UNIVERSITÀ DEGLI STUDI FIRENZE | DINFO DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE | DISIT DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

SNAP4CITY

Powered by KM4CITY

Smart City Air Pollution Services from IOT Data Network

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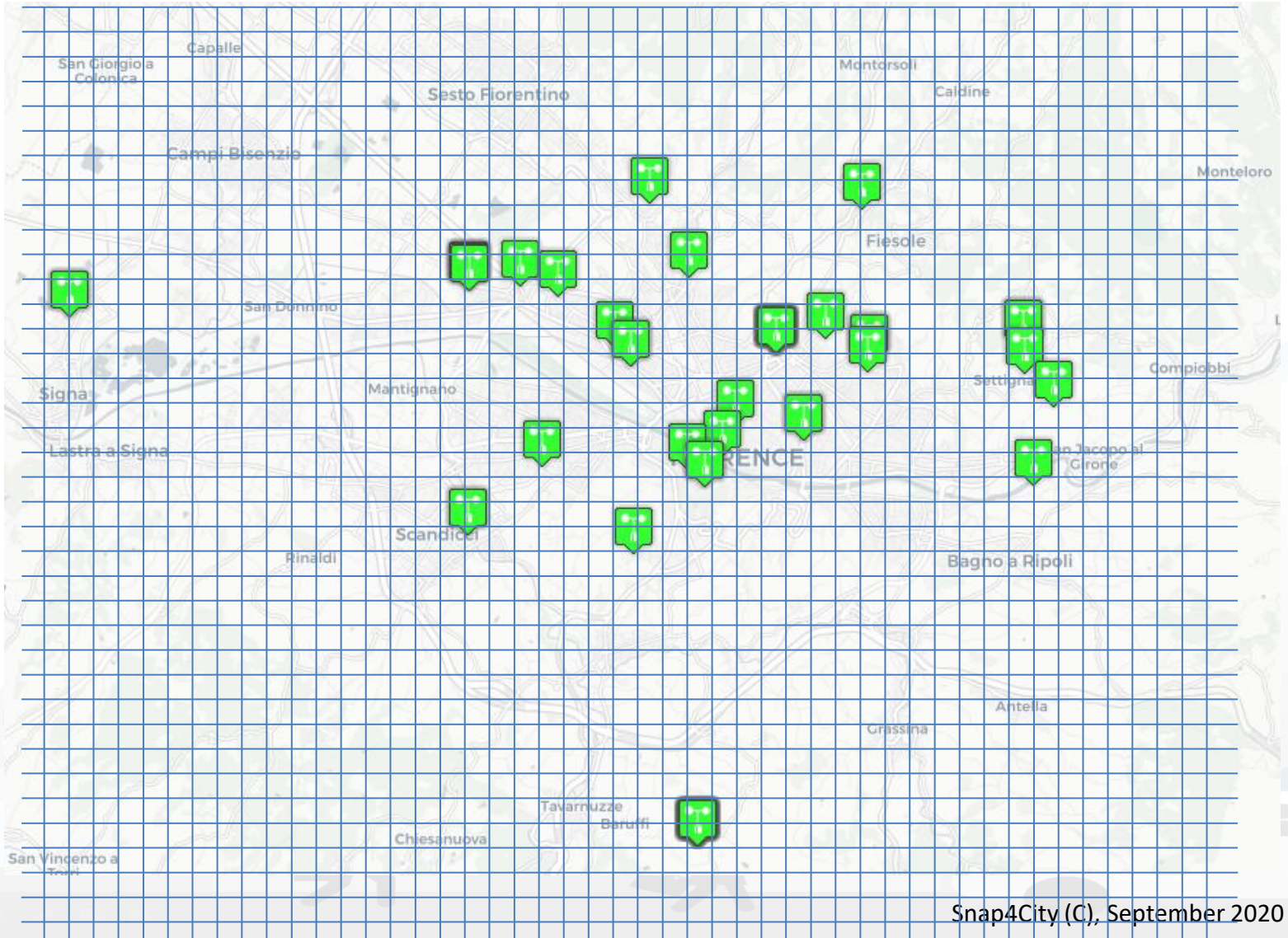
https://www.Km4City.org
https://www.disit.org

Requirements

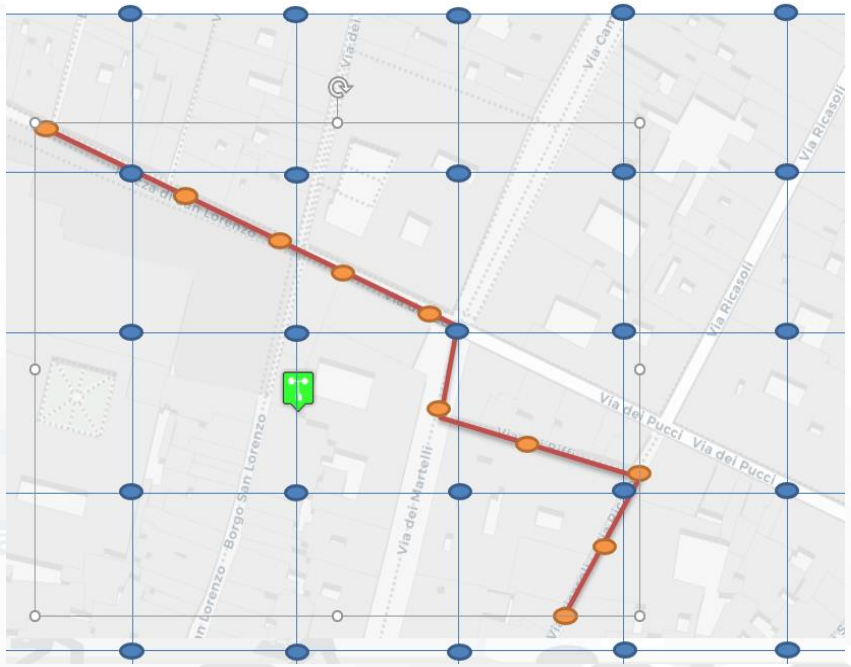
- **Air Quality sensors are**
  - Collected on scattered positions
- **AirQuality Services**
  - AirQuality indicators independent on the sensors' position, in any GPS position of the area
  - **Multiple data:** PM_{10}, $PM_{2.5}$, CO, CO_2, SO_2, O_3, H_2S, NO, NO_2, NO_x, air temperature, air humidity, 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)
4x4mt * 10 variables * 24 hours per day
→ 3.8 Billions of data



