

www.snap4city.org
www.snap4solutions.org











Al Digital Twin Platform to set-up Sustainable Decision Support Systems Business Intelligence

> #snap4city #km4city #disitlab @snap4city









Public Spaces as Critical Infrastructures

- The City is a system of systems for city users
 - Cascading effects
- Transport networks
 - Main means for rescue teams, food, water, etc.
- Communication, ICT infrastructure
 - TV cam, switches, cyber,
- Energy networks
 - power supply for health, cyber systems, etc.
- Hospitals networks
- Aggregation areas



https://www.snap4city.org/download/video/DPL SNAP4SOLU.pdf

SCALABLE SMART ANALYTIC APPLICATION BUILDER FOR SENTIENT CITIES









Main Tasks





- Monitoring via KPI
- Computing predictions data from the field and KPI
- Anomaly detection
- Early warning on critical conditions

Making plan: tactic and strategic, medium and long range

Optimisation: Prescriptions, suggestions

Risk assessment

What-if analysis on scenarios

Simulation and predictions

- Resilience
- **Be ready for Unexpected Unknows**



Big picture and Long-term focused (2 to 5+ years)

Vision, Mission, Why, Policies and Direction

Executive-management

What is the right direction for the company?

- · Short-term focused (3 months to 2 years) **Tactical**
 - Focused on specific business department
 - Middle-management
 - · What activities to be planned in strategic alignment?



- · Focused on day-to-day running
- Detail level processes for specific outcomes
- Execution by teams and managers
- Are we acting in alignment with strategy?













Complex Smart Applications

Recent solutions

- Dynamic traffic light control and synchronizations
- MaaS, sharing, evolution of info-mobility
- Connected and Autonomous Vehicles/solutions
- Integrated Energy & Environmental applications
- Etc.
- Most of them share the same modules, differently implemented and combined, but the same modules
 - Real time data gathering and derived info distribution
 - Predictive and/or simulative models, on edge or cloud
 - Data gathering + monitoring + plan + rendering: dashboard, visual analytics, mobile apps

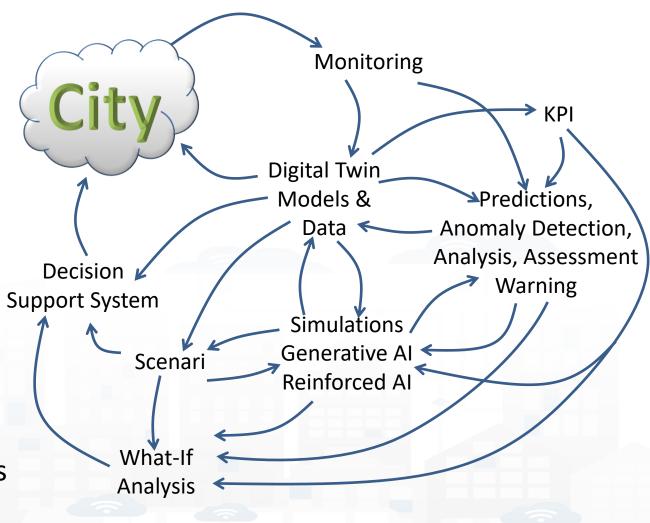




Main tasks



- Controlling Status: management, and operational
 - Monitoring via KPI
 - Computing predictions vs KPI
 - Anomaly detection
 - Neuro-Symbolic analysis
 - Risk assessment
 - Early warning on critical conditions
- Making plan: tactic and strategic, medium and long range, micro/macro
 - Simulation & predictions
 - Generative Al Prescriptions, scenarios
 - Resilience to Unexpected unknows
 - What-if analysis wrt scenarios



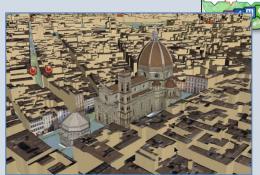
Digital Twin

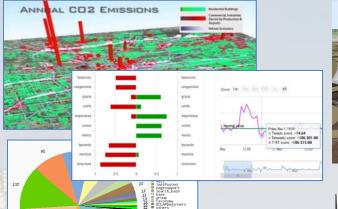
SNAP4CITY

Digital Twin

- Connected with real systems
- Modelling aspects: structural, visual, informative, real time data sensors (context), POI, functional, resources, etc.
- Analytics: AI/XAI techniques, simulations, users' needs, etc.
- Easier to understand the context, review from multiple points of view
- Useful to perform
 - Discussion with city users
 - Support decision makers
 - By Case Experiments for analysing
 - New solutions, impact of disaster (natural and provoked)
 - Reduction of costs in the analysis, in reduction of mistakes

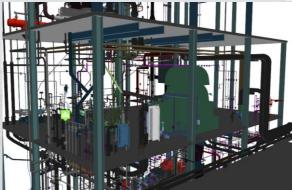






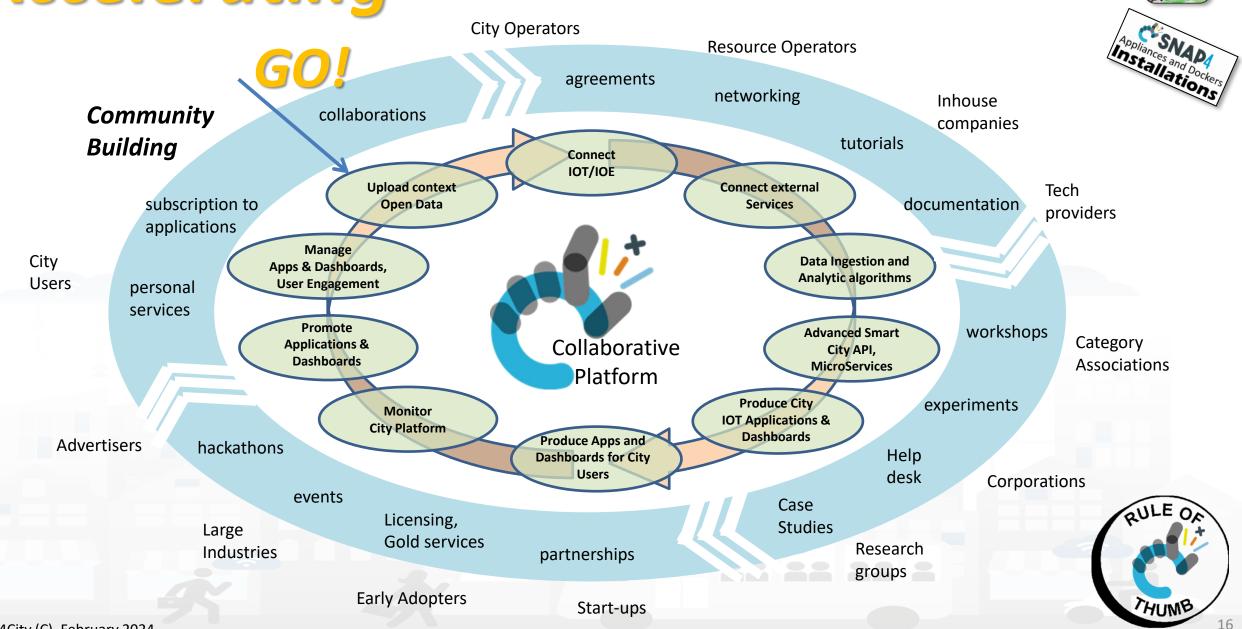






Accelerating

















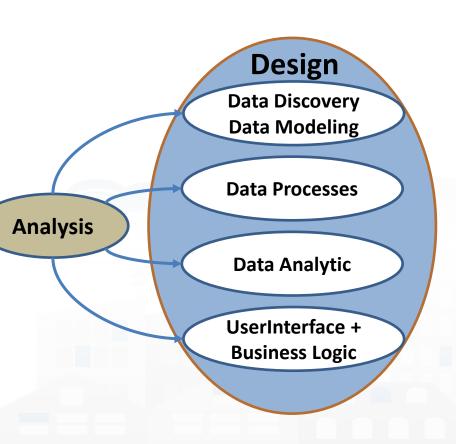


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Main Activities of Design





Data Discovery: Ingestion, gathering, interoperability, discovery, modeling, aggregation, mapping → digital twin modeling



Data Processing: transformation, interoperability; computing Indexes, KPIs and benchmarks, ...



 Data Analytic: statistic, predictions, classification, anomaly detection, simulations, optimization, routing, ML, Al, XAI, HPC, ...



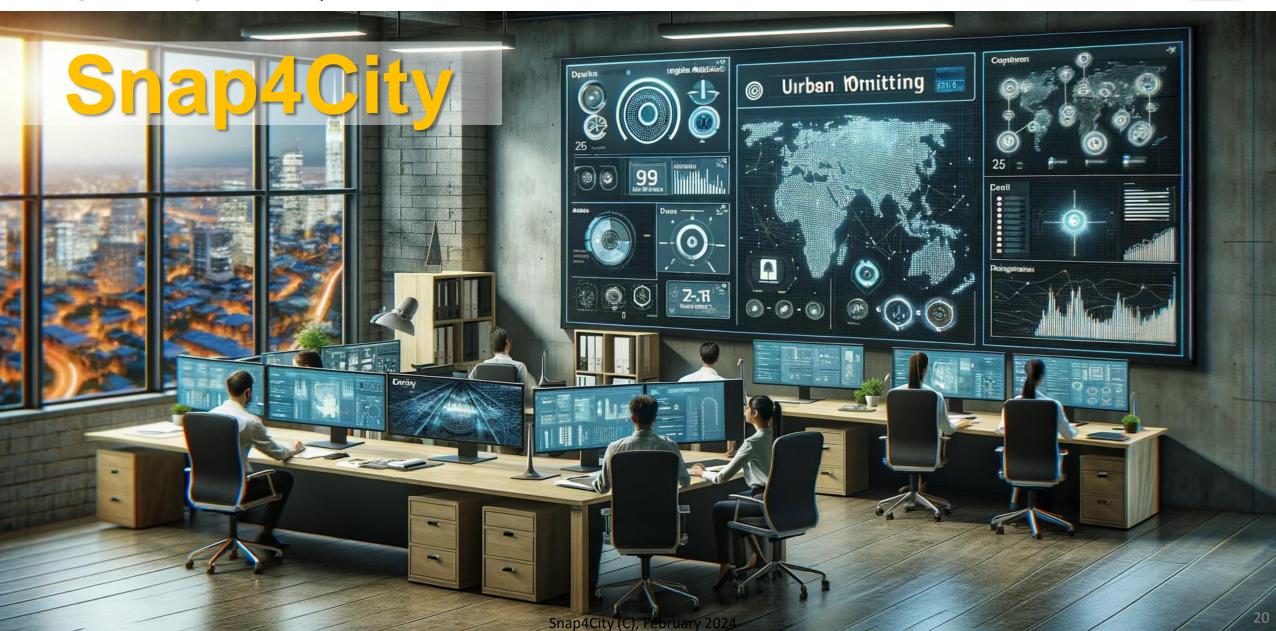
User Interface: dashboards, web pages, business intelligence, visual analytics, what-if analysis, business logic, mobile applications.













Powered by **SET STATE**

> **FREE** TRIAL

> > **PEN Test** Passed



















EXPERT SYSTEM, KNOWLEDGE BASE

SEMANTIC REASONING

SMART DATA MODEL

IOT DEVICE MODELS, STORAGE





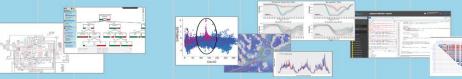
Smart Solutions and Decision Support Systems











BIG DATA ANALYTICS, ARTIFICIAL INTELLIGENCE EXPLAINABLE AI, MACHINE LEARNING OPERATIVE RESEARCH, STATISTICS



VISUAL PROGRAMMING, ADAPTERS DATA FLOWS, WORKFLOWS PARALLEL DISTRIBUTED PROCESSING **EVENT DRIVEN**

Native and External Smart Applications

Mobility & Transport

Light & Energy

Waste Building **Environment** Tourism

Asset Management

Security and Safety

Social Media





https://www.Snap4City.org













• 11 running installations in Europe

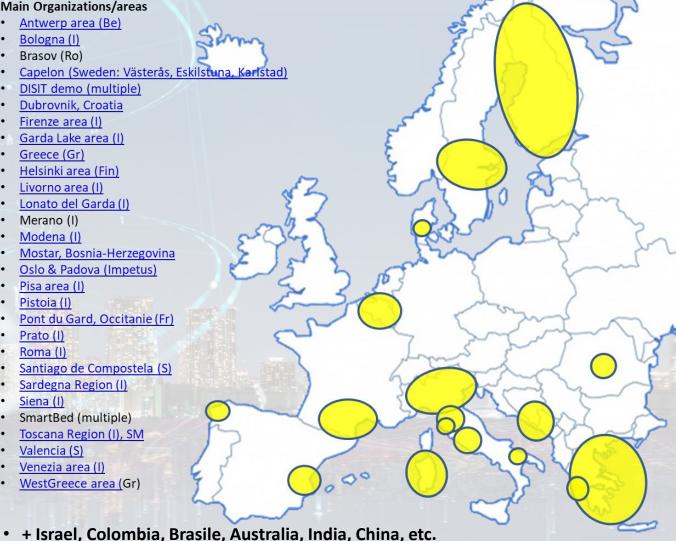
- Snap4.city.org, Greece, Merano, ...
- Toscana, Pisa, Sweden, ISPRA, Snap4.eu,
- Altair, Italmatic, Sweden, Romania,
- 16 projects, 12 pilots on 10 Countries
 - >40 cities/area

Widest MULTI-tenant deploy has

- 19 Organizations / tenant
- > 8000 users on
- > 1600 Dashboards
- > 16 mobile Apps
- > 2.2 Million of structured data per day
- > 520 IoT Applications/node-RED
- > 700 web pages with training
- > 70 videos, training videos



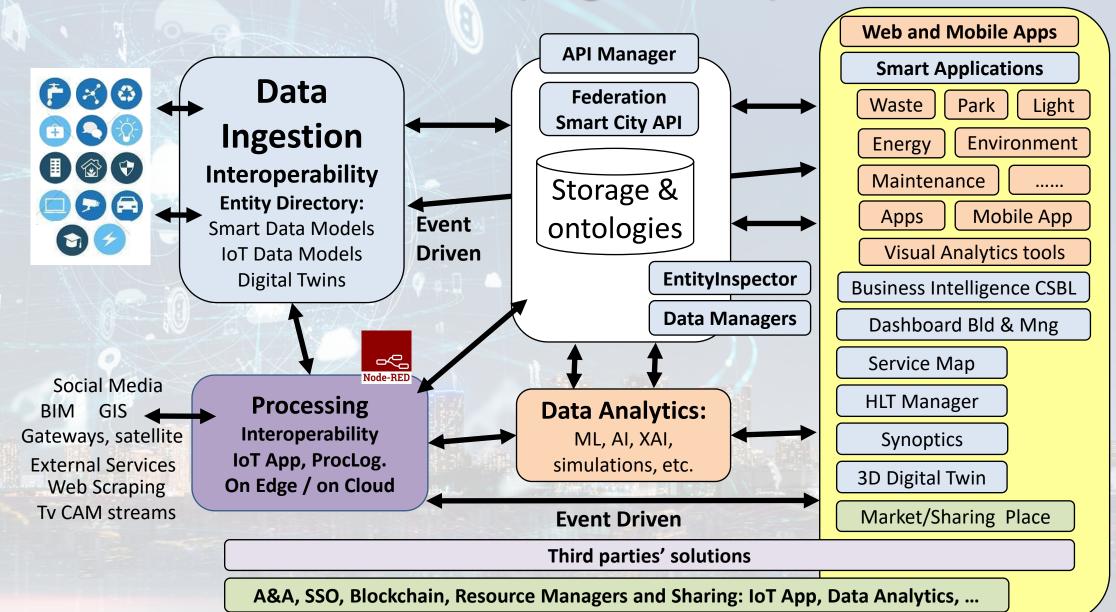
- Antwerp area (Be)
- Bologna (I)
- Brasov (Ro)
- Capelon (Sweden: Västerås, Eskilstuna, Karlstad)
- DISIT demo (multiple)
- · Dubrovnik, Croatia
- Firenze area (I)
- Garda Lake area (I)
- Greece (Gr)
- Helsinki area (Fin)
- Livorno area (I)
- Lonato del Garda (I)
- Merano (I)
- Modena (I)
- Mostar, Bosnia-Herzegovina
- Oslo & Padova (Impetus)
- Pisa area (I)
- Pistoia (I)
- Pont du Gard, Occitanie (Fr)
- Prato (I)
- Roma (I)
- Santiago de Compostela (S)
- Sardegna Region (I)
- Siena (I)
- SmartBed (multiple)
- Toscana Region (I), SM
- Valencia (S)
- Venezia area (I)
- WestGreece area (Gr)



Technical Architecture (high level)



KM 4 CITY



01/24



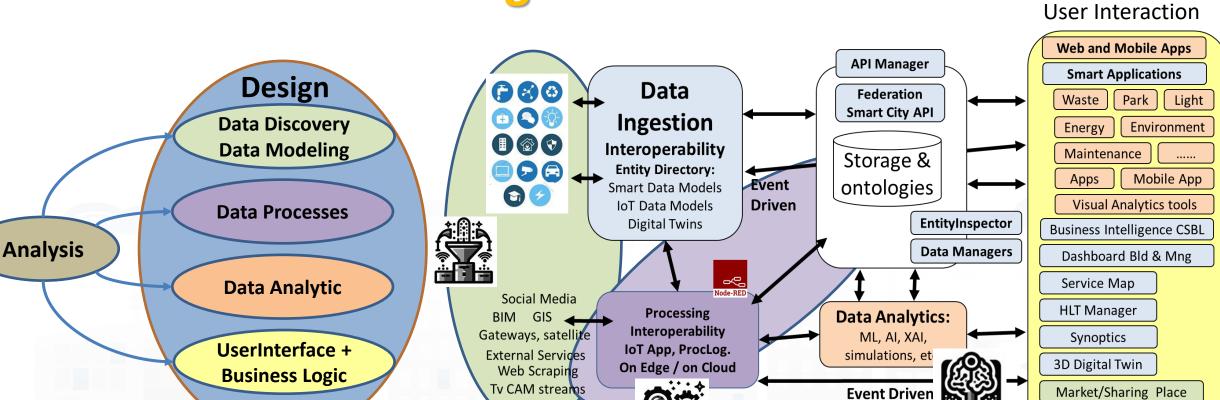






Data Representation

Main Activities of Design





Third parties so

Blockchain, Resource Managers and Sharing: IoT App, Data Analytics, ...

High Level Types

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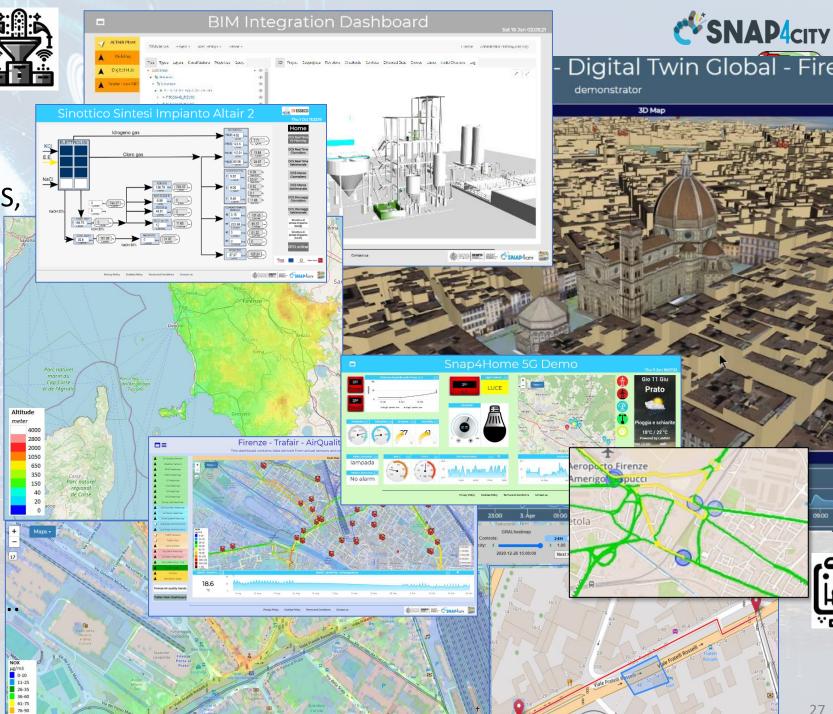
- POI, IOT Devices, shapes,...
 - FIWARE Smart Data Models,
 - IoT Device Models
- GIS, maps, orthomaps, WFS/WMS, GeoTiff, calibrated heatmaps, ...
- Satellite data, any kind...
- traffic flow, typical trends, ...
- trajectories, events, Workflow, ...
- 3D Models, BIM, Digital Twins, ...
- OD Matrices of several kinds, ...
- Dynamic icons/pins, ..
- Synoptics, animations, ...
- KPI, personal KPI,...
- social media data, TV Stream,
- routing, multimodal, constraints,
- decision scenarios,











Standards and Interoperability (6/2023)





Compliant with:

- IoT: NGSI V2/LD, LoRa, LoRaWan, MQTT, AMQP, COAP, OneM2M, TheThingsNetwork, SigFOX, Libelium, IBIMET/IBE, Enocean, Zigbee, DALI, ISEMC, Alexa, Sonoff, HUE Philips, Tplink, BACnet, TALQ, Protocol Buffer, KNX, OBD2, Proximus, ..
- IoT model: FIWARE Smart Data Model, Snap4City IoT Device Models
- **General**: HTTP, HTTPS, TLS, Rest Call, SMTP, TCP, UDP, SOAP, WSDL, FTP, FTPS, WebSocket, WebSocket Secure, GML, WFS, WMS, RTSP, ONVIF, AXIS TVCam, CISCO Meraki, OSM, Copernicus, The Weather Channel, Open Weather, OLAP, VMS,
- Formats: JSON, GeoJSON, XML, CSV, GeoTIFF, OWL, WKT, KML, SHP, db, XLS, XLSX, TXT, HTML, CSS, SVG, IFC, XPDL, OSM, Enfuser FMI, Lidar, glTF, GLB, DTM, GDAL, Satellite, D3 JSON, ...
- Database: Open Search, MySQL, Mongo, HBASE, SOLR, SPARQL, ODBC, JDBC, Elastic Search, Phoenix, PostGres, MS Azure, ...
- Industry: OPC/OPC-UA, OLAP, ModBUS, RS485, RS232,...
- Mobility: DATEX, GTFS, Transmodel, ETSI, NeTEx, ...
- Social:Twitter, FaceBook, Telegram, ...
- Events: SMS, EMAIL, CAP, RSS Feed, ...
- OS: Linux, Windows, Android, Raspberry Pi, Local File System, AXIS, ESP32, etc.

























