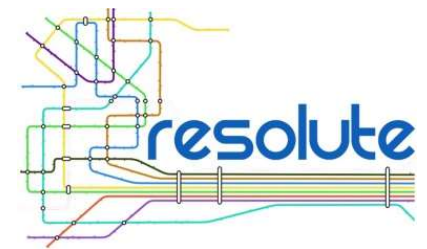




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# **Functional Resonance Analysis Method based- Decision Support tool for Urban Transport System Resilience Management**

E. Bellini, P. Nesi, G. Pantaleo, A. Venturi

Distributed Systems and Internet Technology, DISIT Lab, Univ. of Florence, Italy

<http://www.disit.org/>, <http://www.km4city.org>

[paolo.nesi@unifi.it](mailto:paolo.nesi@unifi.it)



UNIVERSITY  
OF TRENTO - Italy

**IEEE  
Second International  
Smart Cities Conference  
(ISC2 2016)**

Improving the citizens quality of life  
12-15 September 2016 | Trento - Italy



# Problem and issues

- **Cities include critical infrastructures strongly related / depended each other:**  
Transport, energy, communication, cyber, health...
- **Risks for these Critical Infrastructure** (safety and security) may be due to natural and/or human made events.
- **UTS, Urban Transport System**, is one of the most challenging since UTS is the via by which many problems may propagate but also the path used by solutions and the recovery actions.







# Main Approach

- **Three main layers**

- 1. Complex System modeling:** function, processes, resources, time, events, etc..

- Functional Resonance Analysis Method, FRAM
- Resilience Analysis Grid, RAG

- 2. Decision Support System, DSS**

- E.g.: System Thinking, Goal Models

- 3. Data, big data access and exploitation**

- Data Analytics
- Internet of Things, sensors, flows



# Functional Resonance Analysis Method

## Time:

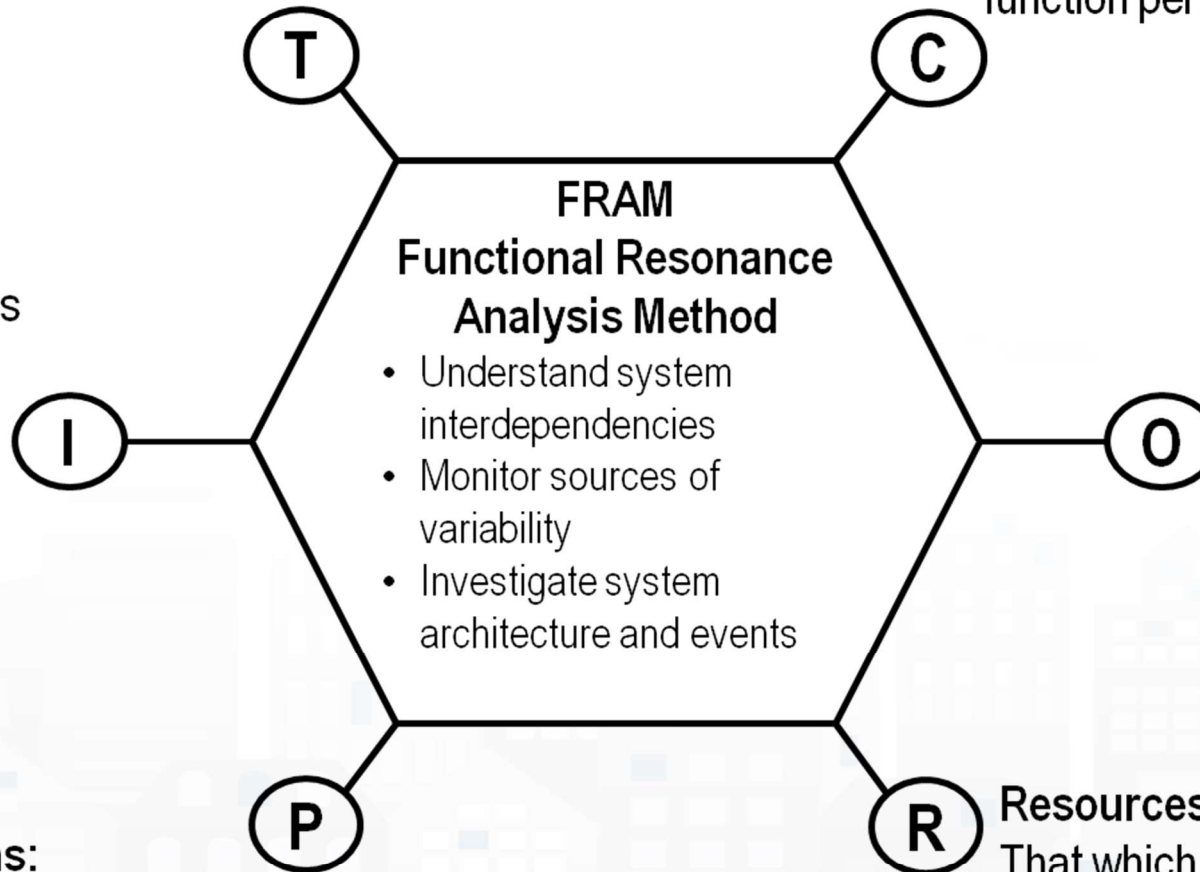
This is simultaneously a resource and a constraint

## 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

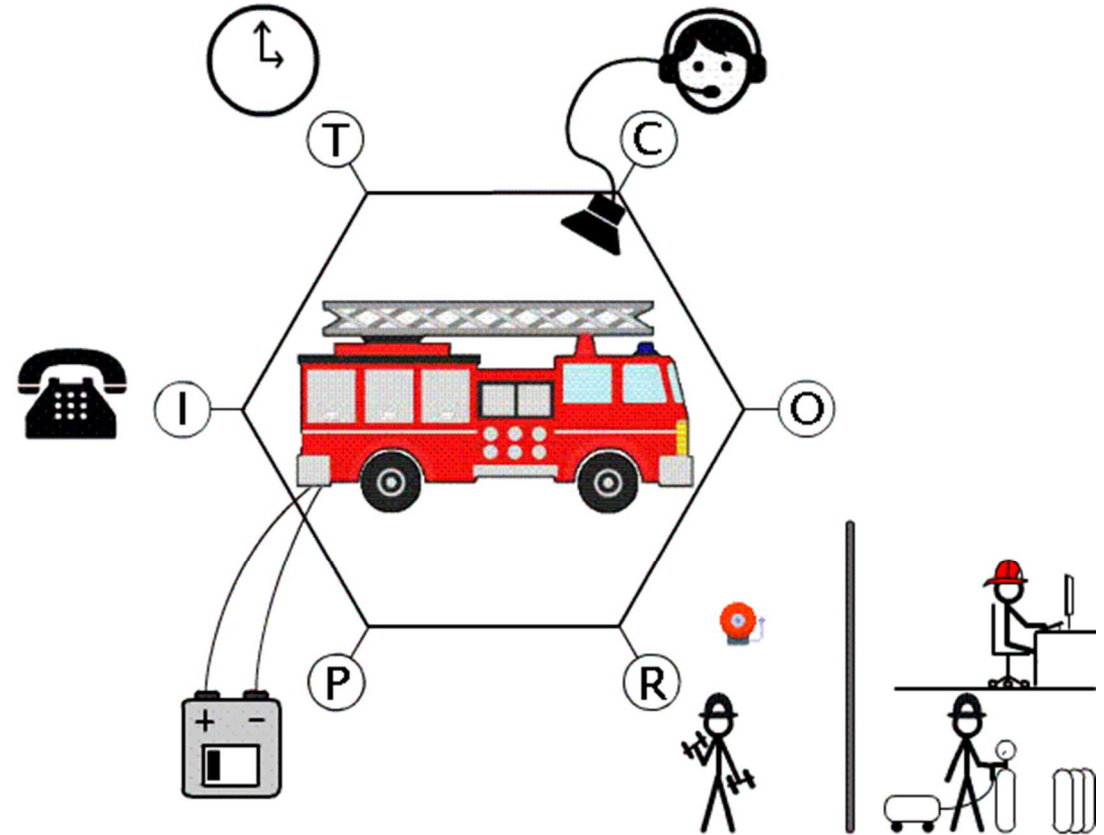
## Resources:

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



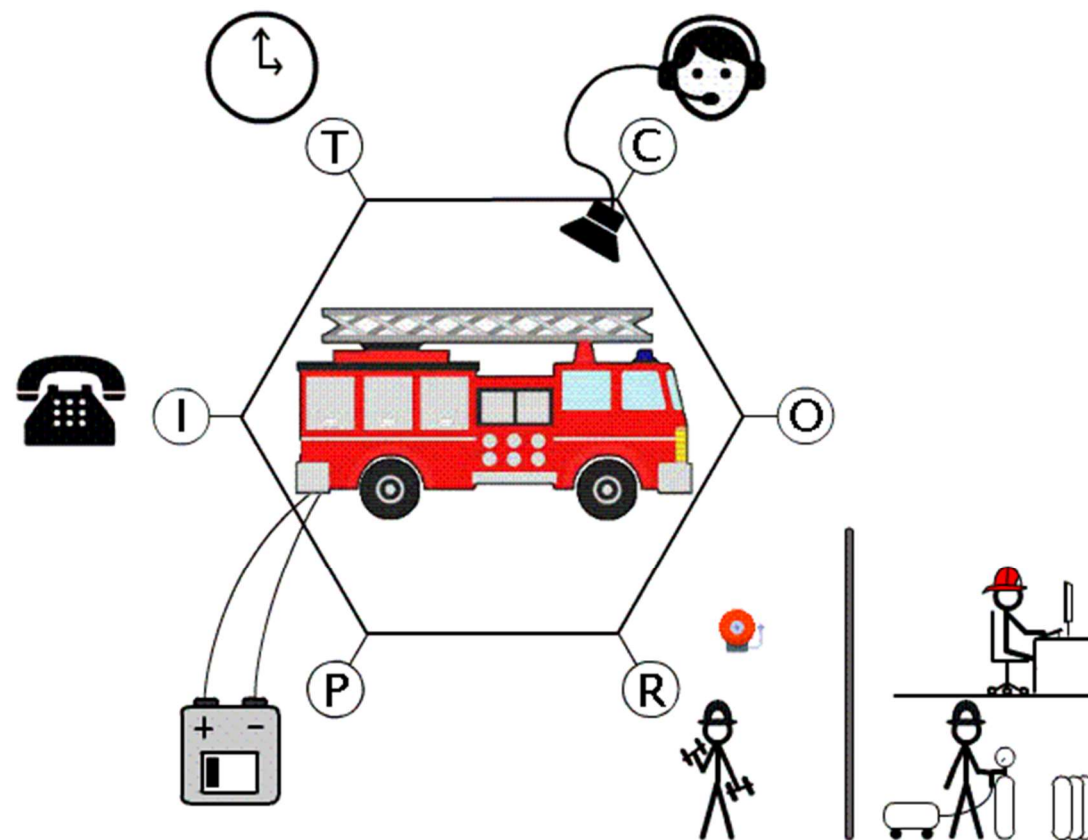
# Functional Resonance Analysis Method

- **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.



# Functional Resonance Analysis Method

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# RESOLUTE Outcomes

- **European Resilience Management Guidelines** – (guidelines) – consensus driven approach improve guidelines acceptability at EU level
  - general version, and UTS version
  - <http://www.resolute-eu.org/index.php/deliverables>
- **CRAMSS** – (tools and algorithms) – ontology based static and dynamic CI data integration, processing and analysing platform
- **Mobile Emergency app** – (tools and procedures) – supporting users in their local decision before (early warnings), during and after an event
- **Game based training app** – (tools and procedures) – improving the current preparedness of the citizen in order to increase the community self-resilience





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<http://www.disit.org>



# Improve city resilience, reducing risks and decision support

- **assessing city resilience level**
  - Resilience Decision Support, <http://resilienceds.km4city.org>
  - Smart decision support system, <http://smartds.km4city.org>
- **improving city users awareness with personal city assistants and participatory tools**
  - Dashboard: <http://dashboard.km4city.org>
  - Km4City Web App <http://www.km4city.org>
  - Km4City Mobile App: <http://www.km4city.org/app>

The collage displays various components of the KM4CITY system:

- Network Diagram:** A complex graph showing nodes representing different city entities and edges representing relationships or flows between them.
- Firenze Dashboard:** A data visualization interface for the city of Florence, featuring multiple charts, maps, and key performance indicators (KPIs) such as '19.4%' and '98.9%'.
- City Map:** A detailed street map of Florence with various colored overlays (red, green, blue) indicating different zones or data points.
- Decision Tree:** A flowchart titled 'DECISIONE: SE TENDI DI APRIRI UN RESTAURANTE' showing different options and their associated costs and benefits.
- Mobile App:** A screenshot of the 'FIRENZE' mobile application showing a map with purple markers and a 'Remove' button.
- Legend:** A list of services and facilities available in the city, including Guardia medica, Ciclopercorsi, Supermercato, Impianti sportivi, Banca, Carabinieri, Piscina, Pronto soccorso, Cinema, Linea del Tram, Parcheggio auto, Rastrelliera per biciclette, and Rivendita biglietti autobus.