Workflow

Scattered IoT sensor Data of Value {V}

Computation of Data Value on Grid

IOT APP

Data Grid {V'} of {V}

Heatmap Data Server

Heatmap GeoTIFF Generation

Area

V'' values on GPS

On Demand Fine Interpolation

Point

Points

Alert Assessment

Conditioned Routing

GeoServer

GeoTIF of {V'}

Point

Alerts

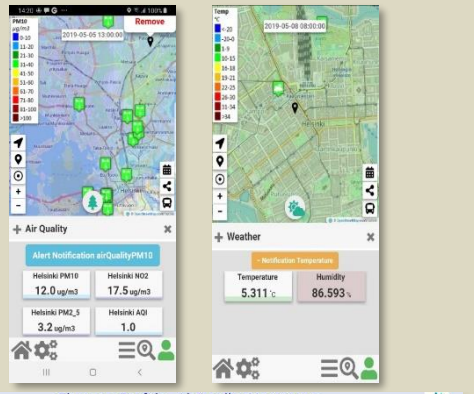
Points

Paths

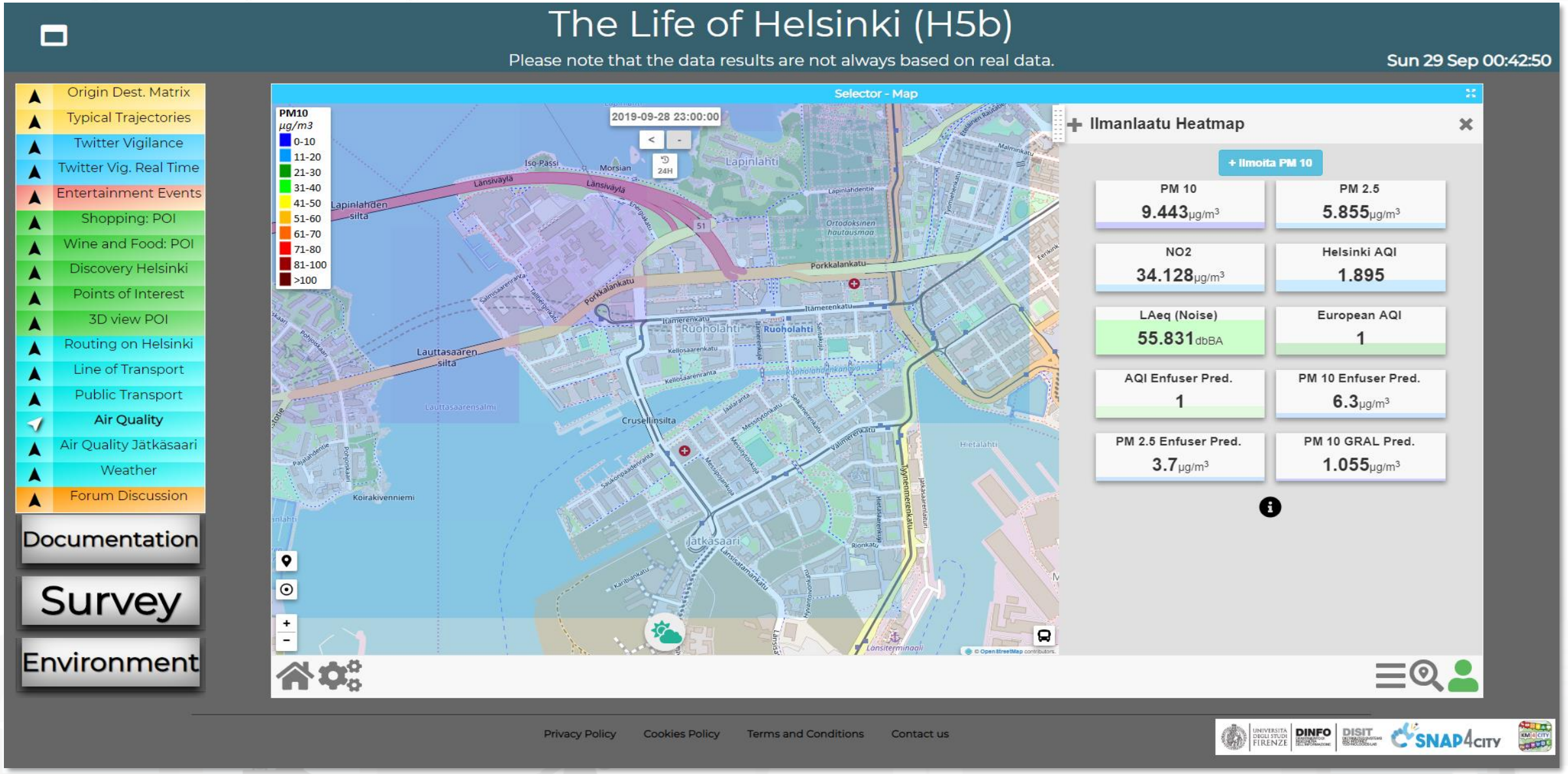
Area

WMS heatmaps

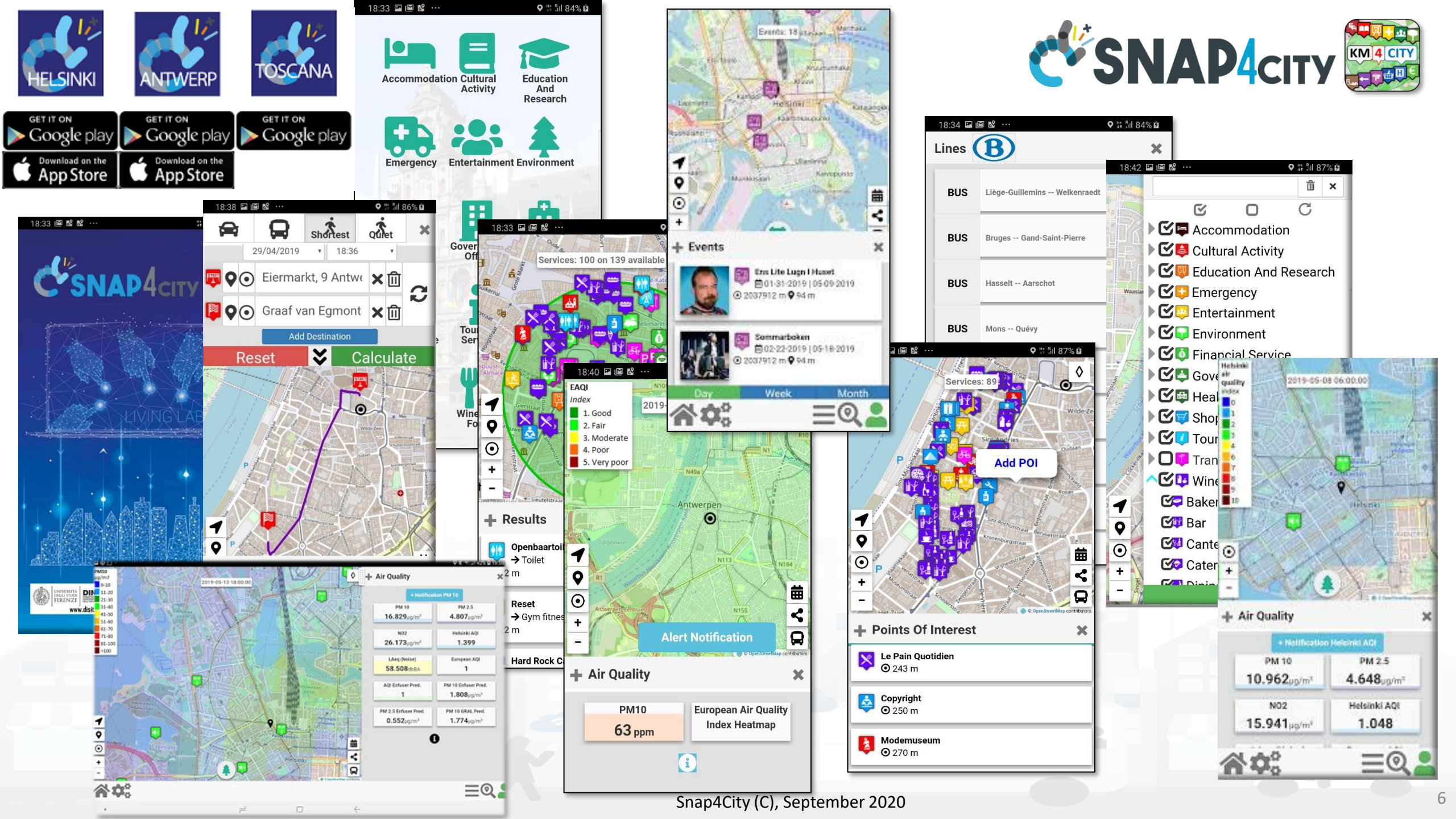
Web and Mobile Apps



Helsinki



https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MTc1Mg==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SNAP4CITY
KM 4 CITY
Accommodation
Cultural Activity
Education And Research
Emergency
Entertainment
Environment
Shortest
Quiet
Add Destination
Reset
Calculate
Events
Day
Week
Month
Services: 100 on 139 available
EAQI
Index
1. Good
2. Fair
3. Moderate
4. Poor
5. Very poor
Results
Antwerpen
Alert Notification
Air Quality
PM10
63 ppm
European Air Quality Index Heatmap
Lines
BUS
Liège-Guillemins -- Welkenraedt
Bruges -- Gand-Saint-Pierre
Hasselt -- Aarschot
Mons -- Quévy
Add POI
Points Of Interest
Le Pain Quotidien
243 m
Copyright
250 m
Modemuseum
270 m
Financial Service
Bar
Air Quality
PM 10
10.962
PM 2.5
4.648
NO2
15.941
Helsinki AQI
1.048