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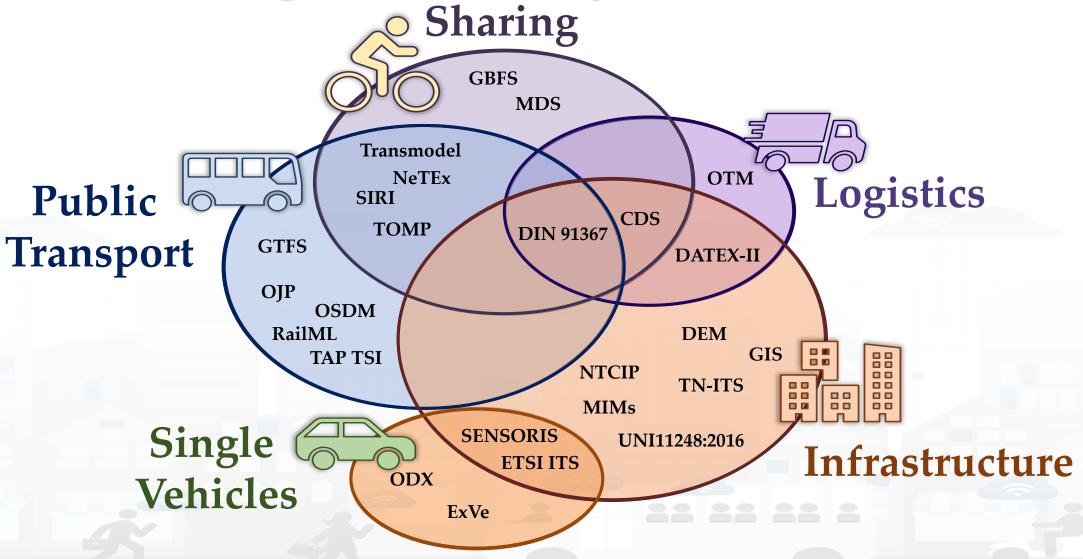








Coverage of Mobility data formats



Ingestion, aggreg. > exploitation

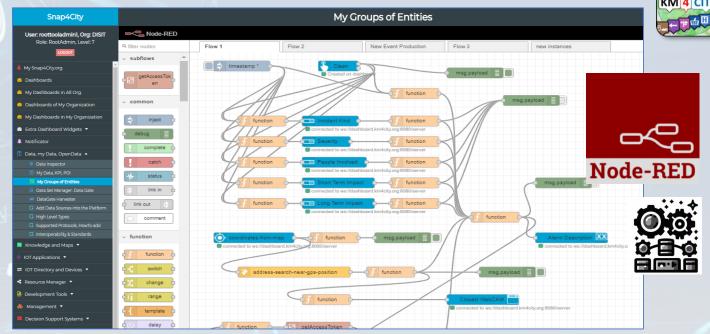




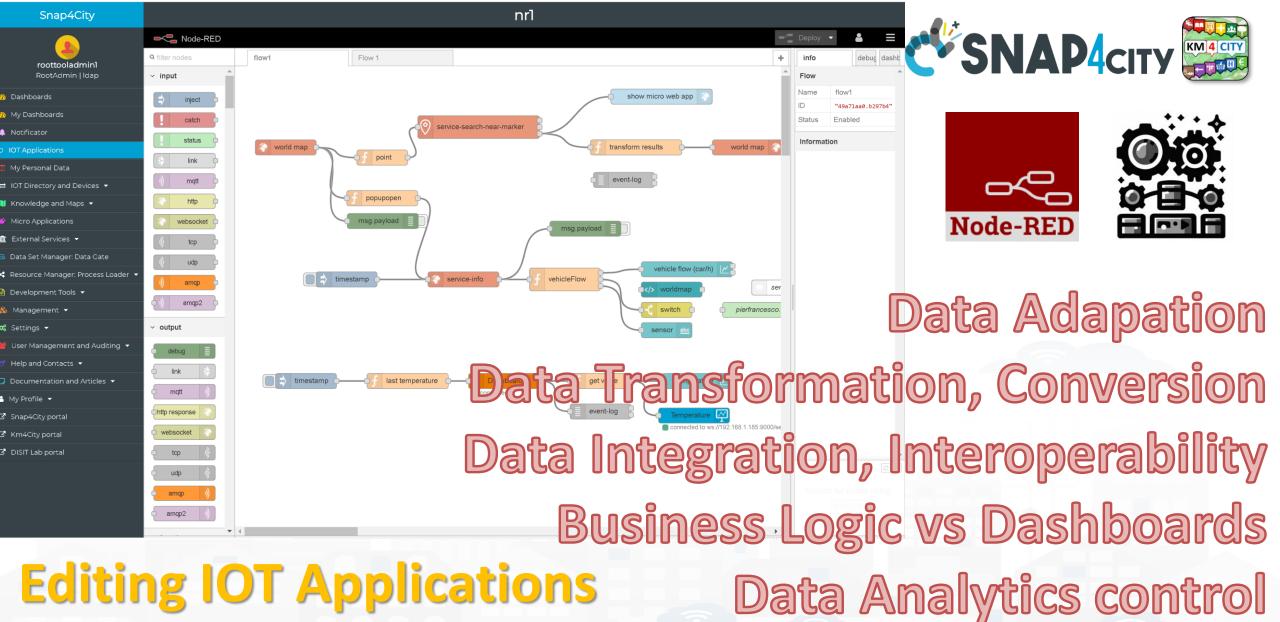




- IoT App Visual Programming, no coding
 - Data transformation
 - Integration, Interoperab.
 - Scripting Data Analytics
 - Data ingestion
 - Business logic Server Side
- Edge and Cloud
- MicroServices data event driven develop via visual language Node-RED







Everywhere: Cloud, on loT Edge Devices

Expert System semantic queries

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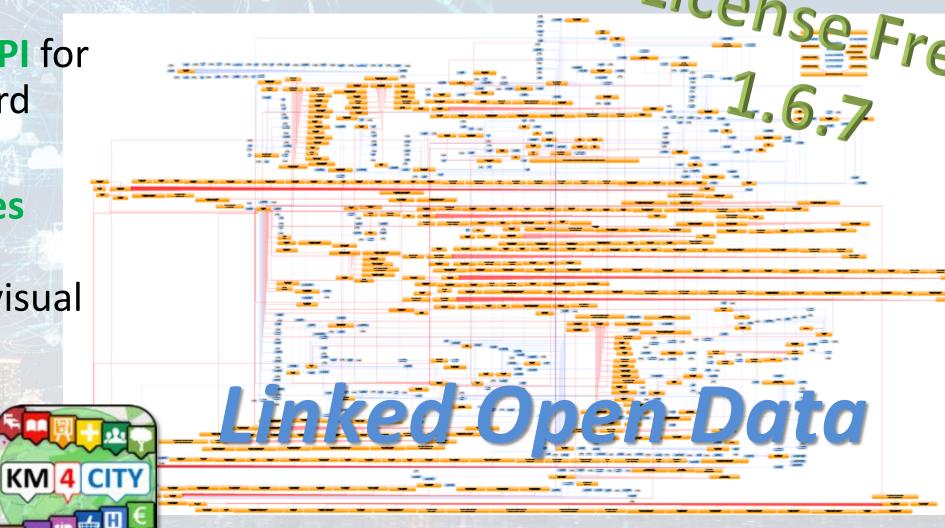
• via:

 Smart City API for Apps and third party

MicroServices
 data driven
 develop via visual
 language
 Node-RED







https://www.snap4city.org/19

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Km4City Ontology elements 1.6.7

- Km4C: Km4City 1.6.7
- Using
 - DCTERMS: for metadata Dublin Core Metadata Initiative
 - FOAF: friends of a friends
 - Good Relation: entities relationships
 - iot-lite: IOT Vocabuary
 - OTN: Ontology of Transportation Networks
 - OWL-Time: time reasoning
 - SAREF Smart Appliances REFerence extension for building devices available at https://saref.etsi.org/saref4bldg/
 - Schema.org for people and organizations
 - SSN: Semantic Sensor Network Ontology (see https://www.w3.org/TR/vocab-ssn/
 - WGS84 Datum of Geo-Objects
 - GTFS, General Transit Feed Specification, and Transmodel, for public transport infrastructures: lines/rides time schedules, real-time records, paths, etc.;



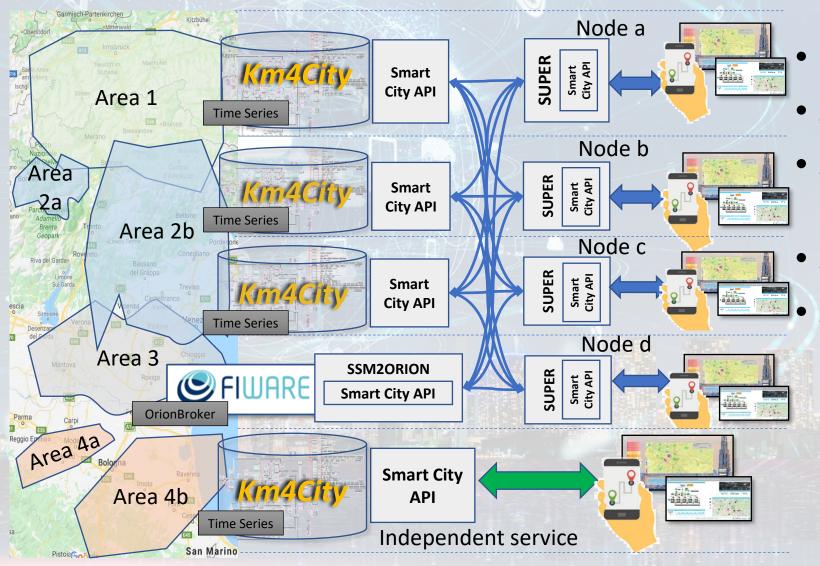




Federation of Smart City Services





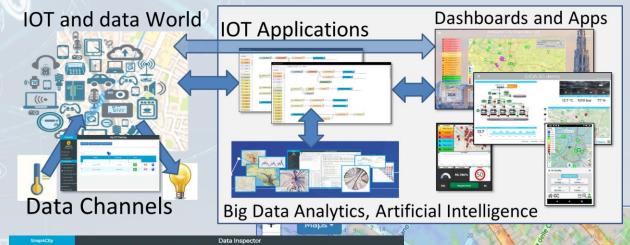


- Km4City **Semantic Reasoner**
- ServiceMap interoperability
- Seamless for multiple **Mobile Apps**
- **Smart City API**
- Super:
 - distributed access and sharing services
 - Each city control its own data
 - Final user can pass from one city / area to another in seamless manner: without changing the mobile Apps

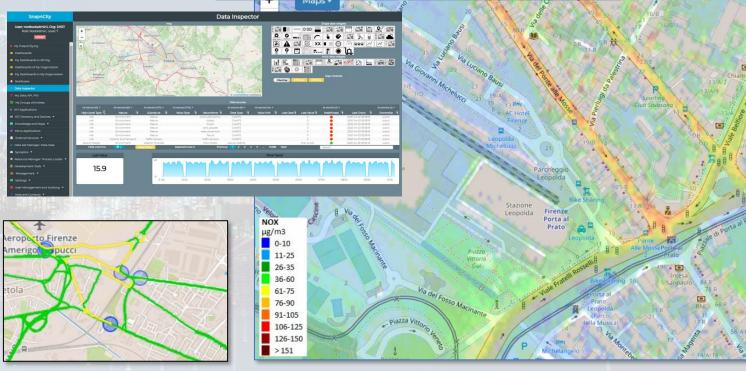
Solutions: reliable, secure and fast to realize

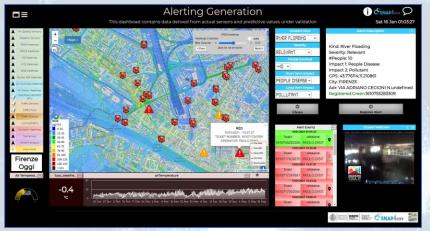
KM 4 CITY

- Via Snap4City tools
 - Dashboard Wizard
 - Dashboard Builder
 - Data/Visual Analytic
- Smart Solutions results to be
 - Real time data drive
 - Secure end-to-end
 - GDPR compliant
 - Reliable, interoperable
 - Auditable, marketable

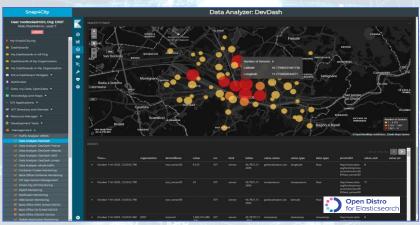






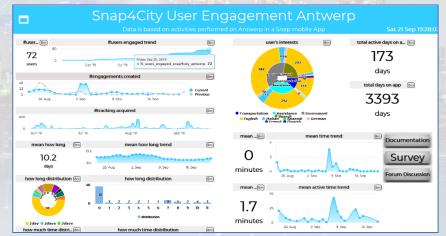


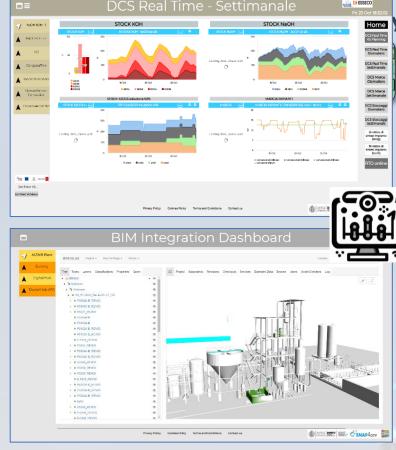


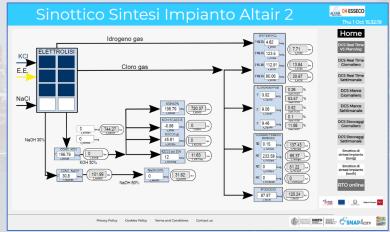


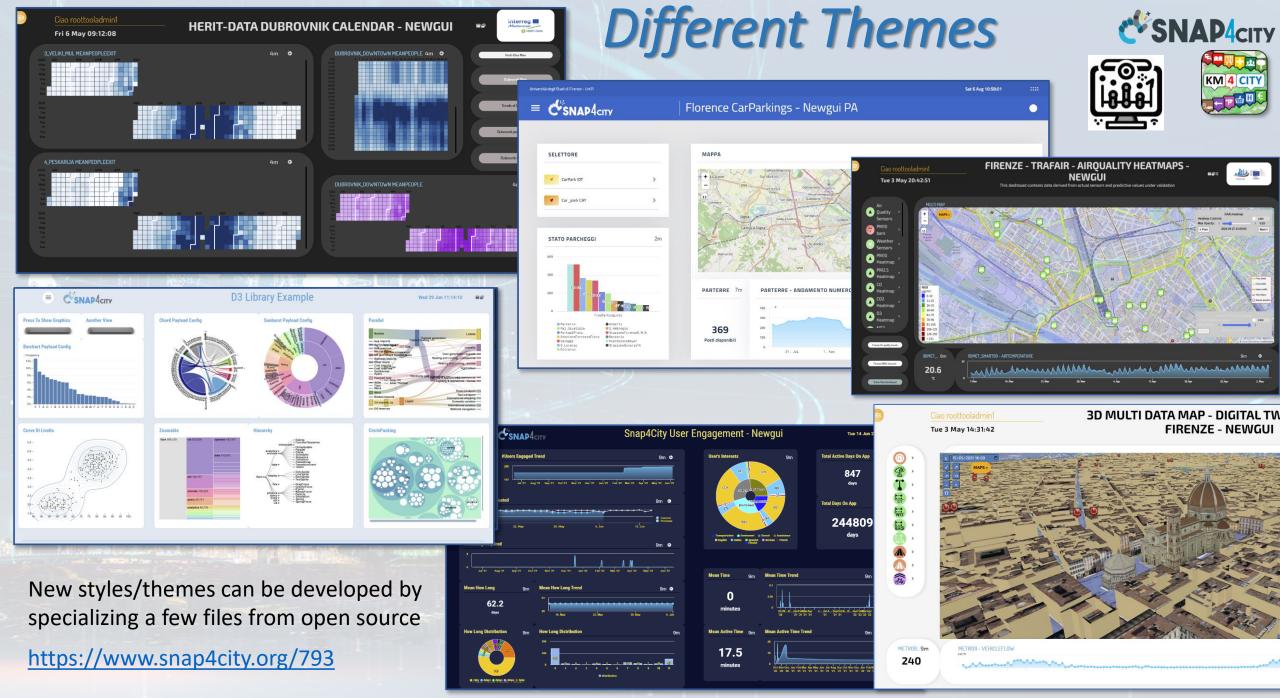












Snap4City (C), February 2024

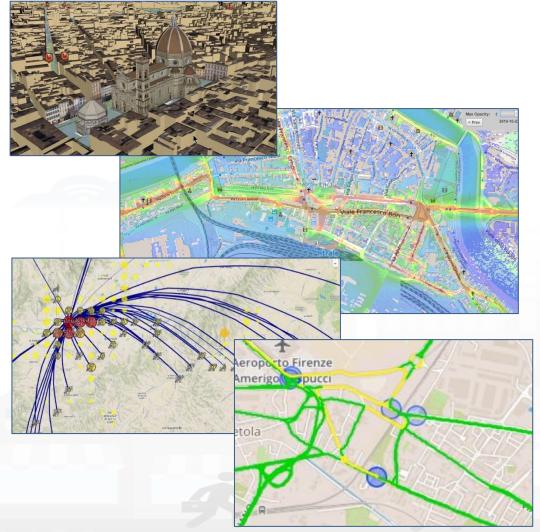








Smart City Digital Twin



City Digital Model with...

- Intuitive platform
- Any Data TYPE, any data source, any protocol
- Data storage seamless
- Data analytics → artificial intelligence, AI/XAI
- Data Ethics, AI Ethics, GDPR
- Data Representation, any kind
- Key Performance Indicators, any kind
- What-IF analysis Simulation, prediction, 2D/3D
- Micro, Meso e macro scales
- Operation, planning tactic and strategic
- Collaborative and shared representation
- Sustainable, shared, open source 100%

Complex and heterogeneous information, interoperability

- o GIS, ITS, AVM, IoT, BIM, CKAN, etc.
- Satellite services
- MaaS, last-mile delivery HUBs
- o etc.





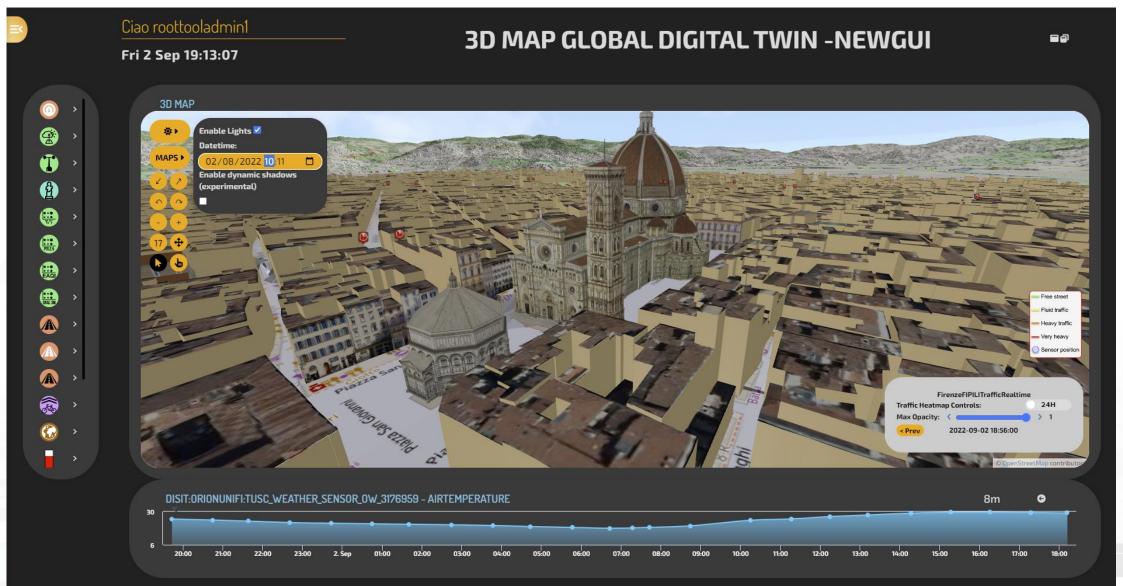








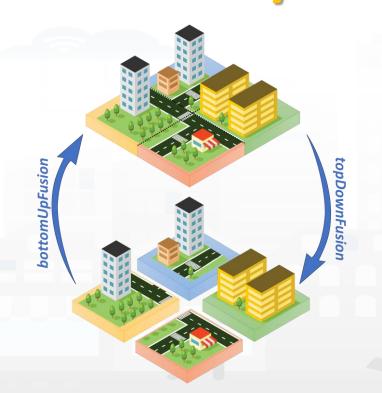


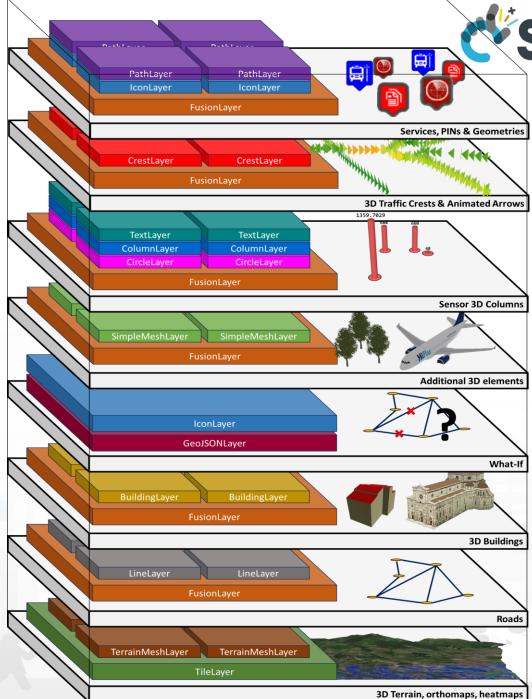




DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

Layers **Fusion Layers**



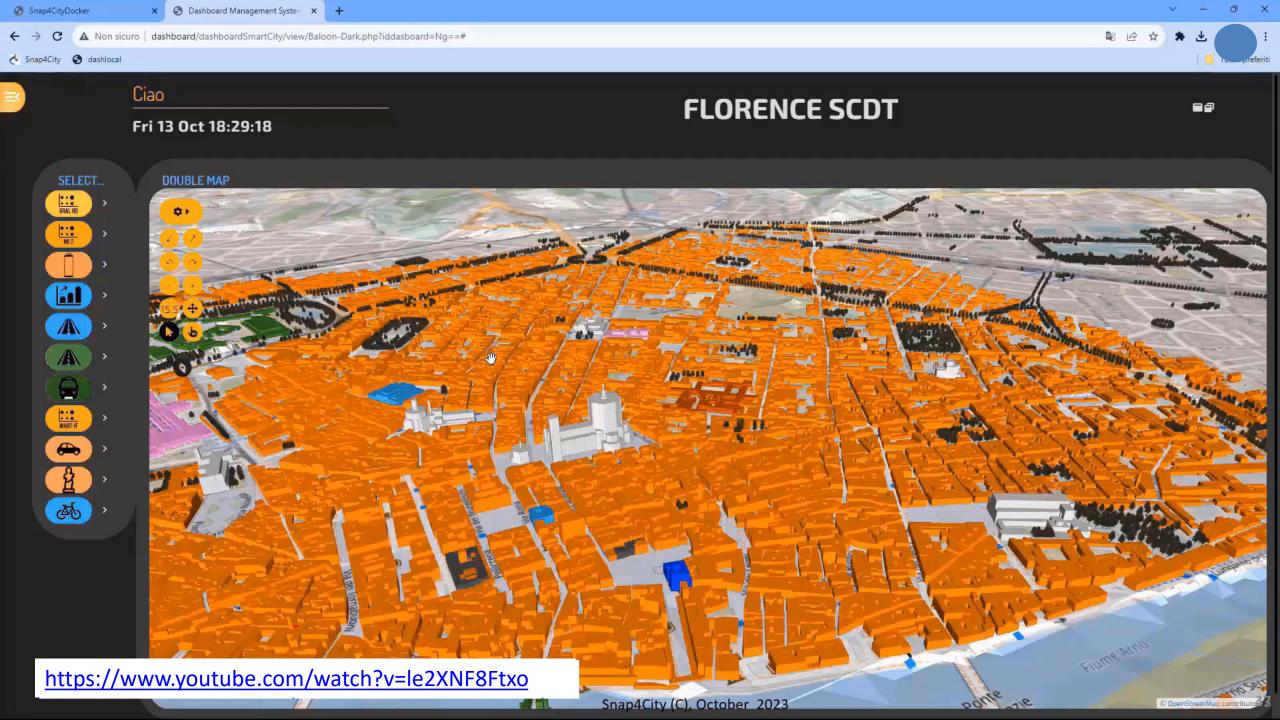












SCALABLE SMART ANALYTIC APPLICATION BUILDER FOR SENTIENT CITIES









Monitoring



- Controlling Status: management, and operational
 - Monitoring via KPI
 - Computing predictions and KPI
 - Anomaly detection, Early warning
 - Control Rooms, situation rooms
- Reacting: Computing in real time
 - Changing semaphore maps
 - Changing Dynamic signage
 - Real time Info Mobility
 - User engagement via Mobile Apps
 - What-if analysis
 - oetc.,





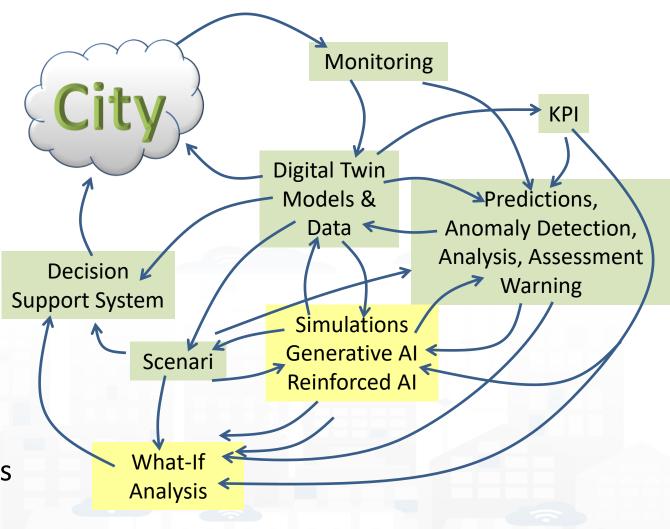




Main tasks



- Controlling Status: management, and operational
 - Monitoring via KPI
 - Computing predictions vs KPI
 - Anomaly detection
 - Neuro-Symbolic analysis
 - Risk assessment
 - Early warning on critical conditions
- Making plan: tactic and strategic, medium and long range, micro/macro
 - Simulation & predictions
 - Generative Al Prescriptions, scenarios
 - Resilience to Unexpected unknows
 - What-if analysis wrt scenarios



Key Performance Indicators, KPI





United Nations Sustainable Development Goals, Slow Services
 SDGs (for which cities can do more to achieve some of the 17 SDGs, https://sdgs.un.org/goals);
 Initial Nations Sustainable Development Goals, SDGs (for which cities can do more to achieve some of the 17 SDGs, https://sdgs.un.org/goals);



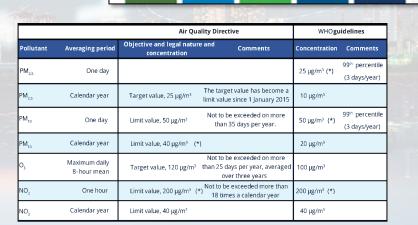
• 15 minutes cities (where primary services must be accessible within 15 minutes on foot);



 objectives of the European Commission in terms of pollutant emissions for: NO2, PM10, PM2.5 (https://environment.ec.europa.eu/topics/air_en);



- SUMI: mobility and transport vs env
 - https://www.snap4city.org/951
- SUMP/PUMS: mobility and transport vs env.
- ISO indicators: city smartness, digitization, tech level.
- Low Level/Real Time: global traffic, quality of service, betweenness, centrality, queue, time to travel, etc.



Mobility

Environment

15Min



Realtime

15MinCityIndex

What would support my neighborhood to become a 15-Minute City?

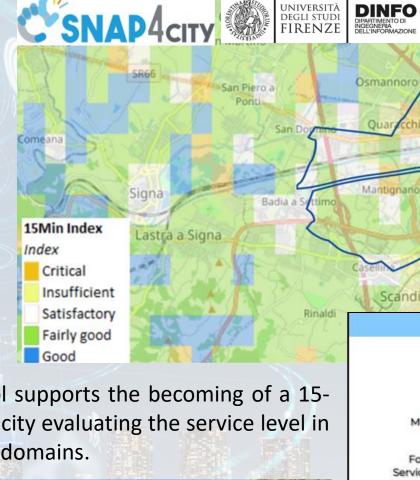
Using the Open Data:

We developed a data analytic tool based on municipal and national open data to assess services adequacy for people living in each 15 minutes areas of the city.

