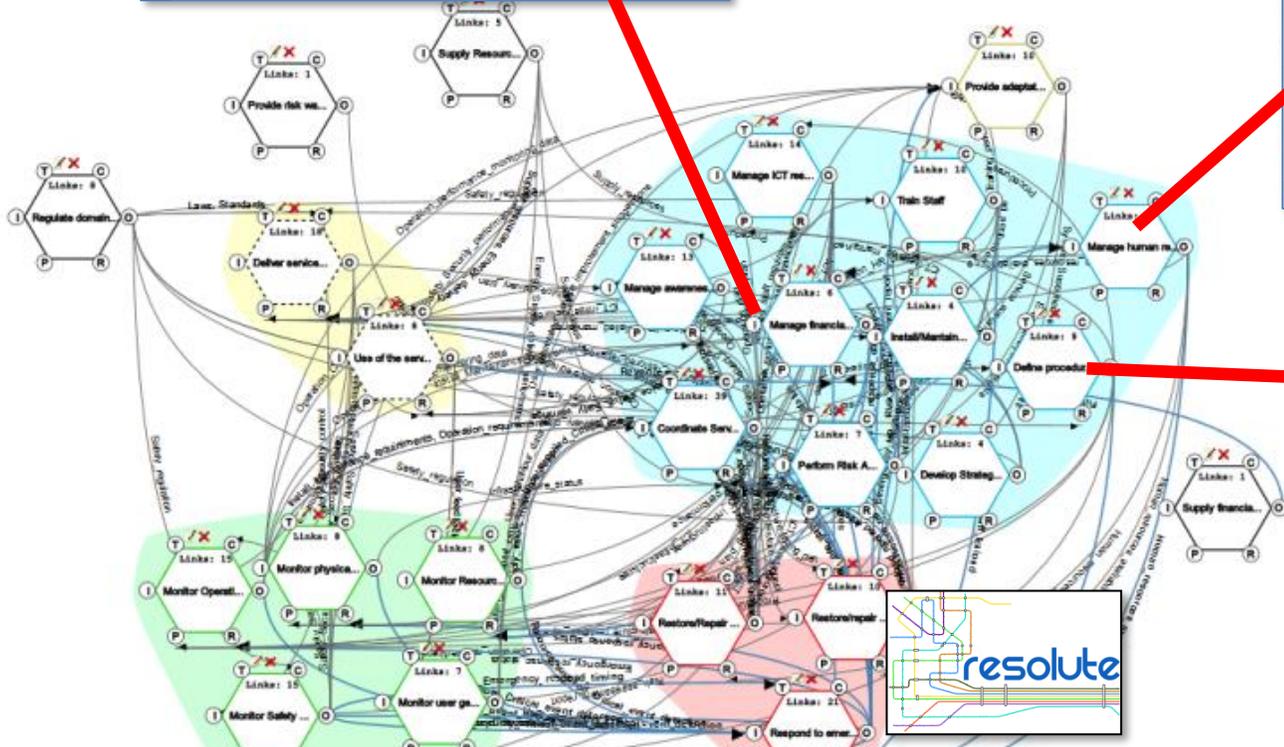
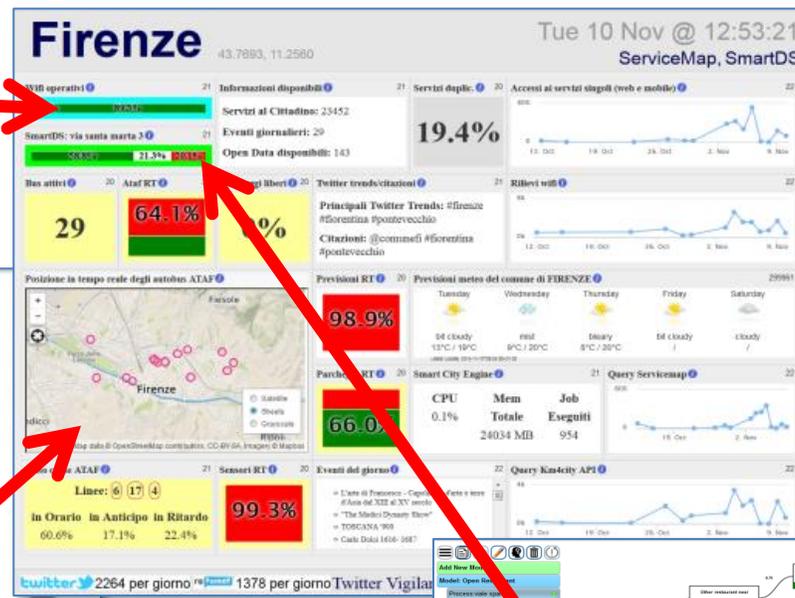
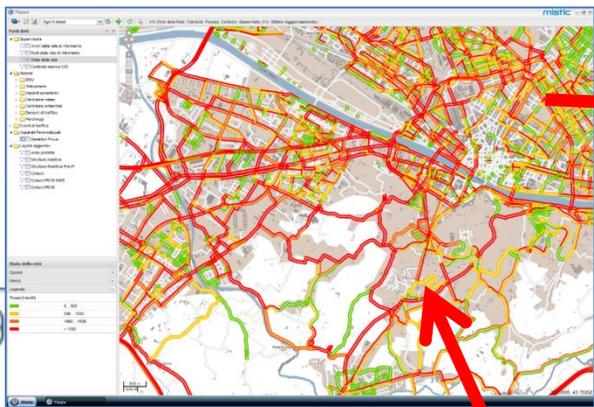


# Improve city resilience, reducing risks and decision support

- **assessing city resilience level**
- **improving city resilience, providing objective hints**
- **improving city users awareness with personal city assistants and participatory tools**



# Dashboarding city resilience



Data and Service Aggregator



<http://resilienceds.km4city.org>

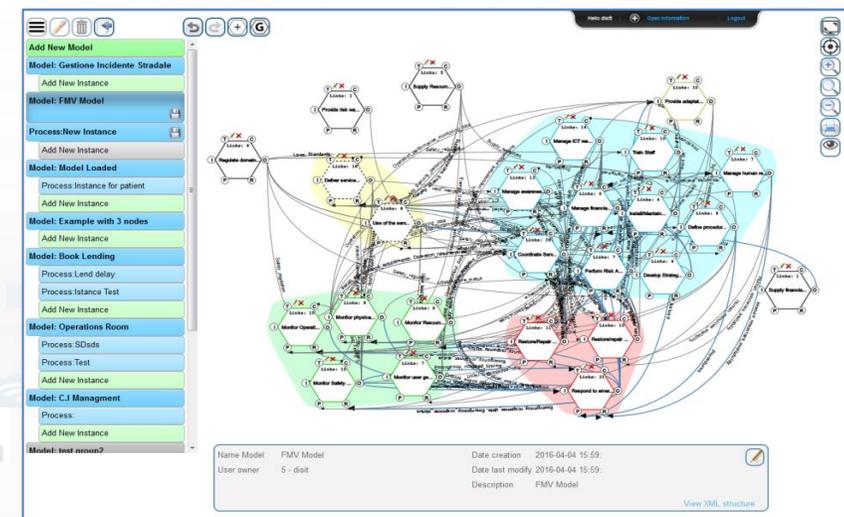
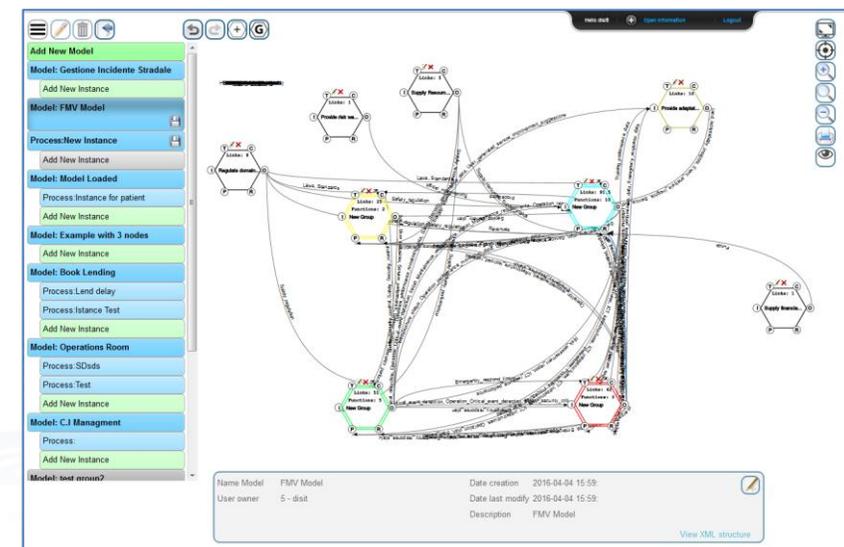
## • FRAM Model

- Macro FRAM processes
- Metrics for Process complexity assessment
- Operational Semantic for executing FRAM model
- Connection with SmartDS
- Connection with BigData open to multiple sources of data and workgroup results, Km4City

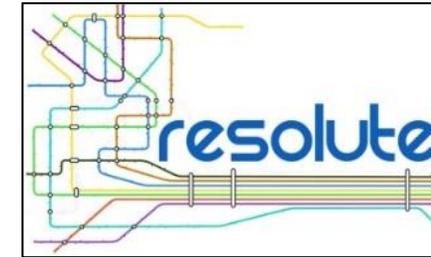
## • Collaborative work, web tool

## • Open for all

## • Validated on ERMG: European Guidelines



# Functional Resonance Analysis Method



**Time:**  
This is simultaneously a resource and a constraint

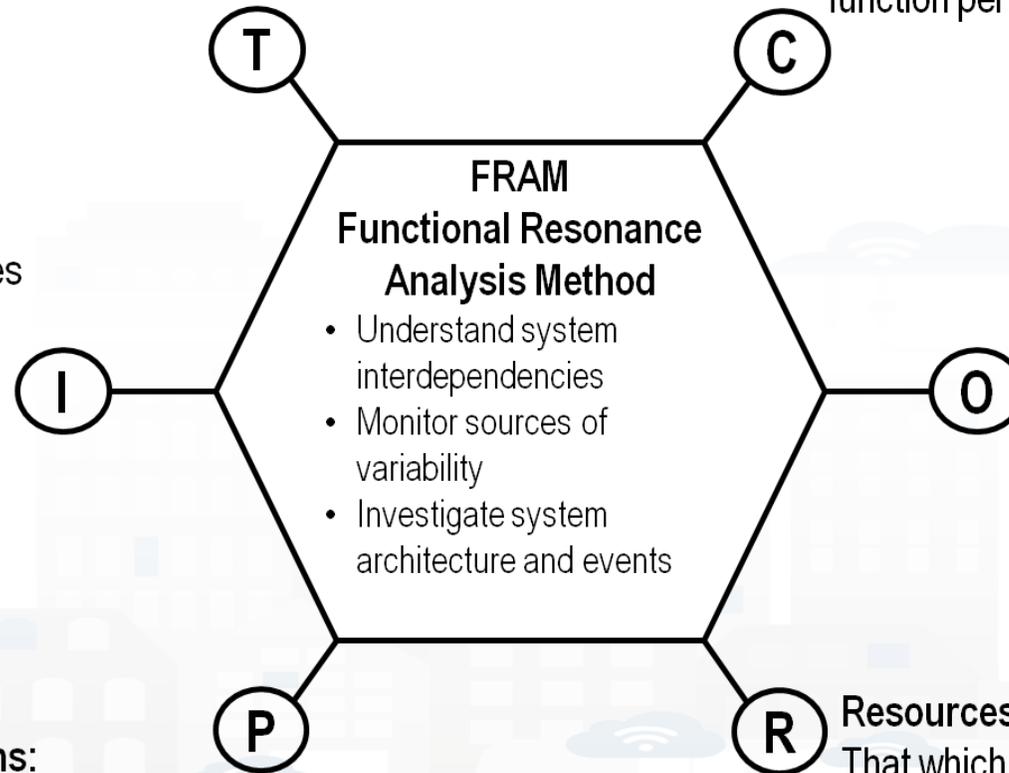
**Controls:**  
That which supervises or adjust function performance

**Input:**  
That which engages function operation and is used to produce the function output

**Output:**  
That which is produced by the function and becomes the input for other functions

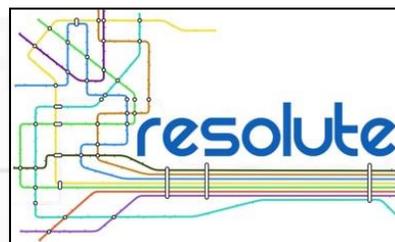
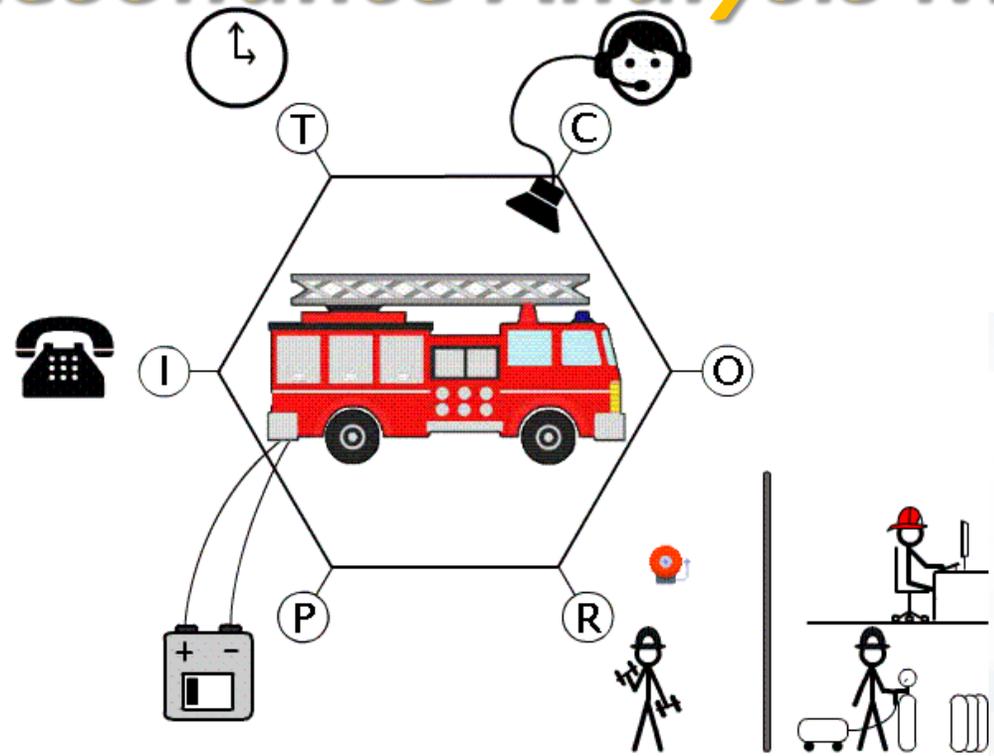
**Preconditions:**  
System conditions that must be met before function can be carried out

**Resources:**  
That which is needed and/or consumed by the function to process the input

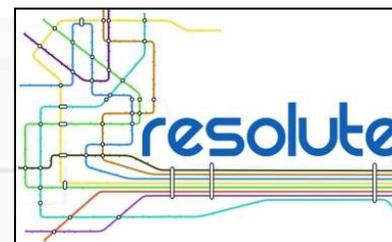
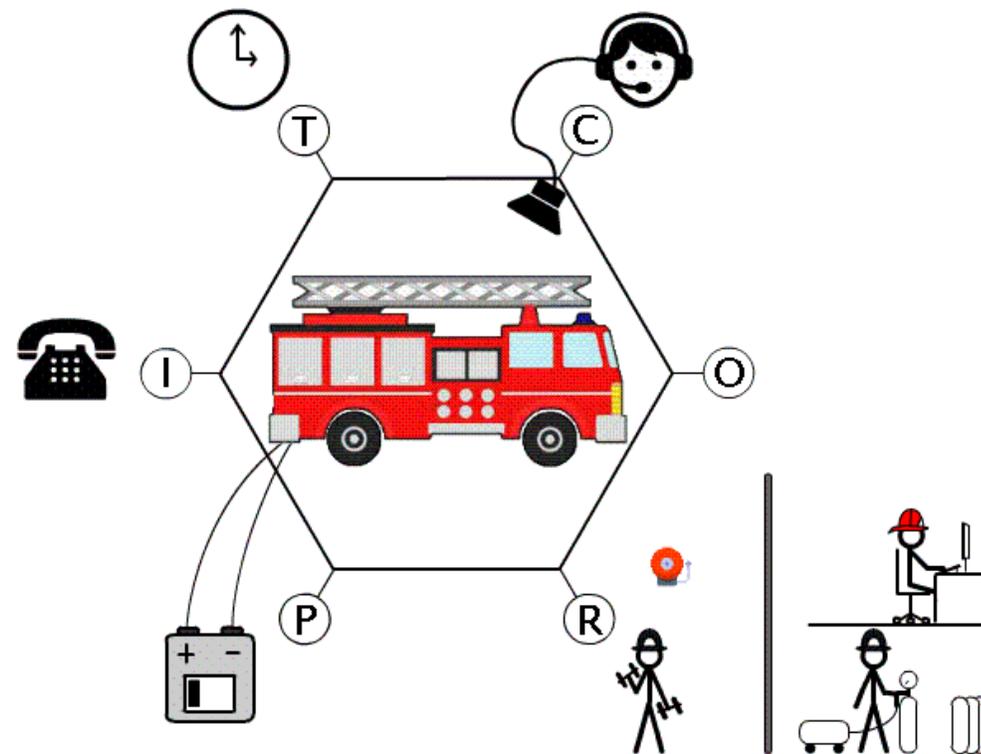


# Fram Model: *Functional Resonance Analysis Method*

- Success and failure are equivalent in the sense that they both emerge from performance variability.
- Variability, intended as a way for people to adjust tools and procedures to match operating conditions.
- Emergence of either success or failure is due to unexpected combination of variability from multiple functions.
- The unexpected “amplified” effects of interactions between different sources of variability are at the origin of the phenomenon described by functional resonance.

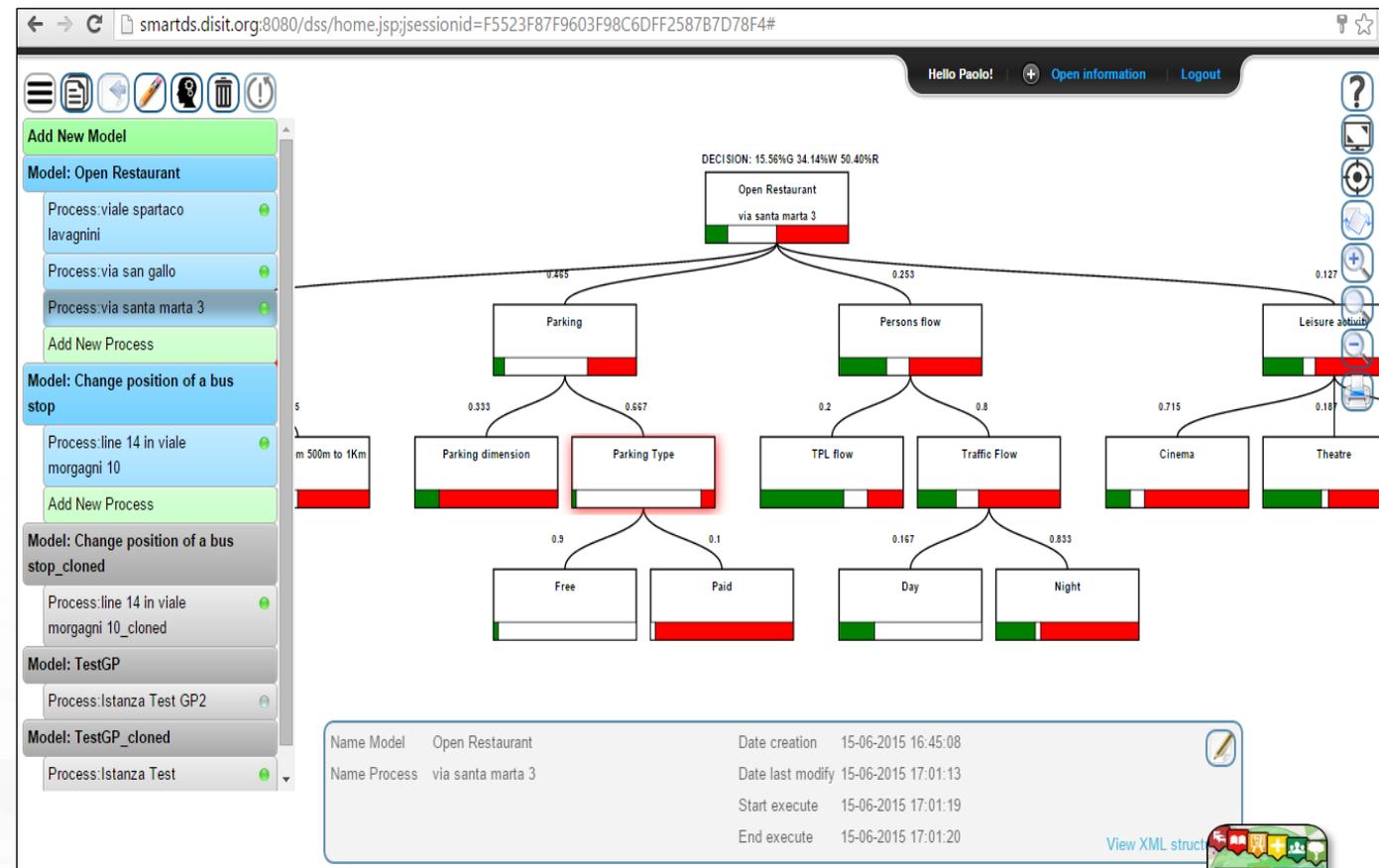


- Success and failure are equivalent in the sense that they both emerge from performance variability.
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- Emergence of either success or failure is due to unexpected combination of variability from multiple functions.
- The unexpected “amplified” effects of interactions between different sources of variability are at the origin of the phenomenon described by functional resonance.