SNAP4CITY

KM4CITY

URBAN PLATFORM: SMART CITY IOT AS A SERVICE AND ON PREMISE

100% OPEN SOURCE

APPLIANCES CONTAINERS

- LOCAL GOVERN
- STAKEHOLDERS
- CITY USERS
- IN-HOUSE
- ENERGY OPERATORS
- MOBILITY OPERATORS
- COMMERCIAL OPERATORS
- SECURITY OPERATORS
- INDUSTRIES
- RESEARCHERS
- START-UPS
- ASSOCIATIONS

- GDPR
- SECURITY
- PRIVACY
- ASSESSMENT
- AUDITING
- PENTESTED

- OPEN IOT DEVICES
- IOT EDGE
- IOT GATEWAY
- PAX COUNTERS
- IOT BUTTONS

- TEST CASES, SCENARIOUS, VIDEOS, HACKATHONS
- OPEN SOURCES, COMMUNITY OF CITIES
- TRAINING TUTORIALS, COMMUNITY MANAGEMENT

IOT APPLICATIONS - INSTANT APPS

DATA DRIVEN APPLICATIONS • REAL TIME PROCESSING • BATCH PROCESSING • ANY PROTOCOL & FORMAT

DASHBOARDS & APPLICATIONS

CONTROL ROOM • SITUATION ROOM • OPERATOR DASHBORDS • BUSINESS INTELLIGENCE • WHAT-IF ANALYSIS • DECISION SUPPORT • SIMULATIONS • RISK ANALYSIS • RESILIENCE ANALYSIS

MOBILE & WEB APPLICATIONS

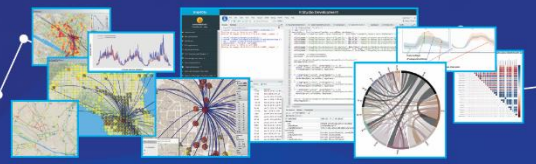
DEVELOPMENT KIT • SUGGESTIONS • MOBILE APPS • MONITORING PANELS • PLATFORM UTILITIES • READY TO USE SMART APPLICATIONS

MICROSERVICES & ADVANCED SMART CITY API

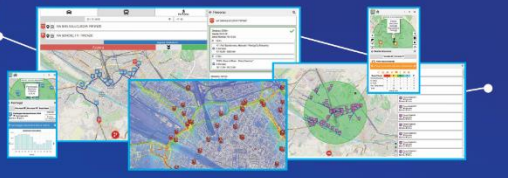
LIVING LAB - DEV TOOLS - COWORKING

IOT DIRECTORY • SERVICE MAP • RESOURCE MANAGER • DATA GATE • R STUDIO • ETL

BIG DATA - DATA ANALYTICS



DATA ANALYTICS TOOLS - MICRO-APPLICATIONS



PREDICTIONS • ANOMALY DETECTION • WHAT-IF ANALYSIS • TRAFFIC FLOW RECONSTRUCTION • ORIGIN-DESTINATION MATRICES • SOCIAL MEDIA ANALYSIS • OFFER VS DEMAND ANALYSIS • ENVIRONMENTAL DATA ANALYSIS AND PREDICTIONS • REAL TIME HEATMAPS • ROUTING • ALERTING • EARLY WARNING • PERSONAL AND VIRTUAL ASSISSTANTS • SMART SOLUTIONS • SMART SHARING • PARTECIPATORY

KM4CITY DATA AGGREGAT KNOWLEDGE BASE - EXPERT SYSTEM OF THE CITY – BIG DATA STORE

IOT MNG - DATA MNG - DATA INSPECTOR – PROCESS MNG – USER ENGAGEMENT – GDPR MNG ...

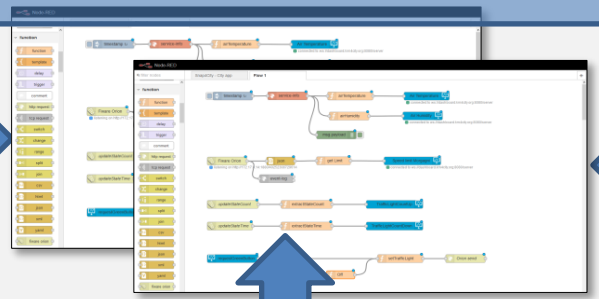
GIS	CITY UTILITIES	OPEN DATA	LEGACY & EXTERNAL SERVICES	PERSONAL DATA	IOT / IOE	BROKERS	KPI	INDUSTRY 4.0	SOCIAL MEDIA

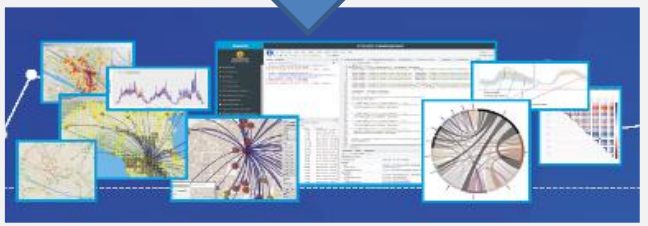
Snap4City: Builder of Sentient Cities Solutions