Good public transport services: bus, new tram line, train stations, cycle paths.

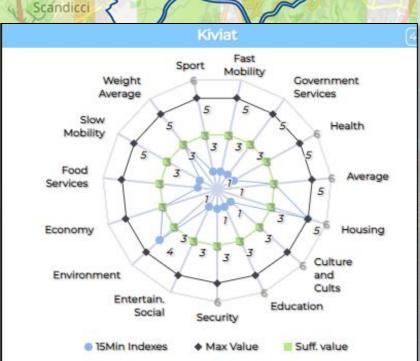


Careggi/Rifredi is a relevant district in Florence because of hosting the main Florence/Tuscany hospitals Careggi and Meyer, but also university headquarters and many other workplaces.



The tool supports the becoming of a 15-Minute city evaluating the service level in various domains.





https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjkzOA==

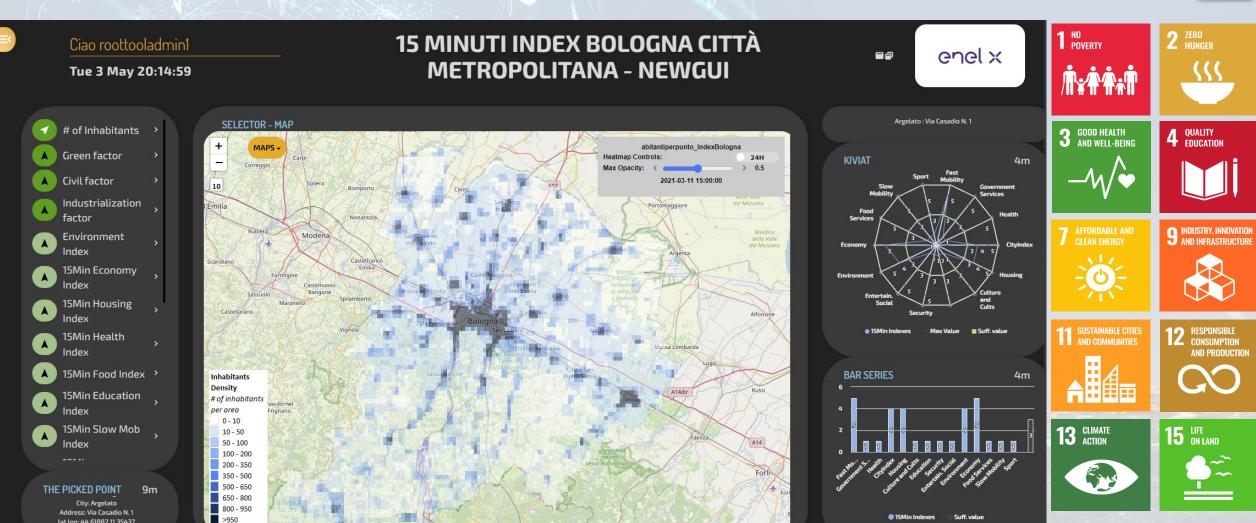
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15MinCityIndex on Bologna









lat.lon: 44.61882.11.35437

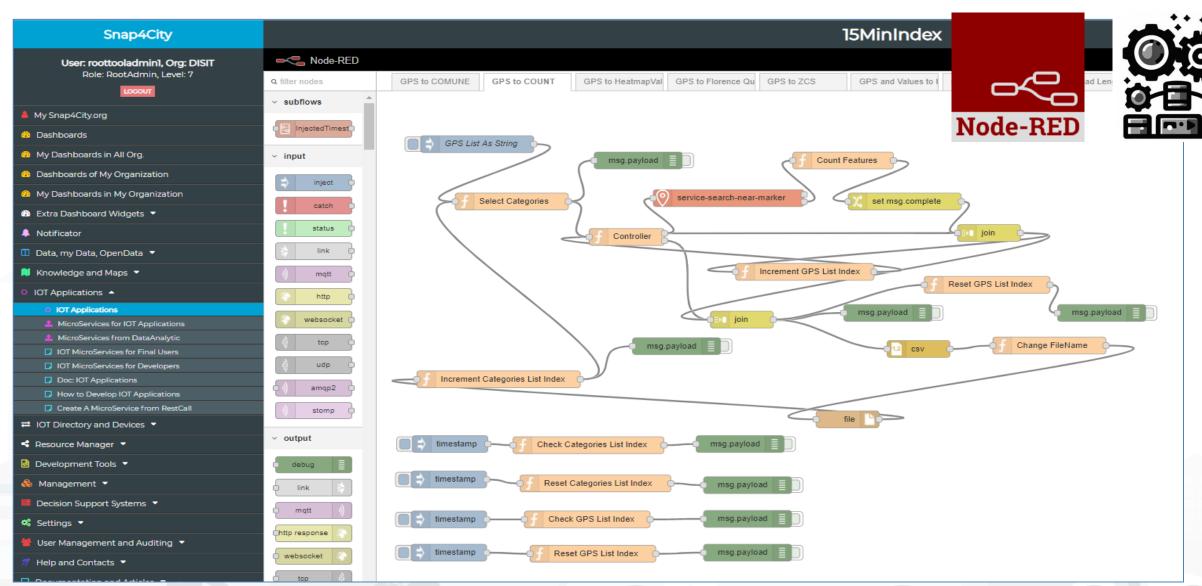












Smart City Control Room Florence Metropolitan City



Firenze Oggi





- Thousands of Open/Private data, POI, IOT, etc.
- mobility and transport: accidents, public transport, parking, traffic flow, Traffic Reconstruction, KPI, ...
- AND: environment, civil protection, gov KPI, covid-19, social & social media, people flow, tourism, energy, culture, ...

Multiple dash/tool Levels & Decision Makers

Real Time monitoring, Alerting, quality assess.

Predictions, KPI, DSS, what-if analysis

Historical and Real Time data

Billions of Data

Services Exploited on:

Multiple Levels, Mobile Apps, API

Since 2017





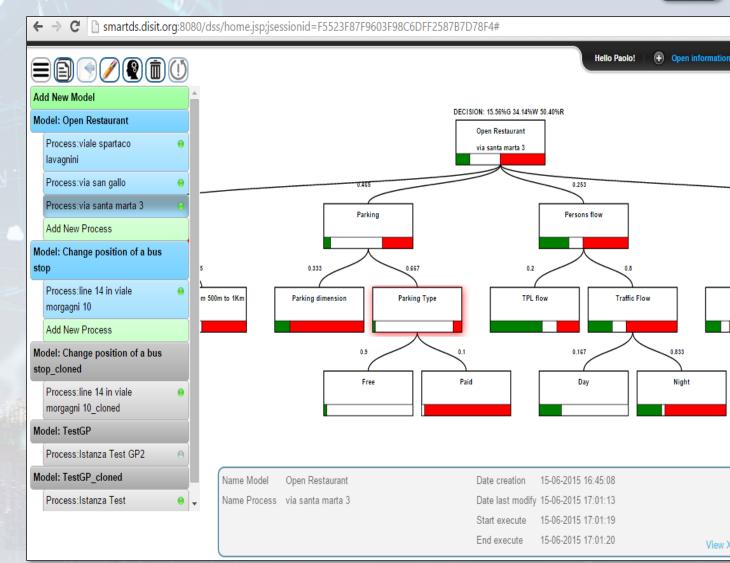








- Smart Decision Support System based on System Thinking plus
- Actions to city reaction, resilience, smartness, ...
- Enforcing Mathematical model for propagation of decision confidence..
- Collaborative work, ...
- Processes connected to city data: DB, RDF Store, Twitter, etc.
- Production of alerts/alarms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



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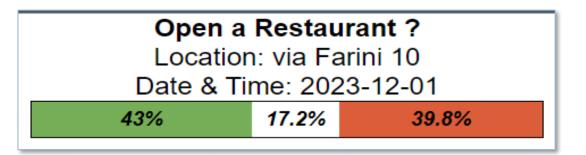








- Supports the definition of the Decision Tree Model, DTM, in terms of System Thinking, with Italian Flag and combinations
- Allows the statistic composition of subDecisions probabilities
- Generating a DTM as an IoT App,
- IoT Apps with DTM can
 - be customized
 - compute root values in real time in any context: location, parameters, etc.
 - Single DTM root value can be produced on Dashboard
 - Several DRM root values can be represented on dashboard as heatmaps for Green/White/Red values



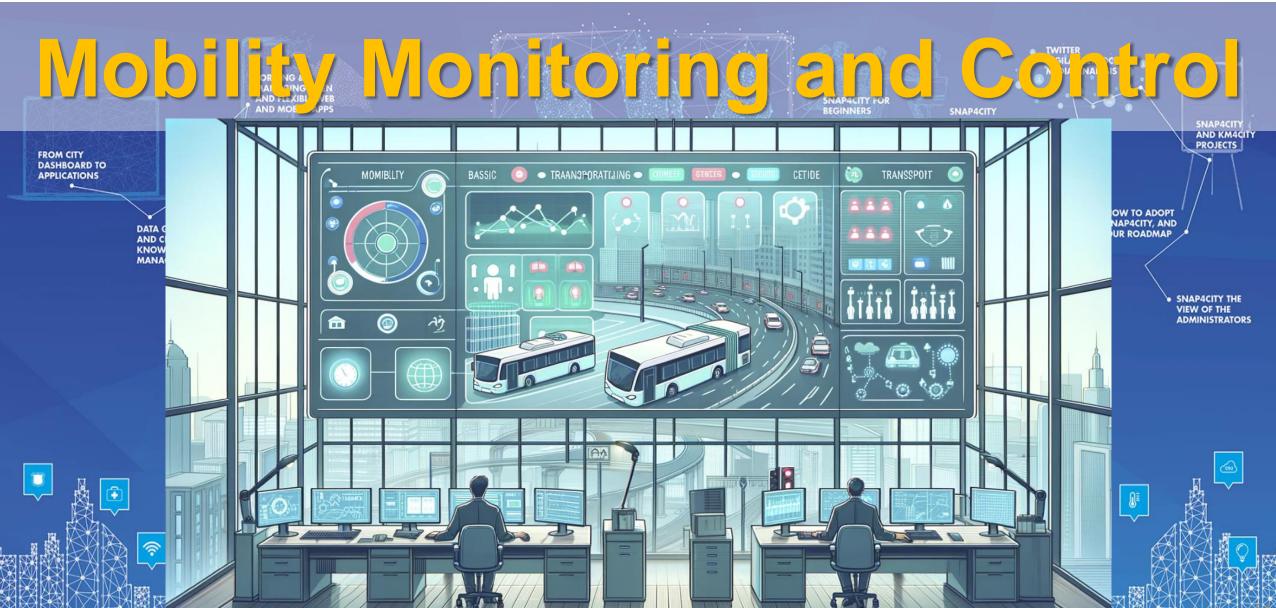






DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB DISTRIBUTED DATA INTELLIGENCE AND TECHNOLOGIES LAB























Traffic Flow Tools

Spire and Virtual Spires (cameras), Bluetooth, ...
Specifically located: along, around, on gates, on x...



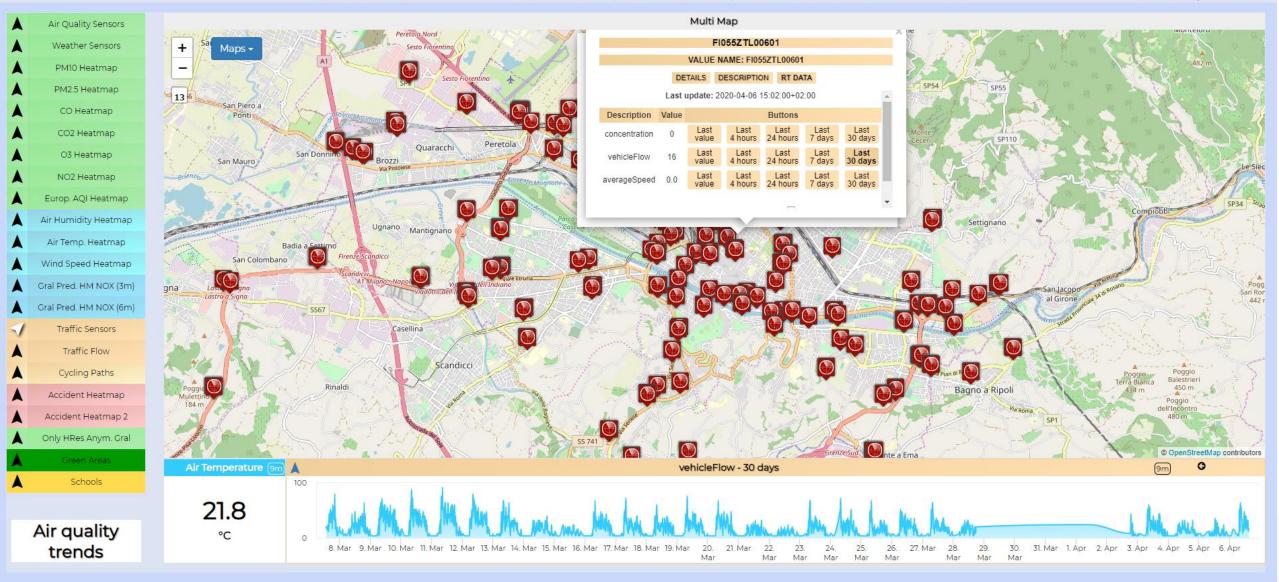
Snap4City (C), February 2024



Firenze - Trafair - AirQuality Heatmaps

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

Mon 6 Apr 15:12:27





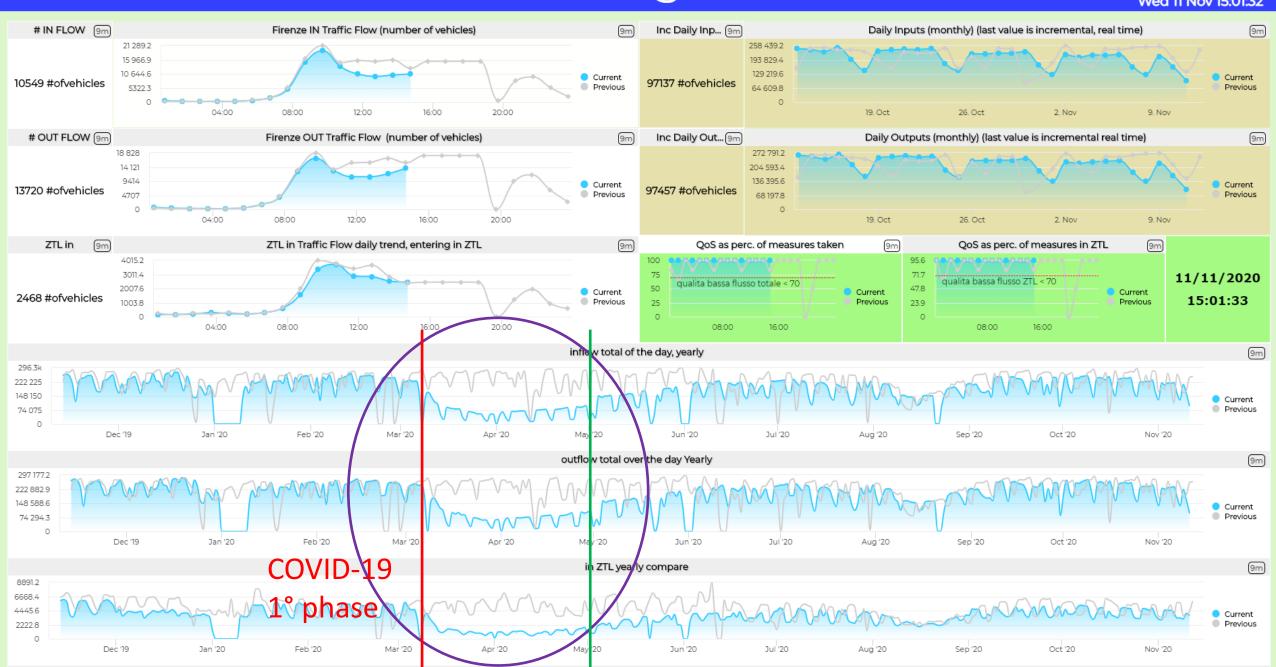






Traffic Flow Monitoring - Firenze - Cloned2

Wed 11 Nov 15:01:32









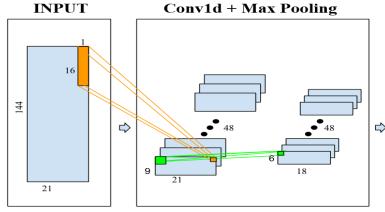


Short-Term Prediction of City Traffic Flow via Convolutional Deep Learning

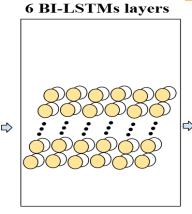


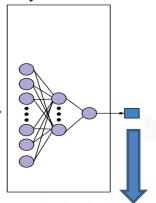






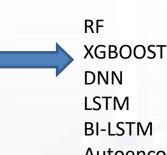
CONV-BI-LSTM



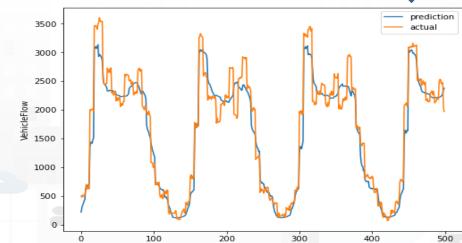


Urban data:

- Date-time
- Traffic
- Temporal
- Seasonality
- Pollution
- Weather



BI-LSTM
Autoencoder BI-LSTM
Attention CONV-LSTM
CONV-BI-LSTM



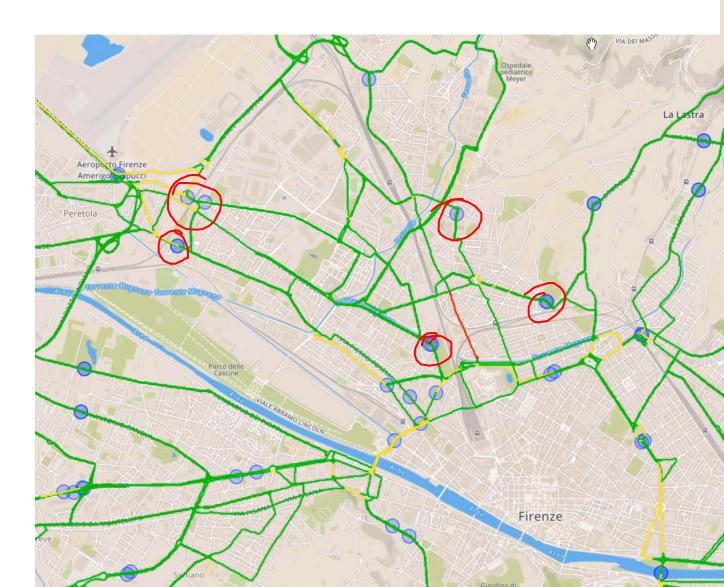






Dense Traffic Flow Reconstruction?

- Making decision on mobility and transport solutions
 what if analysis
- Controlling pollution
- Dynamic Routing for Firebrigade, Ambulances, general public
- Planning Public
 Transportation routing

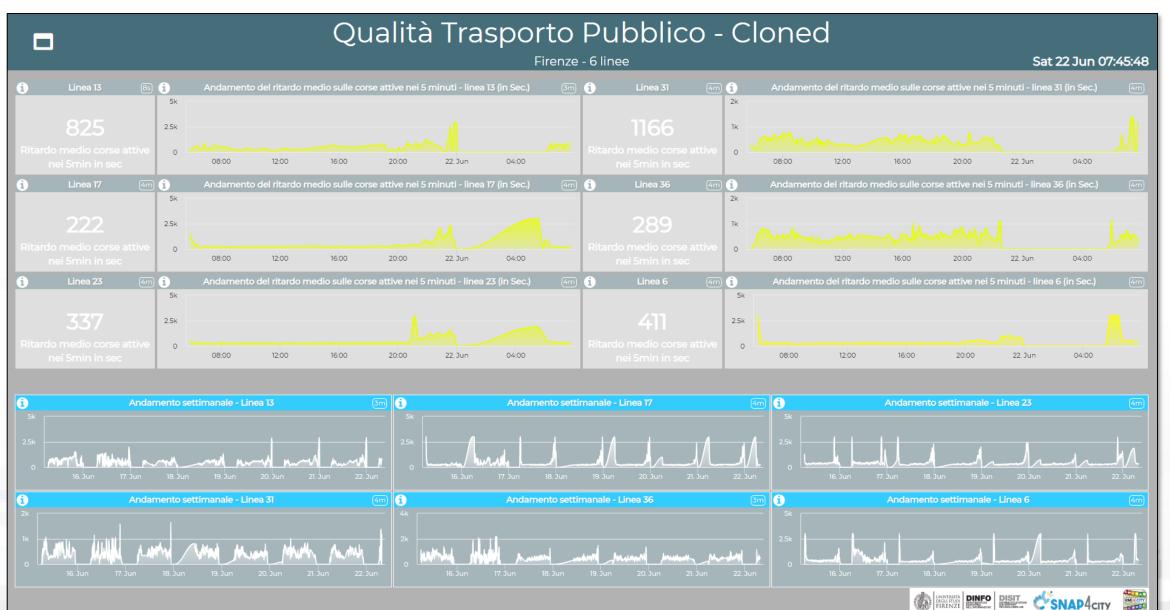
















What-If Analysis SNAP4city SNAP4city



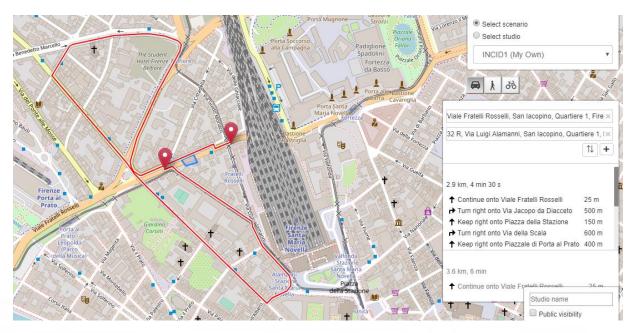


Accidents and elements blocking Points and Shapes taken into account for:

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

Assessment on the basis of changes:

- Mobility demand assessment
- Mobility Offer assessment





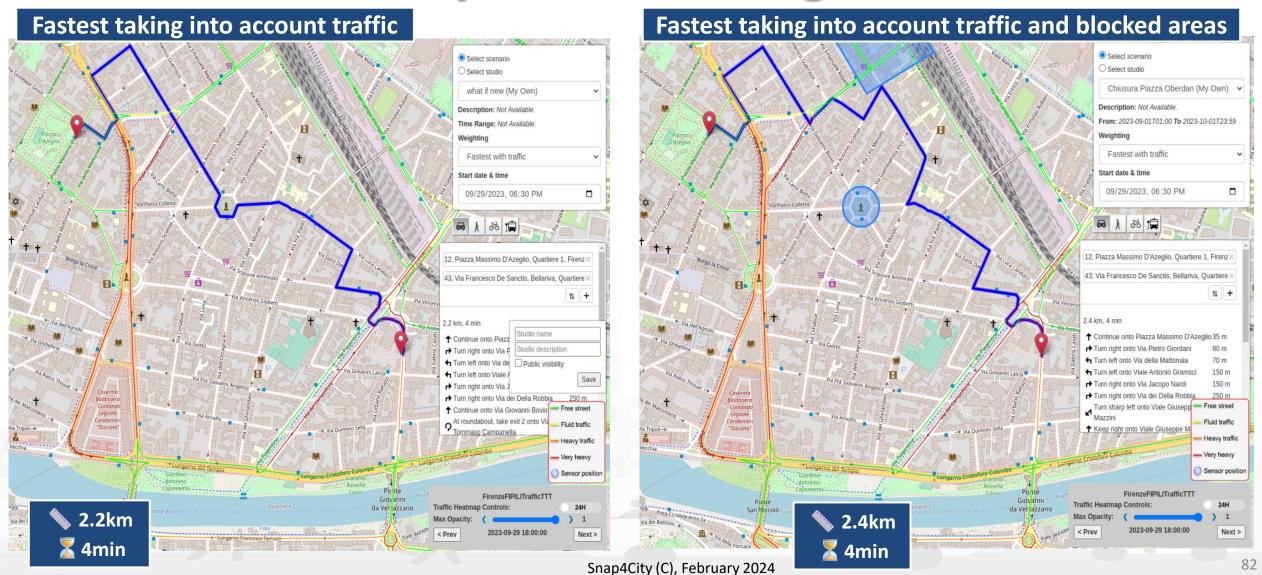








Constrained Dynamic Routing: Traffic Flow









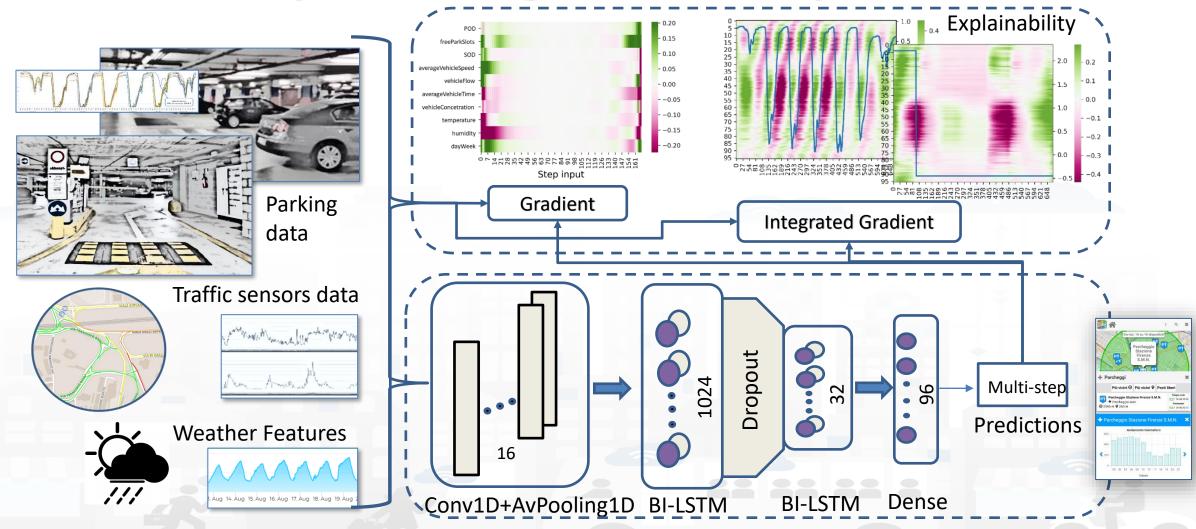








Deep Learning AI to surely Park!