# Smart Decision Support , system thinking

- **Smart Decision Support System** based on System Thinking plus
- Actions to city reaction, resilience, smartness, ...
- Enforcing Mathematical model for propagation of decision confidence..
- Collaborative work, ...
- Processes connected to city data: DB, RDF Store, Twitter, etc.
- Production of alerts/alarms
- Data analytics process
- Twitter Processes
- reuse, copy past, ...



<http://smartds.km4city.org>

Flood Event | Flood Observation | Traffic Observation | Damage analysis | Layers panel | Vulnerability info | Service Observation

Aerial with labels | Save Analysis | Export Configuration

**Flood sensors observations:**

<input checked="" type="checkbox"/>	From	Data	mm/h
<input checked="" type="checkbox"/>	Firenze Genio Civile	2016-04-11T15:59:00	12
<input checked="" type="checkbox"/>	Firenze Peretola	2016-04-11T15:59:00	20.5
<input checked="" type="checkbox"/>	Firenze Università	2016-04-11T15:59:00	10.5

Threshold:

From:   :

To:   :

Draw region to analyze:  On

Load predefined region:

Mean precipitation:

**SERVICE**

NAME: villa maria teresa hospital...

ADDRESS: VIA DELLA CERNAIA, FIRENZE, FIRENZE

SERVICE TYPE: [http://www.disit.org/km4city/schema#Public\\_hospital](http://www.disit.org/km4city/schema#Public_hospital)

SERVICE CLASS: <http://www.disit.org/km4city/schema#HealthCare>

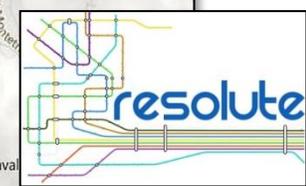
SERVICE: <http://www.disit.org/km4city/resource/7tab1bc45b84357b727dd67fe6081d2db>

VALUE: 100

WKT DESCRIPTION: POINT (11.2561 43.7866)

**Traffic observations:**

<input type="checkbox"/>	From	Date	km/h	car/km	car/h
<input type="checkbox"/>	VIA DELLA MATTONAIA	2016-10-10 18:01:08	58	15	2435
<input type="checkbox"/>	LUNGARNO AMERIGO VESPUCCI	2016-10-10 18:01:08	18	65	1842
<input type="checkbox"/>	VIA CAMILLO CAVOUR	2016-10-10 18:01:08	61	12	2009
<input type="checkbox"/>	VIA VALFONDA	2016-10-10 18:01:08	27	53	3307
<input type="checkbox"/>	VIA VITTORIO ALFIERI	2016-10-10 18:01:08	23	58	2798
<input type="checkbox"/>	VIA SENESE	2016-10-10 18:01:08	27	54	3216
<input type="checkbox"/>	VIA GUELFA	2016-10-10 18:01:08	68	3	420
<input type="checkbox"/>	VIA DELLA SCALA	2016-10-10 18:01:08	60	13	2157
<input type="checkbox"/>	PIAZZA DI SAN FELICE	2016-10-10 18:01:08	62	10	1697
<input type="checkbox"/>	BORGO SAN FREDIANO	2016-10-10 18:01:08	57	17	2690
<input type="checkbox"/>	VIA VITTORIO ALFIERI	2016-10-10 18:01:08	10	74	195
<input type="checkbox"/>	VIA DEL CAMPUCCIO	2016-10-10 18:01:08	60	13	2157
<input type="checkbox"/>	VIA DEI BENCI	2016-10-10 18:01:08	22	59	2679
<input type="checkbox"/>	PIAZZALE DI PORTA ROMANA	2016-10-10 18:01:08	64	8	1361



**Assessing Risk**

- hydraulic
- Seismic

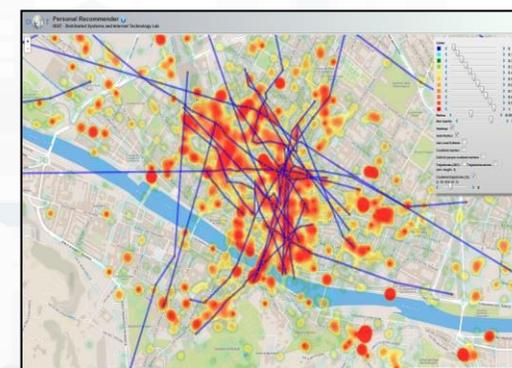
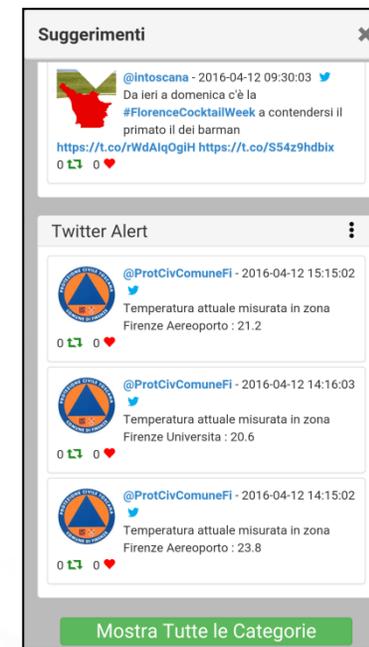
**Relevant Services**

Min asset value:

<input checked="" type="checkbox"/>	Service	Street	Type	Value
<input checked="" type="checkbox"/>	villa delle terme case di cura	VIALE MAZZINI GIUSEPPE, FIRENZE	Public_hospital	100
<input checked="" type="checkbox"/>	villa dei pini srl	VIA FOSCOLO UGO, FIRENZE	Public_hospital	100
<input checked="" type="checkbox"/>	Poggio Sacco	VIA INCONTRI, FIRENZE	Public_hospital	100



- Personalized menu for Operators
- Providing information and suggestions to citizens
  - Civil Protection Page
  - Twitter Info
  - Geolocalized Info
- Tracking people and operators flows
- Collecting information from citizens
  - Comments
  - Images



TOP

# TWITTER VIGILANCE: SOCIAL MEDIA ANALYSIS

FROM CITY DASHBOARD TO APPLICATIONS

FORGING & MANAGING OPEN AND FLEXIBLE WEB AND MOBILE APPS

IoT APPLICATIONS VOT EDGE DEVICES

SNAP4CITY FOR BEGINNERS

SNAP4CITY ARCHITECTURE AND OPEN SOURCE TO DEVELOPERS AND STAKEHOLDERS

TWITTER VIGILANCE: SOCIAL MEDIA ANALYSIS

SNAP4CITY AND KM4CITY PROJECTS

DATA GATHERING AND DATA KNOWLEDGE MANAGEMENT

IOT/IOE DEVICES AND NETWORKS

DATA ANALYTICS, BUSINESS INTELLIGENCE, WHAT-IF ANALYSIS, SIMULATION

HOW TO ADOPT SNAP4CITY, AND OUR ROADMAP

# SOCIAL MEDIA ANALYSIS

IOT APPLICATIONS, THE LOGIC AND THE SMARTNESS

SMART CITY APPS, MICROSERVICES, SNAP4CITY API

DEVELOPMENT SUPPORT SYSTEMS AND RESILIENCE

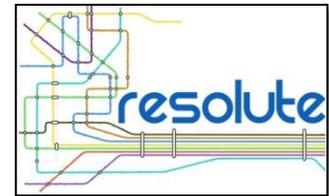
SNAP4CITY THE VIEW OF THE ADMINISTRATORS

SNAP4CITY LIVING LAB FOR COLLABORATIVE WORK





# Twitter Vigilance



## Prediction/Assessment

- Football game results as related to the volume of Tweets
- Number of votes on political elections, via sentiment analysis, SA
- Size and inception of contagious diseases
- marketability of consumer goods
- public health seasonal flu
- box-office revenues for movies
- places to be visited, most visited
- number of people in locations like airports
- audience of TV programmes, political TV shows
- weather forecast information
- Appreciation of services

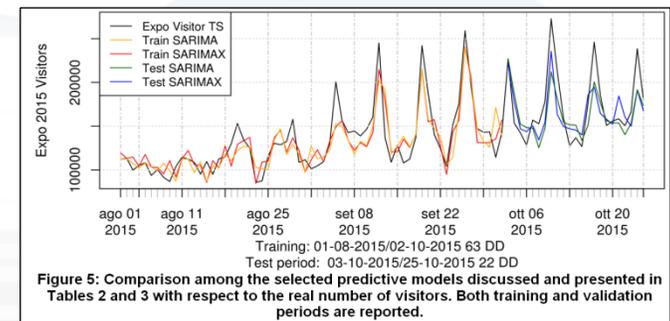
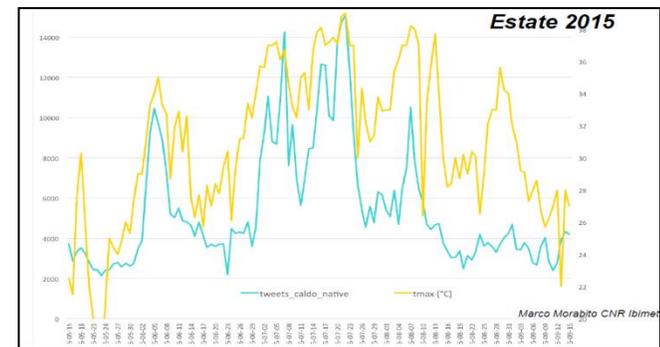
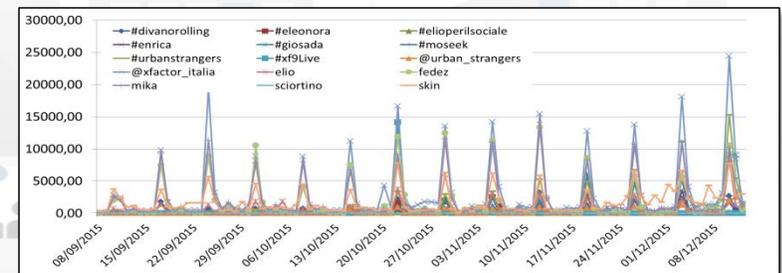
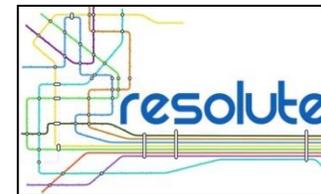


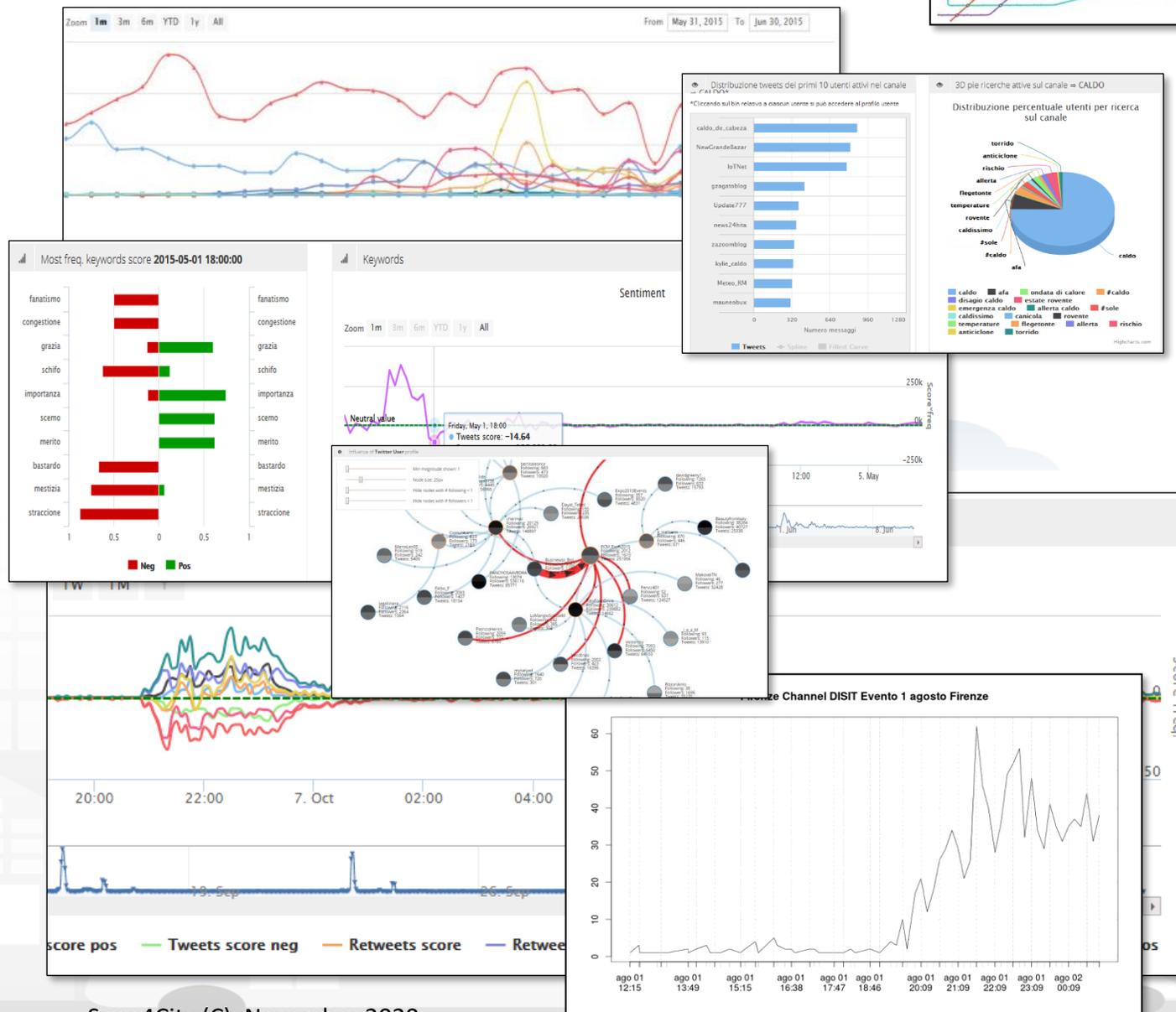
Figure 5: Comparison among the selected predictive models discussed and presented in Tables 2 and 3 with respect to the real number of visitors. Both training and validation periods are reported.



# Twitter Vigilance



- <http://www.disit.org/tv>
- <http://www.disit.org/rttv>
- Citizens as sensors to
  - Assess sentiment on services, events, ...
  - Response of consumers wrt, ...
  - Early detection of critical conditions
  - Information channel
  - Opinion leaders
  - Communities
  - Formation
  - Predicting volume of visitors for tuning the services



## in Numbers

- **Used by several users:**
  - UnivFirenze, LAMMA, IBIMET, ARPAT, Master on Big Data, ...
- **Active since** Aprile 2015
- **3 platforms for automated:**
  - Daily collection: statistical direct analysis and sentiment analysis
  - Real time collection and statistical, sentiment analysis
  - Full faceted indexing: thus enabling search on collected tweets
- **All: precomputation of basic metric opening the activities of deep analysis**
- More than 350 million of tweets in the storage: ready on Hadoop cluster
- More than 250 channels
- More than 450 search activities daily
- From 400.000 to 4 Million of tweets per day.





# Several Channels



Twitter Vigilance Dashboard

Login

Last crawling: 2015-12-11 01:20:20

Search parameters

Data analysis 4

Channel statistics

Search statistics

Retweet statistics

Twitter Users statistics

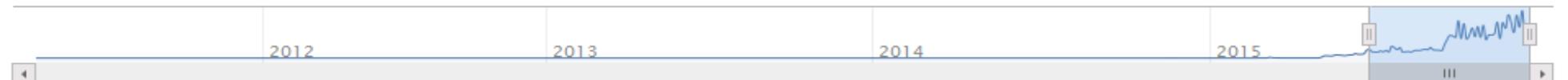
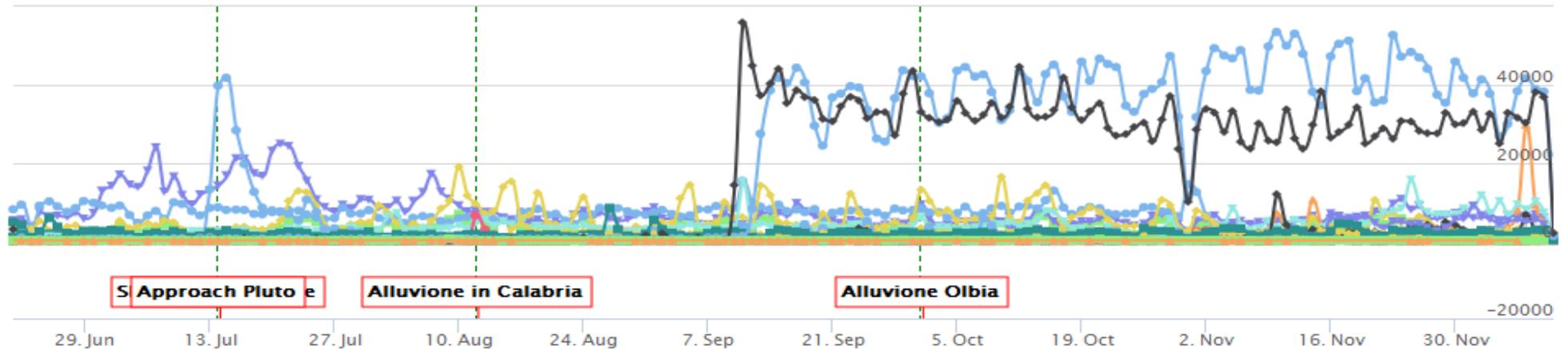
INFO

Home > Channel statistics

Global view of user channels

Zoom 1m 3m 6m YTD 1y All

From Jun 20, 2015 To Dec 11, 2015



- ads
- aeroporto firenze
- Allertameteo TOSCANA
- apretoscana
- CALDO
- cambiamenti climatici
- Codified Hashtags Allerta
- ConsumoSuolo
- Emergenza\_acqua
- Europea
- EXPO2015
- Firenze
- FirenzeICT
- Giubileo
- iononrischio
- LaMMA
- Maltempo
- maturità 2015
- MeteoUSER
- mymeteo
- NASA New Horizons
- papafrancesco
- PA\_social\_PA
- protezione civile toscana
- resilienza
- rossano
- siena
- smartcity
- smartcitybigdata2015
- SOLO allertameteoTOSCANA
- tech
- uber
- Univ-Firenze
- zanzara
- Events