Dashboards with data driven IOT Applications enforcing intelligence

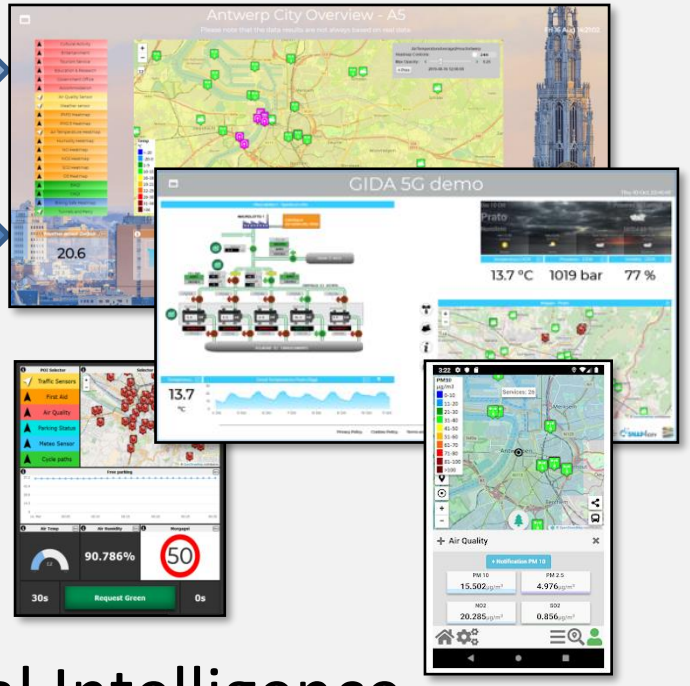
IOT and data World

IOT Applications





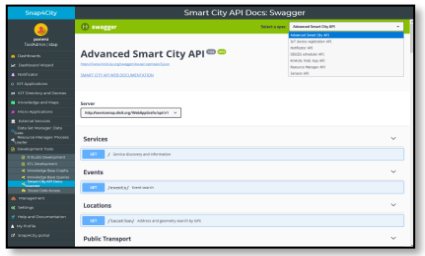
Dashboards and Apps



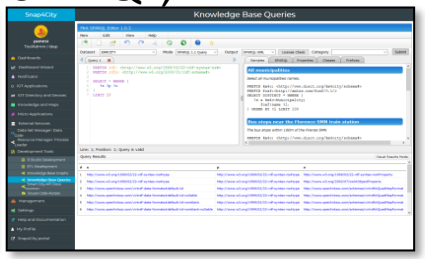
Big Data Analytics, Artificial Intelligence

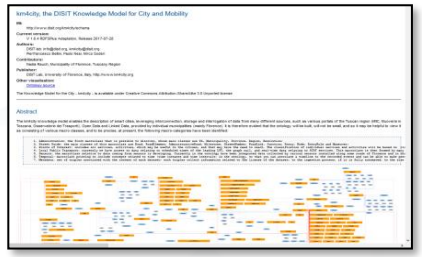
Data Analytics Dev. in R Studio and/or Tensor Flow