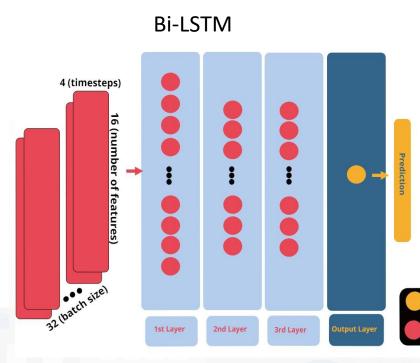
Deep Learning for Short-Term Prediction of Available Bikes on Bike-Sharing Stations

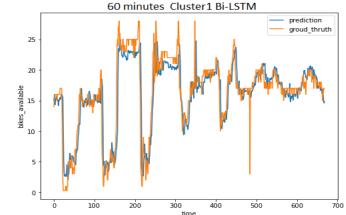












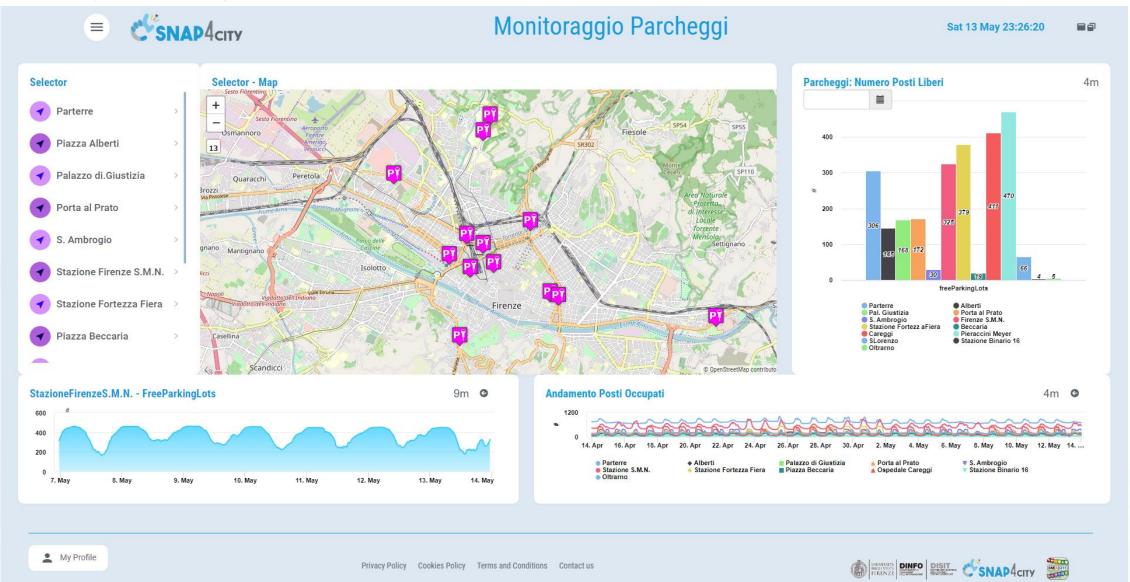












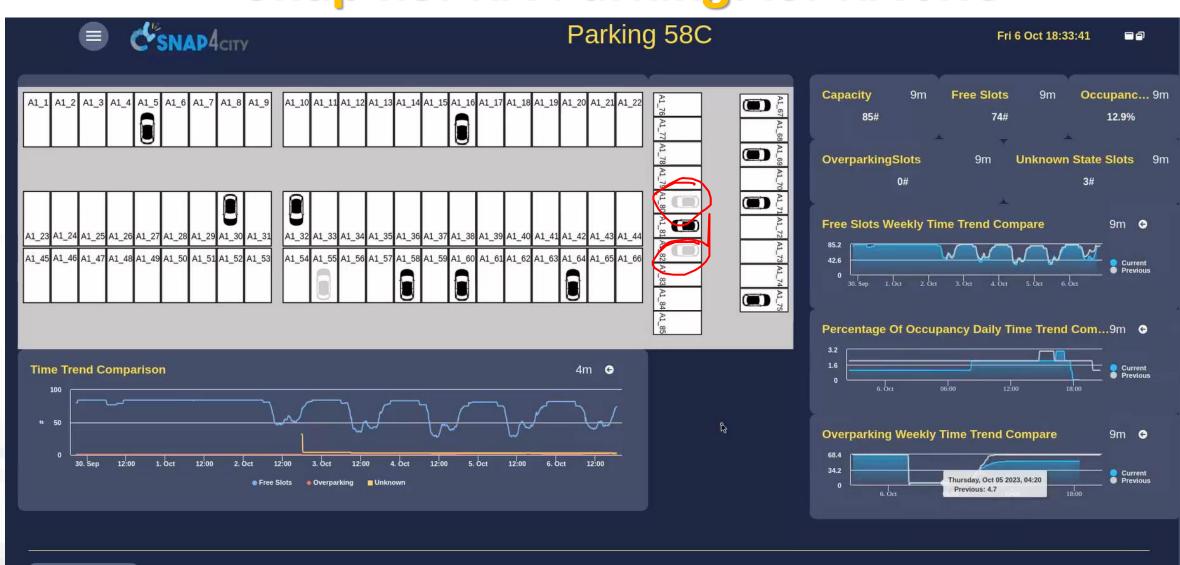








Snap4ISPRA Parking: ISPRA JRC



Smart City / Smart Parking + Environment

Reverberi, Lonato del Garda





DINFO DISIT C'SNAP4CITY



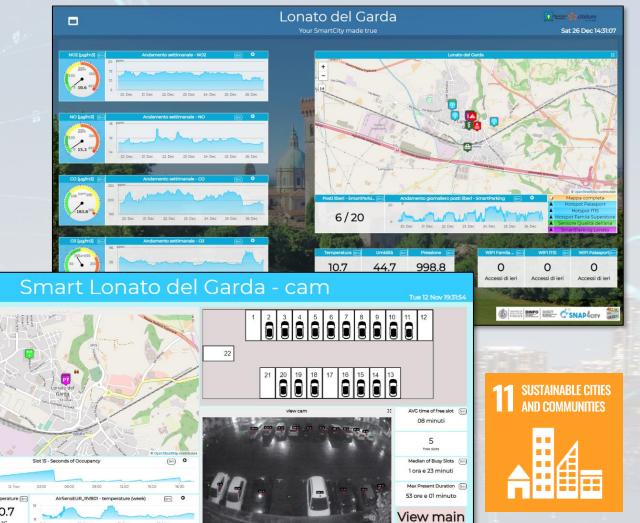
Smart Parking, Environment, Wi-Fi

Multiple Decision Makers

- City Officer, operators
- Data monitoring, alerting
- analytics

Historical and Real Time data

- Dashboards
- Services Exploited on:
 - · Dashboards, API
- Since 2019

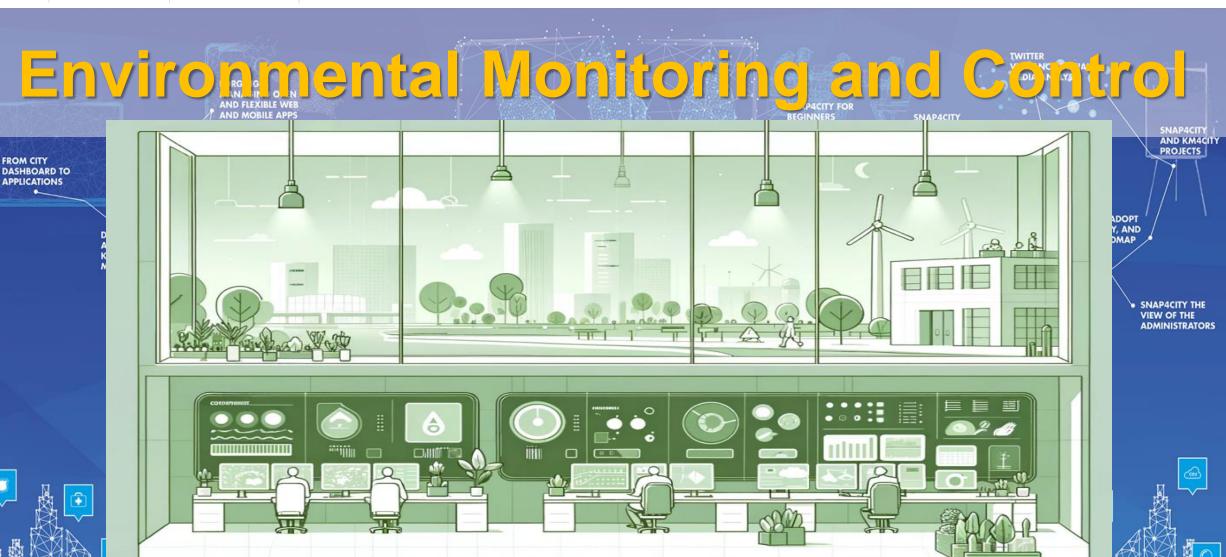










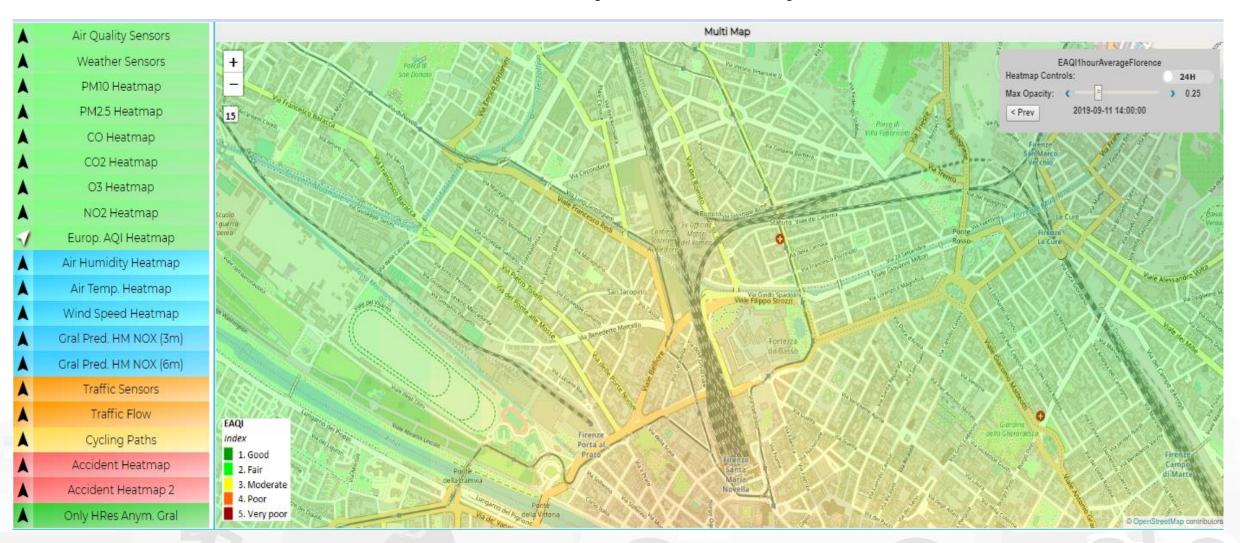








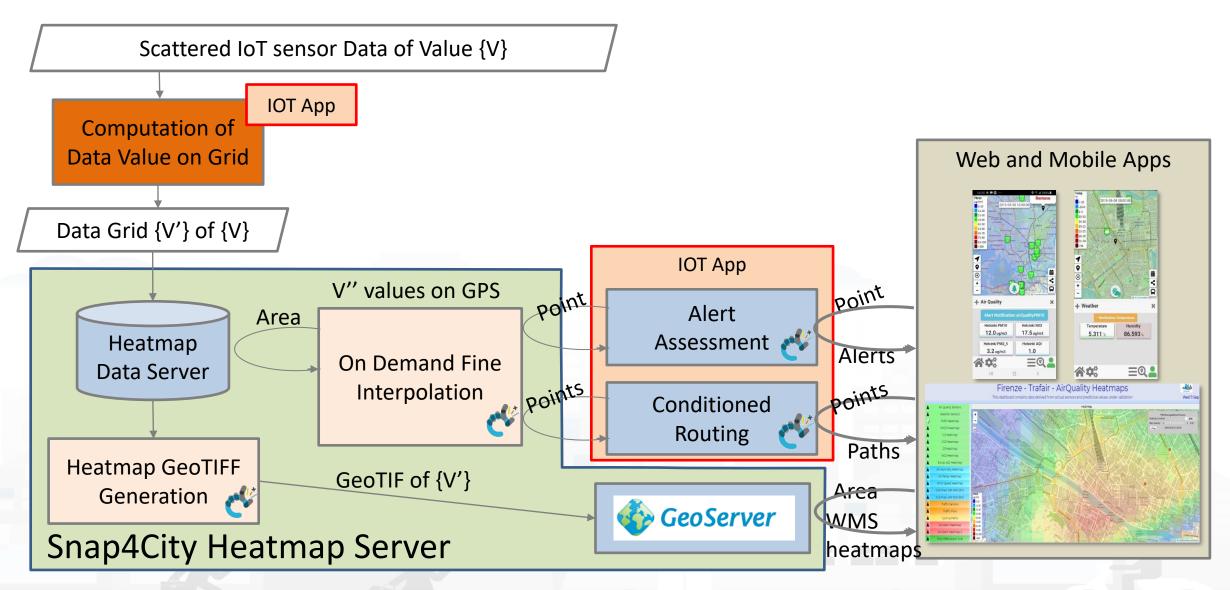
EAQI Heatmap and sequence



















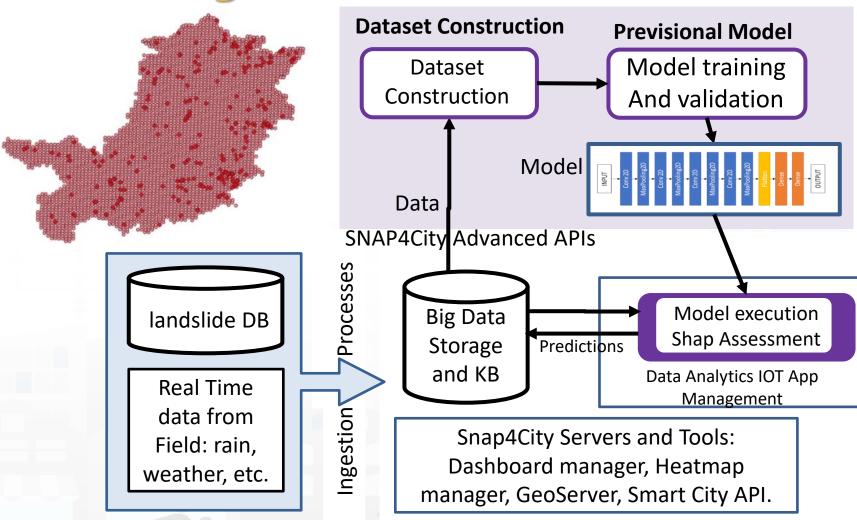








Predicting Land slides



(c) 21-12-2019 predictions Dashboards and

Mobile Apps

E. Collini, L. A. I. Palesi, P. Nesi, G. Pantaleo, N. Nocentini and A. Rosi, "Predicting and Understanding Landslide Events with Explainable Al," in IEEE Access, doi: 10.1109/ACCESS.2022.3158328.



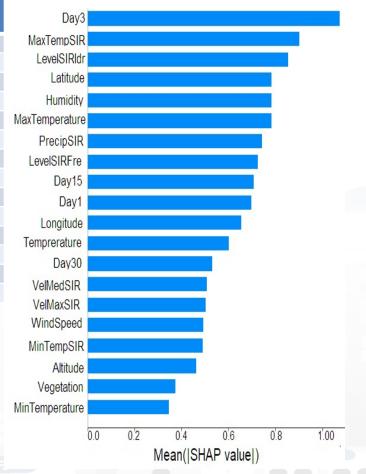


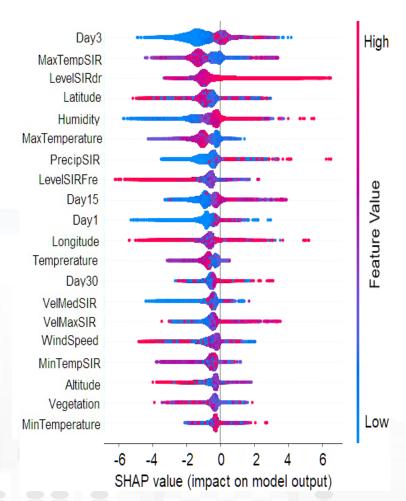




Comparing Predictive Model/architectures

Model	XGBoost	RF	CNN	Auto encoder	SIGMA
MAE	0.000173	0.000334	0.000600	0.009218	0.004169
MSE	0.000173	0.000334	0.000259	0.009218	0.004169
RMSE	0.0131	0.0182	0.0160	0.0960	0.064572
Accuracy	0.99	0.99	0.99	0.99	0.99
Sensitivity	0.79	0.36	0.24	0.19	0.06
Specificity	0.99	0.99	0.99	0.99	0.99
TSS	0.78	0.35	0.23	0.18	0.05
PfA	0.01%	0.02%	0.01%	0.11%	0.39%
Precision	0.63	0.35	0.33	0.64	0.003
F1 score	0.70	0.36	0.27	0.29	0.007
MCC	0.70	0.36	0.28	0.35	0.01
OA	2.40	1.72	1.55	1.64	1.02
Карра	0.70	0.36	0.27	0.29	0.01
AUC	0.89	0.68	0.99	0.92	0.53





Global Explainable Al

- Feature relevance

Red: positive, blue: negeative;

vs intensity and impact





Local Explainable AI - understanding the single event

- The local explanation puts in evidence the features which provided major contribution to the prediction
- For example considering
 Figure 10a, the value of
 VelMaxSIR, MaxTempSIR, Day3
 and Humidity contributed
 significantly to the classification of
 the observation as a landslide
 event

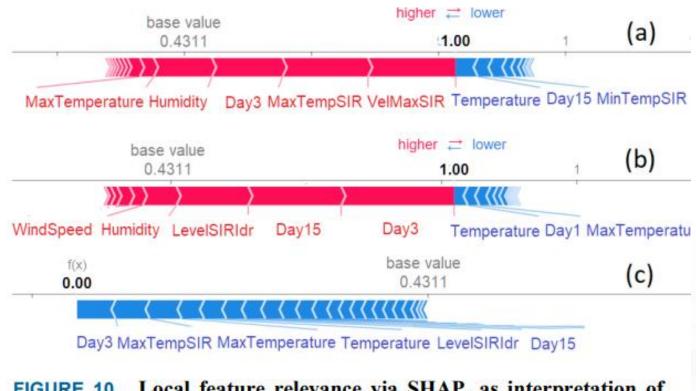


FIGURE 10. Local feature relevance via SHAP, as interpretation of events in terms of feature values: (a) and (b) are events with predictions of landslide, (c) a no landslide event.





DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB



ARCHITECTURE AND

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Opperarication adomtion

FROM CITY DASHBOARD TO APPLICATIONS

SNAP4CITY THE VIEW OF THE ADMINISTRATORS

SNAP4CITY AND KM4CITY PROJECTS













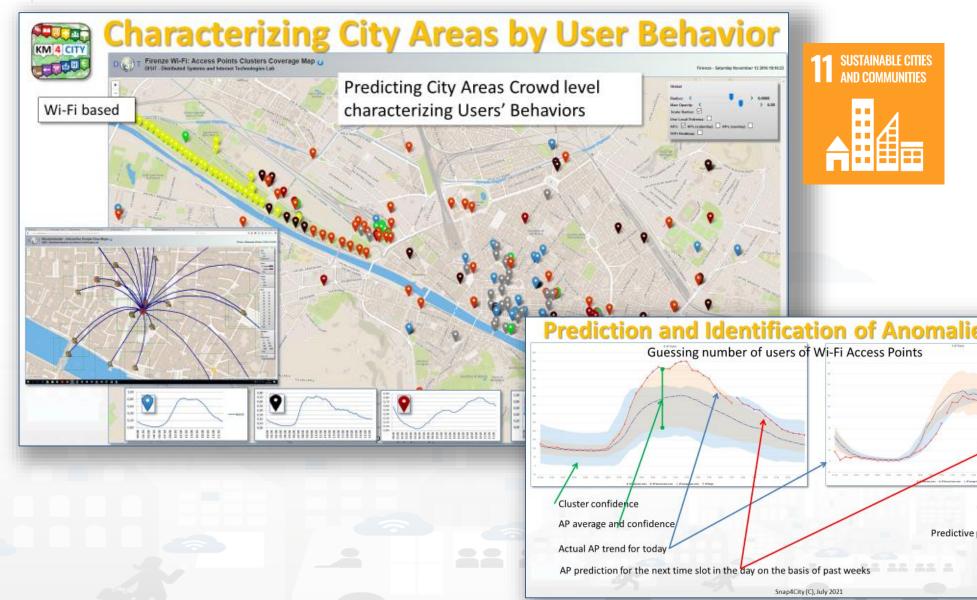
Snap4City (C), February 2024





105

- Prediction of people flows on the basis of Wi-Fi data
- Anomaly detection
- Resolute H2020
- Classification of city areas



SNAD CITY KM 4 CITY Characterizing City Areas

Pirenze Wi-Fi: Access Points Clusters Coverage Map

DISIT - Distributed Systems and Internet Technologies Lab Firenze - Saturday November 12 2016 19:16:33 **Predicting City Areas Crowd level** characterizing Users' Behaviors Wi-Fi based APs: APs (saturday): APs (sunday): Prediction resolute







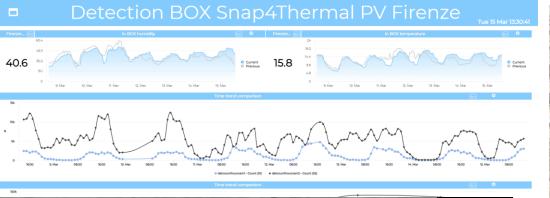








A view and data from the Thermal Camera













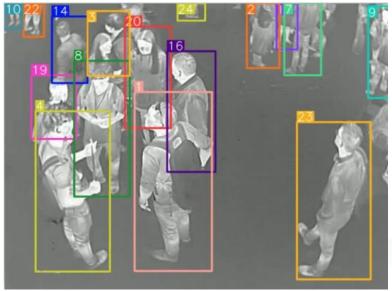


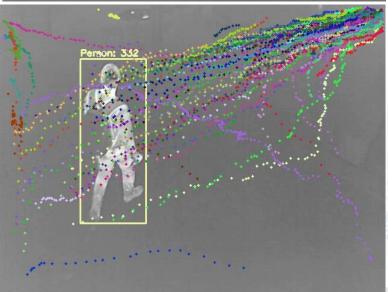




People Counting and Tracking







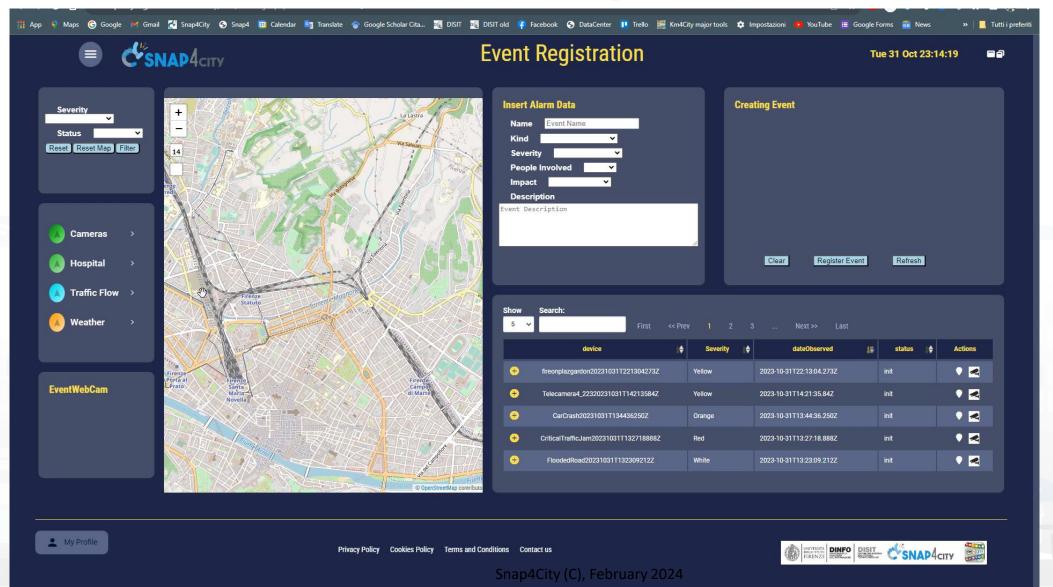








Event Management







DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB DISTRIBUTED DATA INTELLIGENCE AND TECHNOLOGIES LAB



Enging via Mobile Applies

FROM CITY DASHBOARD TO APPLICATIONS

> 100% OPEN SOURCE

DATA AND KNO MAN

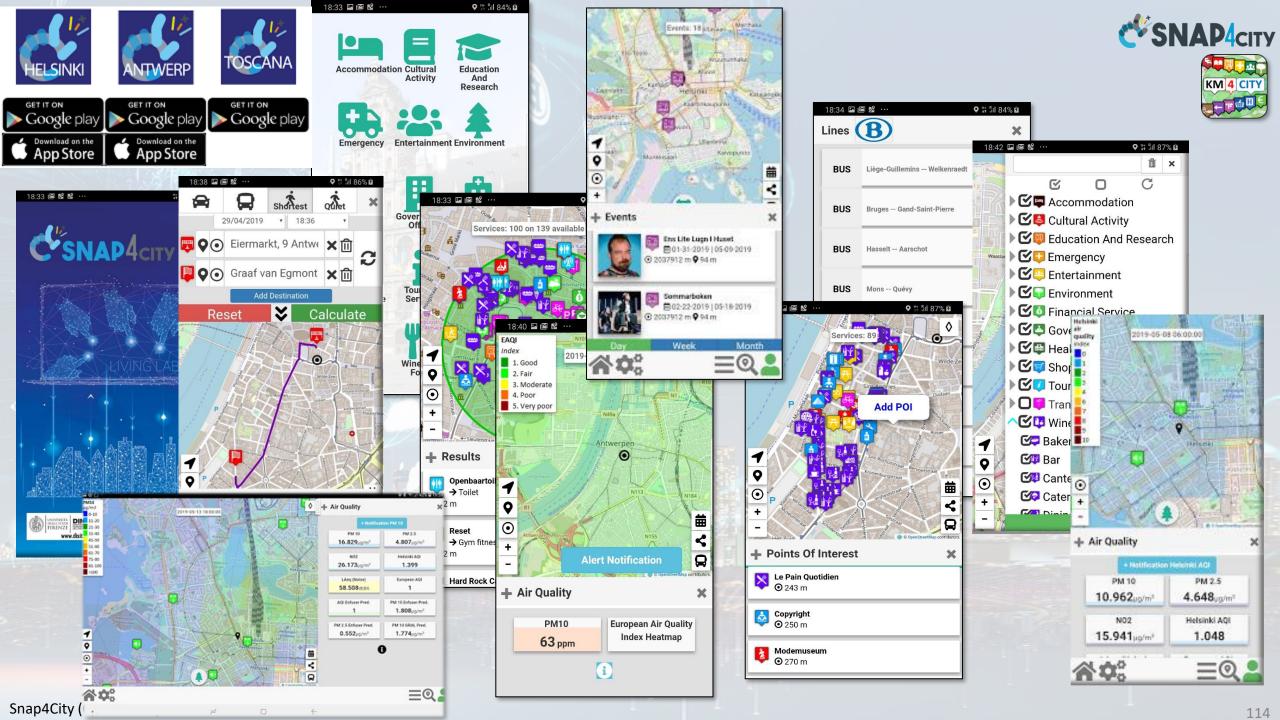




SNAP4CITY AND KM4CITY PROJECTS

SNAP4CITY THE VIEW OF THE ADMINISTRATORS







Citizen Engagement via Mobile Apps

KM 4 CITY

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

Produced information

- Viewed?
- Accepted ?
- Performed?