# A Channel



Channel active from 2009-10-23 to today



Data processed from 2015-05-15 to 2015-09-15

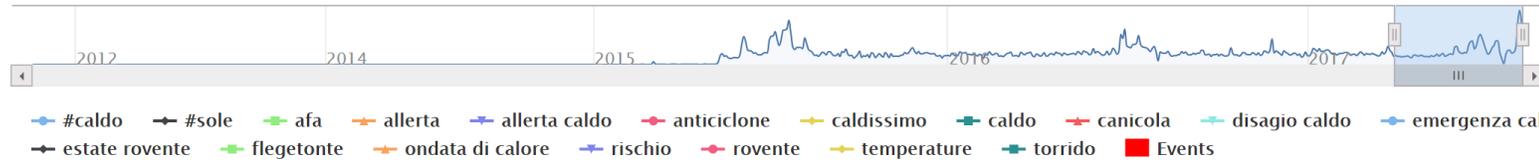
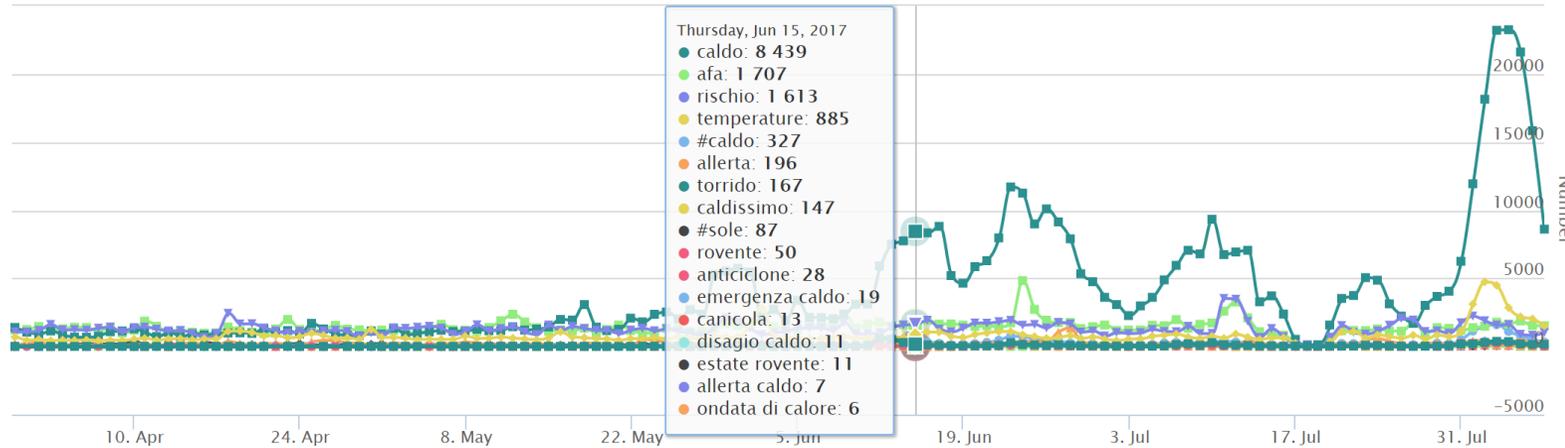
NLP

SA

Search related to channel **CALDO**

Zoom 1m 3m 6m YTD 1y All

From Mar 30, 2017 To Aug 7, 2017

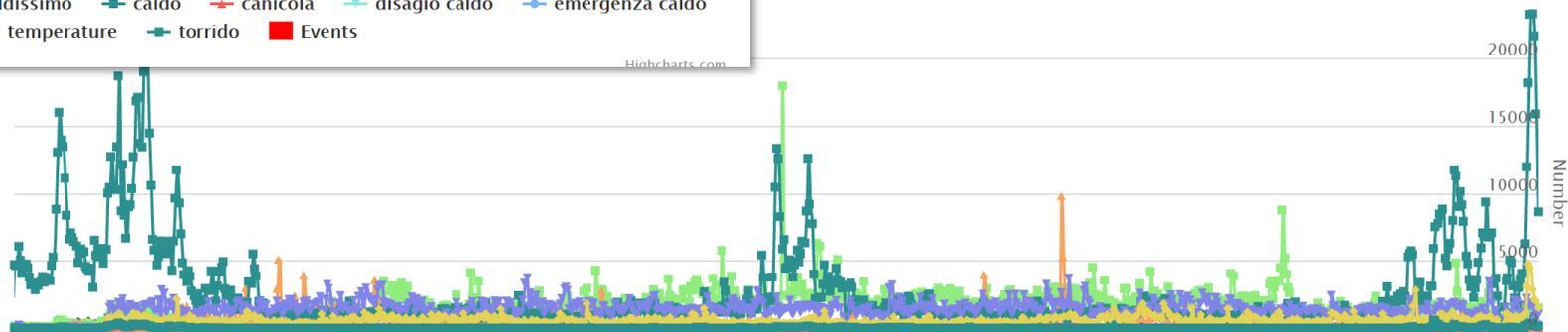


05-15 to 2015-09-15

NLP

SA

From May 11, 2015 To Aug 7, 2017



## Its searches



**Twitter Vigilance**

Snap4City (C), November 2020

257

-5000

# Twitter Syntax for Searches

- String substring: Caldo
- Hashtag: #Caldo,
- Citations: @CivilProtection, @paolonesi
- From users: From:@paolonesi
- Etc.
- ....ANDed and ORed

TPL

#bus #fipili #intreno  
#publictransport #tramviafi #travel  
#trenitalia @AMTToscana  
@AnciToscana @ArezzoPendolari  
@AutolineeCurcio @AutolineeRomano  
@CAPautolinee @capviaggiprato  
@cispeltos @Clickmobility @comunefi  
@CTM\_Cagliari @cttnord\_informa  
@esserependolare @EuroTransMag  
@ferpress @firenzeataf @GroupeRATP  
@iMobChallenge @iMobilityForum  
@InfoBusPisa @InfoParkAT  
@intoscana @ItaloTreno  
@LAMIASFERMATA @LeFrece  
@MobilityPress @MobilityReports  
@muoversintoscana @OrariBus  
@OssMobProvPI @pendolarifr2  
@PiuBus @StazioniSicure  
@SWRTToscana @tolcommunity  
@ToremFerries @Toscanaeturismo  
@tranviafirenze @Trasportitalia  
@TTSItalia @UITPnews

- **Volume Metrics**
  - Number of TW, number of RTW
- **User Metrics**
  - Number of distinct users
  - Number of followers, following
- **NLP and SA metrics**
  - Counting word, adjective, noun, verbs, ....
  - Estimating SA, weighting with SentiWordNet (extended to Italian)
- **High level metrics (compositing all the other metrics)**
  - Addition of metrics..
  - Ratio among metrics, e.g.: num of TW/num of RTW,...
  - Cumulated metrics over time, e.g.: number of TW in the last X days..
- All: (i) per day, per hour, etc. (ii) per channel, per search
- **Recently: we added the possibility of using metrics as firing conditions for alerts and bot on Twitter.**

## Strong Limitations of the Search API of Twitter

- minimizing the number of searches on the basis of the user requests:
  - different users with their queries request tweets already requested by others
- Recovering of parent Tweets from Orphan reTweets taken in the searching process

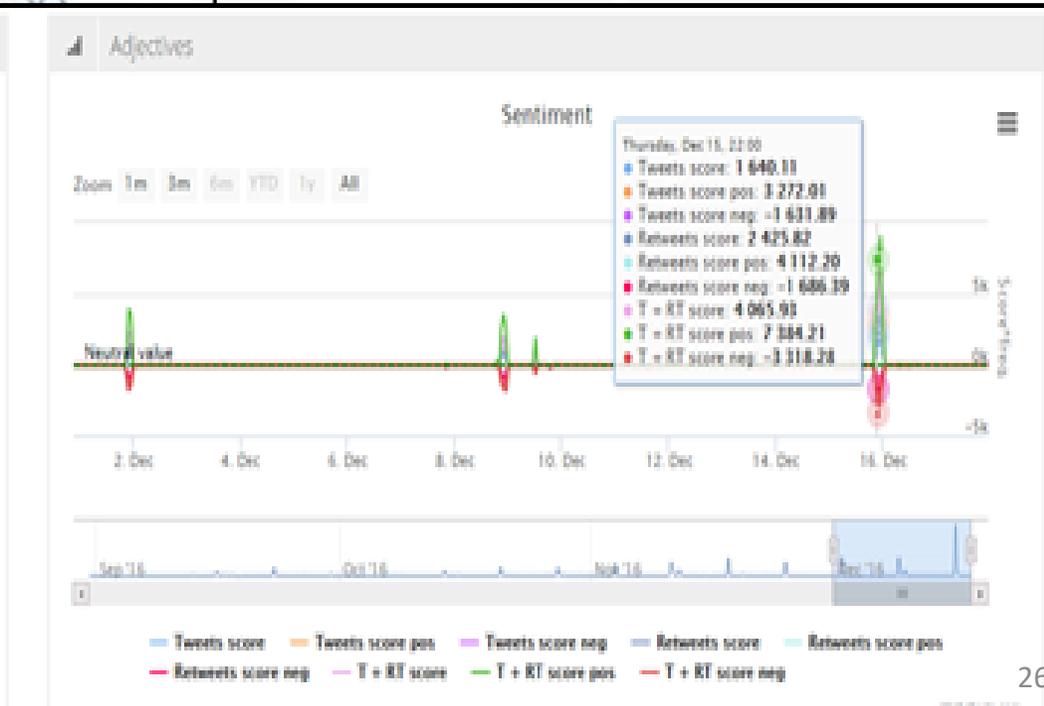
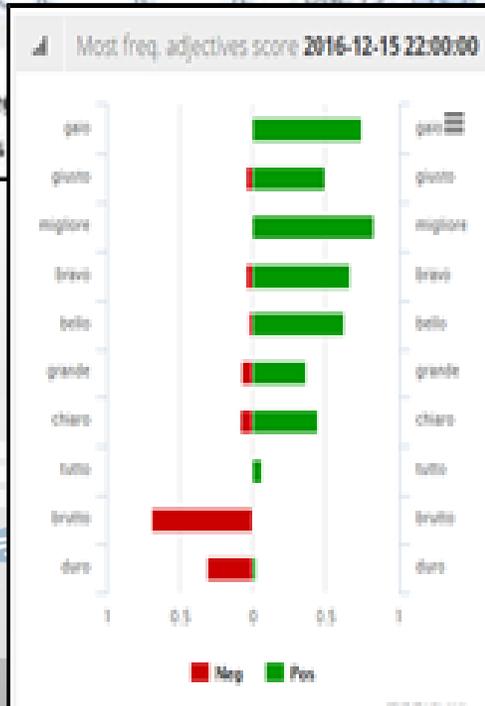
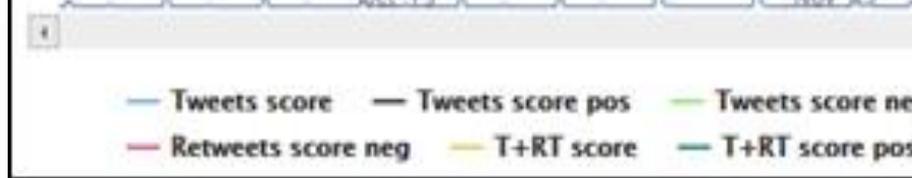
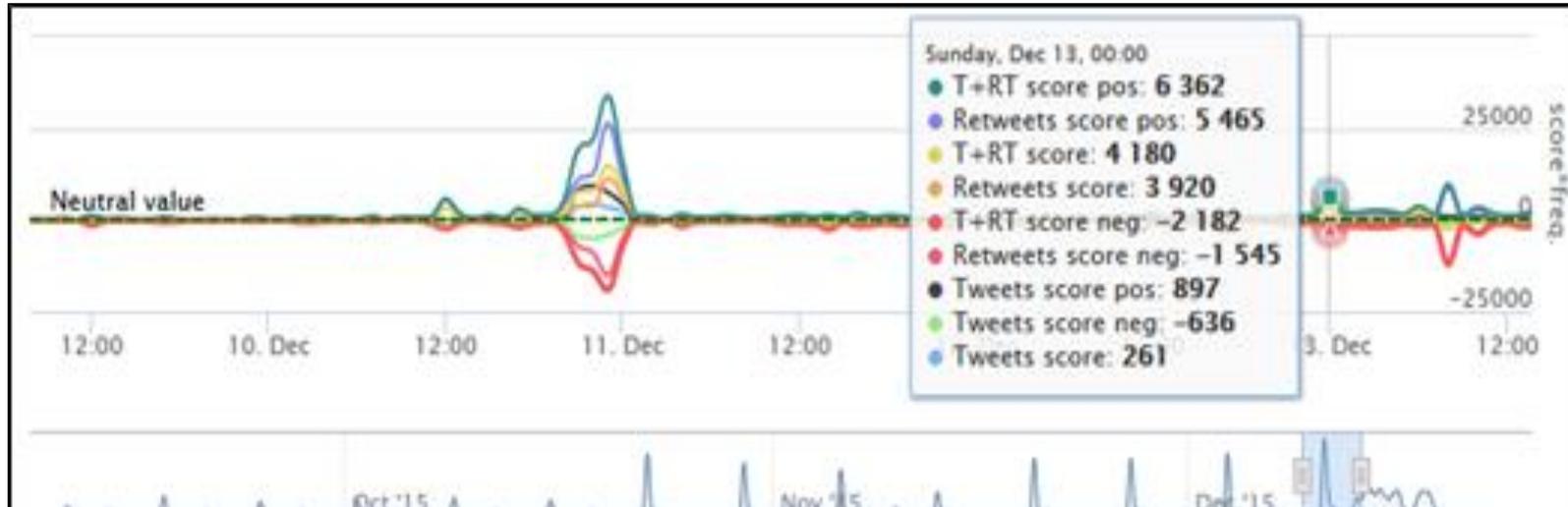
## Analytics:

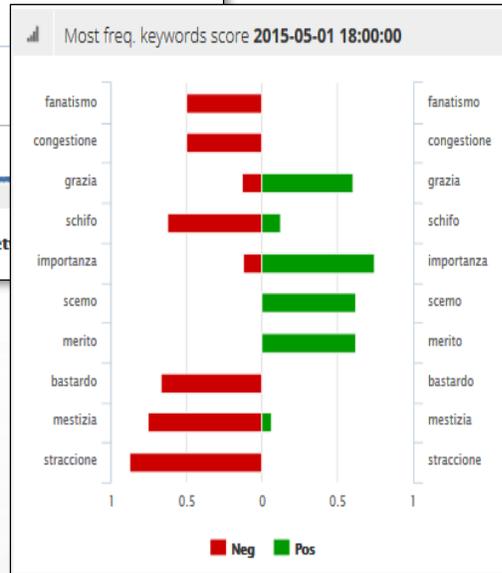
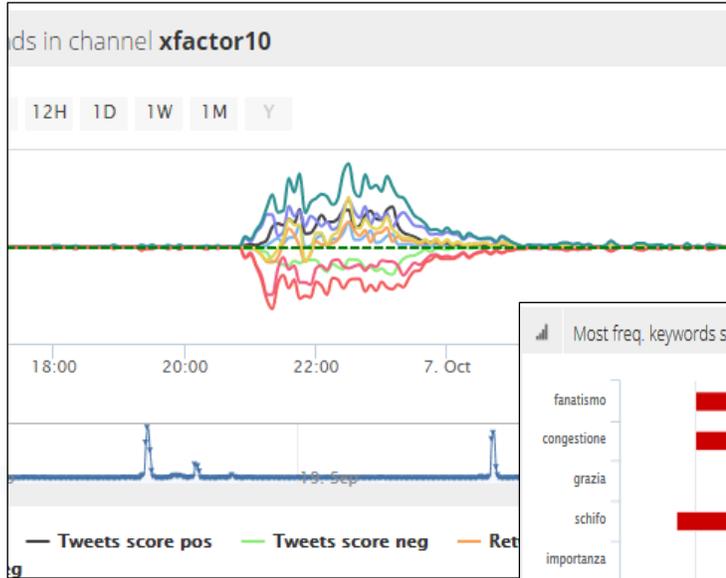
- High performance solution based on HDFS, Hadoop for NLP and SA, exploiting MapReduce programming model
- Estimating the network of influencer
- Computing metrics and prediction in real time.

# Sentiment Analysis

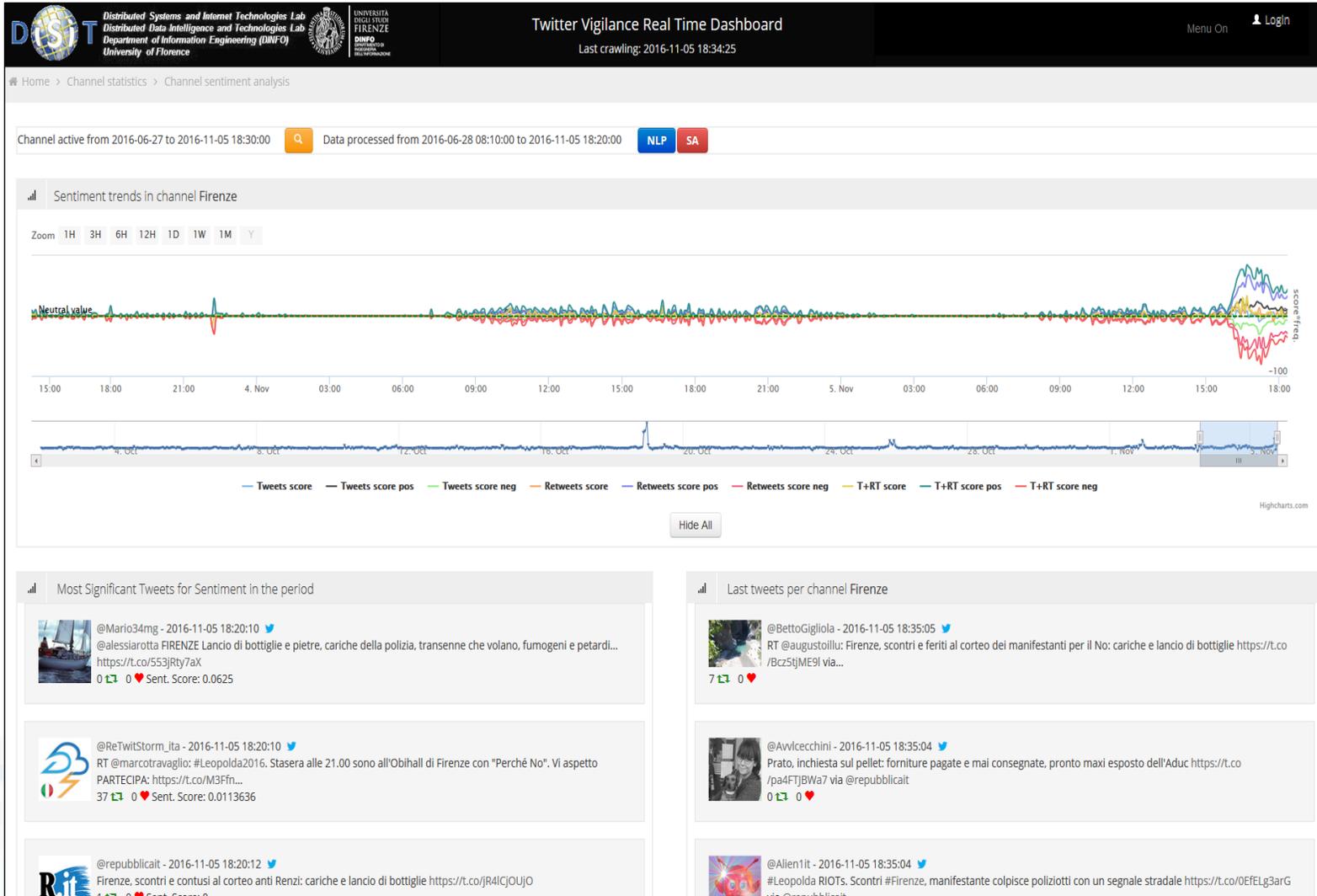
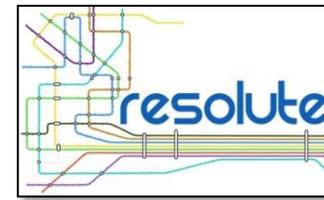


# Sentiment Analysis

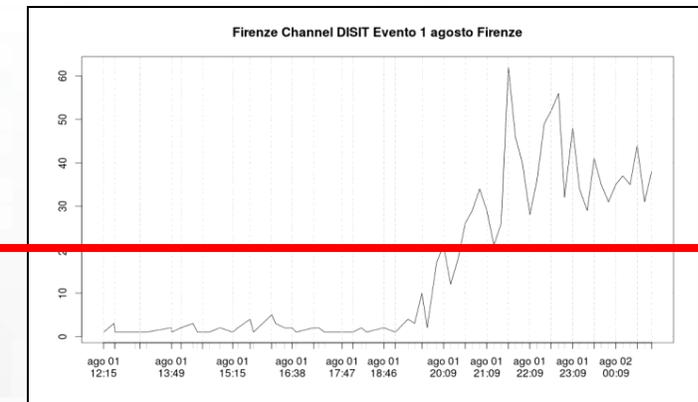
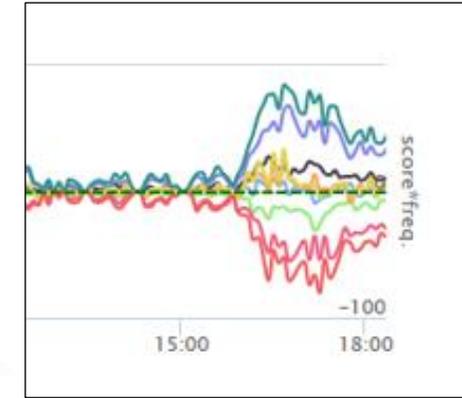