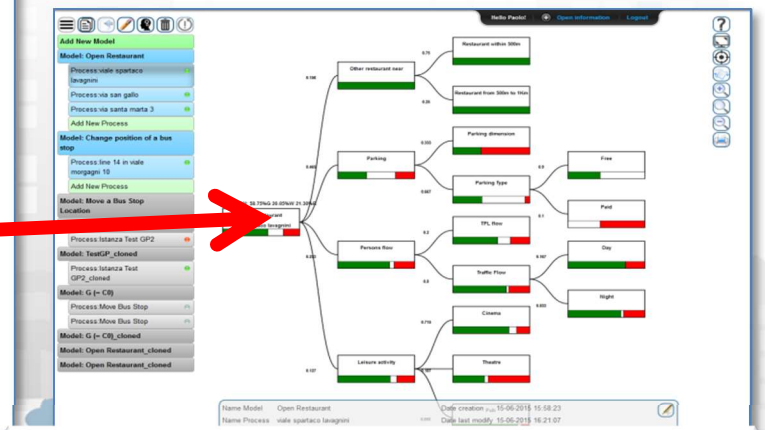
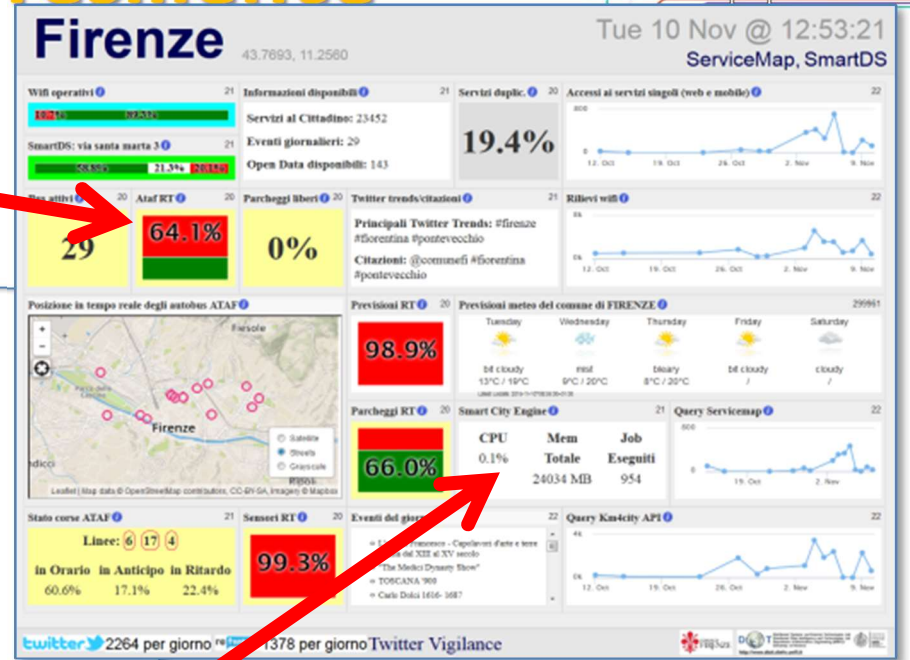
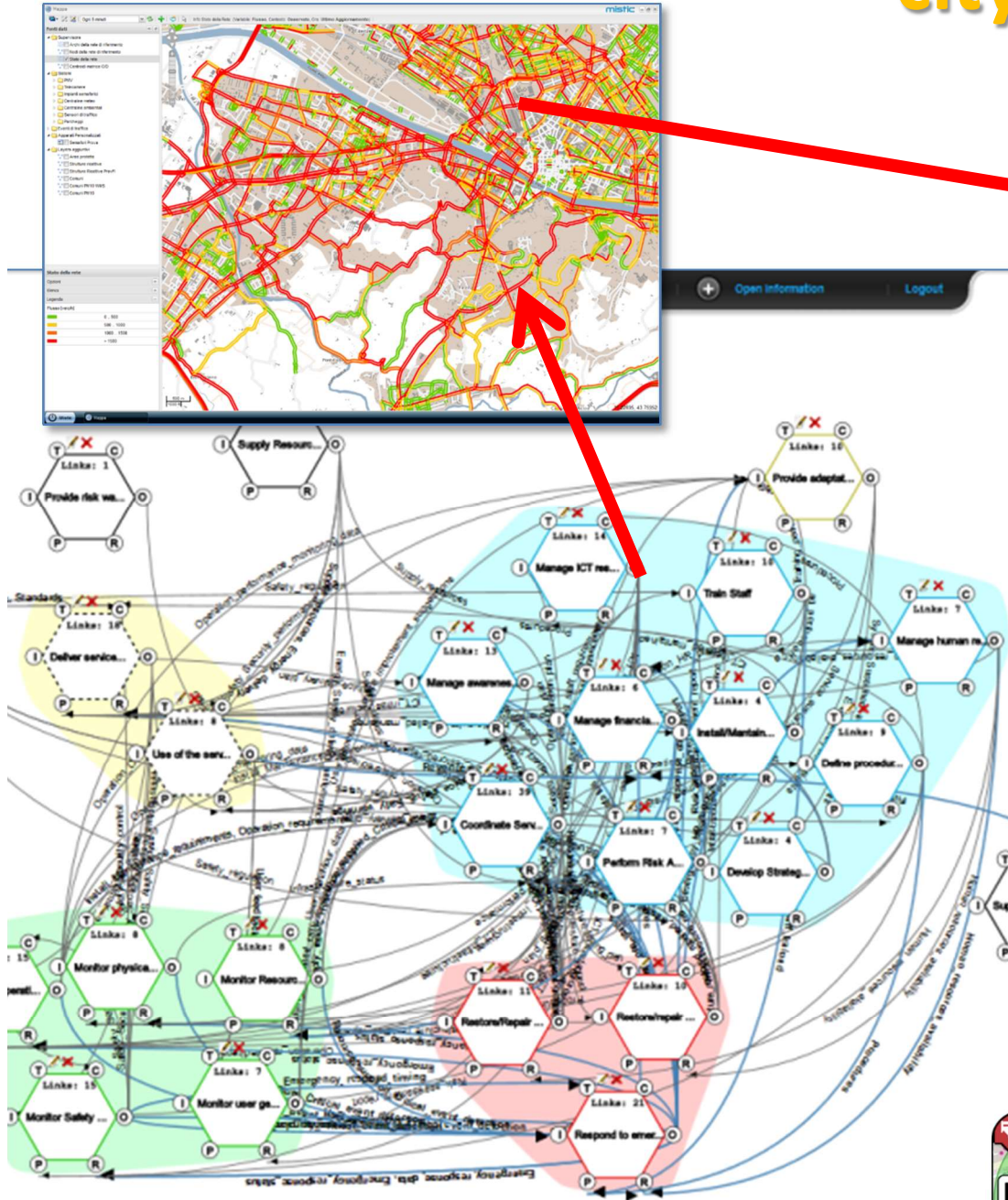


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# Dashboarding city resilience

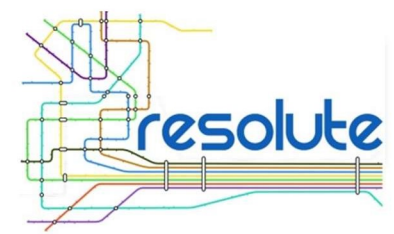


The Resilient City, C





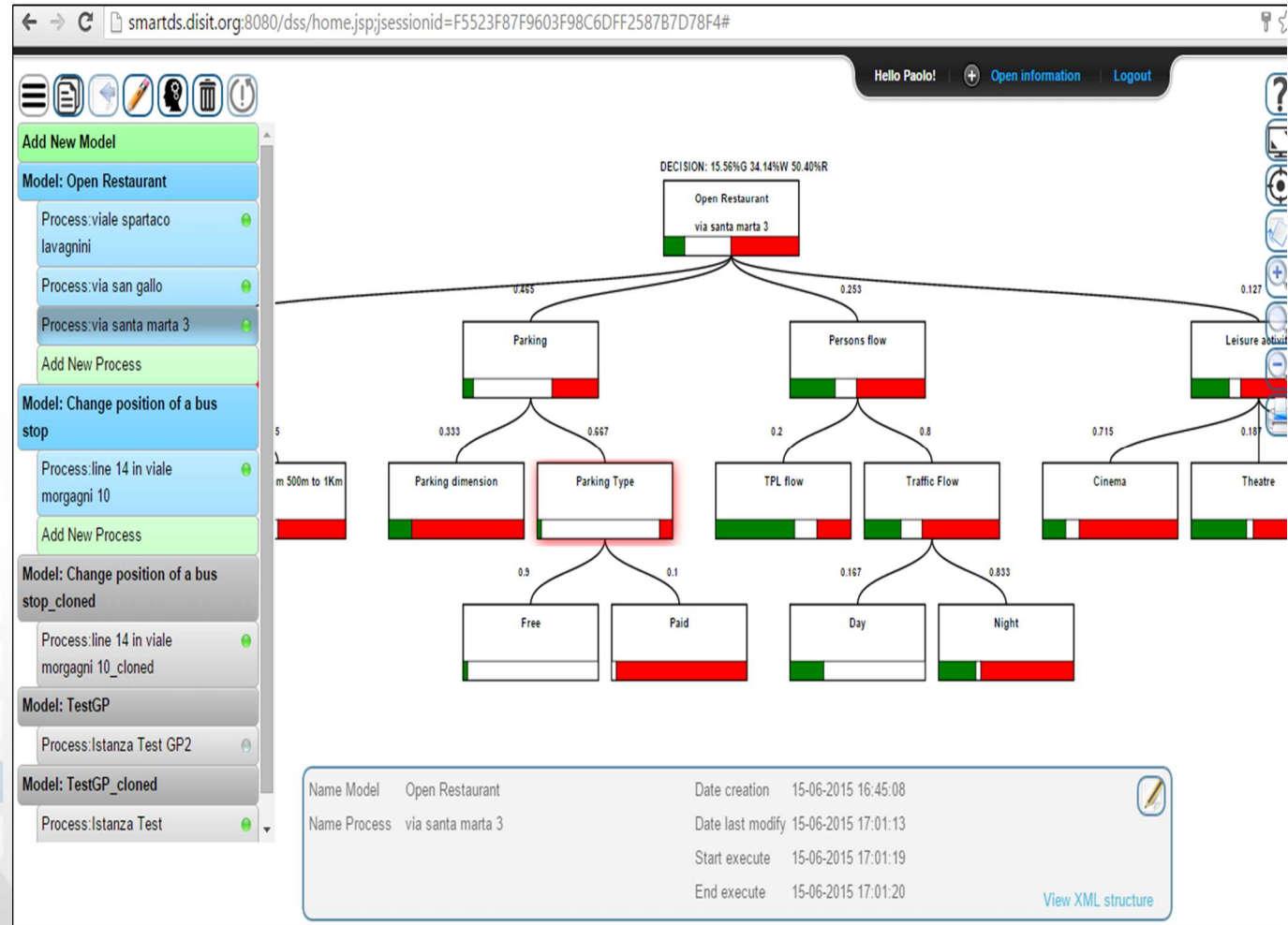
# Smart Decision Support



- **Smart Decision Support System based on System Thinking plus**
- Actions to city reaction, resilience, smartness..