• ..



Snap4City (C), February 2024



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

- Suggestions
- Engagements
- Notifications

System

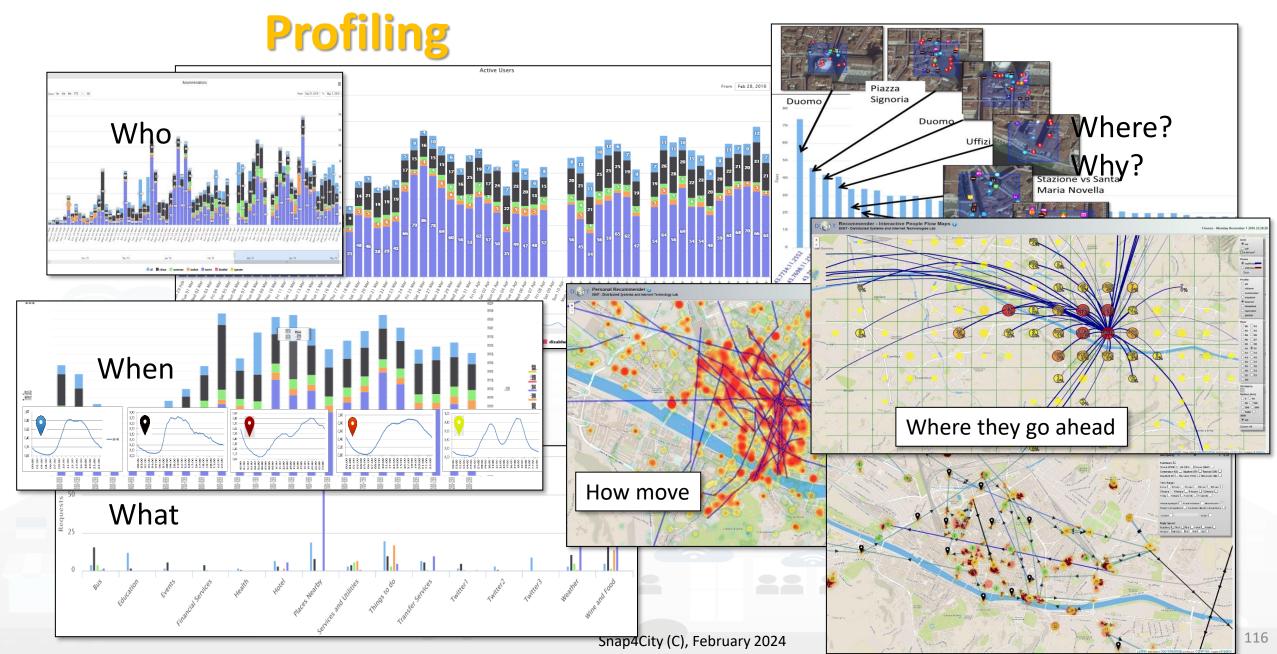




DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

User Behavior Analyser for Collective















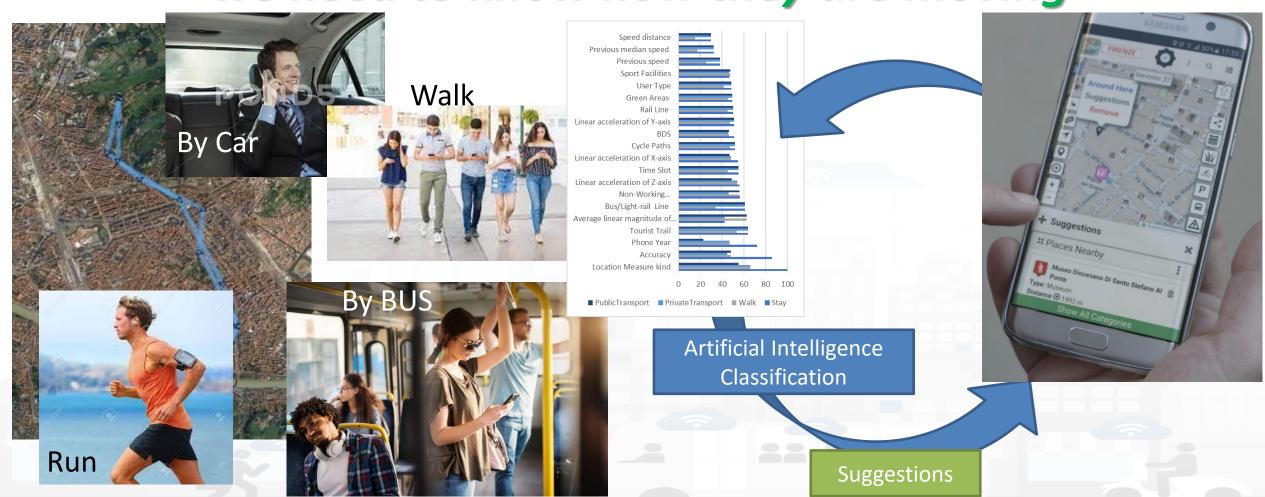






To propose suggestions and Engage city user

we need to know how they are moving

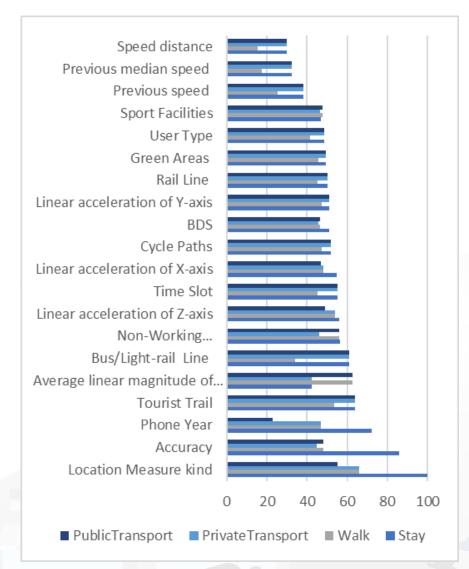












Feature relevance

Model	Extra Tree Model results			
features categories	Accuracy %	Precision %	Recall %	F ₁ Score
Baseline and GPS	91.0	68.2	75.1	0.714
Baseline and GPS + proximity	92.4	73.9	69.1	0.715
Baseline and GPS + proximity + Accelerometer	92.6	81.4	74.4	0.777
Baseline and GPS + proximity + Temporal window	94.9	80.5	78.7	0.787
Baseline and GPS + proximity + Accelerometer + Temporal window	95.3	82.7	86.9	0.847

Decision Support System:

Tommed Managrig open response and Tactiggrean Carchitecture and Architecture and Architecture and Constitution opening the construction of the con

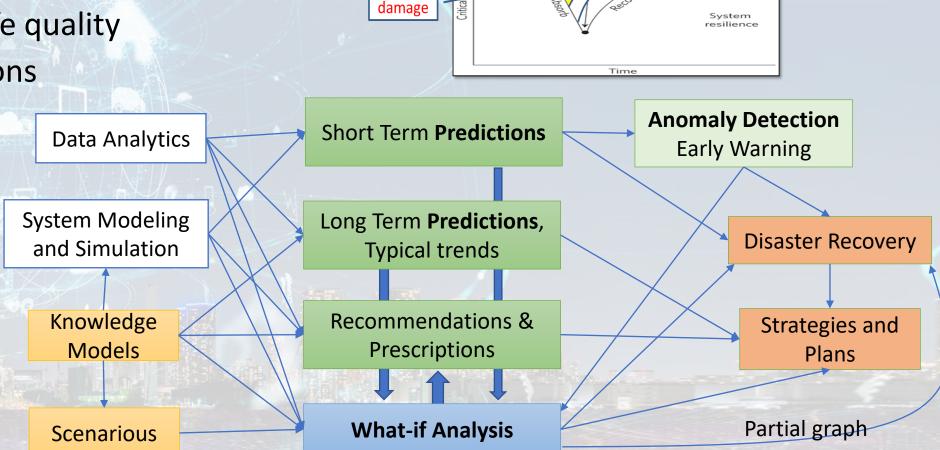
DASHBOARD TO APPLICATIONS

Plans, via What-if Analysis takeholders



Snap4City What-If

- Decision support systems
- Improvement of life quality
- Sustainable Solutions
- Reduction of costs
- Risk Assessment
- Resilience



Consequence

Decision Support System: neuro-symbolic reasoning targeting Indicators: Quality of Life, PUMS, SUMI, KPI, SDG, 15MinIndex,...

Snap4City (C), February 2024

Prepare

Absorb

Recover

Adapt















15 Minute City Index:

 13 subindexes: energy, slow mobility, fast mobility, housing, economy education, culture and cults, health, entertainment, gov, food, security...



- Monitoring and Prediction of energy consumption
- Stimulating: Bike sharing, e-bikes, car charge, etc.



- Smart City infrastructure: monitoring and resilience, long terms predictions
- Effective and Low cost smart solutions
- What-if analysis, Simulations
- Origin Destination matrices computation



Monitoring and Predicting: NO2, NOX, CO2, Traffic flow, pollutant, landslide, waste, etc.

Traffic flow reconstruction

Demand vs Offer of Mobility analysis



- Industry 4.0 integrated solutions
- Decisions Support Systems
- Process optimization, control
- Predictive maintenance



- business intelligence tools for decision makers
- Reduction production costs
- Monitoring resource consumption
- Optimization of Waste Collection



- Shortening justice time
- Anonymization and indexing legal docs.
- Prediction of mediation proneness
- Ethical Explainable Artificial Intelligence

Snap4City (C), February 2024









Challenges vs Technologies

- DSS, Decision Support Systems, with multiple objectives:
 - Quality of life for citizens, improvements of services, cost reduction, innovation, attractiveness for tourists and/or industries and/or commercial activities, etc.
- provide the decision-making process with simulation tools integrated with short-, long- and very long-term prediction algorithms
 - → what-if analysis
 - Analyse *incipient events* to cope with events;
 - Analyse future situations for structural planning: tactics/strategic.
- Opportunities and needs
 - heterogeneous data (Big Data)
 - flexible, dynamic and interoperable models and analysis tools;
 - accessible for:
 - Operators, decision-makers, stakeholders;
 - citizens: illustrating and discussing possible solutions and development plans with them: cowork









Available AI Solutions on Snap4City

SNAP4city

KM4 city

- Mobility and Transport
- Environment, Weather, Waste, Water
- City Users Behaviour and Social analysis
- Energy and Control, Security,
- Tourism and People
- Security and Safety
- High Level Decision Support Solutions
 - Asset management
 - Resilience and Risks Analysis
- Low level Techniques

https://www.snap4city.org/download/video/course/p4/





https://www.snap4city.o rg/download/video/DPL SNAP4SOLU.pdf



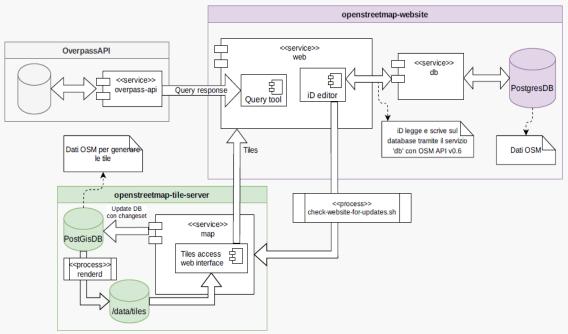






Tactic and/or Strategic Planning

Correction of road graphs which is present on OSM







OSM data with non clear double bidirection lane on Viale Redi, Florence.
Editing OSM data and present Tiles





After Corretion of OSM data defining a clear double bidirection lane on Viale Redi, Florence. Regeneration of the TILEs for the maps



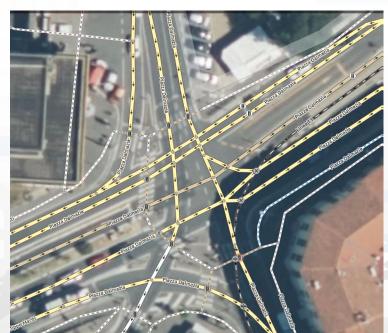


OSM data with non correct viability in Piazza Dalmazia, Firenze





After Correction of OSM data defining a correct viability of Piazza Dalmazia, Florence. Regeneration of the TILEs for the maps















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Micro Simulation







Mobility and Transport

- **Predictions** for: traffic flow, smart parking, smart bike sharing, people flows, etc. (ML, DL)
- What if analysis: routing, traffic flow, demand vs offer, pollutant, etc. (Simulation + ML)
- Traffic flow reconstruction from sensors and other sources (simulation + ML)
- Public Transportation: Ingestion and modelling of GTFS, Transmodel, NeTEx, etc. (DP)
 - Analysis of the **demand mobility vs offer transport** of according to public transportation and multiple data sources (Simulation)
 - Assessing quality of public transportation (analysis)
- Accidents heatmaps, anomaly detection (analysis, ML)
- Tracking fleets, people, via devices: OBU, OBD2, mobile apps, etc. (DP)
- Routing and multimodal routing (multistop travel planning), constrained routing, dynamic routing (DA)
- Computing Origin Destination Matrices from different kind of data (analysis, DP, DP)
- Computing typical trajectories on the basis of tracks (analysis, ML)
- Computing Messages for Connected drive (DP)
- Slow and Fast Mobility 15 Minute City Indexes (analysis, DP, ...ML)
- Computing and comparing traffic flow on devices and at the city border (analysis)
- Typical time trends for traffic flow and IoT Time series. (analysis, ML)
- Impact of COVID-19 on mobility and transport
- Computing SUMI, PUMS, etc. (mainly DP)
- Definition of Scenarios: traffic, road graph, conditions, etc.



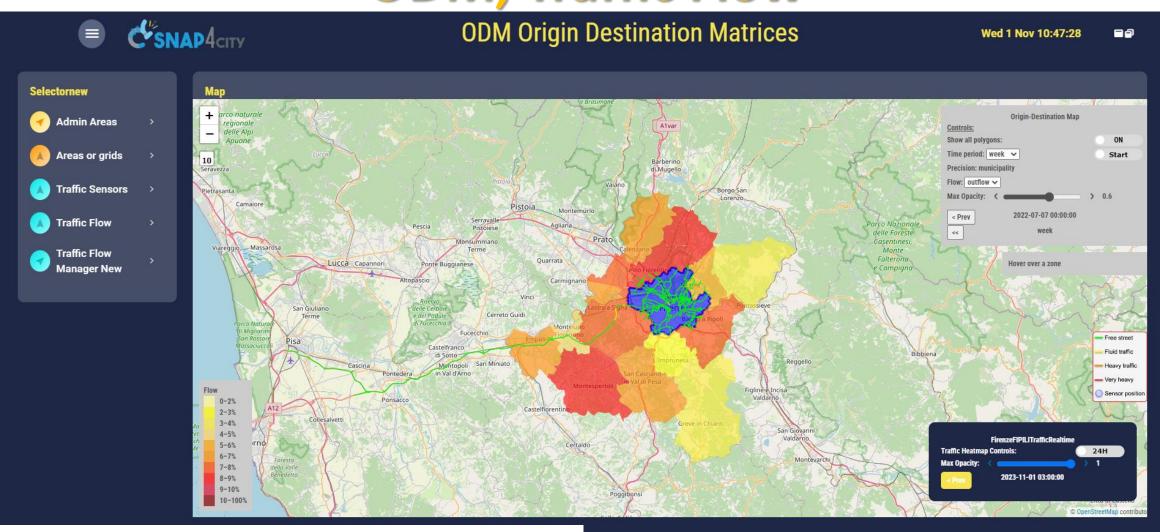








ODM, Traffic Flow



https://www.snap4city.org/dashboardSmartCity/view/Gea-Night.php?iddasboard=Mzk3Nw==







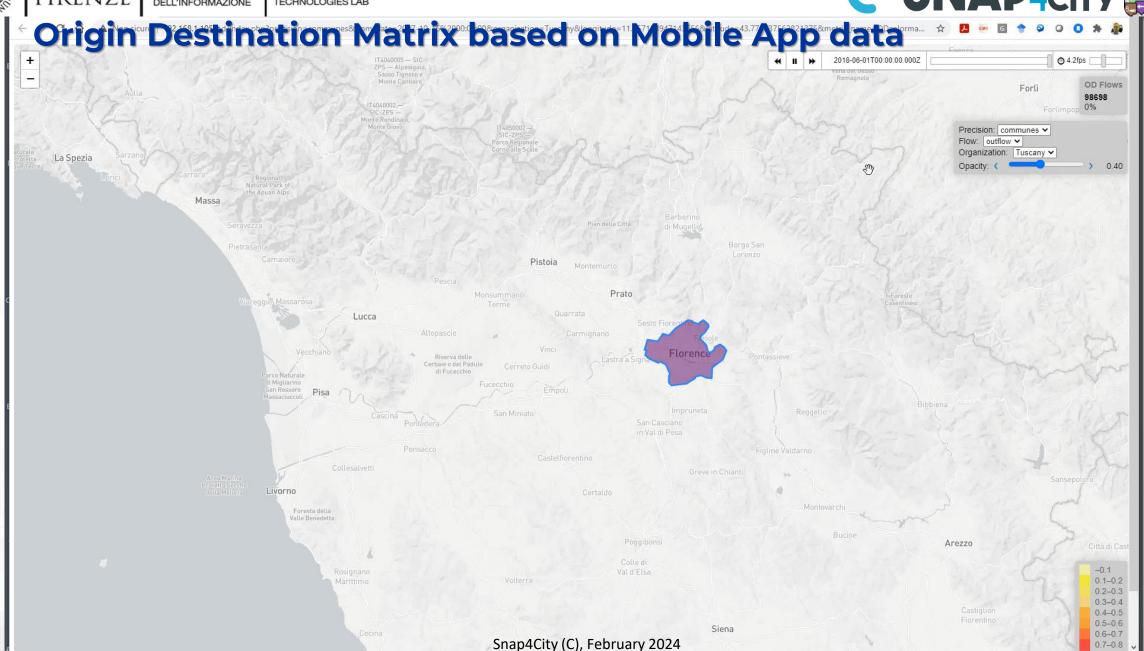






















Decision Support Systems, What-if

Snap4City (C), February 2024

Event planning, via what-if analysis

- Change in the graph structure of the city
- Impact on the flow of people and vehicles
- Adaptation: public transport, traffic, pedestrian management, etc.

Immediate reaction to natural events or not

- Everything is ready and updated in real time
- Each view is contextualized in terms of data: descriptive and prescriptive

Digital Twin

- More detail in the context integrated data
- Greater realism in deductions and representations
- Less fragmentation and non-uniformity in the views to support decisions





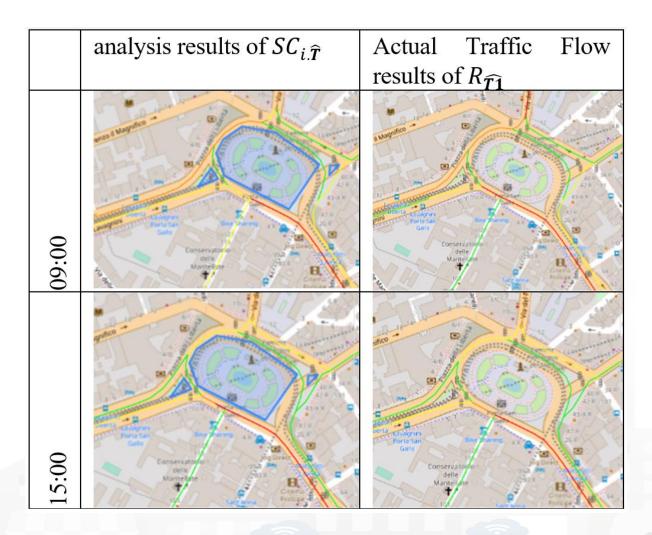


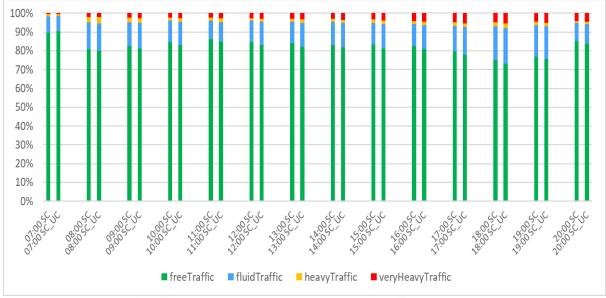


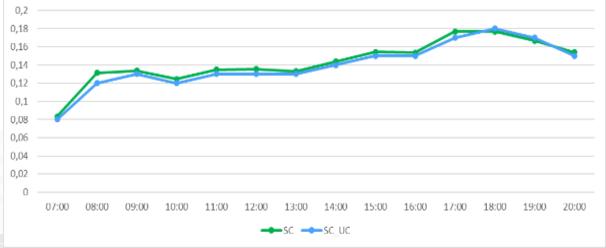


What-if









What-if Analysis on Pub Transport







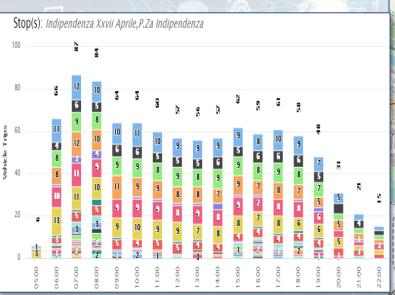


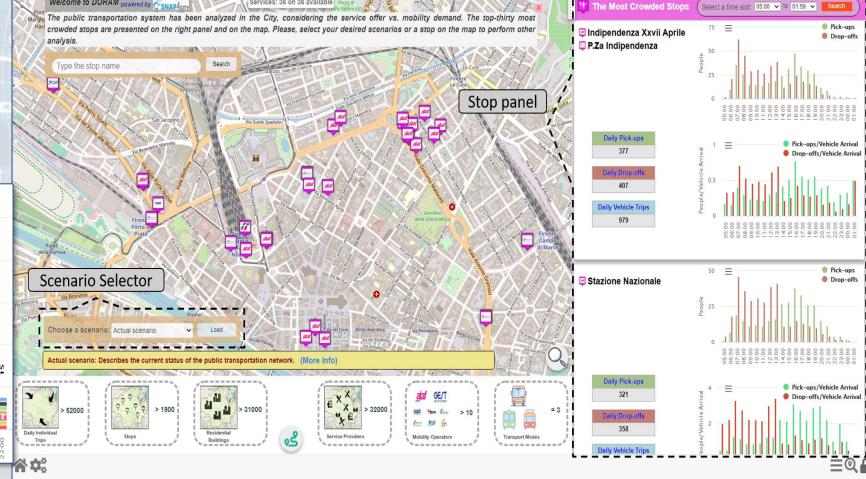


- Definition of scenarious impact on
 - Traffic, Pollutant, parking, public transport, private flows, etc.