# Real Time Twitter Vigilance, Early Warning



## Sentiment Analysis



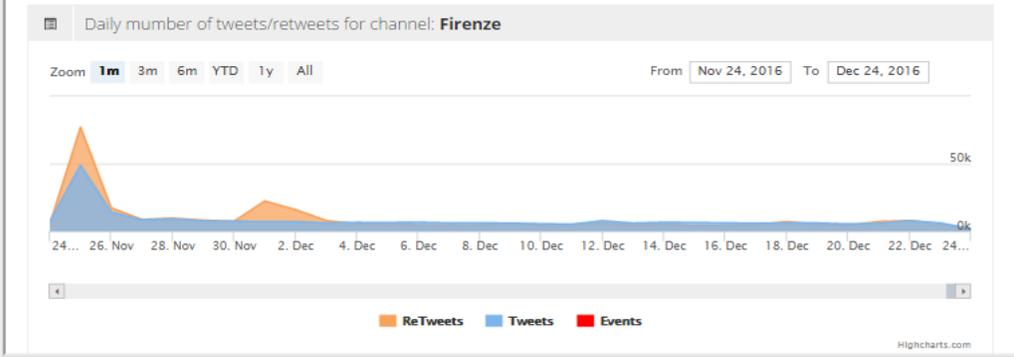
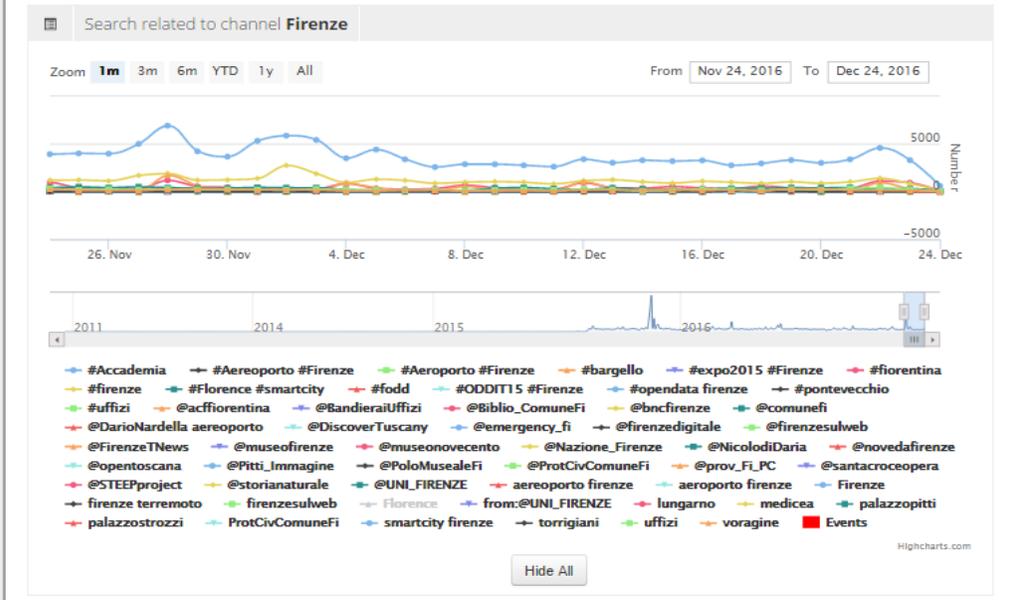
# Twitter Vigilance su Firenze (sperimentale)

### Twitter: Volume di Tweet tramite Twitter Vigilance

Twitter Vigilance Dashboard  
Last crawling: 2016-12-24 12:34:51

Home > Channel statistics > Statistics on single Channel

Channel active from 2009-02-27 to today  
Data processed from 2015-05-22 to 2016-12-02



### Sentiment Analysis in Tempo Reale su Firenze

Twitter Vigilance Real Time Dashboard  
Last crawling: 2016-12-24 10:32:33

Home > Channel statistics > Channel sentiment analysis

Channel active from 2016-06-27 to 2016-12-24 10:30:00  
Data processed from 2016-06-28 08:10:00 to 2016-12-24 10:25:00



#### Most Significant Tweets for Sentiment in the period

- @forealziesdayle - 2016-12-24 10:25:39  
@Ahno\_its\_arno meh, I've only had average curry there  
0 Retweets 0 Likes Sent. Score: 0.166667
- @esercizistorici - 2016-12-24 10:30:01  
Stanotte Concerto di Natale di Peter Guth @ORT\_Toscana in collaborazione con Conservatorio 'L.Cherubini' di Firenze...  
https://t.co/uFETp4wG1y  
0 Retweets 0 Likes Sent. Score: 0
- @infoiterno - 2016-12-24 10:30:05  
Firenze, un piano per un Natale sicuro (055firenze) https://t.co/vpqDASepi  
https://t.co/2Bn5k3zoyv

#### Last tweets per channel Firenze

- @FormulaLatina - 2016-12-24 10:30:26  
\*\*\* CAPODANNO LATINO Woodstock Club Firenze \*\*\* H. 21:00 >> GRAN BUFFET DI SAN SILVESTRO CON BRINDISI E...  
https://t.co/cM84Gw65s0  
0 Retweets 0 Likes
- @MORINEMMANUELL2 - 2016-12-24 10:30:14  
RT @Navymat: Francesco #Salvati Carità,1543 #Manierisme Galleria degli Uffizi, Firenze @ChevernyM @mariaireneali @pieroBENEDETTO @Giusepp...  
6 Retweets 0 Likes
- @infoiterno - 2016-12-24 10:30:12

### Twitter Citazioni

TRENDS QUOTES

- @NICOLODIDARIA
- @COMUNEFI
- @ACFFIORENTINA
- @NAZIONE\_FIRENZE
- @SANTACROCEOPERA
- @MUSEONOVECENTO
- @FIRENZEDIGITALE

### Twitter Hashtag trend

TRENDS QUOTES

- #FIRENZE
- #FIORENTINA
- #UFFIZI
- #PONTEVECCHIO

We suggest to use Chrome browser for better experience



# *Reliability in collecting tweets*



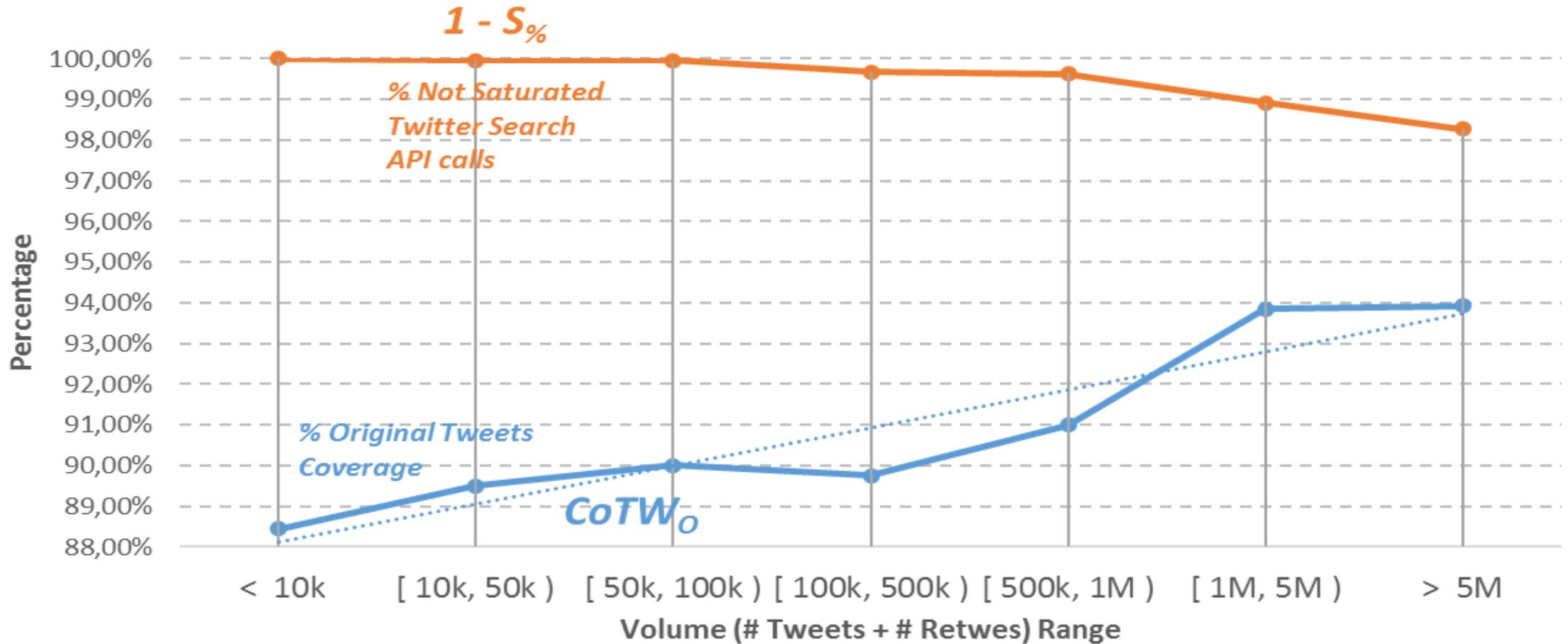
# Efficiency in retrieval



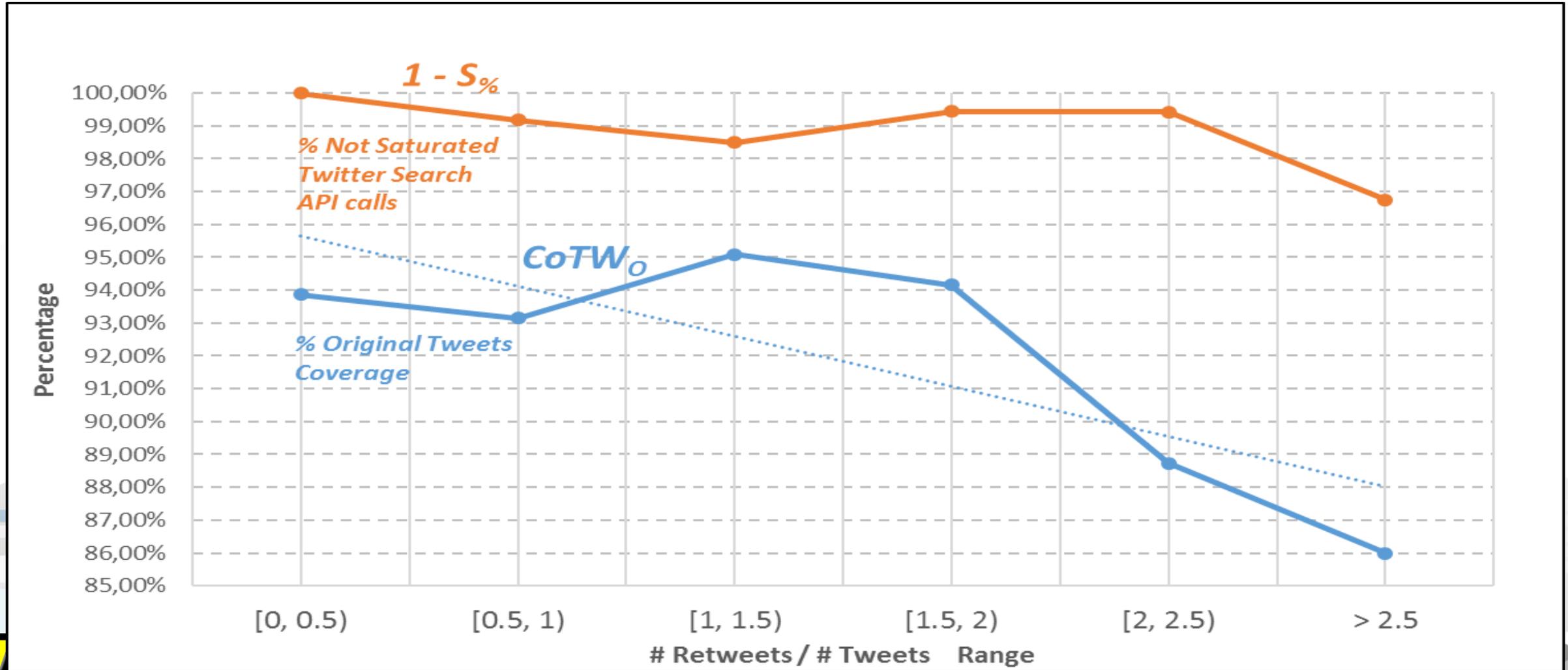
<i>Posts Volume (Tweets + Retweets) Range</i>	<i># Recovered Original Tweets</i>	<i># Missing Original Tweets</i>	<i>% Original Tweets Coverage (CoTW<sub>o</sub>)</i>	<i># Twitter Search API requests</i>	<i># Saturations on Twitter Search API requests</i>	<i>% Saturations on Twitter Search API requests (S<sub>%</sub>)</i>	<i>% Not-Saturated Twitter Search API requests (1-S<sub>%</sub>)</i>
< 10k	18571	2033	89,05%	124299	1	0,00%	100,00%
[ 10k, 50k )	130051	13716	89,45%	399170	100	0,03%	99,97%
[ 50k, 100k )	96171	10278	89,31%	123804	165	0,13%	99,87%
[ 100k, 500k )	997833	86755	91,31%	849062	1589	0,19%	99,81%
[ 500k, 1M )	930646	61632	93,38%	439956	1998	0,45%	99,55%
[ 1M, 5M )	6454463	439628	93,19%	2787485	31585	1,13%	98,87%
> 5M	14714124	899035	93,89%	4509184	64284	1,43%	98,57%



# Original Tweets coverage and Twitter Search API



# Dependance on RTW/TW ratio



# *Tweets as Early Warning*

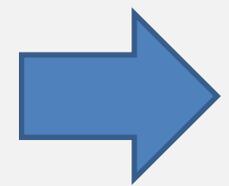


# Early warning, detection



## City Resilience

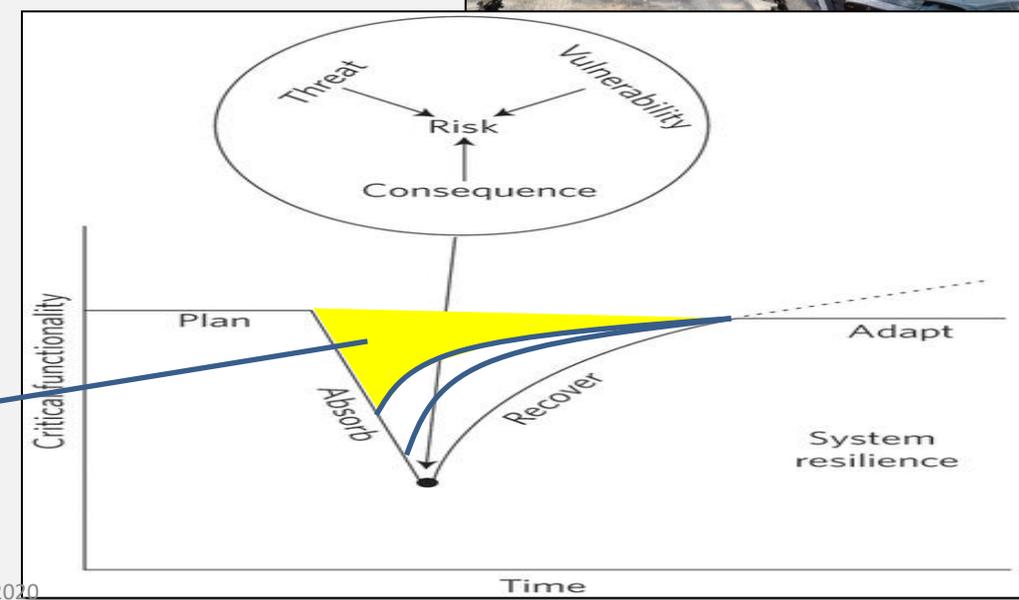
- **Issue:**
  - Detection of critical condition
  - Not easily detected with other means
- **Impact:**
  - Early warning, faster reaction
  - Increased resilience
- **Several metrics related to**
  - Volume of retweets
  - Sentiment analysis

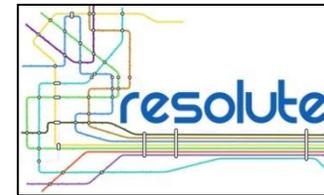


**P**repare  
**A**bsorb  
**R**ecover  
**A**dapt

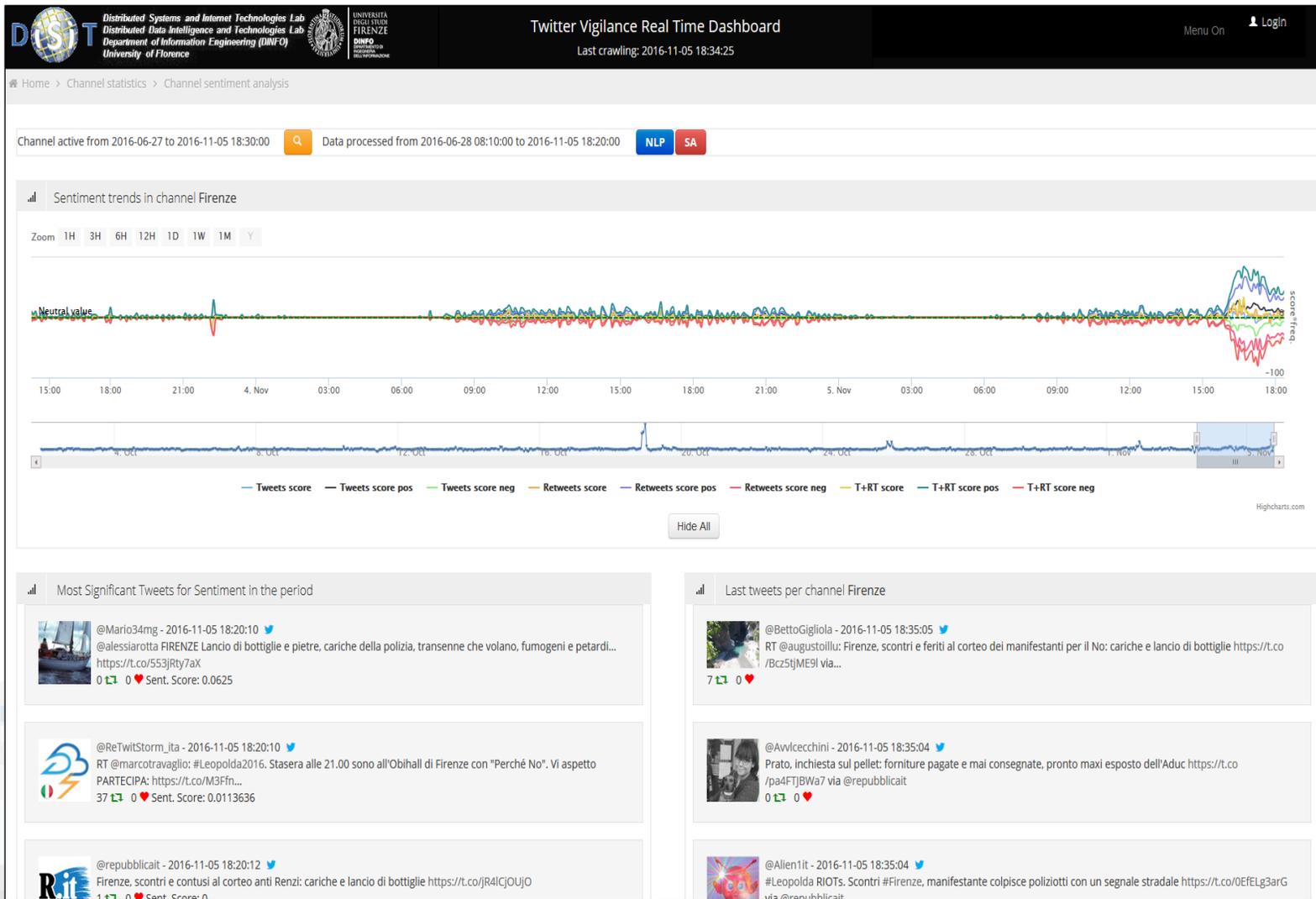


damage

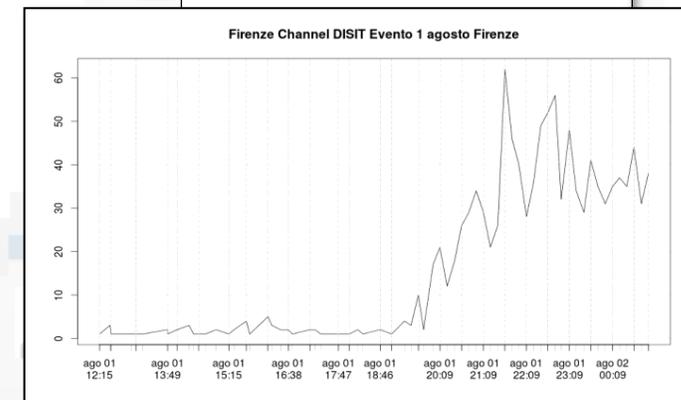
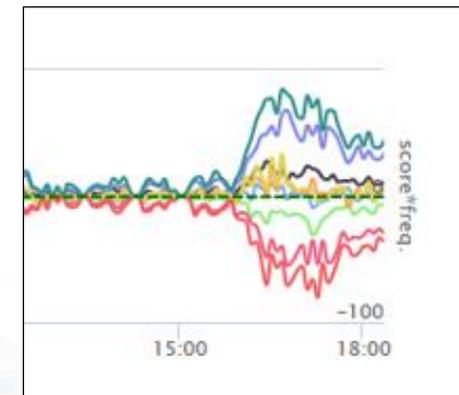