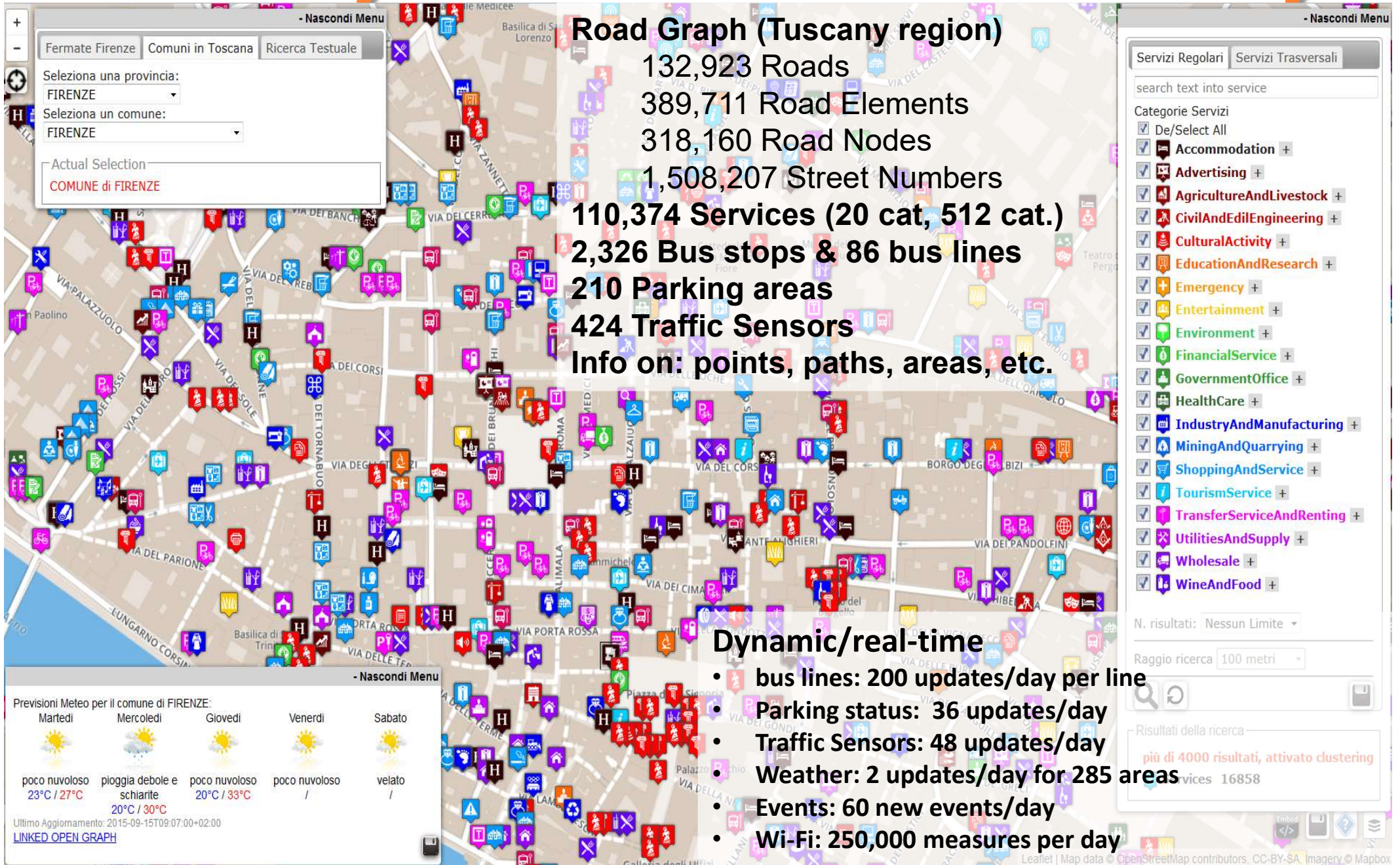
## Enforcing

- 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, ...





# Km4City on Firenze & Tuscany







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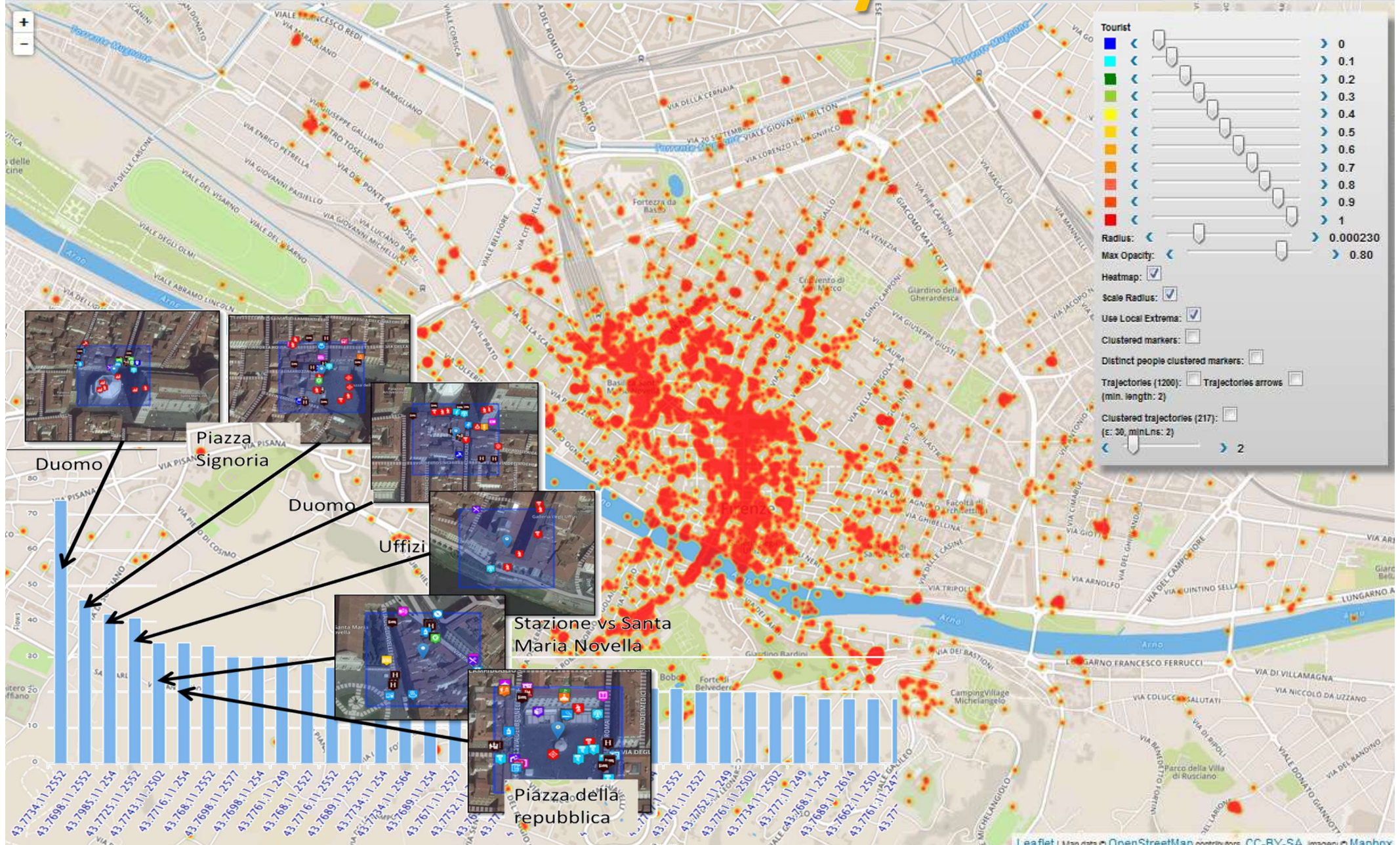
# User Behavior