KPI analysis

Public Services



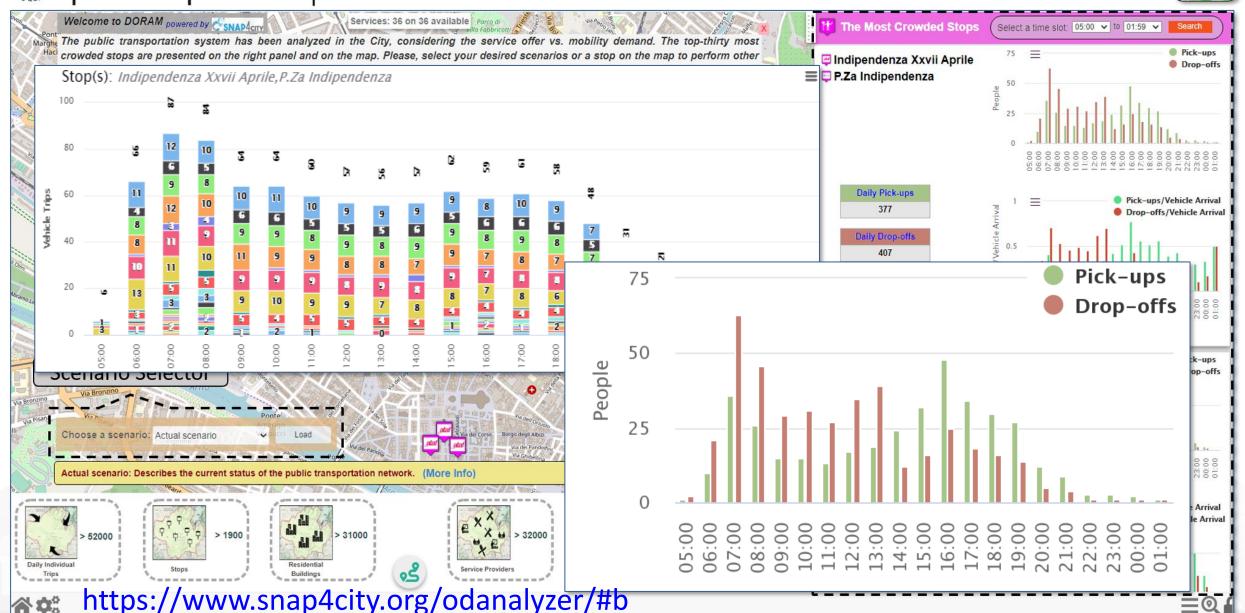




DINFO DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

DORAM









Environment and Weather

- Pollutant Predictions: short, long and very long term European Commission KPIs
 - NOX, PM10 pollution on the basis of traffic flow, 48 hours (ML, AI, DL)
 - Cumulated NO2 average value over the year, (ML, AI, DL)
- Computation of CO2 on the basis of traffic flows (DP), computing emission factor (DA)
 - each road for each time slot of the day
- Prediction of MicroClimate conditions for diffusion (ML, AI)
 - NO2, PM10, PM2.5, etc.
- Prediction of landslides, 24 hours in advance (AI, DL)
- Heatmaps production, dense data interpolation (DP) for
 - Weather conditions: temperature, humidity, wind, DEW
 - Pollutants and Aerosol: NO, NO2, CO2, PM10, PM2.5, etc.
- Impact of COVID-19 on Environmental aspects (DP)
- Optimisation of waste collection schedule and paths (DP, ML)
- Computing SDG, SUMI, PUMS, .. (mainly DP)
- Etc.

Environment and Quality of Life

Air Quality Predictions

Multiple Domain Data

- Traffic Flow data, Pollutant: NOX, CO2, PM10, PM2.5, O3,
- 3D City structure, weather, ...

Multiple Decision Makers

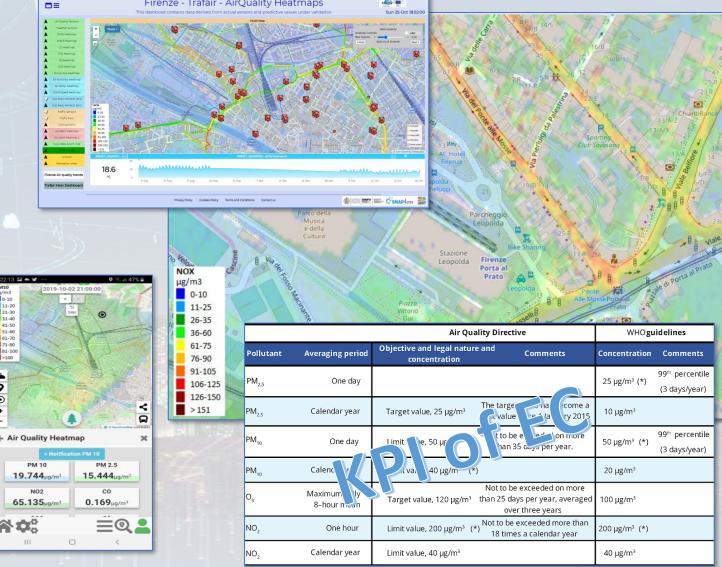
- Pollutant Predictions: NOX, NO2, ...
- City officers, energy industries
- Dashboards, What-IF analysis
- Traffic Flow Reconstruction

Historical and Real Time data

- Billions of Data
- Services Exploited on:
 - Dashboards, Mobile App
- Since 2020















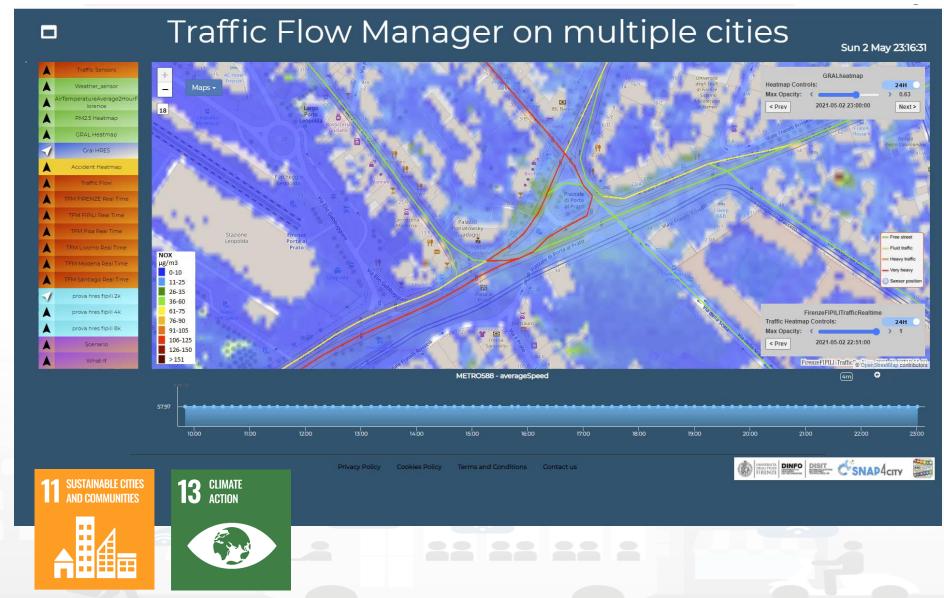


Prediction

- NOX Pollutant diffusion on the basis of Traffic Flow (prediction), weather and 3D structure
- NO2 progressive average (Long term)

Project:

- Trafair CEF EC
- Mixed solutions of Fluidinamics modeling and Al



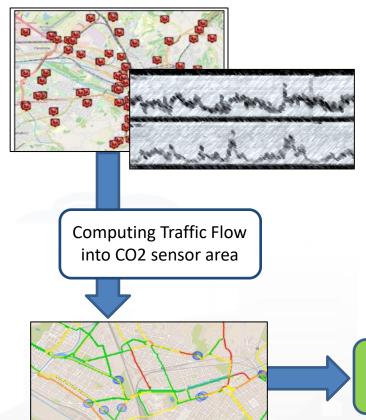








Estimating City Local CO2 from Traffic Flow Data



 Traffic Flow is one the main source of CO2 (ton of CO2 x Km x Vehicle)



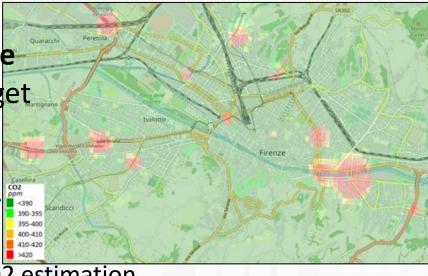


K1: Fluid Flow

K2: Stop and Go

 Dense estimation of CO2 into the city is very useful to know to target EC's KPIs

Computing CO2 on the basis of traffic flow data



CO₂ estimation

Traffic Flow data

S. Bilotta, P. Nesi, "Estimating CO2 Emissions from IoT Traffic Flow Sensors and

Reconstruction", Sensors, MDPI, 2022. https://www.mdpi.com/1424-8220/22/9/3382/





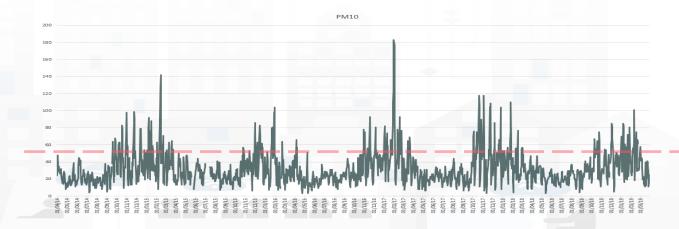




- European Air Quality Directive
- Predicting critical days
 - PM10 with an accuracy of more than 90% and precision of 85%;
 - PM2.5 with an accuracy of 90% and precision greater than the 95%.
- Simulating Long terms values
 - For long terms predictions



		Air Quality Directive			WHOguidelines	
Pollutant	Averaging period	Objective and legal nature concentration	e and Comments	Concentration	Comments	
PM _{2.5}	One day			25 μg/m³ (*)	99 th percentile (3 days/year)	
PM _{2.5}	Calendar year	Target value, 25 μg/m³	The target value has become a limit value since 1 January 2015	10 μg/m³		
PM ₁₀	One day	Limit value, 50 μg/m³	Not to be exceeded on more than 35 days per year.	50 μg/m³ (*)	99 th percentile (3 days/year)	
PM ₁₀	Calendar year	Limit value, 40 μg/m³ (*)	20 μg/m³		
O ₃	Maximum daily 8–hour mean	Target value, 120 μg/m³	Not to be exceeded on more than 25 days per year, averaged over three years	100 μg/m³		
NO ₂	One hour	Limit value, 200 µg/m³ (*	Not to be exceeded more than 18 times a calendar year	200 μg/m³ (*)		
NO ₂	Calendar year	Limit value, 40 μg/m³		40 µg/m³		







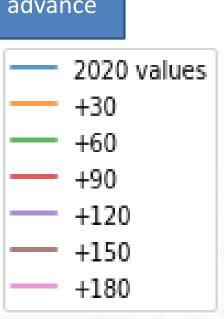




Predicting EC's KPI on NO2 months in advance

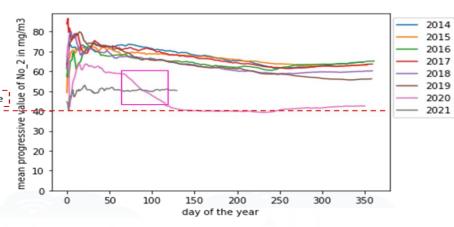
Deep Learning Long Terms Predictions of NO2 mean values, From 30 to 180 days in advance

- The features used as input for the predictive models are:
- Month
- dayOfTheYear
- NO2
- Tmean
- Humidity
- windMean 🤔
- **NoxDomestic**
- numberOfVehicles
- NO2cumulated
- NO2progresseveMean
- numberOfVehiclesCumulated









		Air Quality Directive			WHOguidelines	
Pollutant	Averaging period	Objective and legal nature concentration	and Comments	Concentration	Comments	
PM _{2.5}	One day			25 μg/m³ (*)	99 th percentile (3 days/year)	
PM _{2.5}	Calendar year	Target value, 25 µg/m³	The target value has become a limit value since 1 January 2015	10 μg/m³		
PM ₁₀	One day	Limit value, 50 μg/m³	Not to be exceeded on more than 35 days per year.	50 μg/m³ (*)	99 th percentile (3 days/year)	
PM ₁₀	Calendar year	Limit value, 40 μg/m³ (*)		20 μg/m³		
O ₃	Maximum daily 8–hour mean	Target value, 120 µg/m³	Not to be exceeded on more than 25 days per year, averaged over three years	100 µg/m³		
NO ₂	One hour	Limit value, 200 μg/m³ (*	Not to be exceeded more than 18 times a calendar year	200 µg/m³ (*)		
NO ₂	Calendar year	Limit value, 40 μg/m³		40 μg/m³		









Smart Buildings, Snap4Building

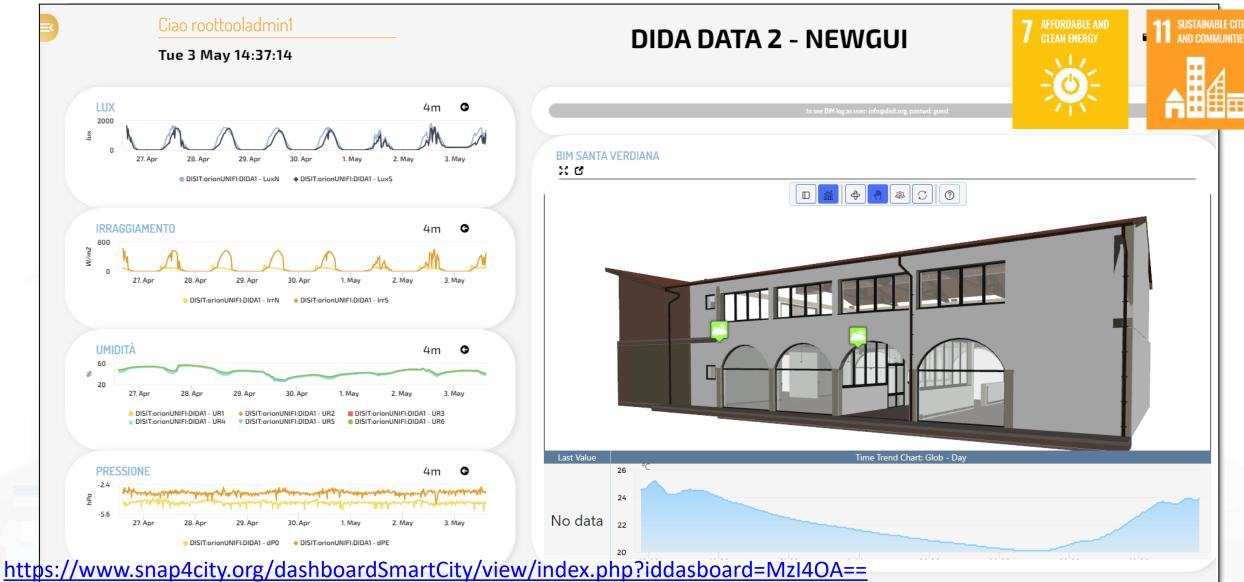
- Digital Twin for monitor, control and manage distributed infrastructures
 - 2D/3D representations of the whole set of buildings, BIM modeling
 - Entities (building, floors, rooms, parking, charging stations, gates, etc.) with their shapes and descriptors, and data monitoring the allocation to office, meeting, cafeteria, storage, stairs, elevator, etc.
- Monitoring and computing KPI on real time for
 - energy consumed or produced (hot/cold), parking, logistic, presences, cleaning, air quality, departments, subareas, maintenance, etc.
 - allocation/designation, dispositions, heating, cooling, temperature, equipment, etc.
 - grouped in Zones









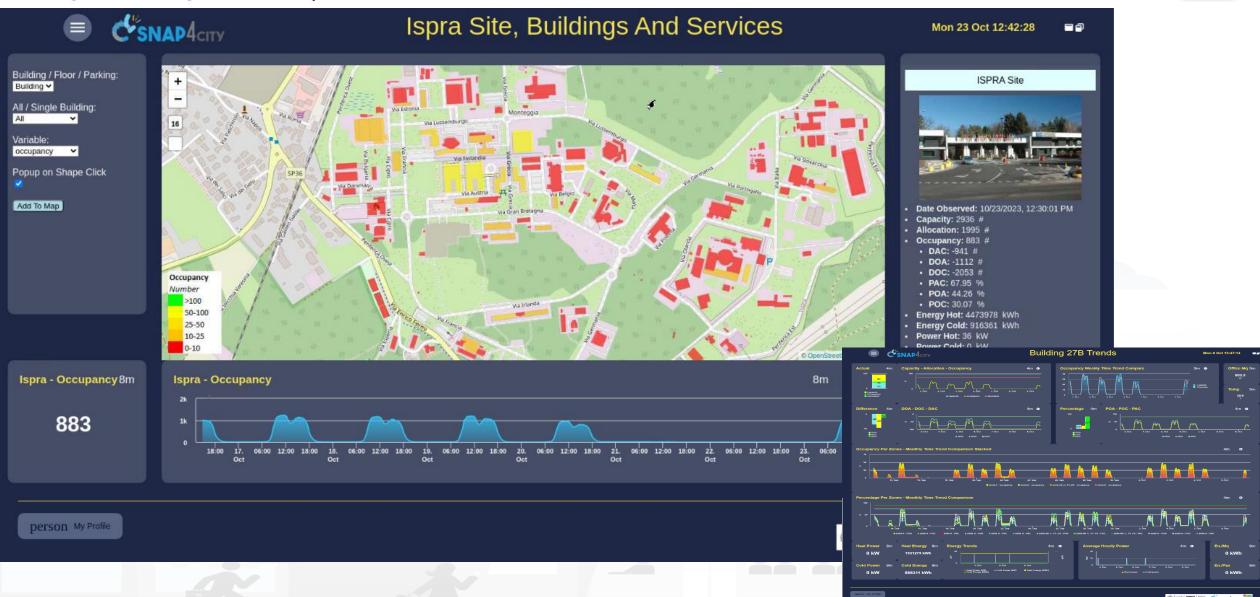






ISPRA JRC Site











Floor Details



ISPRA JRC Site

C'SNAP4CITY

Percentage Per Zones - Monthly Time Trend Comparison

Occupancy Per Zones - Monthly Time Trend Comparison Stacked

Capacity - Allocation - Occupancy

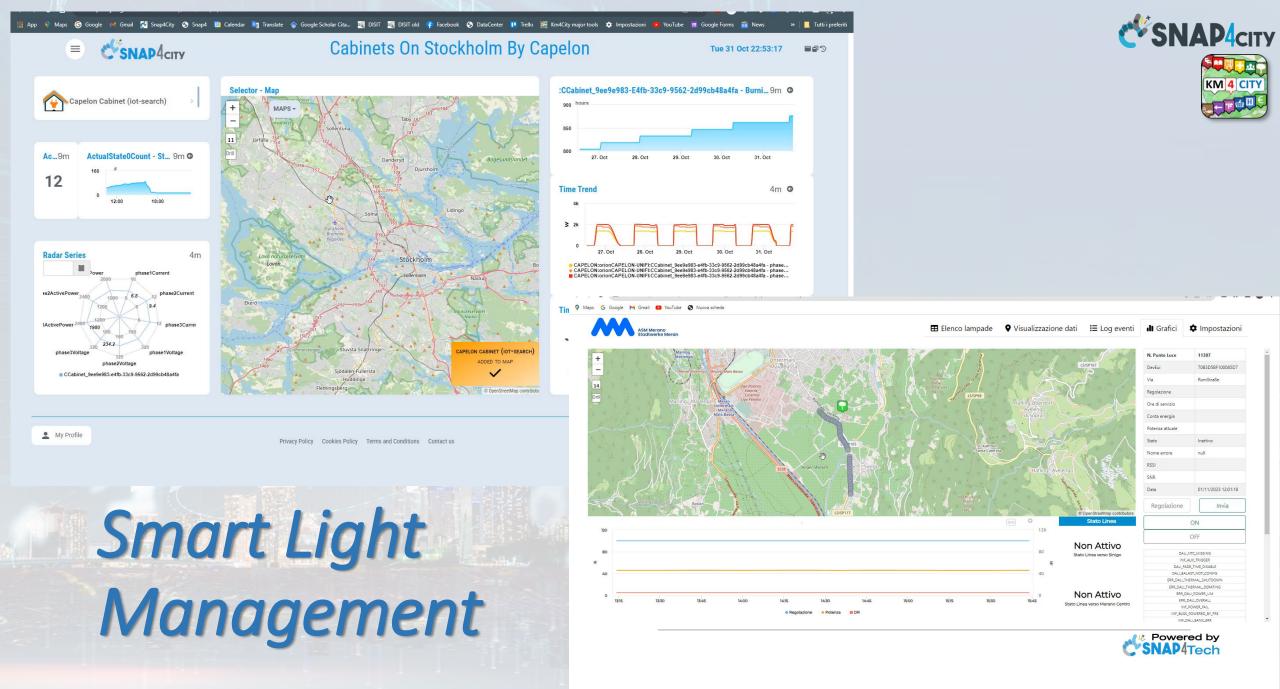






Energy

- Monitoring Energy Consumption in single building, area and per zone
- Matching Energy consumption with respect to the actual usage
- Computing Roof orientation for Photovoltaic installations
- Simulation of Photovoltaicc installations to identify the best parameters of size and storage
- Smart Light management, unicast and multi cast management, smart light controlled by traffic flow data
- Collecting and managing Communities of Energy
- Monitoring Energy provisioning on recharging station
- Optimization of battery life
- Computing KPI
- Etc.



Snap4City (C), February 2024

Smart Light in Merano





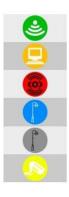






Merano - tutti i servizi

Wed 13 Dec 15:34:57







Snap4City (C), February 2024







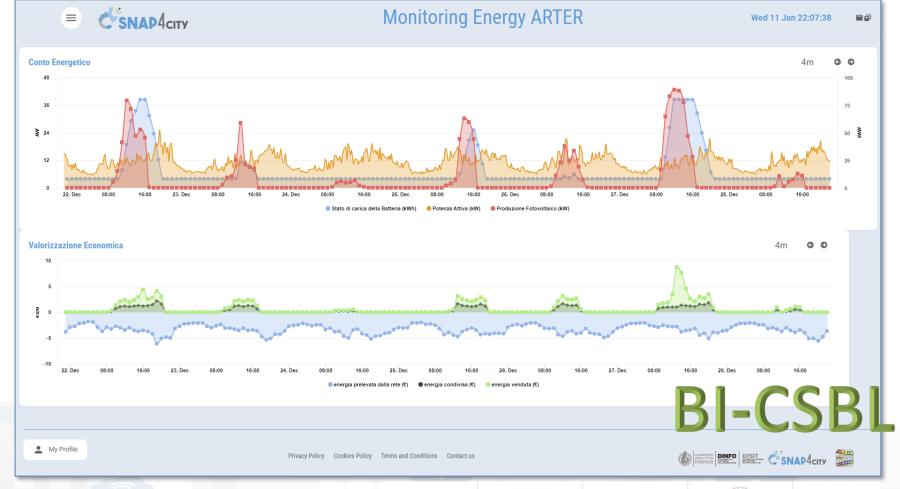








- Field-tested energy community: the selfconsumer condominium
- The Self User project creates in the pilot condominium, through the collection and analysis of data, a model for calculating and enhancing the impact of an energy community on a community of people, with a view to actions to combat energy poverty







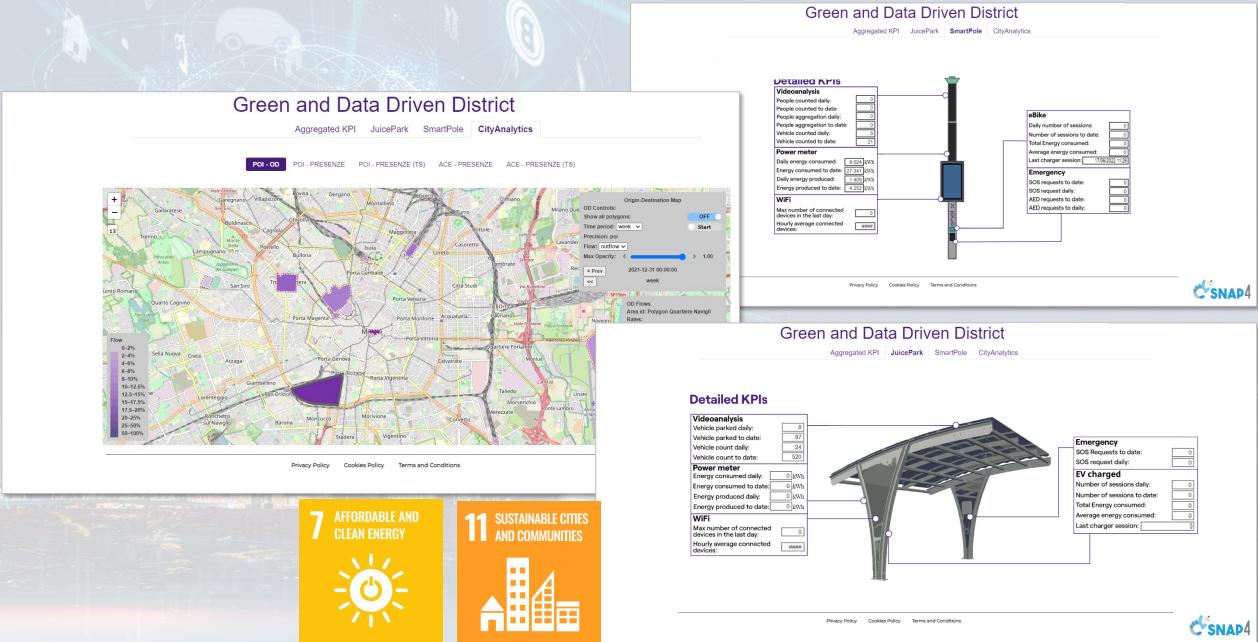




enel x

Energy monitoring and business intelligence





Snap4City (C), February 2024

15:



▲ - PV + battery 10kWh

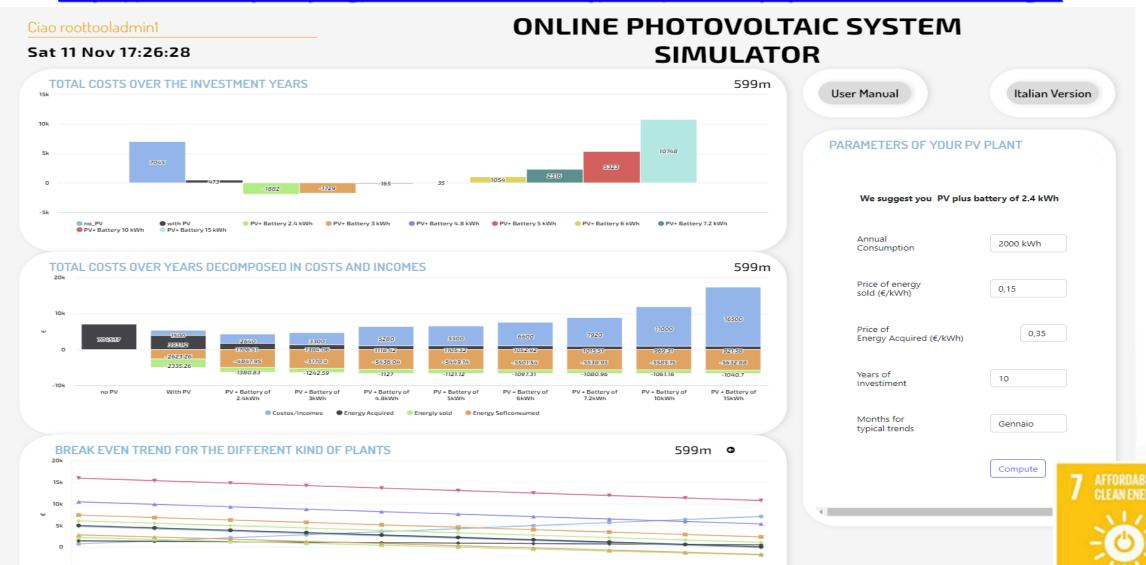
PV + battery 15kWh





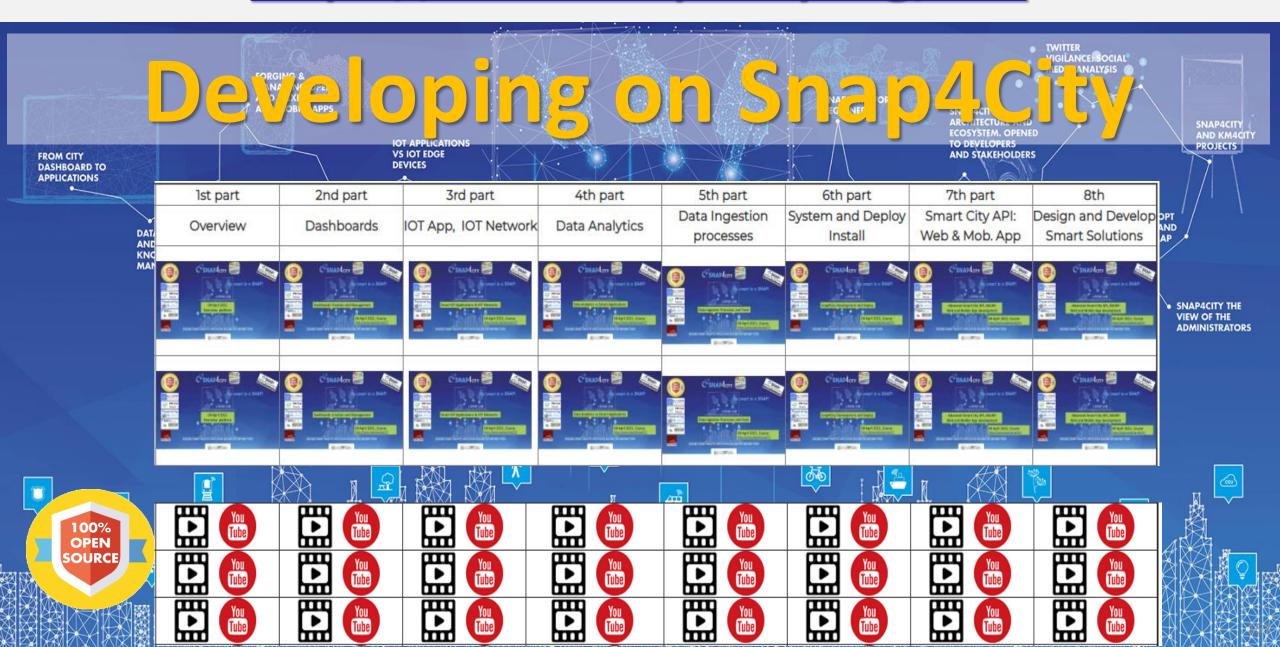


https://www.snap4city.org/dashboardSmartCity/view/Baloon.php?iddasboard=MzczNg==



2032

https://www.snap4city.org/944

















Development Life-Cycle

https://www.snap4city.org/download/video/Snap4Tech-Development-Life-Cycle-v1-1.pdf

From Snap4City:

- We suggest you to read the TECHNICAL OVERVIEW:
 - https://www.snap4city.org/download/video/Snap4City-
- https://www.snap4city.org
- https://www.snap4industrv.org
- https://twitter.com/snap4city
- https://www.facebook.com/snap4city
- https://www.youtube.com/channel/UC3tAO09EbNba8f2-u4vandg

Coordinator: Paolo Nesi, Paolo.nesi@unifi.it

DISIT Lab, https://www.disit.org DINFO dept of University of Florence, Via S. Marta 3, 50139, Firenze, Italy Phone: +39-335-5668674







Development

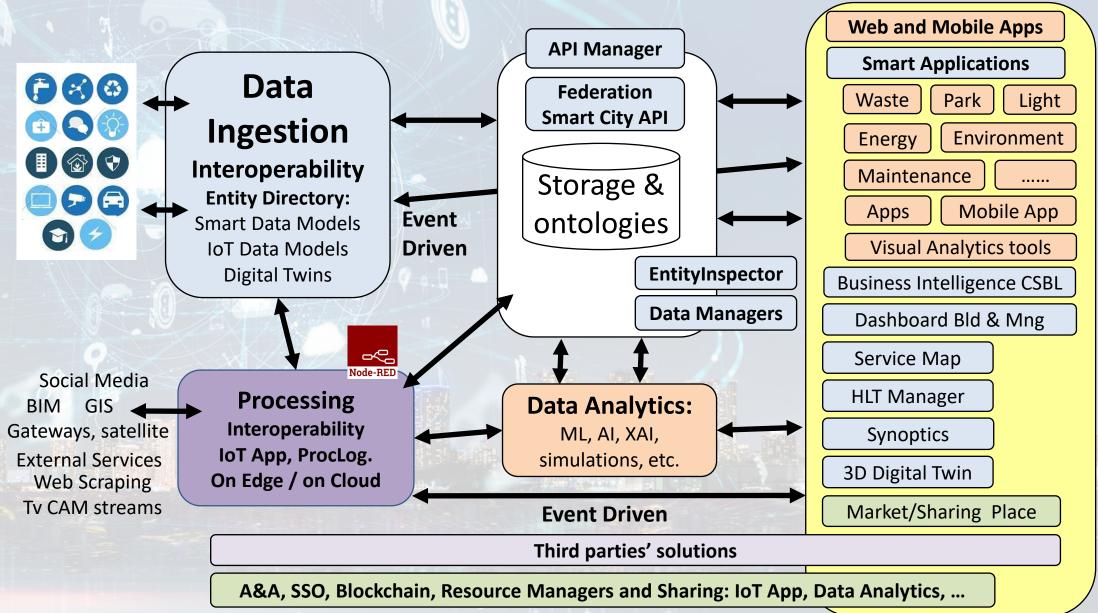
https://www.snap4city.org/d ownload/video/Snap4Tech-**Development-Life-Cycle.pdf**



Technical Architecture (high level)



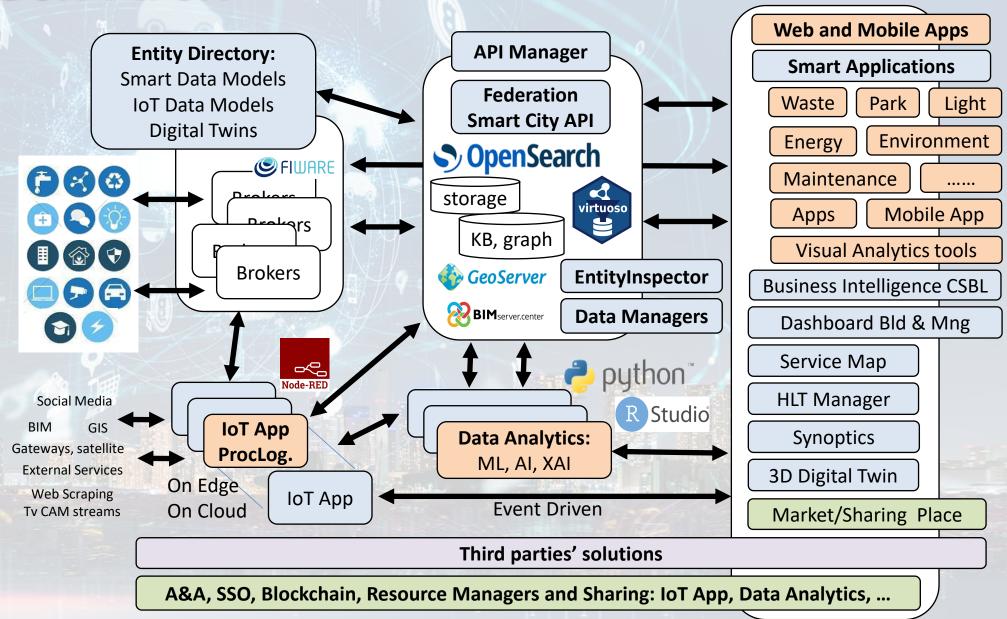




Tech Arch



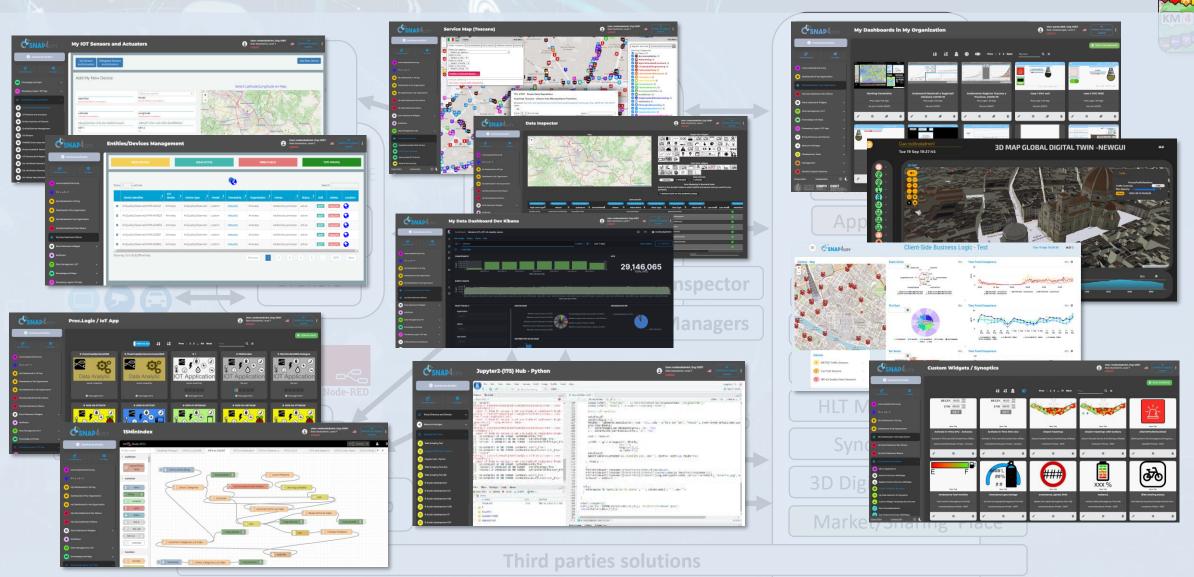




11/23

Tools of Tech. Arch.





A&A, SSO, Blockchain, Resource Managers and Sharing: IoT App, Data Analytics, ...

09/23



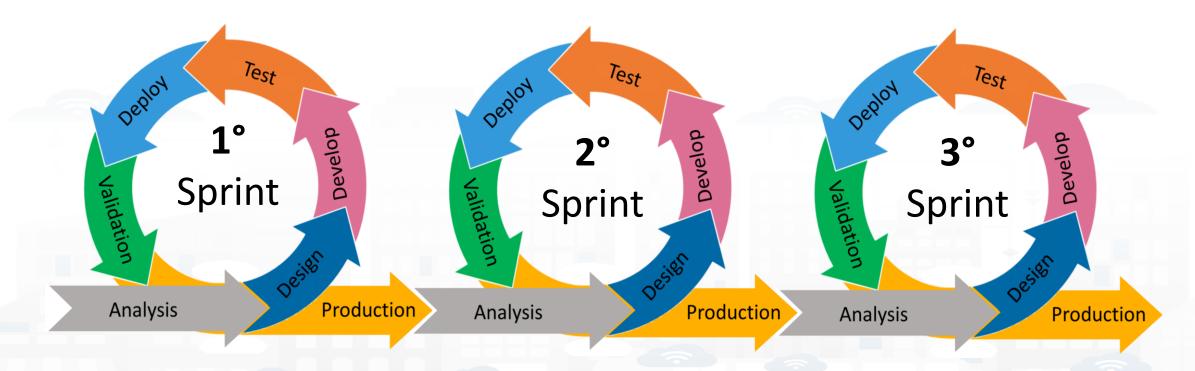






Agile Development Life Cycle by sprint Smart Solutions





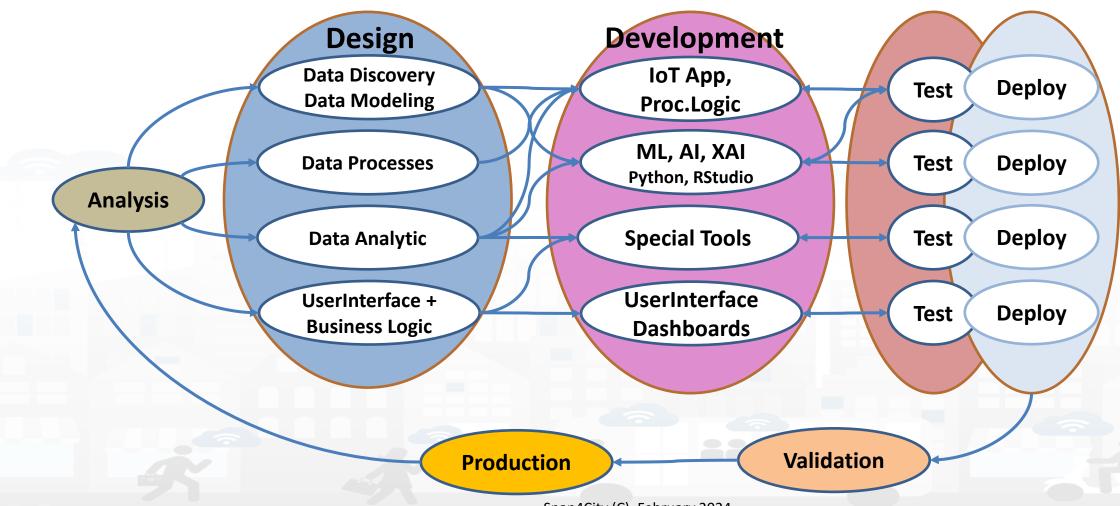








Development Life Cycle Smart Solutions



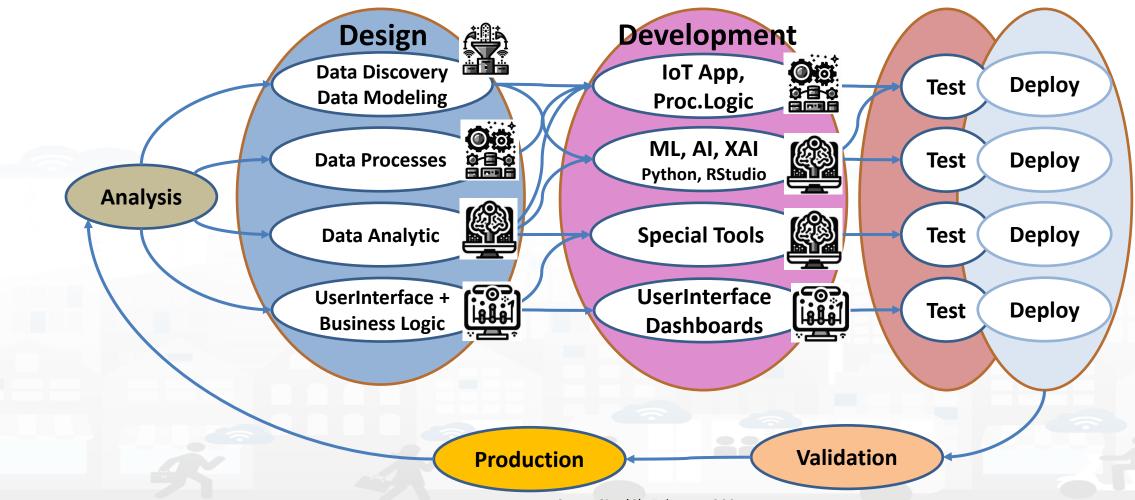


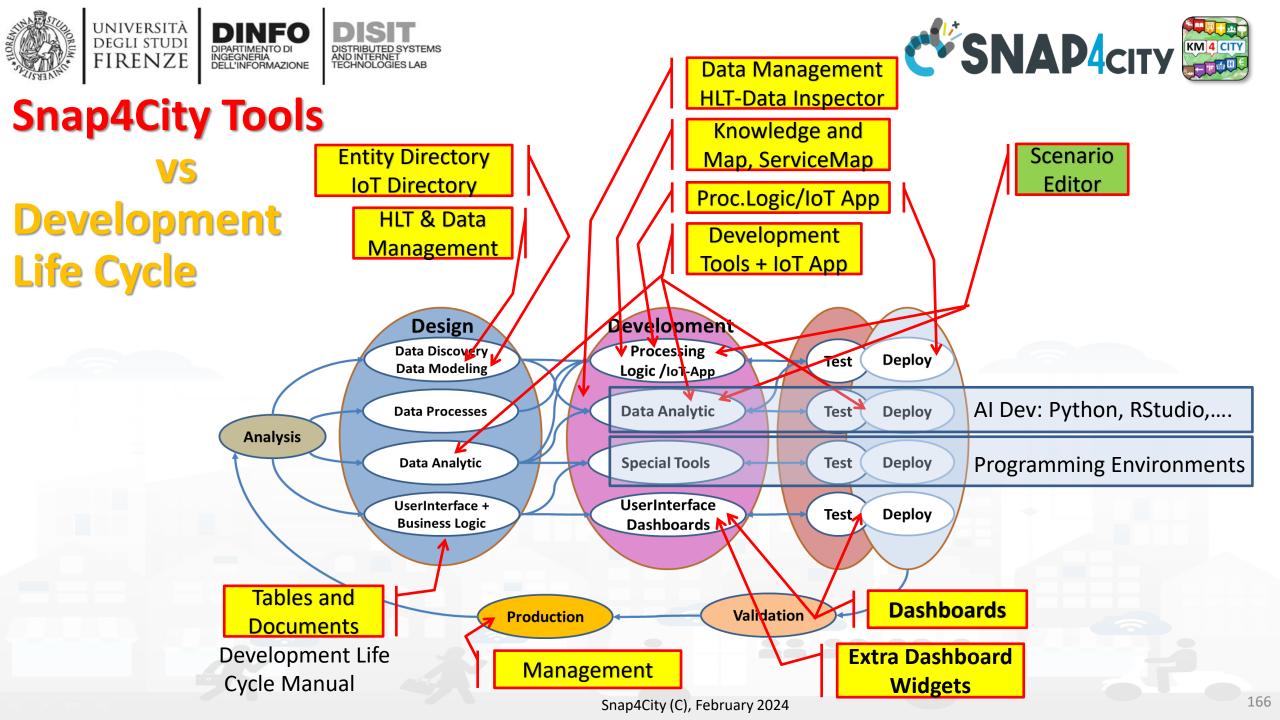






Development Life Cycle Smart Solutions





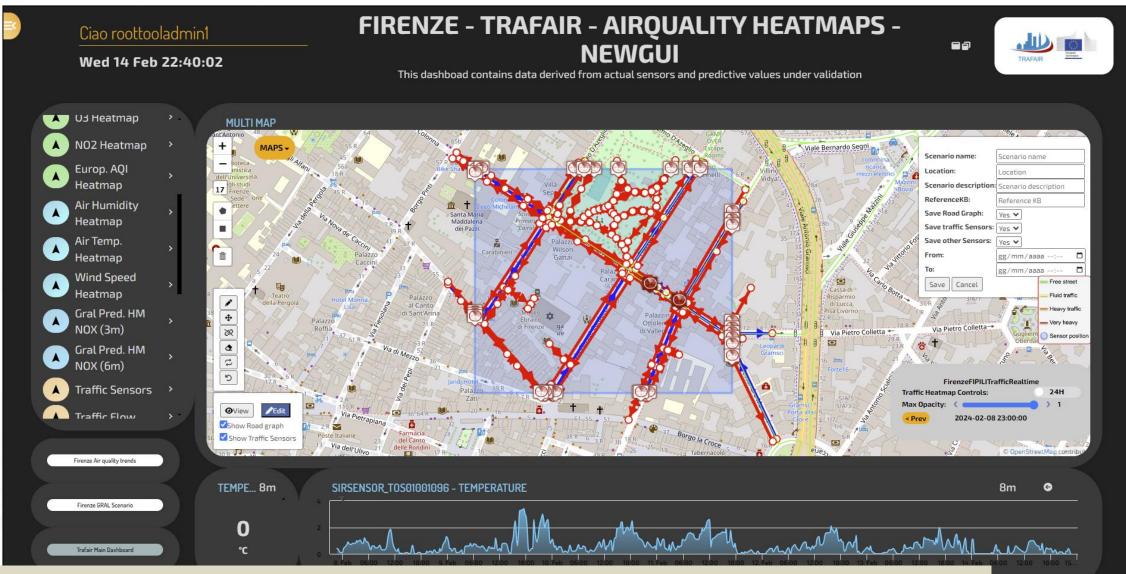












https://www.snap4city.org/dashboardSmartCity/view/Baloon-Dark.php?iddasboard=MzQyMw==



For example:

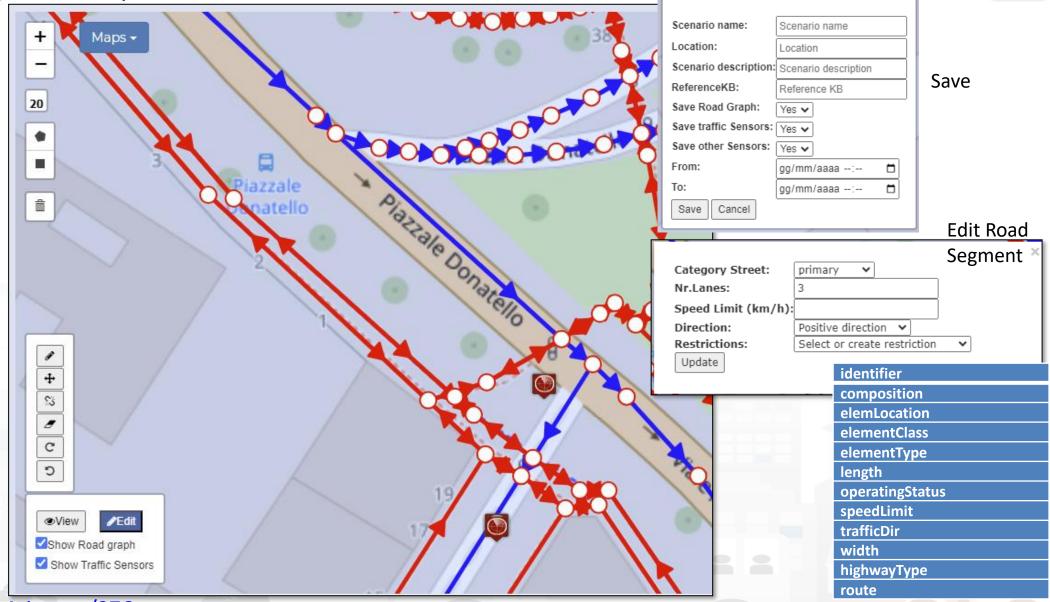




Select map Zoom

New Scenario

Editing Drag & drop Split & Join Delete Do and Undo



Properties of Road Elements



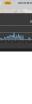






The actual Scenario Exploitation

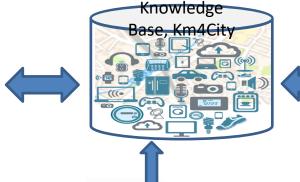






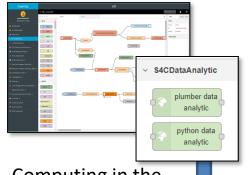
Defining Context via Editing Scenario:

- Select area and data
- Editing roads, POI, IoT entities, ..
- Save/load, share
- Change status





- Metadata
- Status and versions, date time
- Period of validity
- Road graphs, cycling, pedestrian seg.
- List of data, sensors
- Etc.



Computing in the Scenario Context as:

- KPI, Metrics,SUMI, SUMP,15MinCity Index
- Heatmaps
- OD Matrices
- Traffic Flow reconstructions
- Predictions
- Routing, constrained routing
- Early Warnings
- Etc.