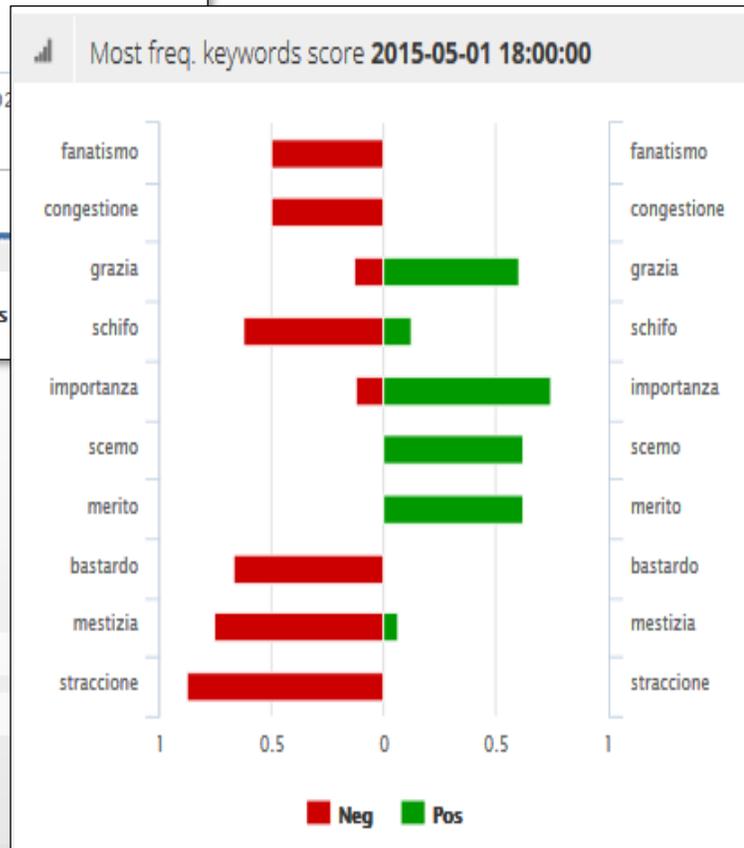
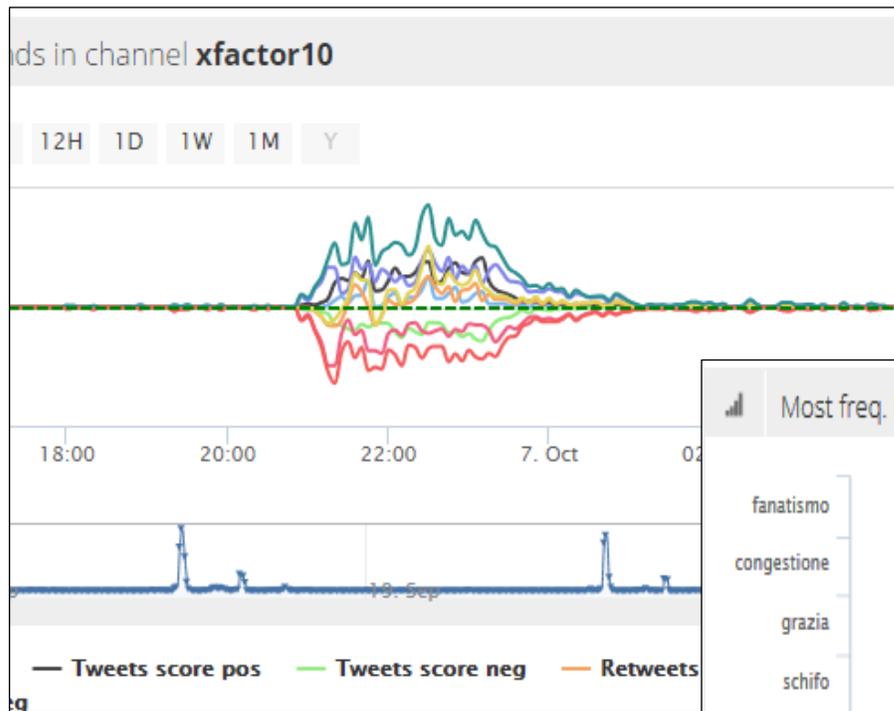
# Twitter Vigilance RT: sentiment analysis



## Real time Early Warning

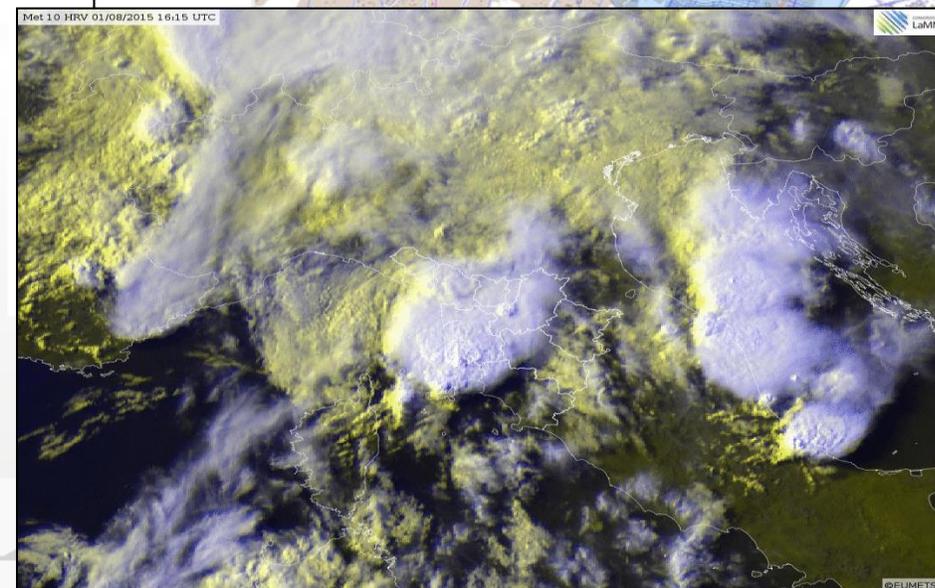
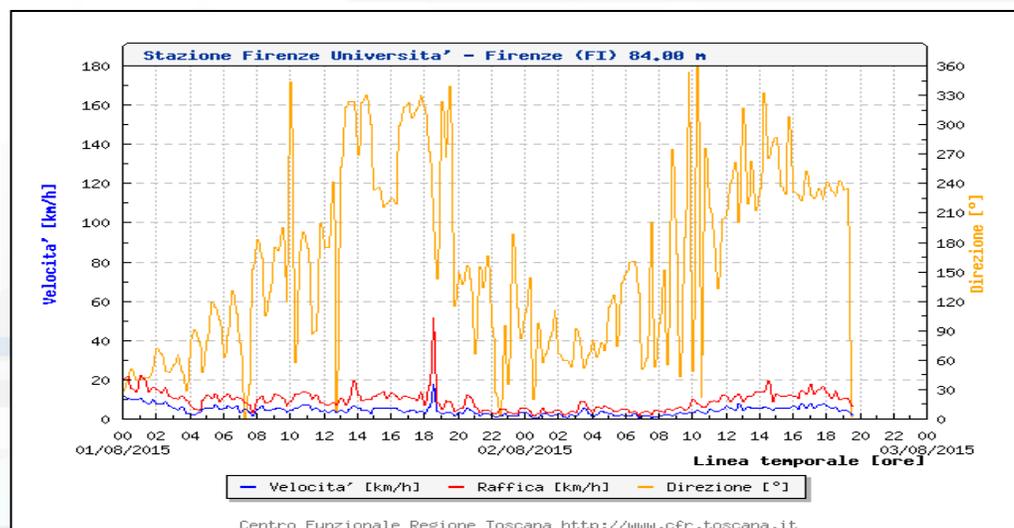
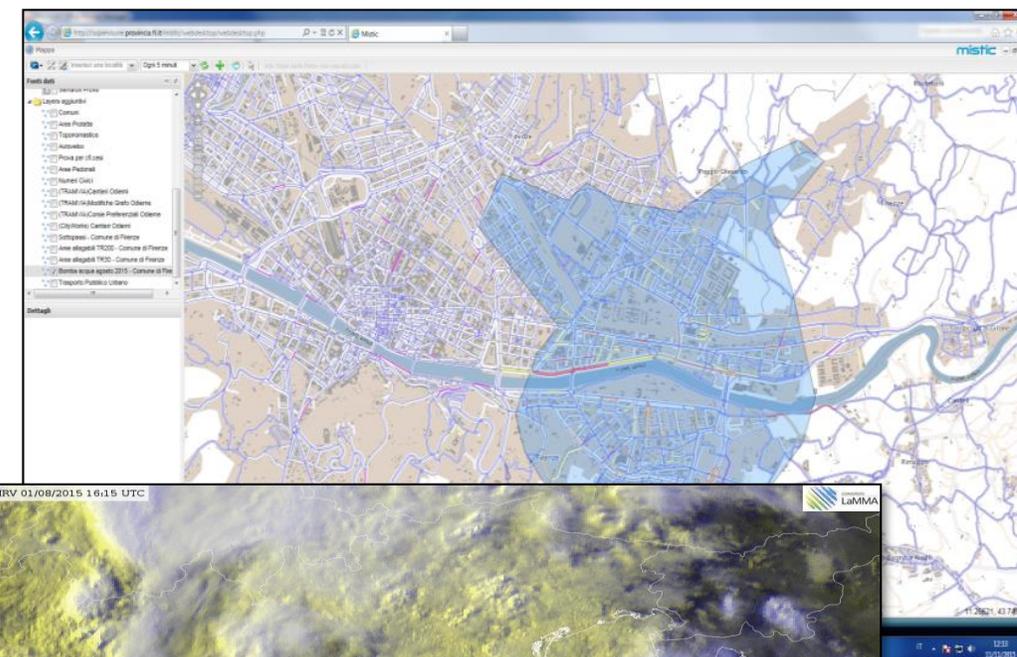
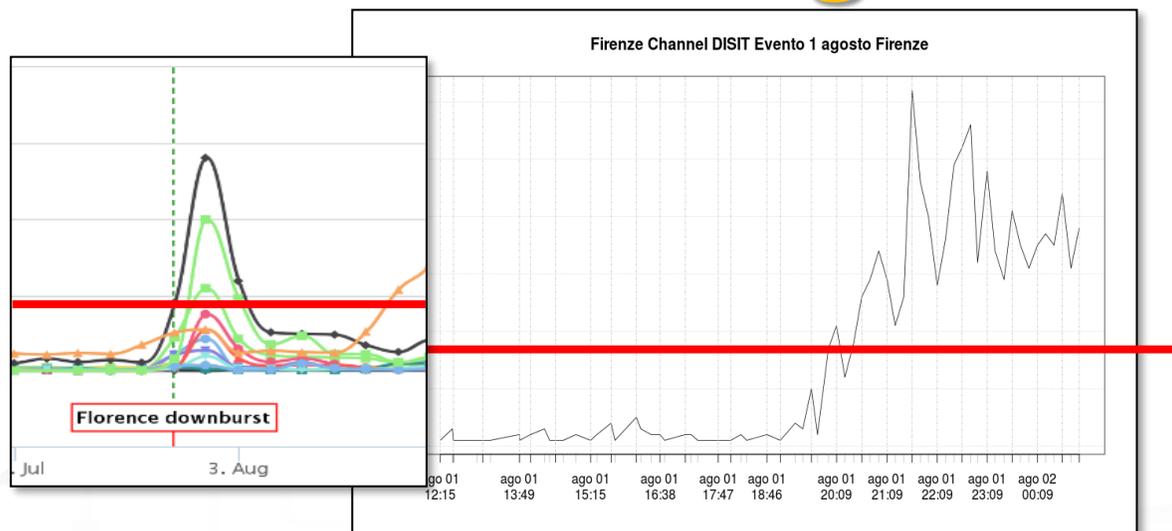
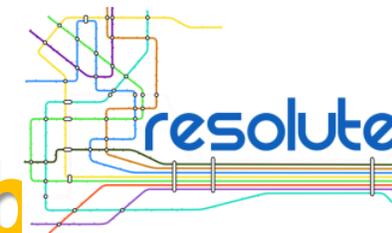


# Sentiment Analysis



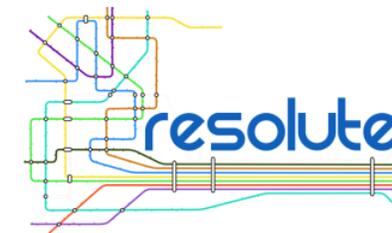
# Early Warning

# Twitter Vigilance and Water Bomb

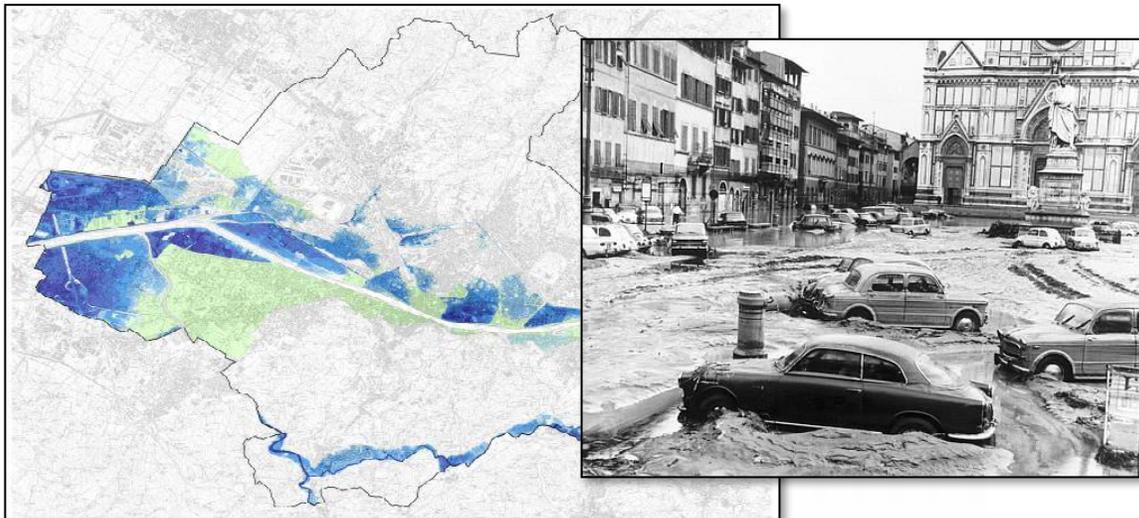


## Twitter Vigilance

# City Resilience ERMG



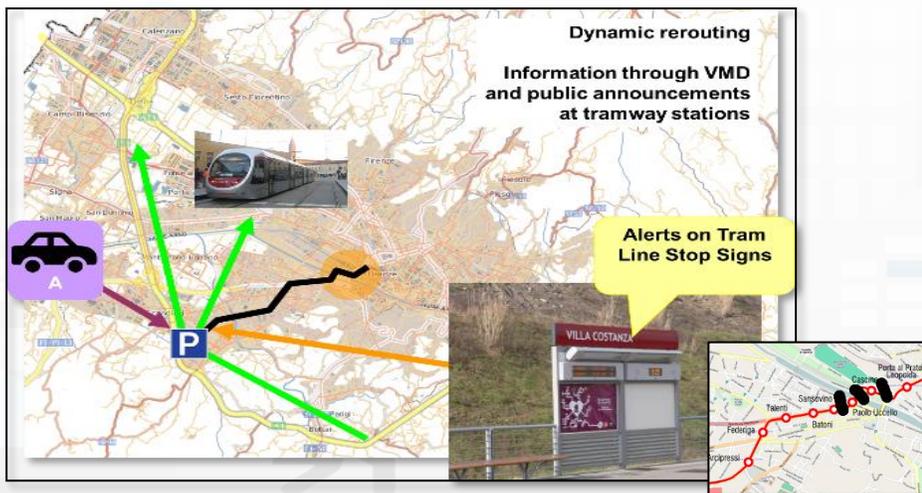
## 200 years probability Arno flooding



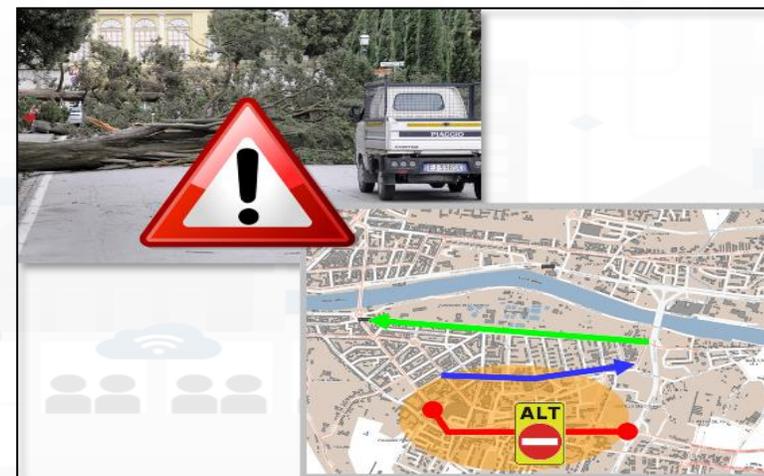
## 30 years probability Arno flooding



## Arno Flood Impact on Tram Line & Traffic



## Water bomb (down burst) in South Florence



Case Study D

# Twitter Vigilance su Firenze (sperimentale)

Twitter: Volume di Tweet tramite Twitter Vigilance

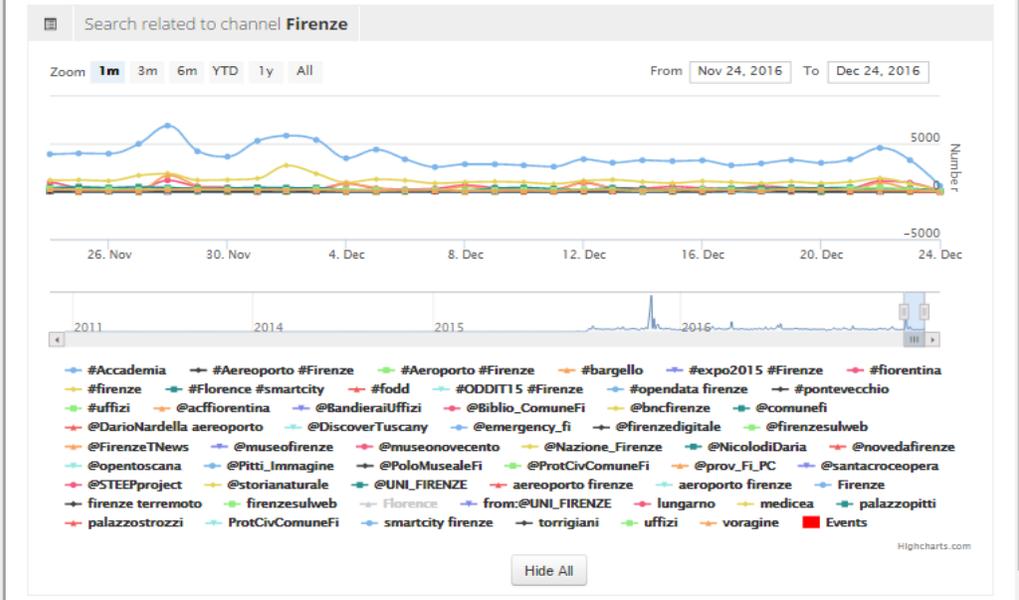
Twitter Vigilance Dashboard  
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Menu On Login