Personal Recommender

DISIT - Distributed Systems and Internet Technology Lab

# Analyzer





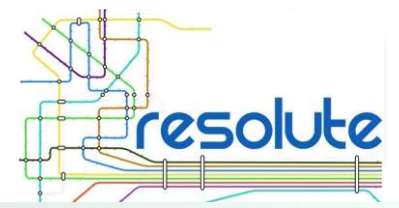


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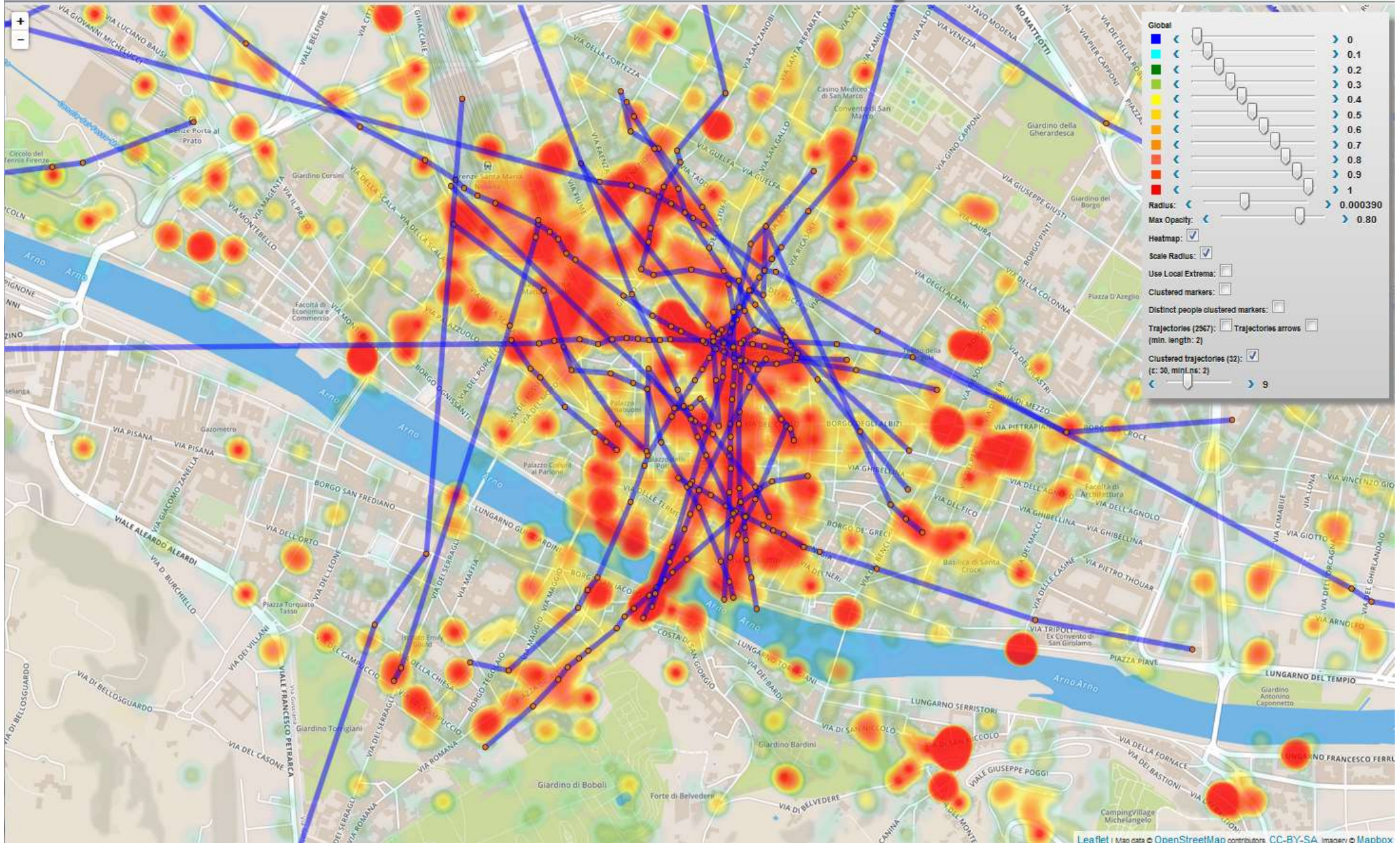
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# User Behavior



**DISIT** Personal Recommender  
DISIT - Distributed Systems and Internet Technology Lab

# Analyzer

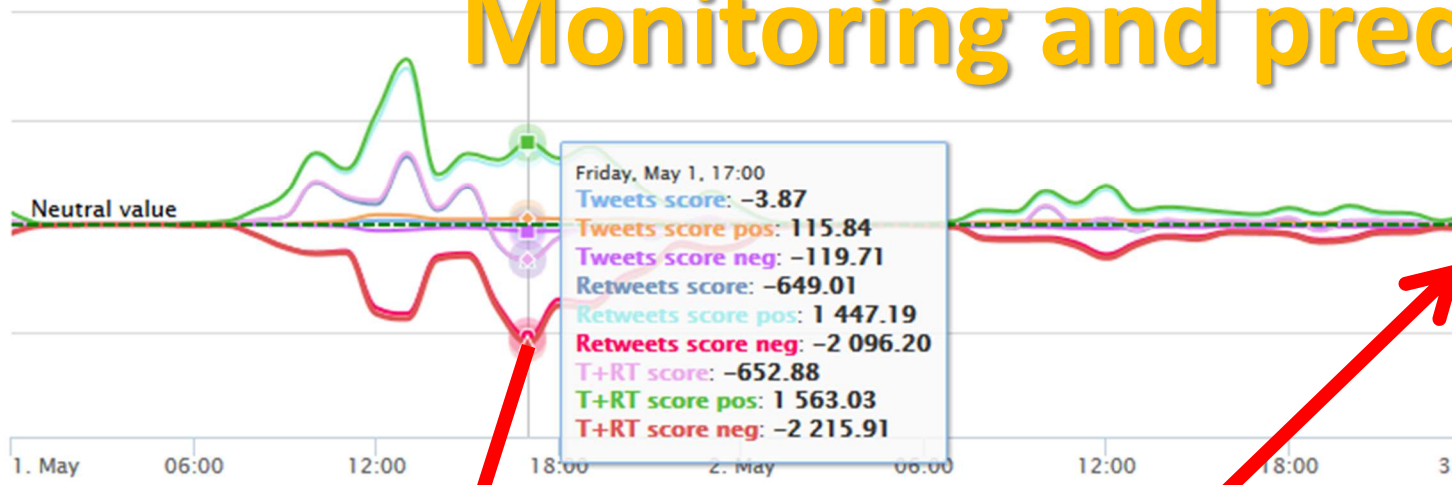




# Sentiment analysis #Expo2015

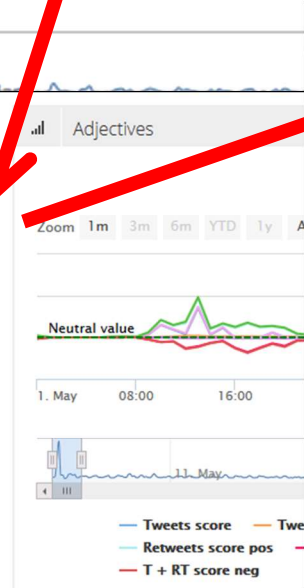
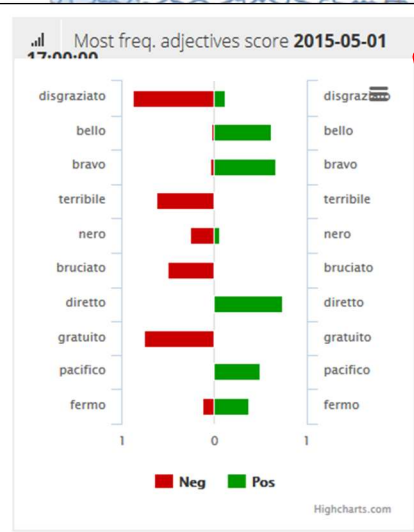
## Twitter Vigilance, Sentiment Analysis, Monitoring and prediction