Swagger



SPARQL, FLINT





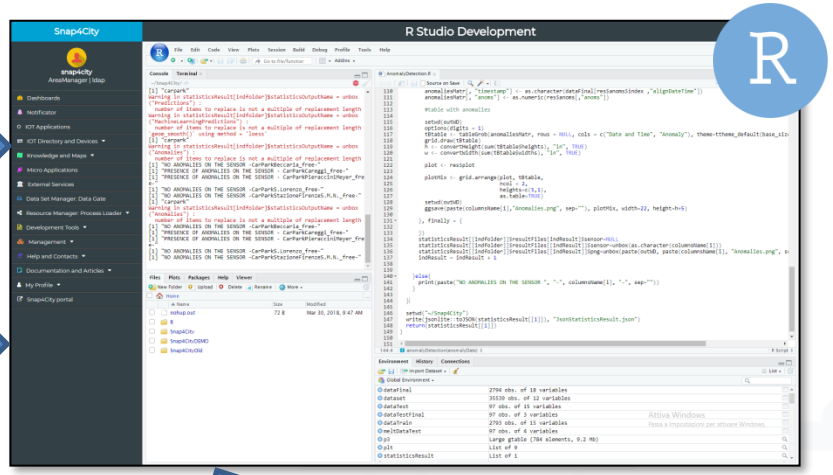
Ontology Schema

LOG.disit.org

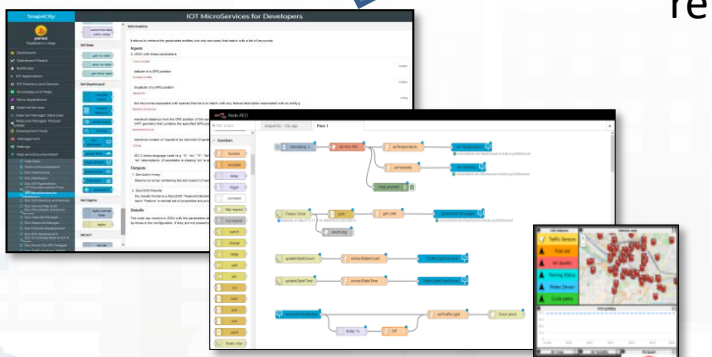
Knowledge Base, Km4City

Big Data Store Facility

Smart City API from Knowledge Base and other tools



Creating MicroServices

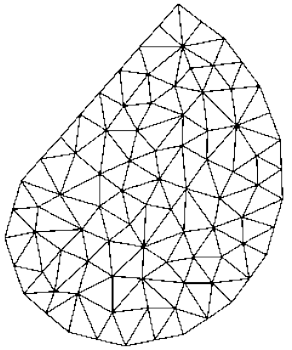


Using them into IOT Applications

Saving / Sharing reusing

Resource Manager

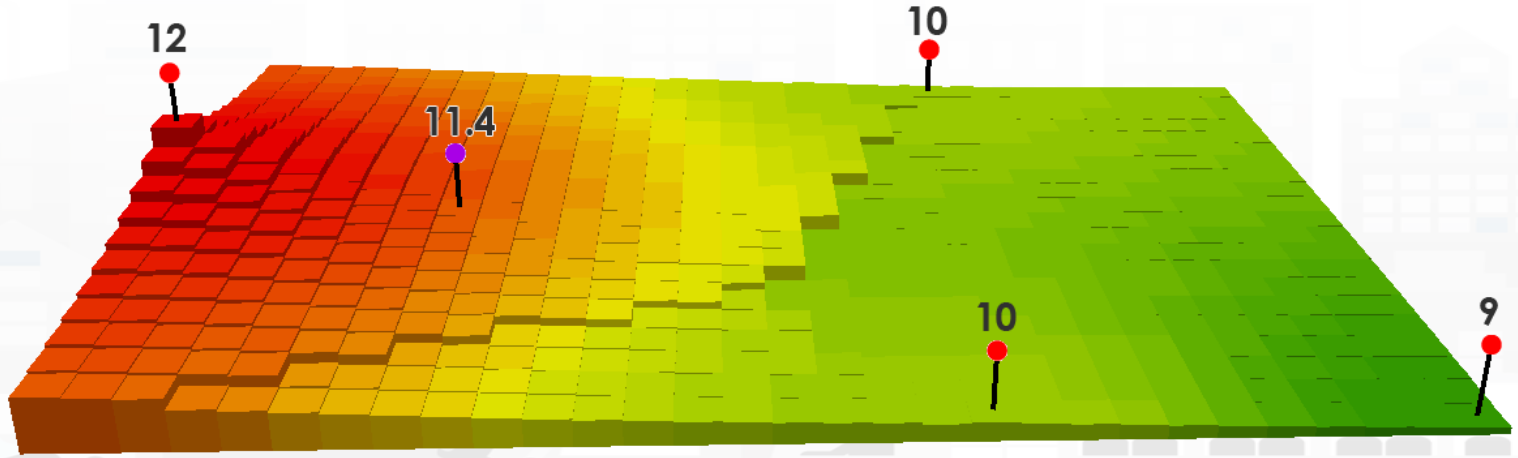
Bivariate Interpolation Method [Akima]



- 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

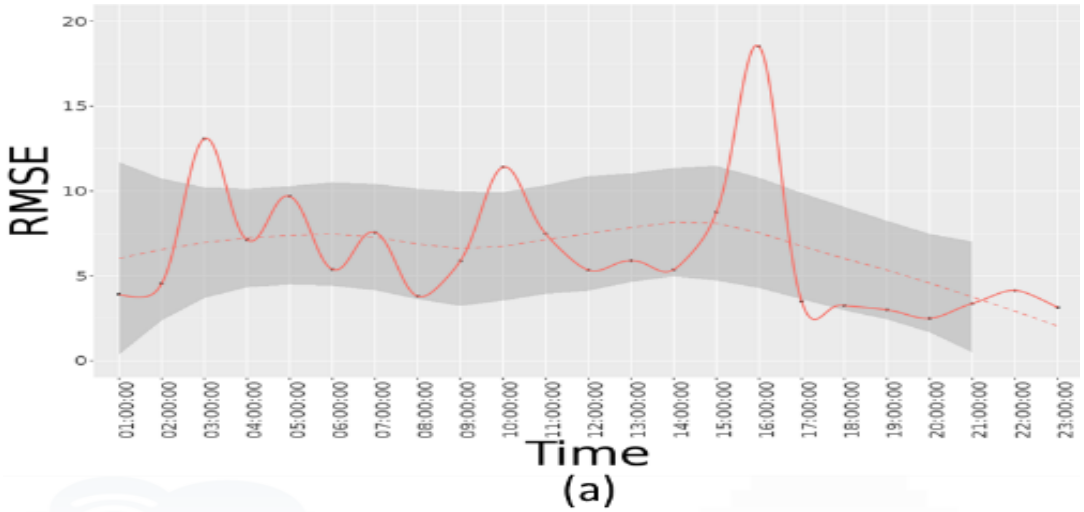
- alternate exclusion of selected air quality sensor in contributing to the model and using the excluded as true value for validation in that point on the basis of the estimation performed exploiting all the others.

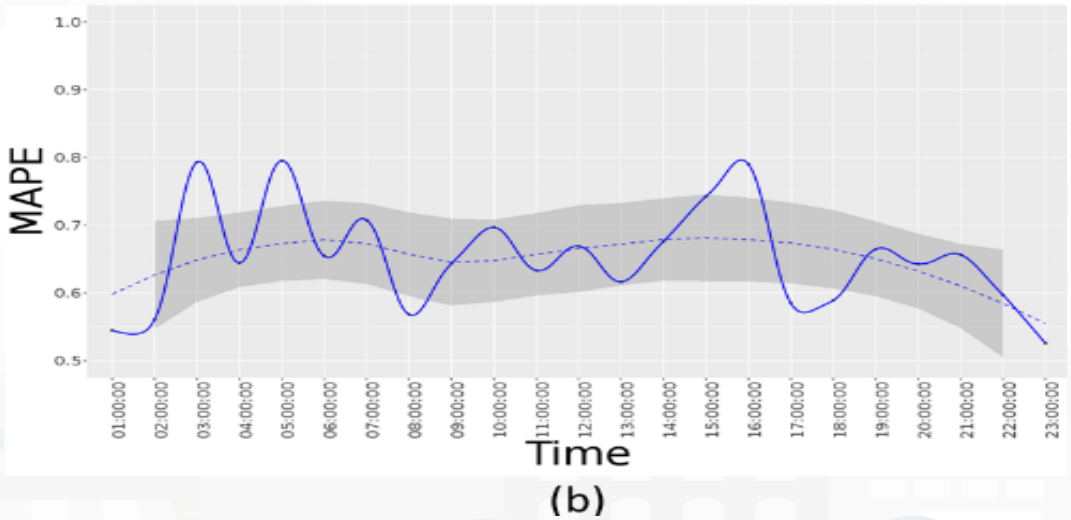
Error Measures	Akima	IDW
MAPE	**0.69**	0.79
RMSE	**8.90**	12.20
MAPE-we	**0.60**	0.95
MAPE-wd	**0.70**	0.93
RMSE-we	**8.60**	10.70
RMSE-wd	**9.70**	17.00