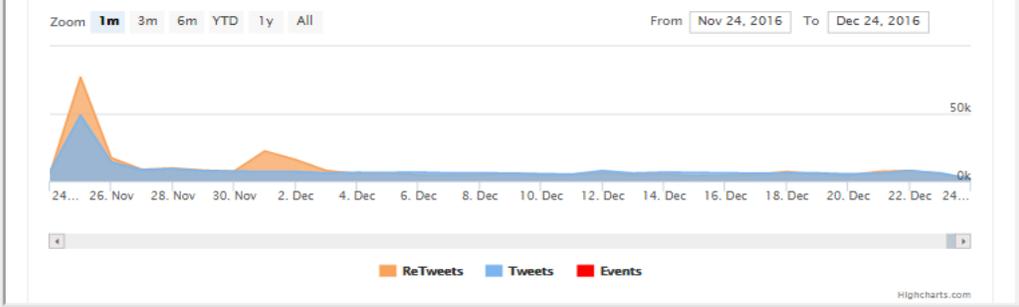
Home > Channel statistics > Statistics on single Channel

Channel active from 2009-02-27 to today  
Data processed from 2015-05-22 to 2016-12-02

NLP SA



Daily number of tweets/retweets for channel: **Firenze**



Sentiment Analysis in Tempo Reale su Firenze

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Menu On Login

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Data processed from 2016-06-28 08:10:00 to 2016-12-24 10:25:00

NLP SA



Most Significant Tweets for Sentiment in the period

Last tweets per channel **Firenze**

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https://t.co/uFETp4wG1y  
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Firenze, un piano per un Natale sicuro (055firenze) https://t.co/vpqDASepi https://t.co/2Bn5k3zoyv  
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- @SANTACROCEOPERA
- @MUSEONOVECENTO
- @FIRENZEDIGITALE

Twitter Hashtag trend

TRENDS QUOTES

- #FIRENZE
- #FIORENTINA
- #UFFIZI
- #PONTEVECCHIO

We suggest to use Chrome browser for better experience

# Venezia Social - Twitter Vigilance

Sun 11 Nov 00:09:40

## Venezia Twitter vigilance Channel

Twitter Vigilance Dashboard

Last crawling: 2018-11-11 00:09:16

Menu On Login

Home > Channel statistics > Statistics on single Channel

Channel active from 2018-07-17 to 2018-11-10

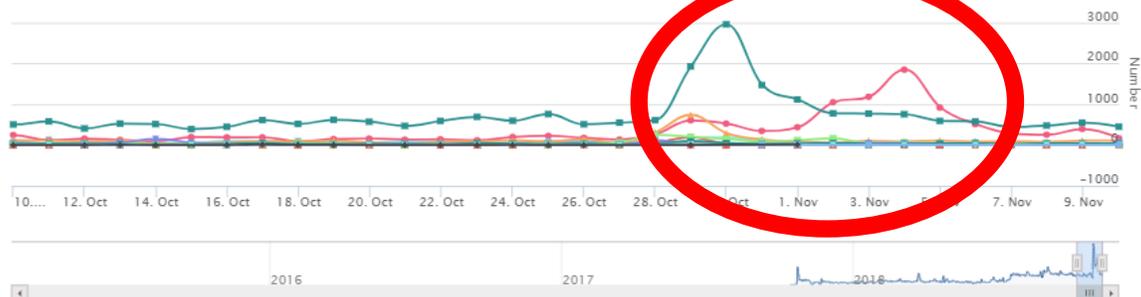
Data processed from 2018-05-02 to 2018-11-08

NLP SA

Search related to channel **venezia**

Zoom 1m 3m 6m YTD 1y All

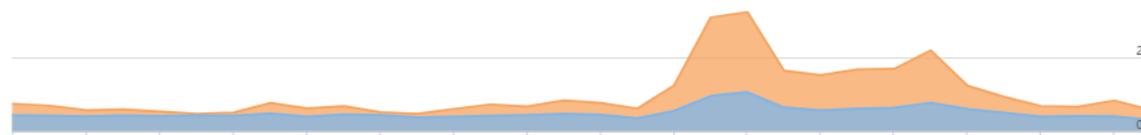
From Oct 9, 2018 To Nov 10, 2018



Daily number of tweets/retweets for channel: **venezia**

Zoom 1m 3m 6m YTD 1y All

From Oct 9, 2018 To Nov 10, 2018



## Sentiment Analysis

Twitter Vigilance Dashboard

Last crawling: 2018-11-11 00:09:16

Menu On Login

Home > Channel statistics > Channel sentiment analysis

Channel active from 2018-07-17 to 2018-11-10

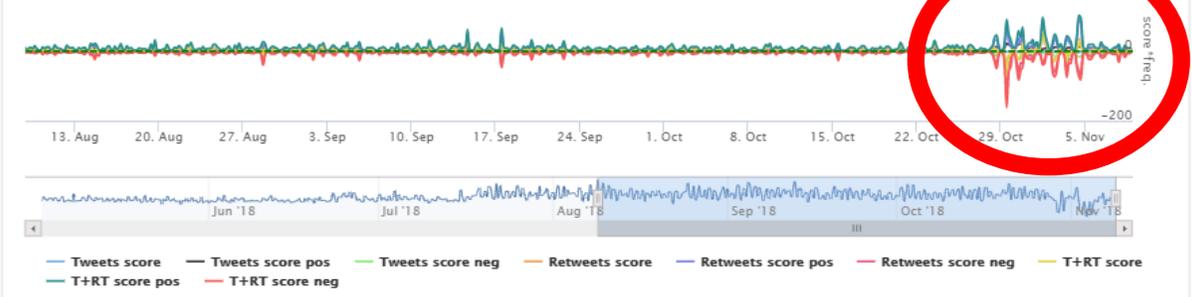
Data processed from 2018-05-02 to 2018-11-08

NLP SA

Sentiment trends in channel **venezia**

Zoom 1m 3m 6m YTD 1y All

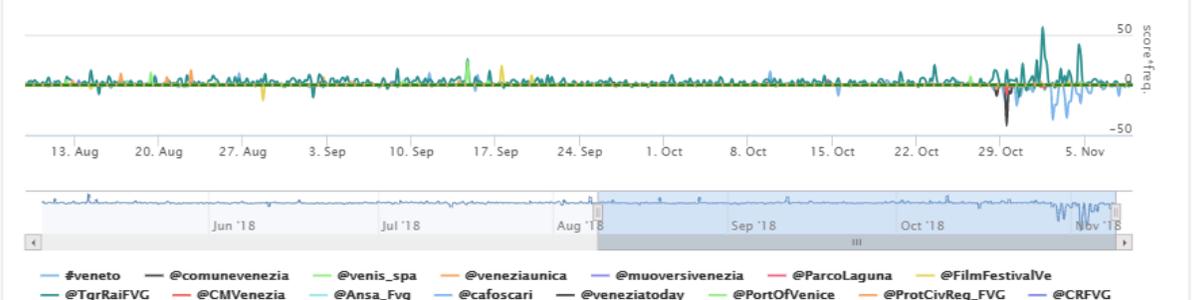
From Aug 8, 2018 To Nov 8, 2018



Sentiment trends in channel **venezia** research

Zoom 1m 3m 6m YTD 1y All

From Aug 8, 2018 To Nov 8, 2018



<https://main.snap4city.org/view/index.php?iddashboard=MTIxOA==>

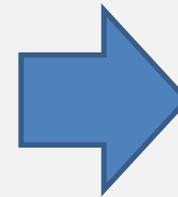
10

# *Reliability Audience on TV programs*



# Predicting Audience on Social intensive TV show

- **Issue:**
  - How to predict the number of people following a TV reality show in life
- **Impact:**
  - Making Advertising, promotion
  - Valorizing advertising
  - Adjusting the show
- **Several metrics related to**
  - Structure of volume of TW, RTW
  - Features of the tweet authors
  - Relationships ....



- Periodic events
- Specific rules
- Strong influence and user engagement
- Audience can vote
- Audience express appreciation and rejects
- .. Similar to the presence at large and long terms event, such as EXPO2015



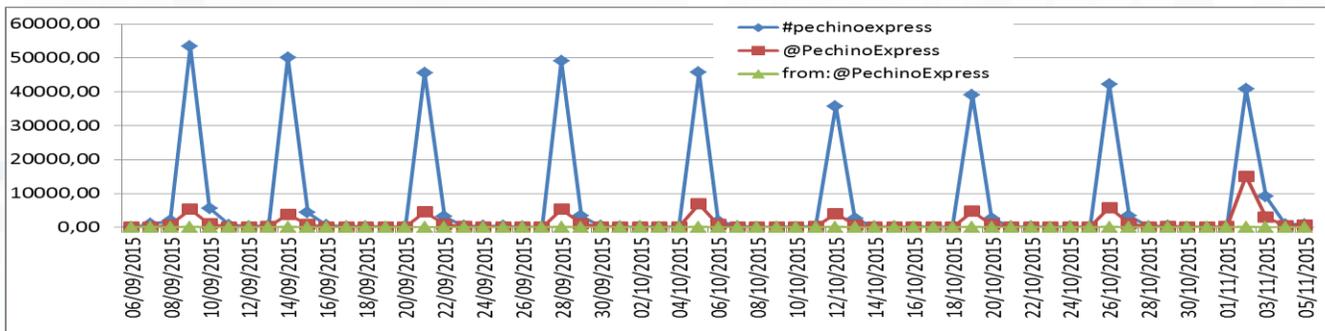
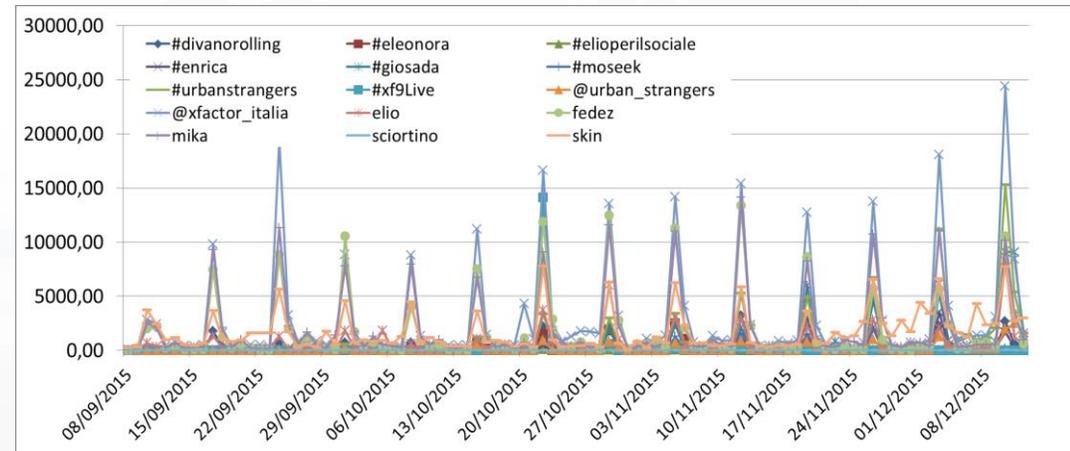
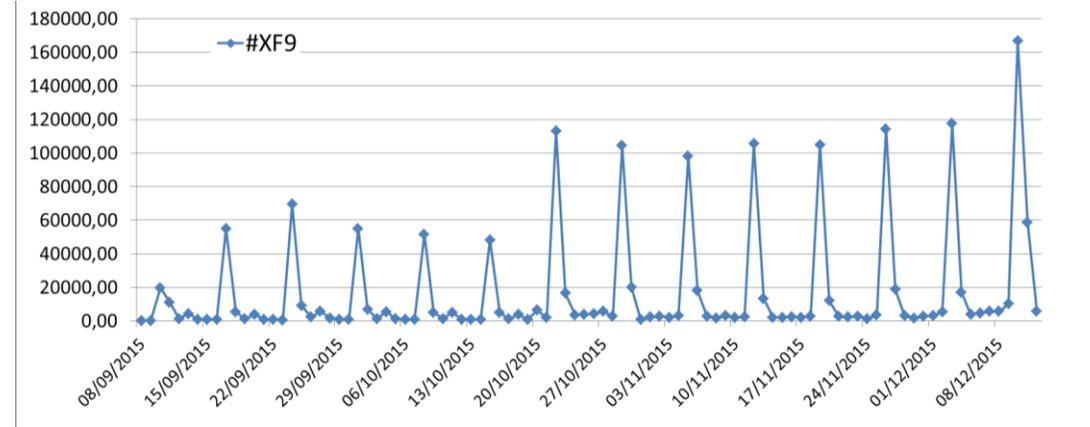
# Twitter Metrics

- TW: Number of Tweets per **Search/Channel** (as called Volume) , per day, per hour
- RTW: Number of ReTweets per **Search/Channel**, per day, per hour
- NRT/TW: ratio from ReTweets and Tweets per **Search/Channel**, per day, per hour
- NumSearch: number of Tweets including the Search per **Channel**, per day, per hour
- Sentiment Analysis Score per **Search/Channel**, per day, per hour
- Num of xxxxx

# Predicting Audience: X-Factor, PechinoExpress, ...

- Trend of TW and RTW for X-Factor 9
  - Several searches
- Similar model for other Social Intensive TV shows
  - See below Pechino Express

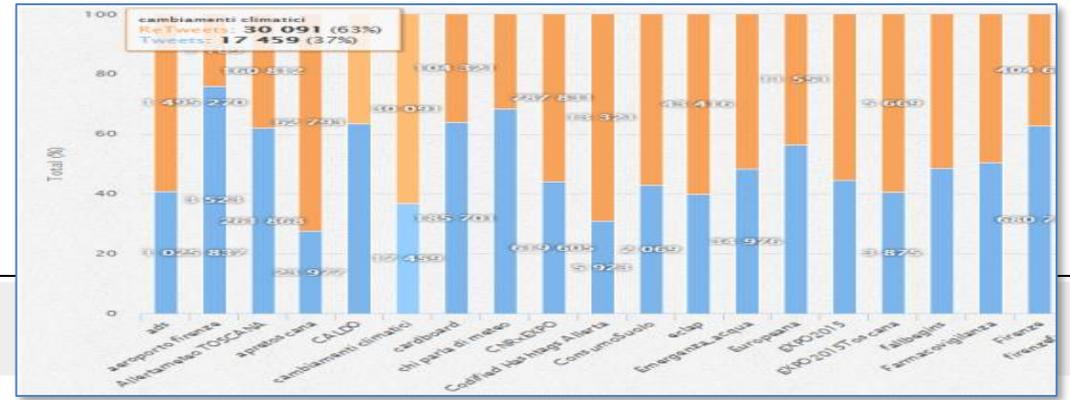
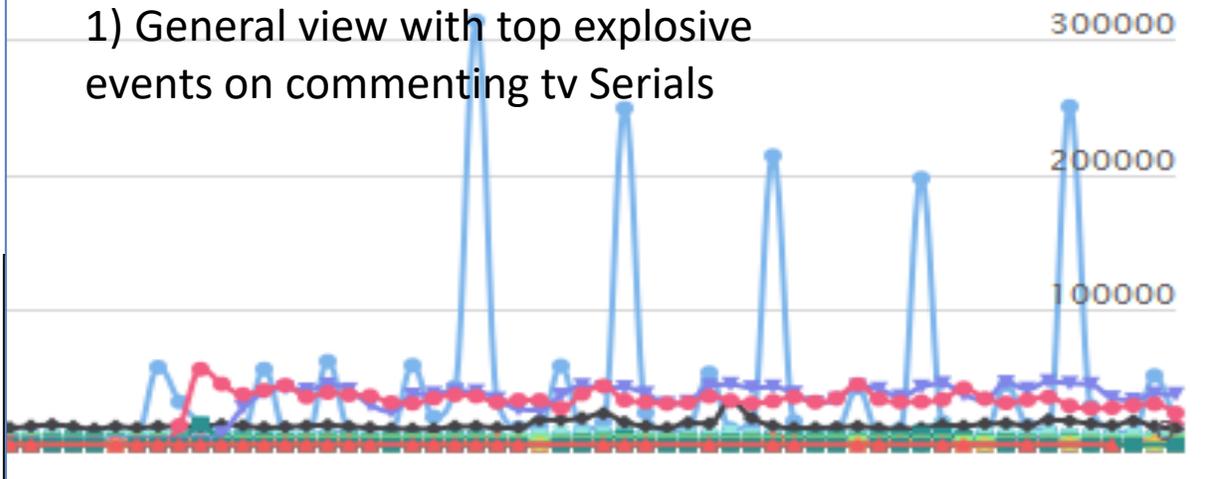
$$x_t = \beta_1 z_{1,t} + \beta_2 z_{2,t} + \beta_3 z_{3,t} + \dots + \beta_k z_{k,t} + n$$



# All Channels (private information)

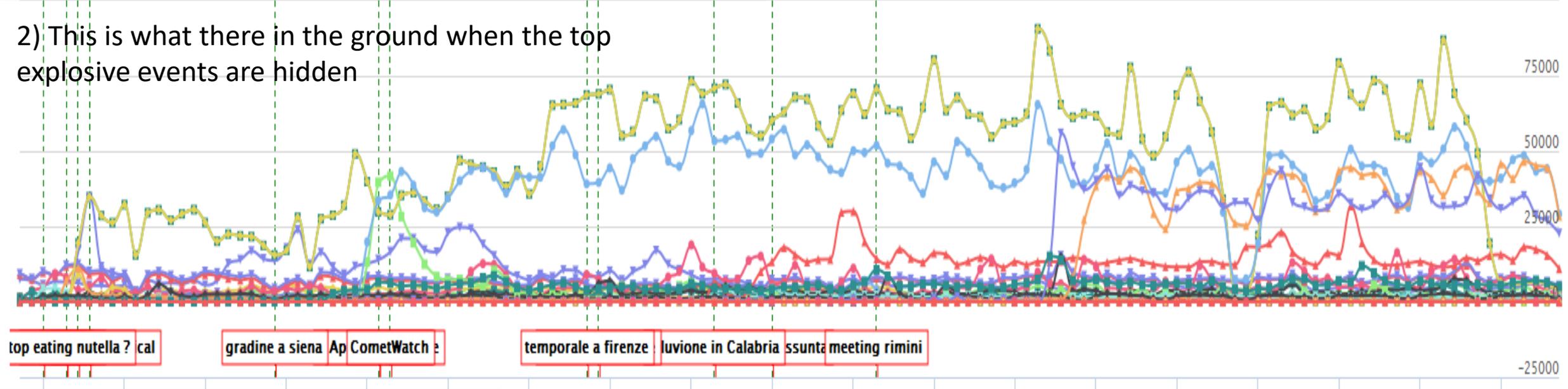


1) General view with top explosive events on commenting tv Serials



From Jun 12, 2015 To Oct 24, 2015

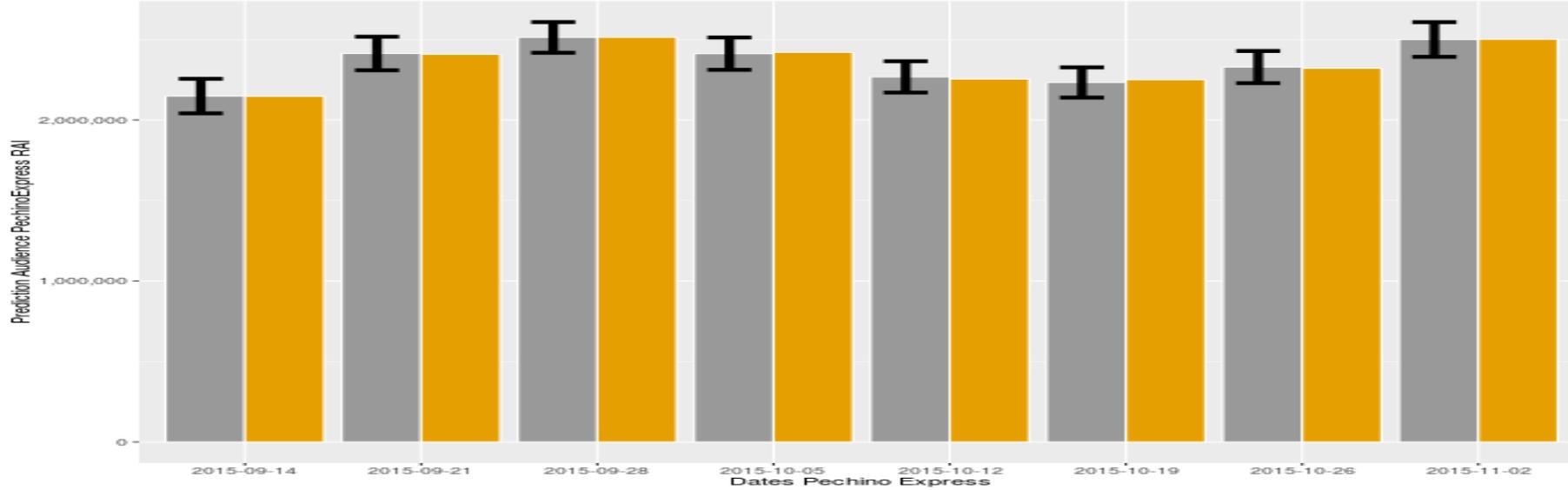
2) This is what there in the ground when the top explosive events are hidden