Zoom 1m 3m 6m YTD 1y All From May 1, 2015 To May 3, 2015



**Серена Сі**  
 @SerenaSignorile

Fermate queste bestie. Animali, incivili, ignoranti, mostri. Fateschifo. Mi vergogno di essere italiana. #noexpo #Expo2015



Results 1 - 1 of 1:

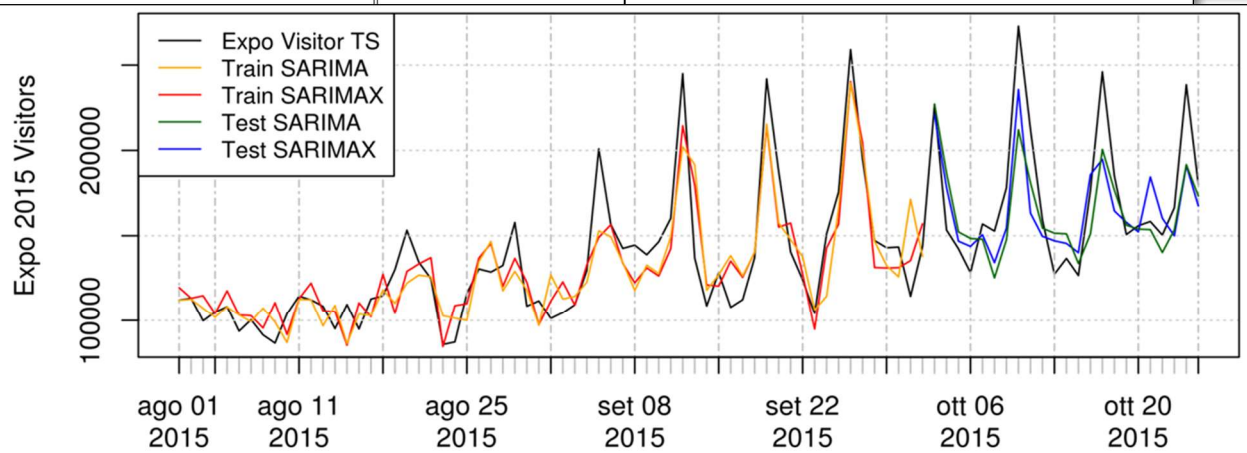
message: Fermate queste bestie. Animali, incivili, ignoranti, mostri. Fateschifo. Mi vergogno di essere italiana. #noexpo #Expo2015 http://t.co/PUo3kR...

twitterUser: SerenaSignorile  
 publicationTime: 2015-05-01 18:29:06  
 locationUser: In Billico  
 retweet: 0

Results 1 - 11:

message: Non sei d'accordo quindi macchine di gente che va Schifo totale #Expo2015

twitterUser: FabrizioColella  
 publicationTime: 2015-05-01 18:53:09  
 locationUser: In Billico  
 retweet: 0



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

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.

# #EXPO2015 search

## Twitter Vigilance



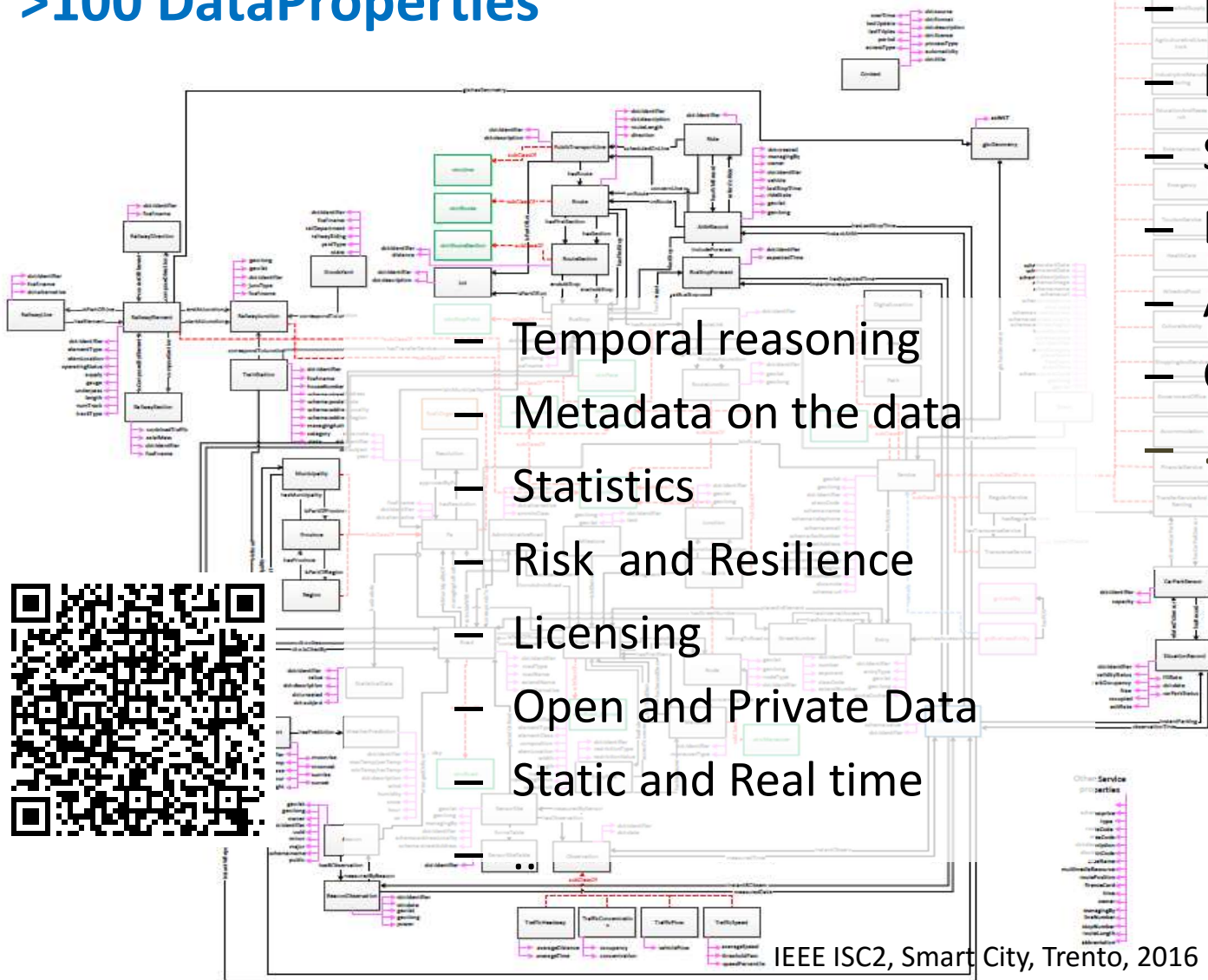


# Km4City Ontology

- >84 Classes
- >100 ObjectProperties
- >100 DataProperties

- to cover different aspects:

- Street-Guide
- Mobility and transport
- Points of interest
- Sensors, IOT, ..
- Energy
- Administration
- Citations from strings
- ..