mean absolute percentage error (MAPE)

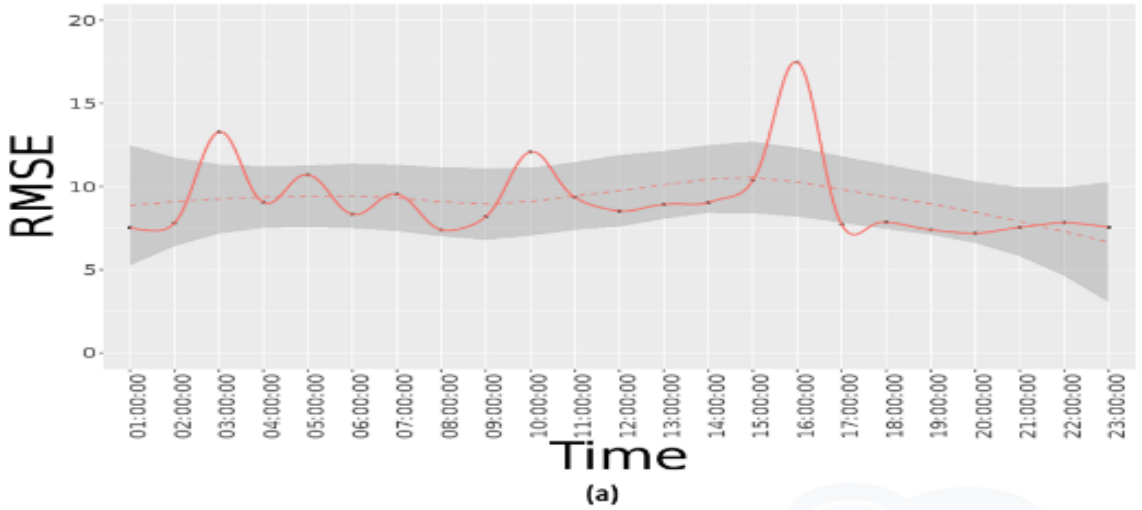
root mean squared error (RMSE)