# Details of Predictive Models Validities

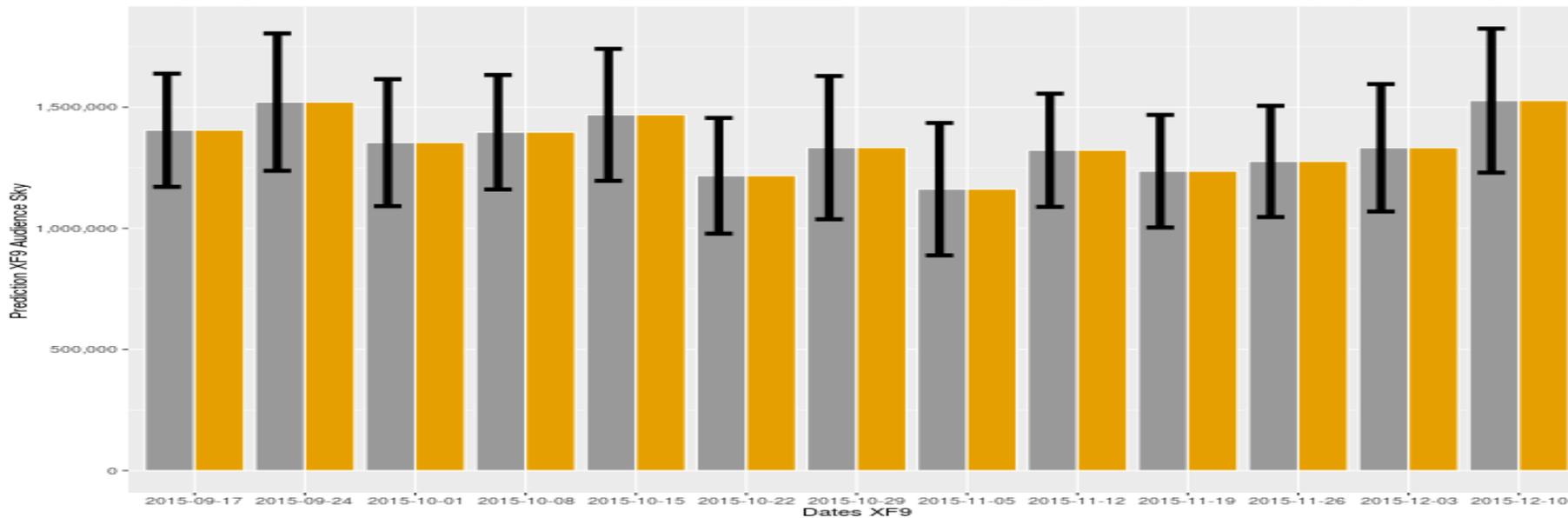
Metrics collected over the 5 days before the event.		X-Factor 9 - Model				Pechino Express - Model			
		Coeff	Std Err	t-val	p-val	Coeff	Std Err	t-val	p-val
Total number of tweets + retweets on main hashtag	$\beta_1$	-73.48	58.49	-1.256	0.2494	-954.3	64.69	-14.750	0.0045
Total number of tweets on main hashtag,	$\beta_2$	122.7	70.27	1.745	0.1244	4144	284	14.590	0.0046
Ratio between: number of RTW/TW on main hashtag,	$\beta_3$	135885	462704	2.937	0.0218	937920	80946	11.590	0.0073
UnqURetweet	$\beta_4$	264.3	153	1.728	0.1277	2175	345.6	6.293	0.0243
FUnqUsers	$\beta_5$	-214.9	132.5	-1.622	0.1488	-1640	270.6	-6.061	0.0261
Intercept	$n$	-762730	627238	-1.216	0.2634	-2560461	401675	-6.374	0.0237
R squared		<b>0.727</b>				<b>0,995</b>			
RMSE		66467				8851			
MAE		55589				6805			
AIC		340				182			
TV broadcasting company		Sky				RAI			
Weeks		13				9			
millions of registered tweets on Twitter Vigilance		1.625				0.455			

# Predicting Confidence



Prediction Audience PechinoExpress RAI

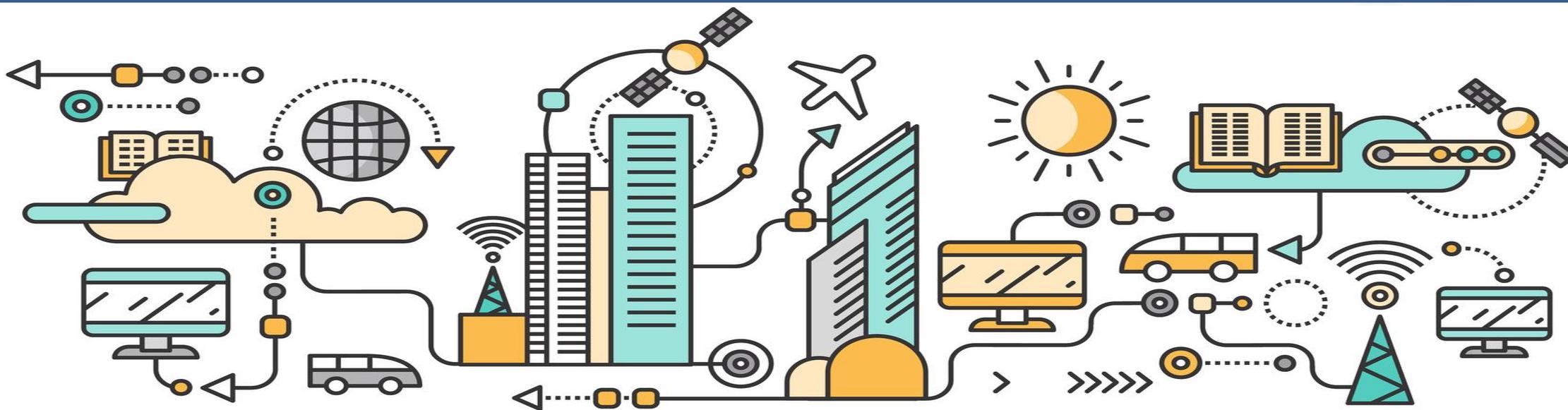
- Prediction
- Observed



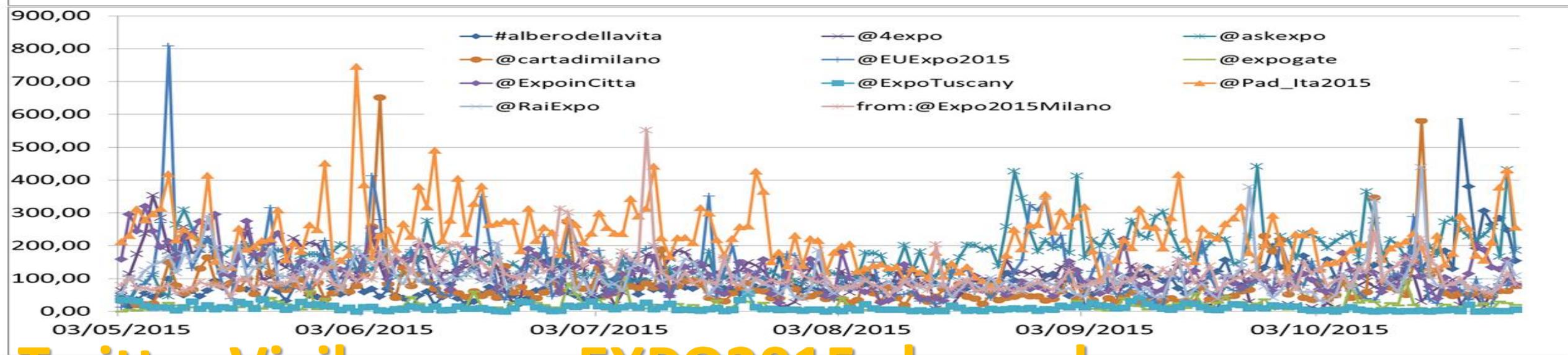
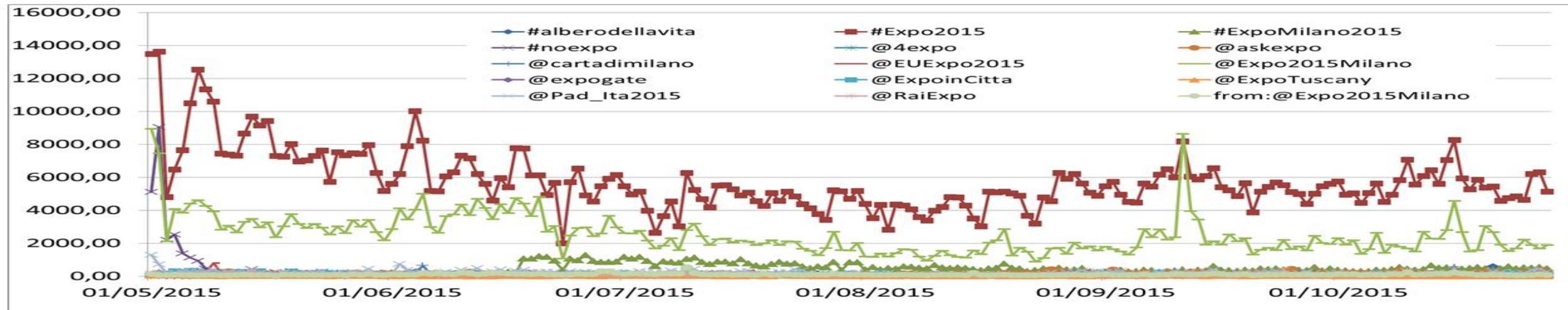
Prediction XF9 Audience Sky

- Prediction
- Observed

# *Reliability presences to major events*



# Predicting EXPO2015



## Twitter Vigilance on EXPO2015 channel

**Twitter Vigilance**

# Twitter Metrics

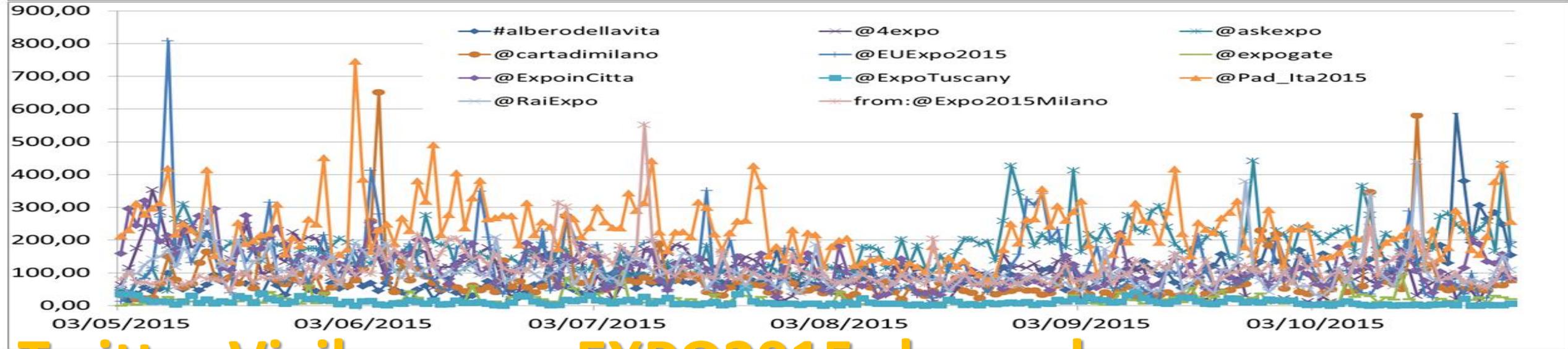
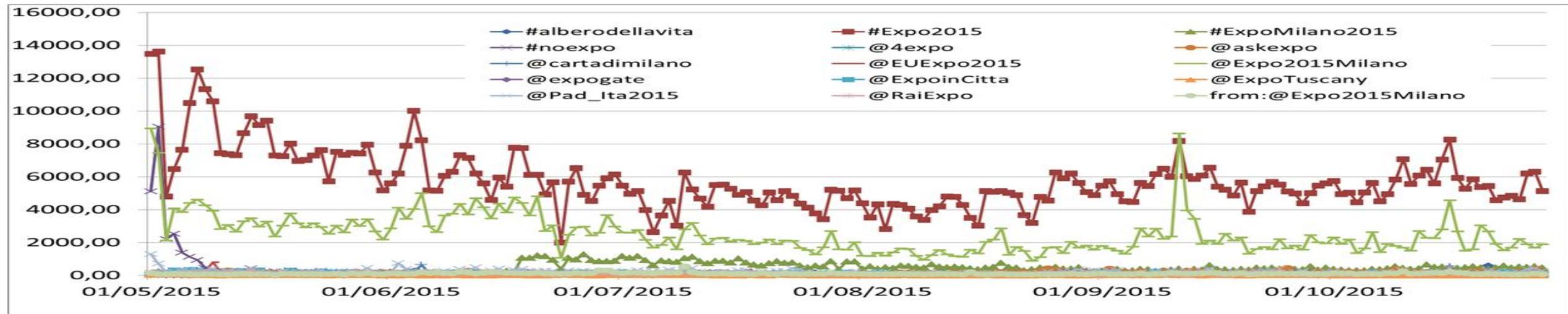
- TW: Number of Tweets per **Search/Channel** (as called Volume) , per day, per hour
- RTW: Number of ReTweets per **Search/Channel**, per day, per hour
- NRT/TW: ratio from ReTweets and Tweets per **Search/Channel**, per day, per hour
- NumSearch: number of Tweets including the Search per **Channel**, per day, per hour
- Sentiment Analysis Score per **Search/Channel**, per day, per hour
- Num of xxxxx

# *Predicting presences at events*





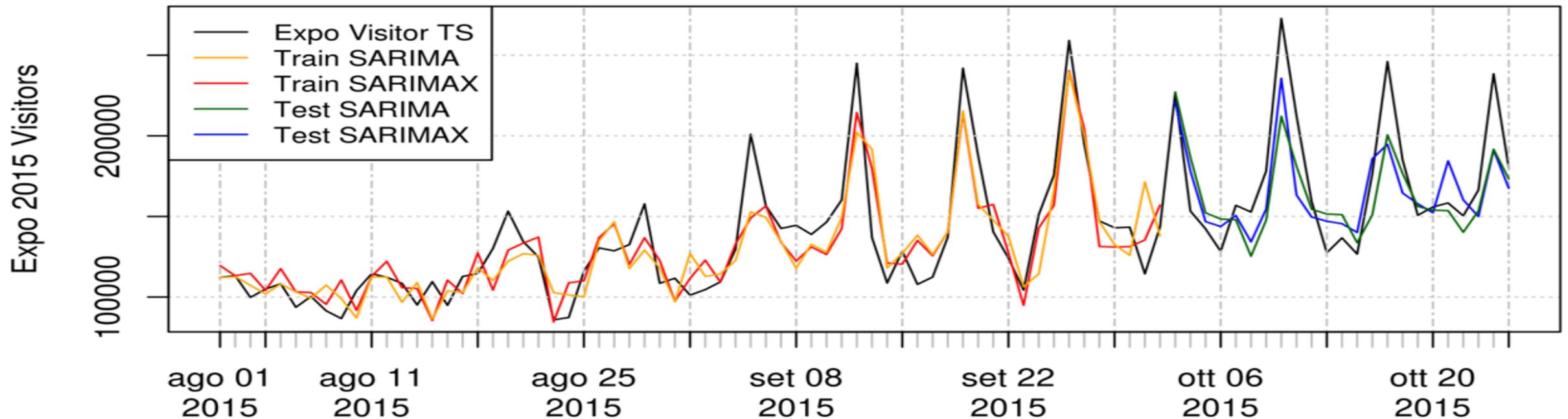
# Predicting EXPO2015



## Twitter Vigilance on EXPO2015 channel

# Twitter Vigilance

## monitoring and predictions



Training: 01-08-2015/02-10-2015 63 DD  
Test period: 03-10-2015/25-10-2015 22 DD

Predizioni al 90%

Precision: 96%

## Twitter Vigilance on EXPO2015 channel

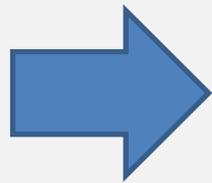
Predicting volume of visitors for tuning the services

# *Predicting reTweet Proneness*

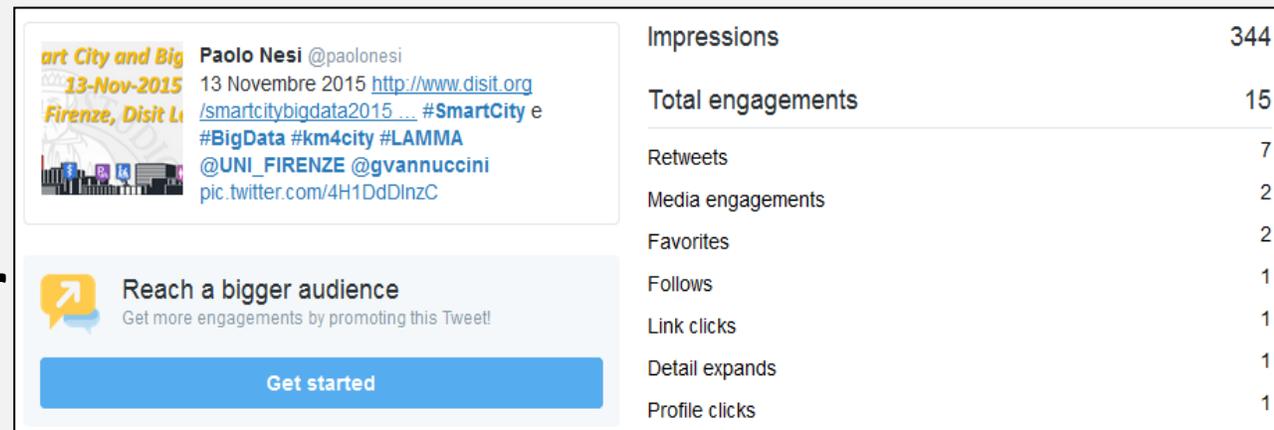


# Predicting the reTweet Proneness

- **Issue:**
  - How to understand if a tweet has a good probability of being retweeted?
- **Impact:**
  - Advertising, promotion, training
- **Several metrics related to**
  - Structure of the tweet
  - Features of the tweeting author
  - Relationships ....



## Twitter Analytics

**art City and Big** 13-Nov-2015 Firenze, Disit Li

**Paolo Nesi** @paolonesi  
 13 Novembre 2015 <http://www.disit.org/smartcitybigdata2015...> #SmartCity e #BigData #km4city #LAMMA @UNI\_FIRENZE @gvannuccini pic.twitter.com/4H1DdDlnzC

Metric	Value
Impressions	344
Total engagements	15
Retweets	7
Media engagements	2
Favorites	2
Follows	1
Link clicks	1
Detail expands	1
Profile clicks	1

Reach a bigger audience  
 Get more engagements by promoting this Tweet!