- Temporal reasoning
- Metadata on the data
- Statistics
- Risk and Resilience
- Licensing
- Open and Private Data
- Static and Real time



## Ontology Documentation:

<http://www.disit.org/6506>

<http://www.disit.org/6507>

<http://www.disit.org/5606>

<http://www.disit.org/6461>



Transport systems  
Mobility, parking



Public Services  
Govern, events,



Sensors, IOT  
Cameras, ..



Environment,  
Water, energy



Shops, services,  
operators



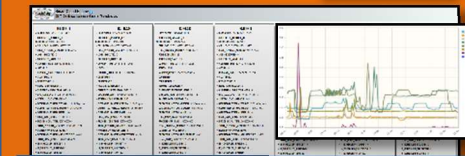
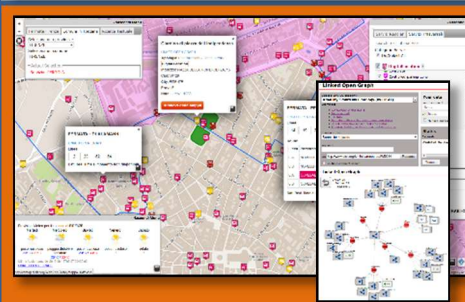
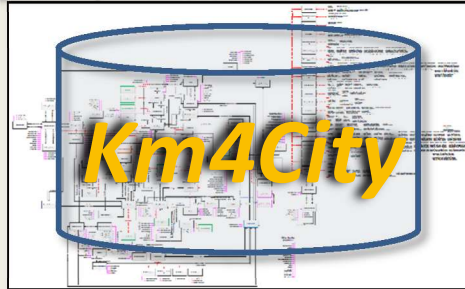
Social Media  
WiFi, network



Static, Slow and Real Time data flows

DISCES -- Distributed and parallel architecture on Cloud

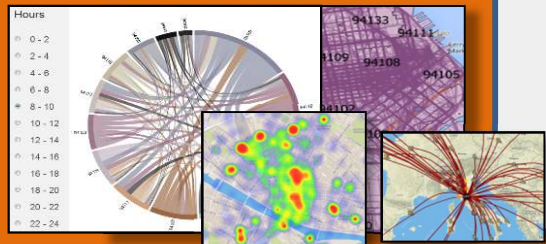
# Km4City Smart City Engine



## User Profiling and Suggestion Engine

Flow and Origin Destination Matrix

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



Km4City Tools for Developers



[www.km4city.org](http://www.km4city.org)

Km4City Smart City API

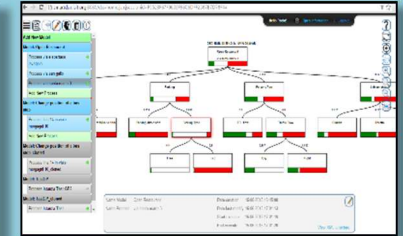
## Tools for City Operators and Decision Makers

Smart City Dashboard

<http://dashboard.km4city.org/>

Smart Decision Support

<http://Smartds.km4city.org>

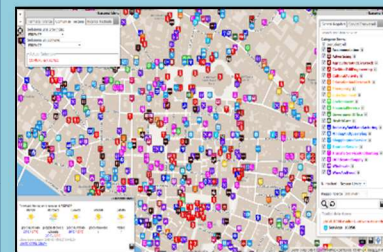


Service map browser

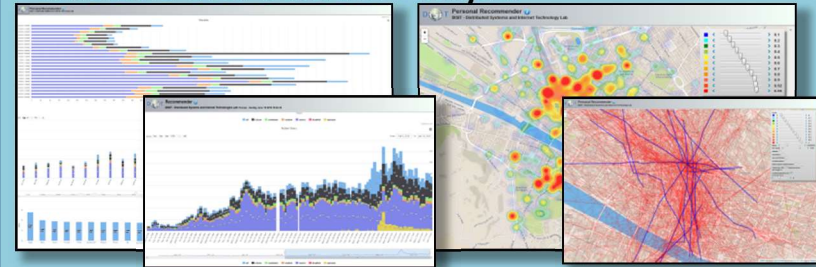
<http://servicemap.km4city.org>

Twitter Vigilance

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



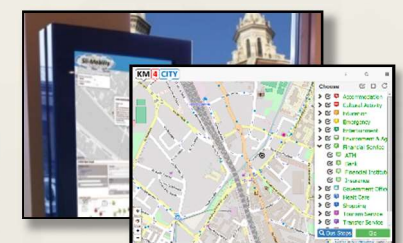
Collective User behavior Analyzer



## Tools for Final Users

Mobile e Web Apps

<http://www.km4city.org>



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





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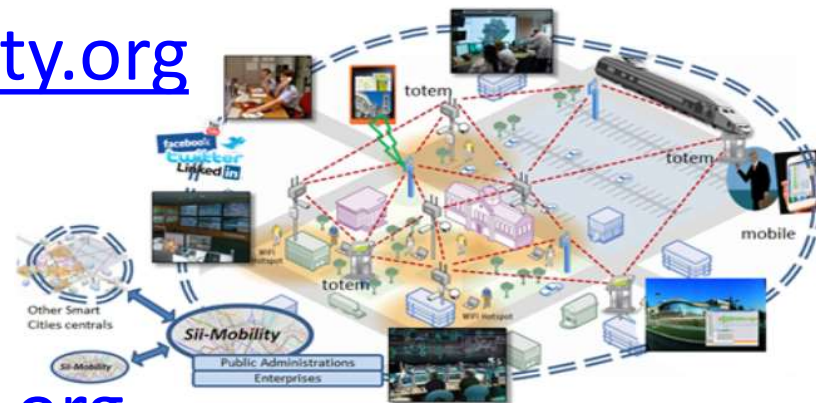
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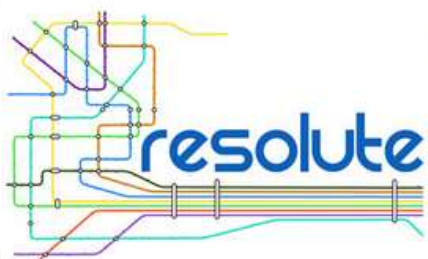


# Projects based on KM4City

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



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



**RES**ilience management guidelines  
and **O**perationalization app**L**ied to  
**U**rban **T**ransport **E**nvironment



Horizon 2020  
European Union Funding  
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- Replicate, <http://www.disit.org/6778>



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REnaissance of PLaces  
with Innovative Citizenship  
And TEchnology

REnaissance of Places with Innovative Citizenship And Technology  
Acronym: REPLICATE  
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# www.km4city.org



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**KM4CITY**  
FROM DATA TO SERVICES  
FOR SENTIENT CITIES

TRANSFORMING DATA IN VALUE FOR THE CITY

- aggregating data and services for SMEs and city operators
- suggesting new services for SMEs and city operators
- enabling a wide range of commercial and business applications
- accelerating and simplifying the implementation of business and service oriented apps
- enabling integrated city services and third party web portals for all
- keeping city services under constant and automatic
- accessing and improving city resources