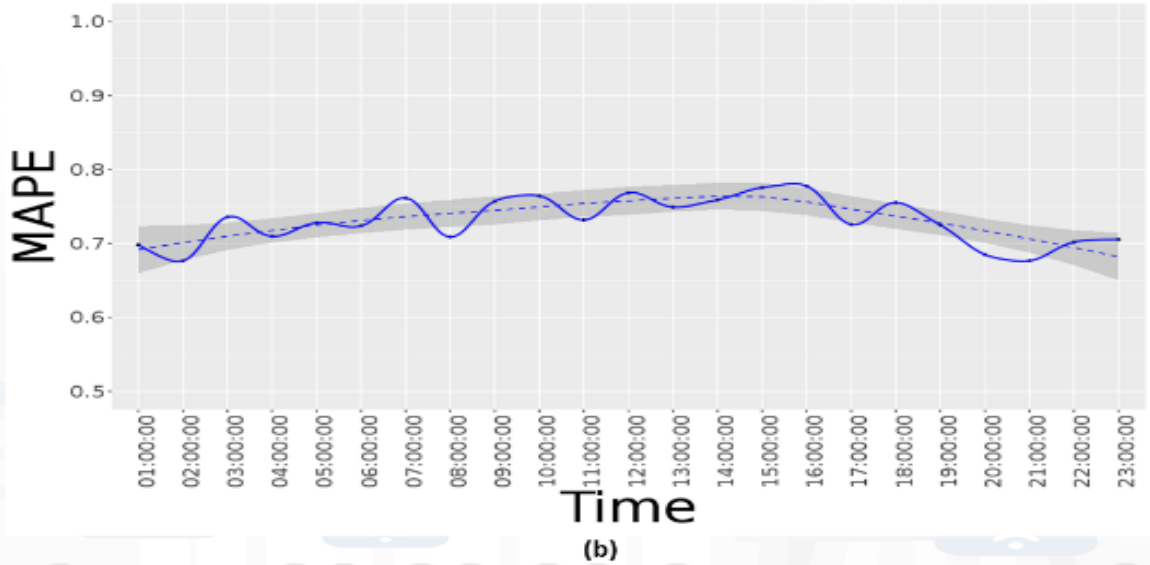
Error Trends





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

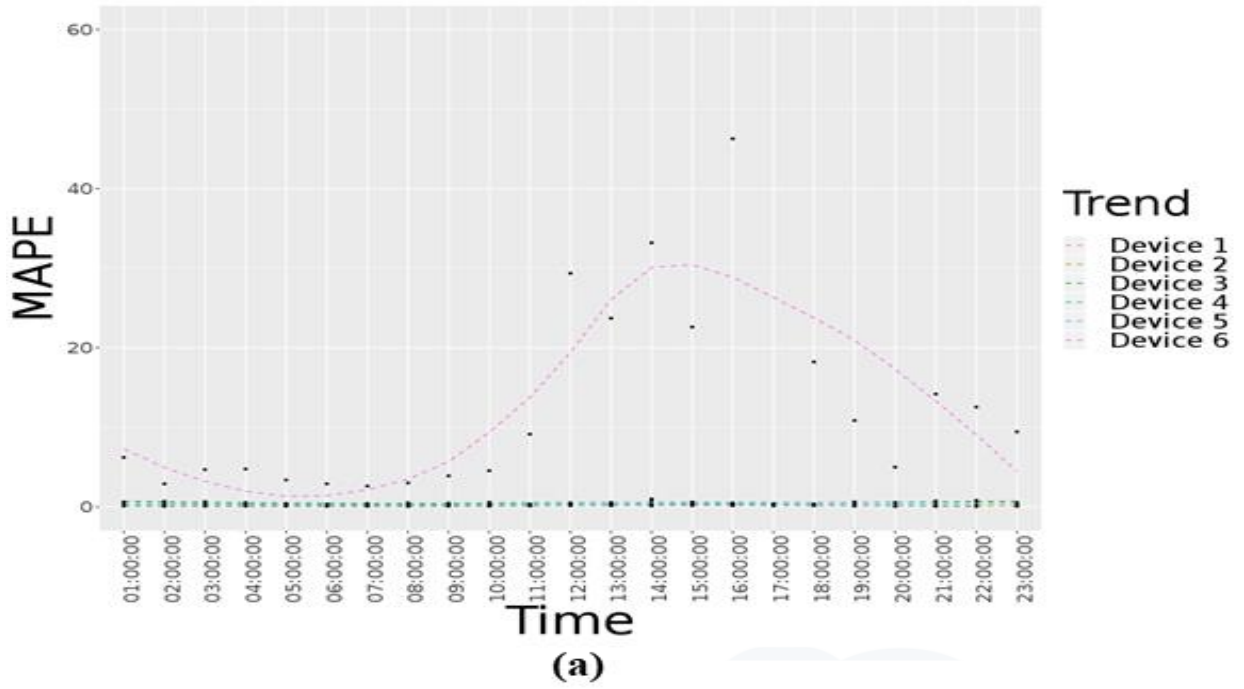




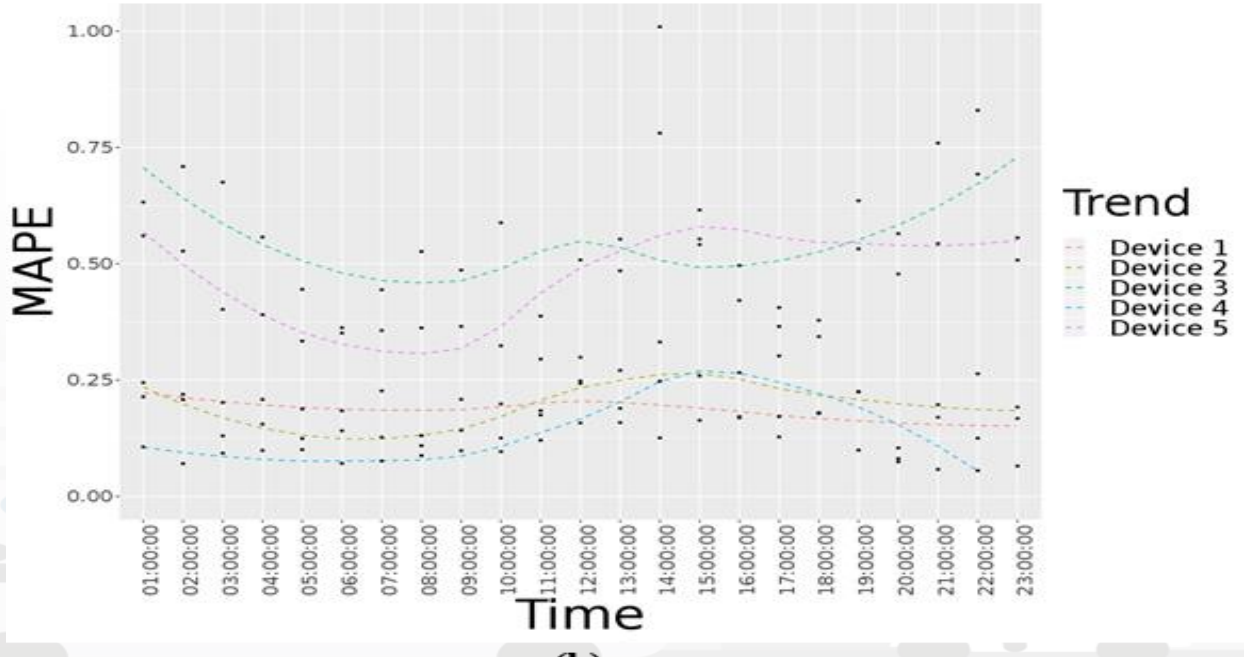
PM_{10} working days RMSE (a) and MAPE (b) per time slots (IDW Method)

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



(a)



(b)

Conclusions

- 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 dysfunctions of specific IOT Devices in the same area, for example for bad positioning, turned off, etc.