[Get started](#)

# Tweet proneness Metrics

## Tweet metrics

<b>URLs Count</b>	# of URLs in the tweet
<b>Mentions Count</b>	# of mentions/citation of Twitter users in the tweet
<b>Hashtags Count</b>	# of hashtags included in the tweet
<b>Favorites Count</b>	# of favorite obtained by the tweet
<b>Publication Time</b>	Local hour H24 in which the tweet has been published in the day according to the author' local time.

## Author of Tweet metrics

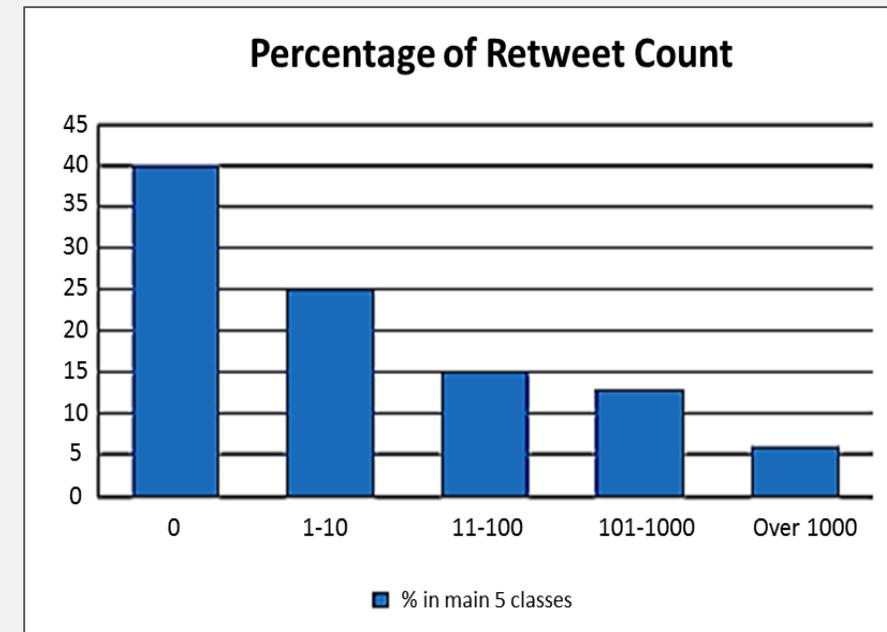
<b>Days Count</b>	# of days since the tweet's author created its Twitter account
<b>Statuses Count</b>	# of tweets made by the tweet's author since the creation of its own account

## Author Network metrics

<b>Followers Count</b>	# of followers the author of the tweet
<b>Followees Count</b>	# of friends the tweet's author is following
<b>Listed Count</b>	# of people added the tweet's author to a list

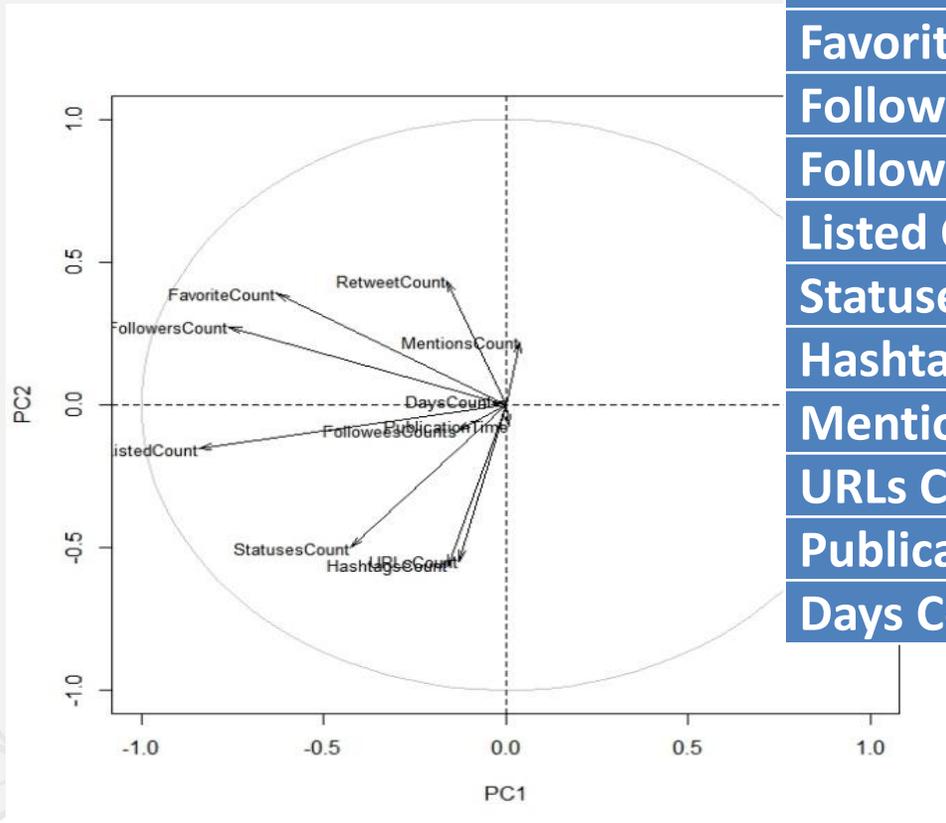
Data sets:

- 100 Million of Tweet
- 500 K
- 100 K



# reTweet proneness: assessment

- PCA



Metrics	PC1	PC2	PC3	PC4	PC5
Retweet Count	-0.1623	0.4346	0.1635	-0.0026	-0.1009
Favorites Count	<b>-0.6294</b>	0.3908	0.1922	-0.1128	-0.1880
Followers Count	<b>-0.7599</b>	0.2736	0.0522	-0.0983	-0.0857
Followees Count	-0.1336	-0.0907	<b>-0.4627</b>	-0.2494	0.1182
Listed Count	<b>-0.8431</b>	-0.1549	-0.0498	0.1500	0.1871
Statuses Count	-0.4256	<b>-0.5016</b>	-0.3781	0.2795	0.2410
Hashtags Count	-0.1585	<b>-0.5661</b>	0.4377	-0.0517	0.0309
Mentions Count	0.0394	0.2194	0.0786	-0.1607	<b>0.7697</b>
URLs Count	-0.1288	<b>-0.5483</b>	0.2539	-0.3388	-0.3248
Publication Time	0.0076	-0.0728	0.3639	<b>-0.5186</b>	0.3707
Days Count	-0.0370	0.0070	<b>-0.5072</b>	<b>-0.6604</b>	-0.1691

# *reTweet proneness: Classification methods*

- Statistic classifications vs machine-learning methods
- 80% of training data set, 20% of testing data sets; 500K data set
- → Recursive partitioning procedure models (RPART), good compromise for Big data problems

Classifier Models	Accuracy	Precision	Recall	F <sub>1</sub> score	Processing Time in sec.
Recursive Partitioning (Stat)	<b>0.6807</b>	<b>0.8512</b>	<b>0.7767</b>	<b>0.8122</b>	<b>180</b>
Random Forests (ML)	0.6884	0.8601	0.7866	0.8217	198968
Gradient boosting (ML)	0.6796	0.8534	0.7731	0.8113	64448
Multinomial Model (Stat)	0.6411	0.8367	0.7245	0.7765	31576

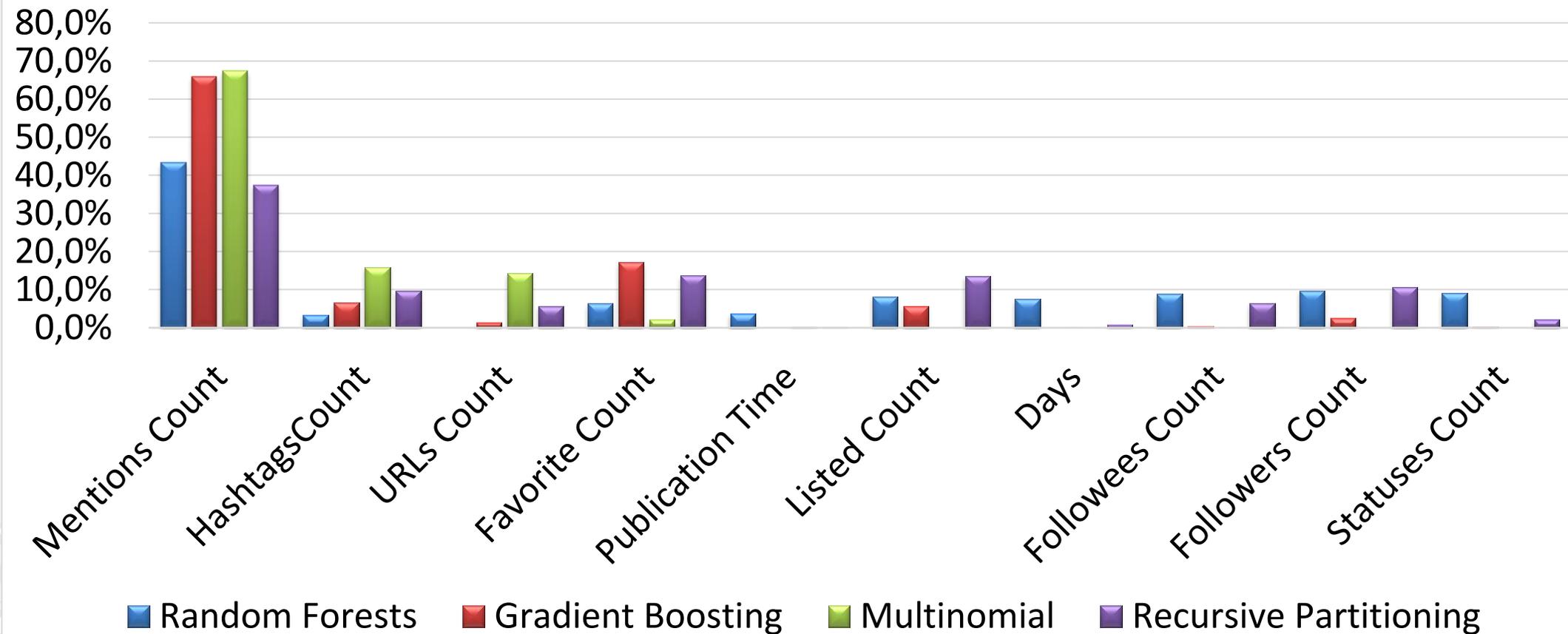
# reTweet proneness (RPART), 100M

Assessment drivers	Degree of Retweeting Classes				
	0	1-100	101-1000	1001-10000	Over 10000
Sensitivity	0.7737	0.8105	0.3142	0.0208	0.0136
Specificity	0.9132	0.6694	0.9199	0.9996	1.0000
Positive Predictive Value	0.8564	0.6256	0.3752	0.7345	0.8488
Negative Predictive Value	0.8579	0.8382	0.8975	0.9485	0.9915
Prevalence	0.4007	0.4053	0.1328	0.0526	0.0086
Detection Rate	0.3100	0.3285	0.0417	0.0011	0.0001
Detection Prevalence	0.3620	0.5251	0.1112	0.0015	0.0001
Balanced Accuracy	<b>0.8435</b>	<b>0.7399</b>	<b>0.6170</b>	0.5102	0.5068

Accuracy	<b>0.6815</b>
Accuracy 95% Confidential Interval (min, max)	(0.6813, 0.6817)
Recall	0.7737
Precision	0.8564
Kappa	0.4922

# Predictive models VS metrics relevance

## Variable Importance between Models

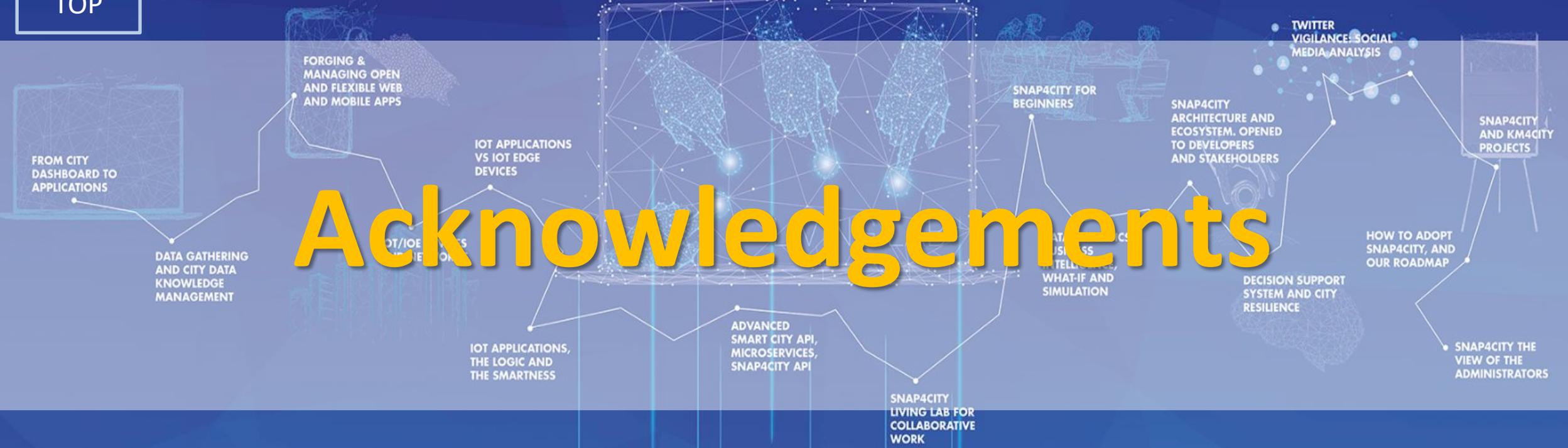


# Citations and self training

- P. Nesi, G. Pantaleo, I. Paoli, I. Zaza, "Assessing the reTweet Proneness of tweets: predictive models for retweeting", Multimedia Tools and Applications, Springer, 2018.  
<https://link.springer.com/article/10.1007/s11042-018-5865-0>
- A. Crisci, V. Grasso, P. Nesi, G. Pantaleo, I. Paoli, I. Zaza, "Predicting TV programme Audience by Using Twitter Based Metrics", Multimedia Tools and Applications, springer. 10.1007/s11042-017-4880-x, 2017 <https://link.springer.com/article/10.1007/s11042-017-4880-x>
- V. Grasso, A. Crisci, M. Morabito, P. Nesi, G. Pantaleo, "Public crowdsensing of heat waves by social media data", Adv. Sci. Res., 14, 217-226, <https://doi.org/10.5194/asr-14-217-2017>, 2017, 10.5194/asr-14-217-2017 . <http://www.adv-sci-res.net/14/217/2017/>
- V. Grasso, A. Crisci, M. Morabito, P. Nesi, G. Pantaleo, I. Zaza, B. Gozzini, "Italian codified hashtags for weather warning on Twitter—who is really using them?." Advances in Science and Research 14 (2017): 63-69. <http://www.adv-sci-res.net/14/63/2017/asr-14-63-2017.pdf>

TOP

# Acknowledgements



# 2013 Km4City Ontology 1.1

- Tuscany, Road Graph
- Mobility
- culture, tourism
- Events
- Parking
- Services
- Linked open graph

# 2014

- Weather Forecast
- Real Time Wi-Fi
- Entertainment
- LOD
- Twitter Vigilance
- Social Media Analytics, Sentiment Analysis

# Km4City 1.4

# 2015



(2016-21)  
 H2020  
**REPLICATE**

- Smart Energy
- Sustainable Mobility
- Control Room
- Dashboard

**Km4City 1.6.2**

(2016-21)  
 Sii-Mobility  
**SII-MOBILITY SCN**

- Infomobility
- Mobile App
- Routing
- Multimodality

**2016**  
**FIWARE**

- Resilience Decision Support
- Smart First Aid
- User Behaviour Analysis, predictions
- Risk Analysis

# Km4City 1.6.4



- Origin-Destination and trajectories
- Traffic Reconstruction
- Offer Analysis
- OBU, smart devices

**E015**  
 digital ecosystem  
 Powered by EXPO MILANO 2015

(2016-19)  
**GHOST SIR**

- Sardinia Region Smart City Strategies and plan

**GREEN IMPACT CAPACITY**

# GREEN IMPACT

- POR FESR 2014-2020
- Industry 4.0
- Critical Plant
- Monitoring

# 2017

(2017-20)  
**life weee**

- Smart Waste

**MOSAiC**  
 Mobility 4.0 for Smart (II) City  
 (2018-20)

# 2018



- User engagement
- Bike Sharing
- Data Analytics ++
- Social Predictions
- OBD2

# IOT/IOE Km4City 1.6.6

**Node-RED**

**SNAP4CITY**

**SELECT for Cities**  
 H2020  
 (2017-19)

- IOT/IOE, IOT App
- Living Lab
- Maker Support
- IOT Edge
- Smart City IOT
- GDPR, Privacy & Security

- Mobility Demand / Offer Analytics and Strategy



5G tech  
 Energy  
 Industry 4.0  
 Synoptics

**TRAFAIR**  
**CEF** (2018-21)

- Traffic and Mobility Impact on Pollution
- NOX predictions

# 2019

**EUROPEAN OPEN SCIENCE CLOUD**

**LAID Smart Bed**

- Smart Health

**GREEN FIELD PEAS Soda4.0**  
 Optimization and Automated Decision System 4.0

- Industry 4.0

# bee smart city

- Smart Lonato

- PCP Award

**Reverberi Enetec**  
 Gruppo MPES

**SELECT**  
 1<sup>st</sup> place award to  
 SNAP4CITY

# 2020

**Interreg Mediterranean**  
 HERIT-DATA

- Smart Tourism
- 6 Pilots
- Data Analytics
- Extended platform

# 2021

- CAPELON
- Sweden

**smartGARDAlake**

**Interreg**  
 MARITTIMO-IT FR-MARITIME  
**MOBI MART**

- Smart Mobility
- PISA, PUMS
- Living lab

# Main running instances

**SELECT**  
for Cities



- Sii-Mobility → mobility and transport, sustainability
- REPLICATE → ICT, smart City Control room, Energy, IOT
- RESOLUTE → Resilience, ICT, Big Data
- GHOST → Strategies, smart city
- TRAFair → Environment & transport
- MOSAIC → mobility and transport
- WEEE Life → Smart waste, environment
- Smart Garda Lake → Castelnuovo del Garda
- 5G → Industry 4.0 vs SmartCity
- Green Impact → Industry 4.0, Chemical Plant
- SmartBed (laid) → smart health
- Green Field Peas (soda) → Industry 4.0, Chemical plant
- MobiMart and PISA Agreement → data aggregation, mobility and transport, Living Lab
- Lonato del Garda → smart parking, environment
- Herit Data → tourism, culture and management
- ISPRA JRC → site management and services
- Capelon (Sweden) → smart light solutions

# Acknowledgements

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INGEGNERIA  
DELL'INFORMAZIONE

**DISIT**  
DISTRIBUTED SYSTEMS  
AND INTERNET  
TECHNOLOGIES LAB

# DISIT thanks to

Herit Data: Tourism and Mng. <https://herit-data.interreg-med.eu/>

Snap4City: IOT/IOE smart city [www.snap4city.org](http://www.snap4city.org)

Trafair: CEF project with several Cities <http://trafair.eu/>

Mosaic: Mobility and transport model

Km4City: <http://www.km4city.org>

REPLICATE H2020, SCC1, EC flagship

<http://replicate-project.eu/>

Sii-Mobility SCN MIUR: <http://www.sii-mobility.org>

Feedback: retail and GDO Big Data analytics

5G with 3G-Wind, Open Fiber, Estra

Coll@bora Social Innovation, MIUR:

<http://www.disit.org/5479>

RESOLUTE H2020, EC:

<http://www.resolute-eu.org>

TRACE-IT, RAISSS, TESYSRAIL, ...

Mobile Emergency:

<http://www.disit.org/5404>



TESYS RAIL



**RAISSS**



# Further readings



# SNAP4CITY



<https://www.snap4city.org/108>

- [HOW TO: create a Dashboard in Snap4City](#)
- [HOW TO: add a device to the Snap4City Platform](#)
- [HOW TO: add data sources to the Snap4City Platform](#)
- [HOW TO: define privacy rules for personal data, produced by the end-users own device](#)
- [HOW TO: Develop Smart Applications, Snap4City development Life Cycle](#)
- [HOW TO: HLT vs Ingestion, and HLT vs Widgets](#)
- [HOW TO: Develop an IOT Application for Data Ingestion](#)
- [HOW TO: Upload data into Knowledge Base, ServiceMap \(triple upload\)](#)
- [HOW TO: Create as set of Devices with BulkProcessing](#)
- [HOW TO: Create an IOT Device Model](#)
- [HOW TO: Create an IOT Device Instance from IOT Directory tool](#)

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*Be smart in a SNAP!*

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