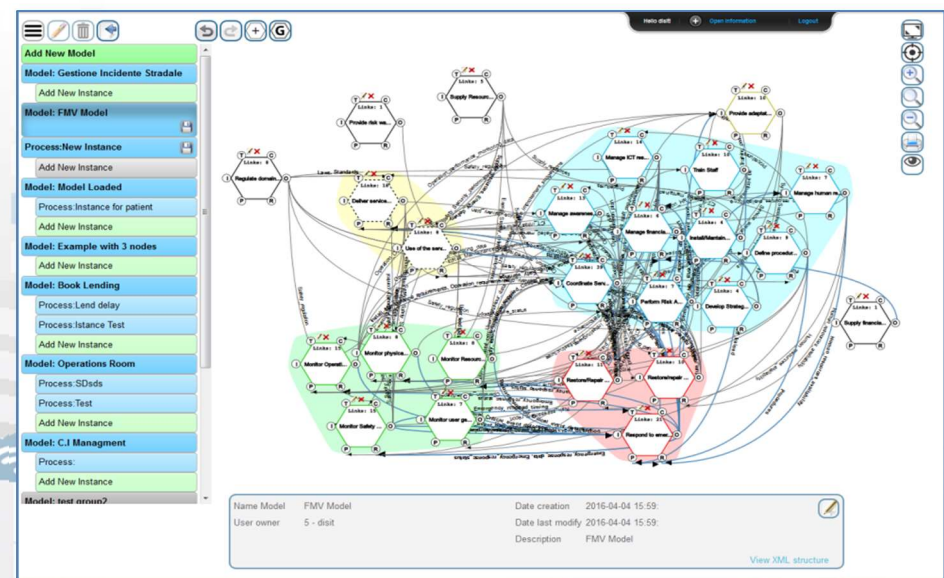
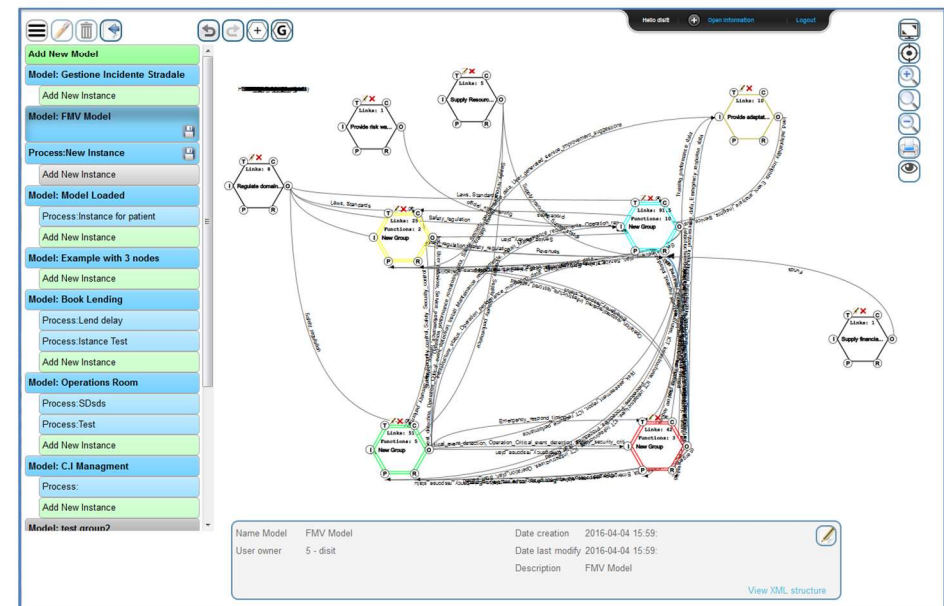
- |                   |                             |                          |                              |                             |                           |                   |                        |
|-------------------|-----------------------------|--------------------------|------------------------------|-----------------------------|---------------------------|-------------------|------------------------|
| Service Map       | Bus Stops                   | Real Time Busses (Embed) | Traffic Sensors              | Services in Tuscany         | Services in Florence      | Km4City App Video | Km4City Video 2015     |
| Services in Pisa  | Green Areas                 | Bus Lines                | Hotels                       | Florence Downtown           | Events in Florence        | DISIT Lab         | Km4City Slides         |
| Dashboard         | Dashboard Mugnone2016       | Linked Open Graph, LOD   | SPARQL & Data Licenses       | Resilience Decision Support | Smart Decision Support    | Km4City Info Page | Km4City Projects       |
| Recommendations   | Monitoring City Users       | City Users Heat Map      | Tourists Heat Map            | Monitoring Wi-Fi Users      | Monitoring Wi-Fi Coverage | Km4City Ontology  | Km4City Smart City API |
| Twitter Vigilance | Real Time Twitter Vigilance | Twitter Search           | Interactive People Flow Maps | OD Matrix for People Flow   |                           | Km4City WebApp    | PUBLIC                 |

Technical info on: <http://www.disit.org/km4city>



## ResilienceDS tool

- 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
- Open for all
- Validated on ERMG
- Web Tool





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# Km4City

# Smart City Ecosystem

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

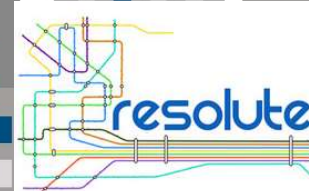
[Http://www.km4city.org](http://www.km4city.org)

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

Paolo Nesi, [paolo.nesi@unifi.it](mailto:paolo.nesi@unifi.it)



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and Operationalization appLied to  
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And TEchnology

Acronym: REPLICATE  
INNOVATION ACTIONS





# km4City Roadmap



2013

## Km4City 1.1

- Tuscany Map
- Services
- AVM
- Sensors
- Parking

<http://servicemap.disit.org> API  
<http://log.disit.org>  
<http://www.disit.org/food>  
<http://www.disit.org/tv> Twitter Vigilance  
<http://smartds.disit.org>

2014

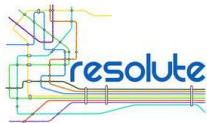
- Weather
- Cultural Heritage
- Energy recharge pillar
- Wi-Fi
- Events in the city

2015

- Cultural Heritage
- Enrichment-cities
- Events in the city
- Digital Locations
- Fresh places

## Km4City 1.4

- Embed
- More API
- iBeacon



RESilience management guidelines  
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Urban Transport Environment



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## Km4City 1.5

- SmartDS
- Km4City

RESOLUTE H2020  
2015-2018 - Started

2016

Sii-Mobility SCN  
2016-2018 - Started  
Km4City 1.6.2



- Dashboards
- Risk analysis
- Territorial, areas and paths
- Environmental: water, health
- Statistics, Energy, ICT, ...
- Data Licensing models
- User Engagement

- Suggestion on demand
- People flow tracking

REPLICATE H2020  
2016-2021 - Started



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# Smart City EcoSystem



<https://github.com/disit>

- **Decision Makers, Public administrator tools:**
  - ✓ Smart City Dashboards, <http://dashboard.km4city.org> → Dashboard Builder
  - ✓ Resilience Decision Support, <http://resilienceds.km4city.org>
  - ✓ Smart decision support system, <http://smartds.km4city.org>
  - ✓ Twitter Vigilance, <http://www.disit.org/tv>
  - ✓ Recommender and User Behavior Analyzer, <http://recommender.km4city.org>
  - ✓ WiFi monitor, <http://wifimap.km4city.org>
  - ✓ ServiceMap Server, <http://servicemap.km4city.org>
  - ✓ Traffic and People Flow Assessment <http://www.disit.org/6694>
- **Final Users tools:**
  - ✓ Km4City mobile applications, <http://www.km4city.org/app>
  - ✓ Km4City web application, <http://www.km4city.org>
  - Open Source Mobile Application, FODD <http://www.disit.org/6595>
- **Developers tools:** <http://www.disit.org/km4city>
  - ServiceMap Server, plus API, <http://servicemap.km4city.org>
  - ✓ Smart City API , <http://www.disit.org/6597>
  - ✓ Km4City Ontology, <http://www.disit.org/km4city>
  - SPARQL query tool and licenser, [http://log.disit.org/sparql\\_query\\_frontend/](http://log.disit.org/sparql_query_frontend/)
  - LOG LOD browser, <http://log.disit.org>
- **Back Office tools:**
  - Data Ingestion Manager, DIM, <http://www.disit.org/6732>
  - Distributed Smart City Engine, SCE, Scheduler, DISCES <http://www.disit.org/6515>
  - RDF Indexer Manager, RIM, <http://www.disit.org/6708>
  - RDF store enricher with dbPedia
- **Adopted on projects and real scenarios**
  - Sii-Mobility SCN MIUR, <http://www.sii-mobility.org>
  - RESOLUTE H2020, <http://www.resolute-eu.org>
  - REPLICATE H2020, <http://www.zabala.co.uk/en/projects/replicate>