ReLoading Scenario in JavaScript

- **Evolve Scenarios**
- Use Scenario to context the Data Analytics: R Studio,
 Python for computing





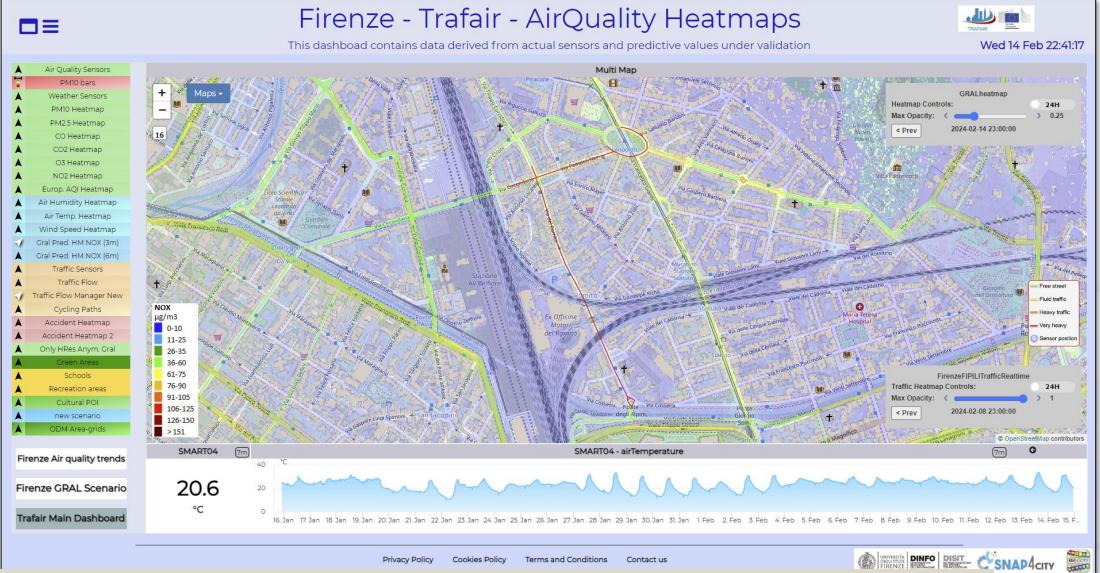
UNIVERSITÀ **DEGLI STUDI** FIRENZE











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

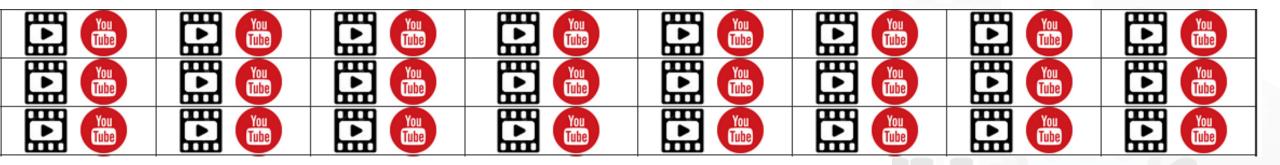
https://www.snap4city.org/944

On Line Training Material (free of charge)





	<u> </u>										
1st part	2nd part	3rd part	4th part	5th part	6th part	7th part	8th Design and Develop Smart Solutions				
Overview	Dashboards	IOT App, IOT Network	Data Analytics	Data Ingestion processes	System and Deploy Install	Smart City API: Web & Mob. App					
C'SHAP4en State St	CSNAP4cm Experience is a SEAT	CEMANAGE STATE STA	CENAMON Somer transport	C SAASAm Commander to the saasam to the saas	COMANAM STATE OF STAT	CENADACH CONTROL OF STATE OF S	CENADAGY START STA				
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Part 2: Dashboard production and management

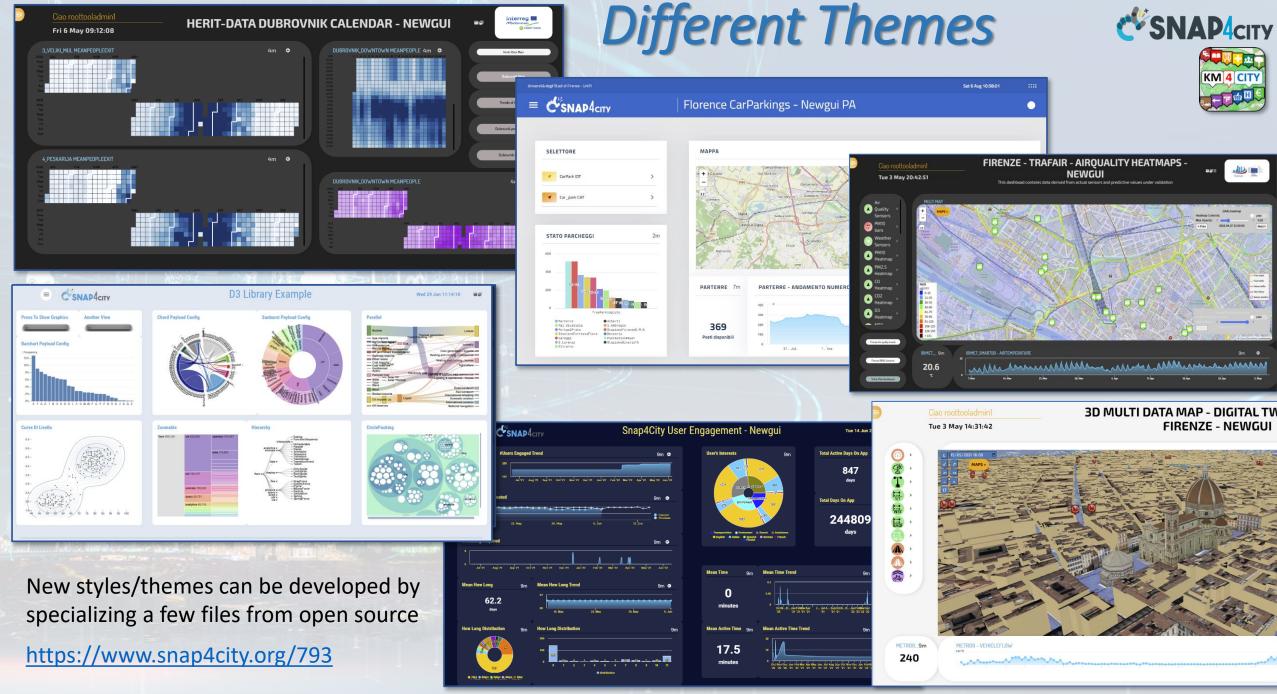
Part 2: Dashboards production and management

SLIDES

Interactive Slides



- Recall on Snap4City Architecture
- Dashboards Purposes and Uses
- Main Data Kinds: data vs representations
- Dashboards Main Concepts and simple Widgets
- Creating a Snap4City Dashboard, wizard
- Multi Data Map Widget
- High Level Types, video, external services, synoptics
- Selector for the Multi Data Map Widget
- Data Inspector vs Data Processes Details
- Dashboard Management



Snap4City (C), February 2024









Visual Representations



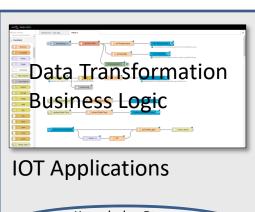






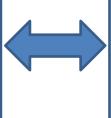


Dashboard Builder: Development





Knowledge and Storage Data from the Field and City + MyKPI ++

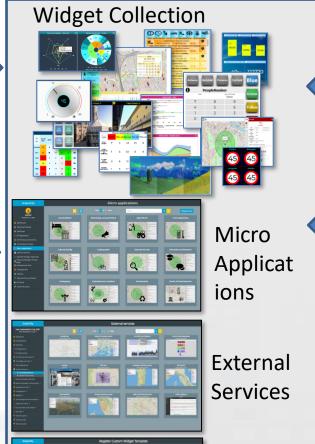






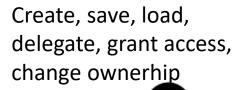




















Collection



My Own Dash/App

Custom

Widgets/

Synoptics

Snap4City Dashboards

Wizard

Data and widgets

H
Carmignano
Aeroporto
Ficenze
Arrigoro
Véspucci
Bagno a Ripoli
SR69

Dashboard features





Data sources

				Da	ta sources			
All selected (10) ▼	All selected (55) ▼	All selected (776) ▼	All selected (315) ▼		All selected (47) ▼			All selected (2) ▼
High-Level Type	Nature	Subnature If	Value Type	Value Name 🕸	Data Type	Last Datr	Last Check	Ownership
Special Widget	Environment	Weather Forecast		Previ_Meteo	special weather	\	2018-07-08 16:00:18	public
Special Widget	Environment	Weather Forecast		Previ_Meteo	special weather	Vergemoli	0 2018-07-08 16:00:18	public
Special Widget	Environment	Weather Forecast		Previ_Meteo	special weather	chiano	0 2018-07-08 16:00:18	public
Special Widget	Environment	Weather Forecast		Previ_Meteo	special weather	vaiano	0 2018-07-08 16:00:18	public
Special Widget	Environment	Weather Forecast		Previ_Meteo	special weather	Vaglia	2018-07-08 16:00:18	public
Special Widget	Environment	Weather Forecast		Previ_Meteo	special weather	Vagli sotto	0 2018-07-08 16:00:18	public
Special Widget	Environment	Weather Forecast		Previ_Meteo	special weather	Vagli di sotto	2018-07-08 16:00:18	public
Special Widget	Environment	Veather Forecast		Previ_Meteo	special weather	Uzzano	2018-07-08 16:00:18	public
Hide columns	O. I	S	elected rows: 0	Previous 1	2 3 4 5 1081 N	ext	rch	

Select the area of your interest: panning and zooming

Select the

Cr

lata Timo

Last Value

Healthines

Remove

- graphic aspect of your interest, or
- High Level Type of your interest, or
- Make a search if you a have a precise idea or
- Act on filters: nature, subnature, type, name, value, date, health, owner, ...
- Combine them as you like
- Select the lines of your interest
- Then click on Next and get the Dashboard by wizard













Widget selection





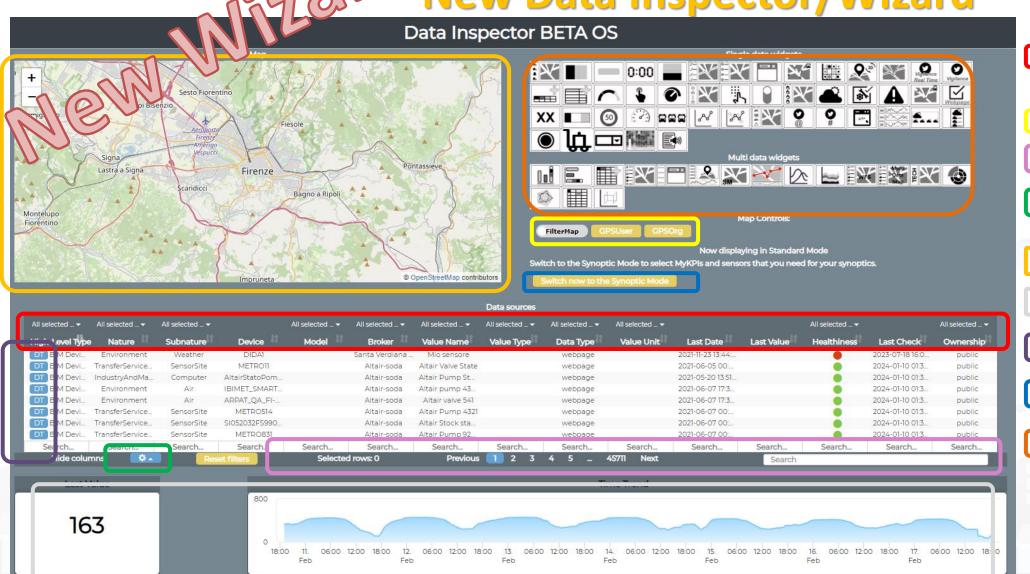
INGEGNERIA DELL'INFORMAZIONE







lew Data Inspector/Wizard



Filtering/Searching for individual fields (even for some fields not displayed as geographic coordinates)

Geographic Filtering

Text Search on all fields

Menu for choosing the fields to display in the table

View on Map(via PREVIEW)

Data and Trend visualization

Opening Digital Twin

Pass to Synoptic mode

> Select the graph representation











Custom Widget / Synoptic /

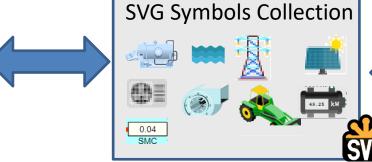
Development
Inkscape editor on your computer SVG

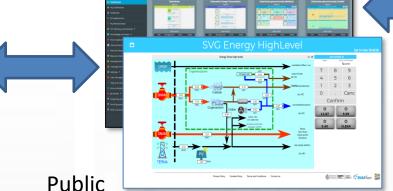


IOT Applications



Knowledge and Storage Data from the Field and City





Dashboard Collection

My Own Dash/App



Create, save a Custom Widget in SVG

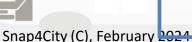


Create, save, load, delegate, grant access

- Create and Load a Custom SVG
- Select/Reuse an SVG

Dashboard Editor

- Make and Instance of Synoptic by Associate Variables with MyKPI
- 4. Create on Dashboard a Widget based on Synoptic HLT such as Ext. Srv.:
 - https://www.snap4city.org/synoptic/v 2/synoptic.html?id=xxxx











Smart parking

• Smart Energy

Smart Light

Smart

Begin

Finish

Energy View

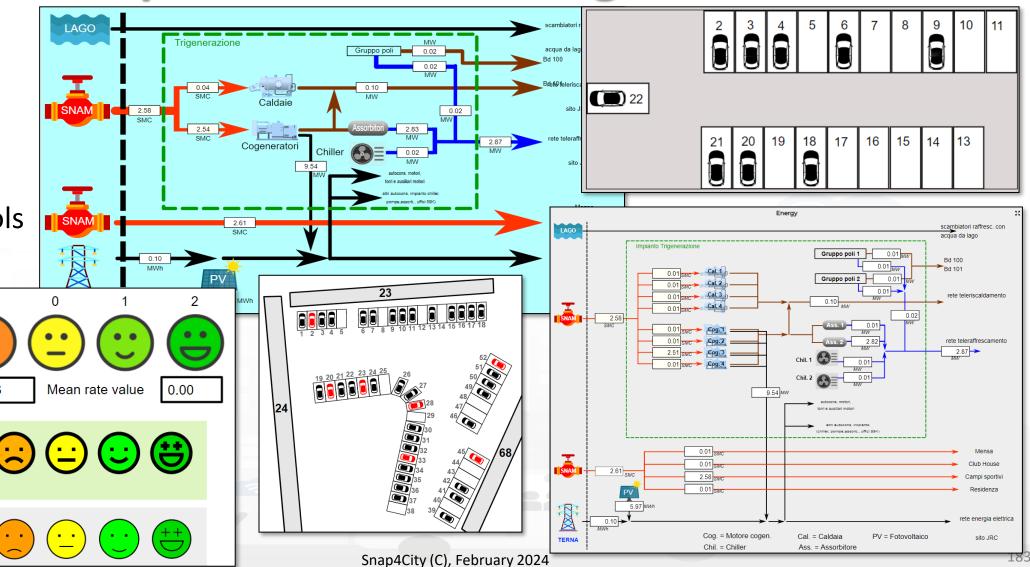
Custom Controls

Total clicks

17:00

4:00













Part 3: IoT App, process logic, server side BL

Part 3: IOT App, Process Logic, Server Side Business Logic

SLIDES

Interactive Slides

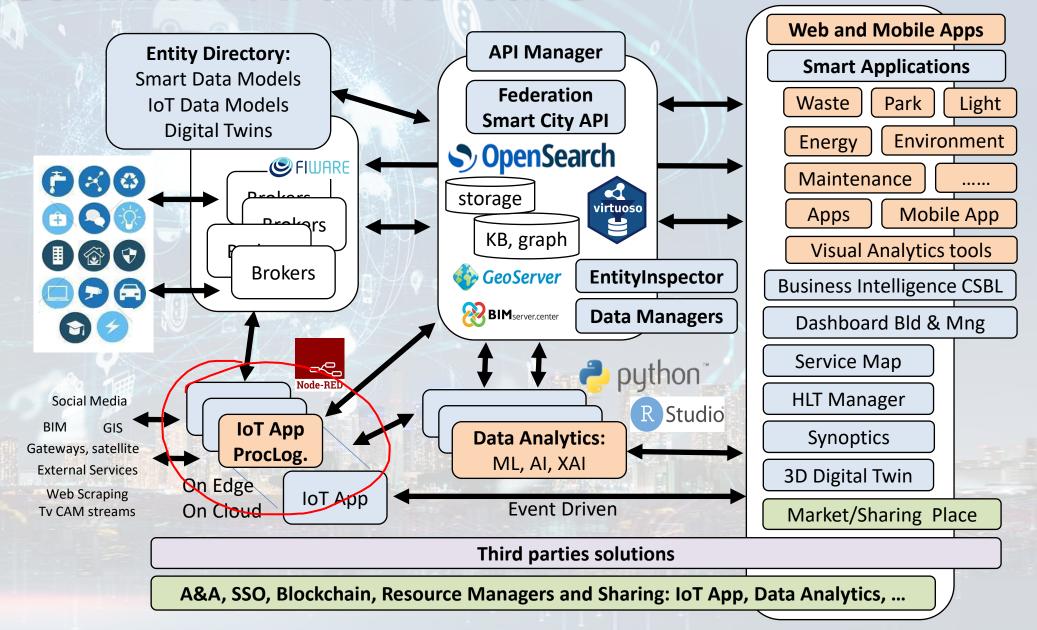


- Recall on Snap4City Architecture
- Node-RED
- IOT App = Node-RED + Snap4City
 - IoT App === Proc.Logic
- Examples of IOT App for Smartening Solutions
- Exploiting/Generating data by using: IoT App/Proc.Logic
- External Service <-> IoT App/Proc.Logic
- Dashboards <-> IoT App/Proc.Logic
 - Server Side Business Logic
- training material

Technical Architecture







11/23

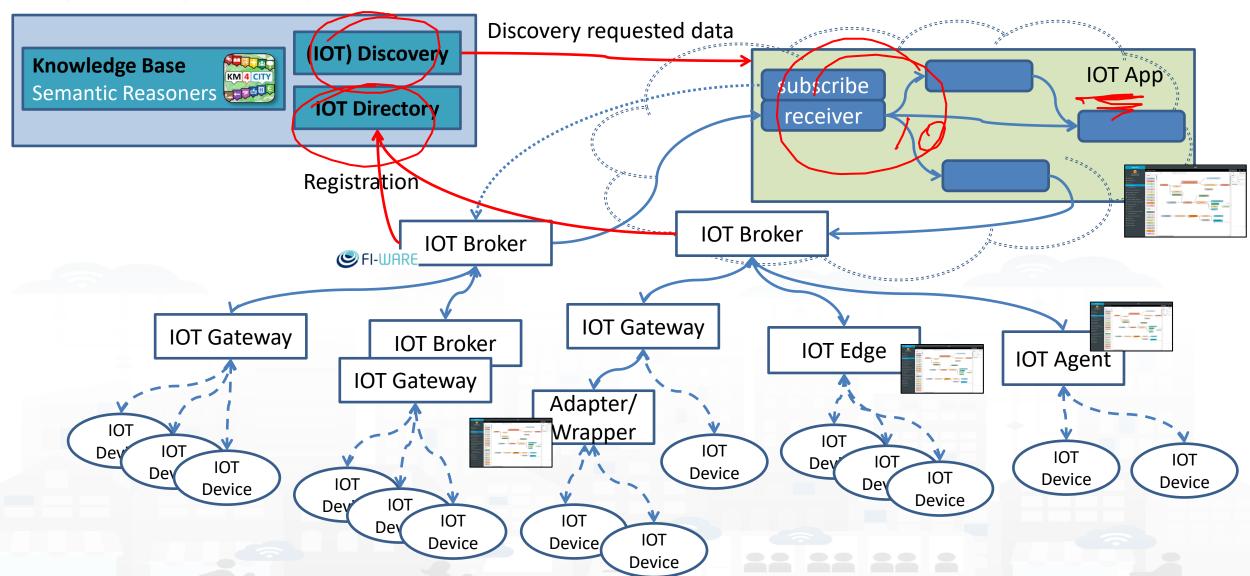


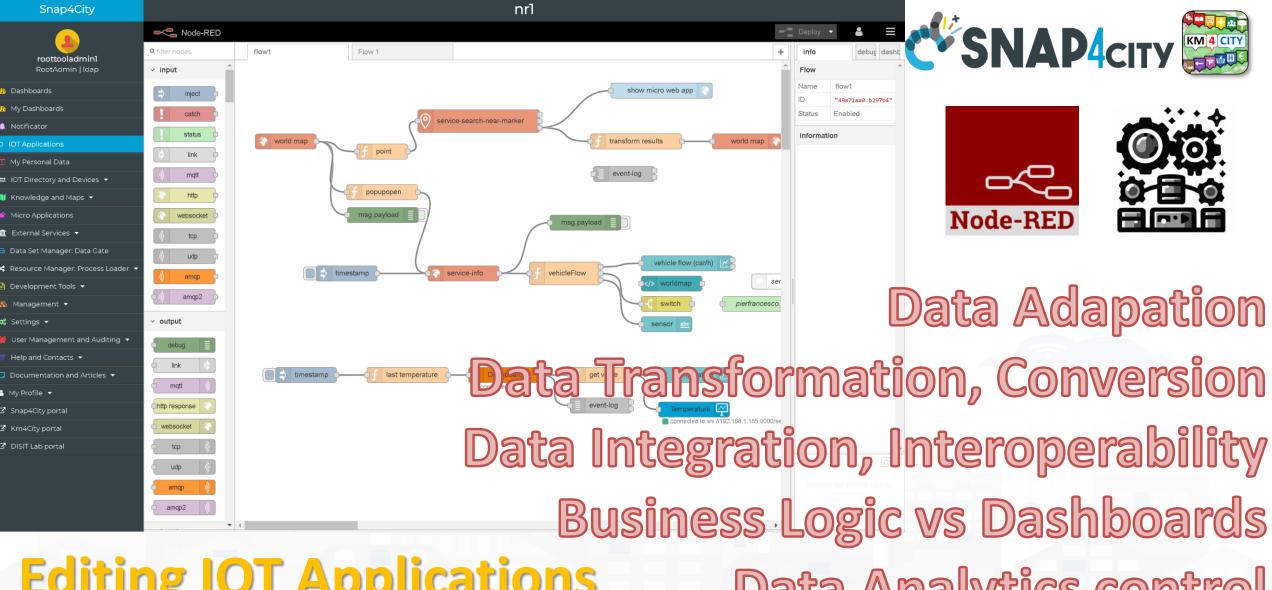




IoT Network



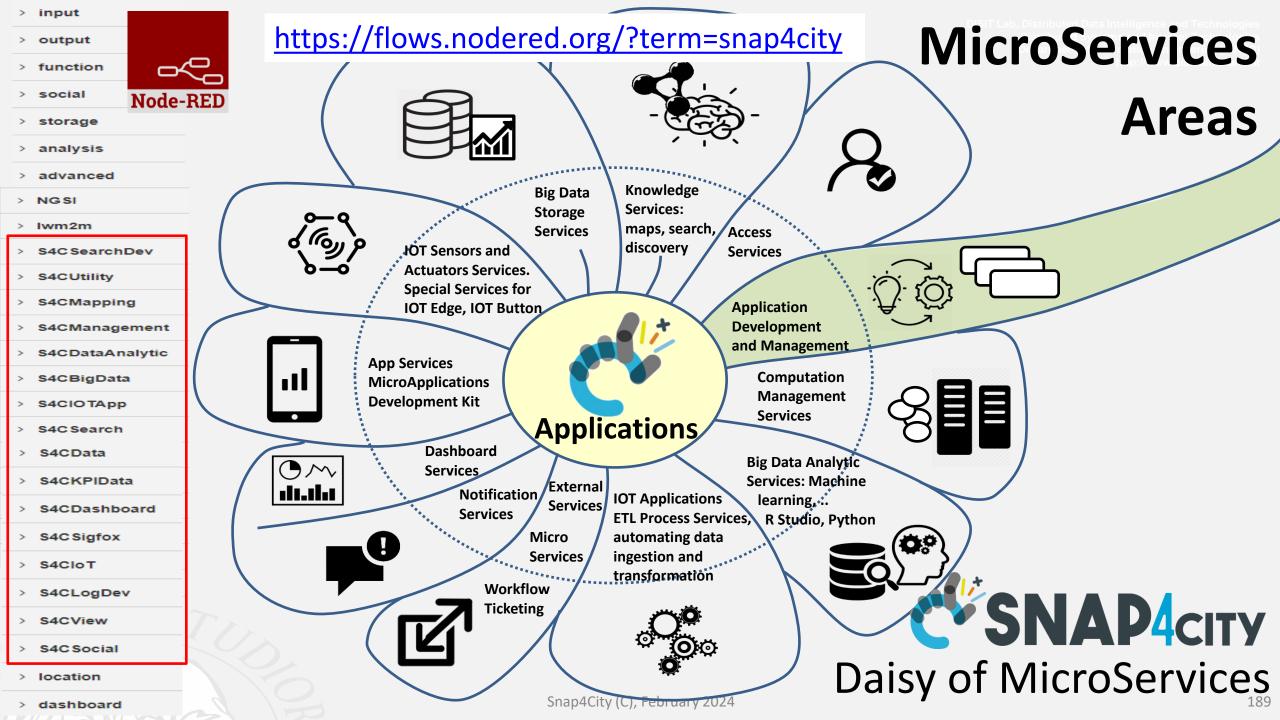




Editing IOT Applications

Data Analytics control

Everywhere: Cloud, on loT Edge Devices





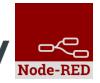
> time

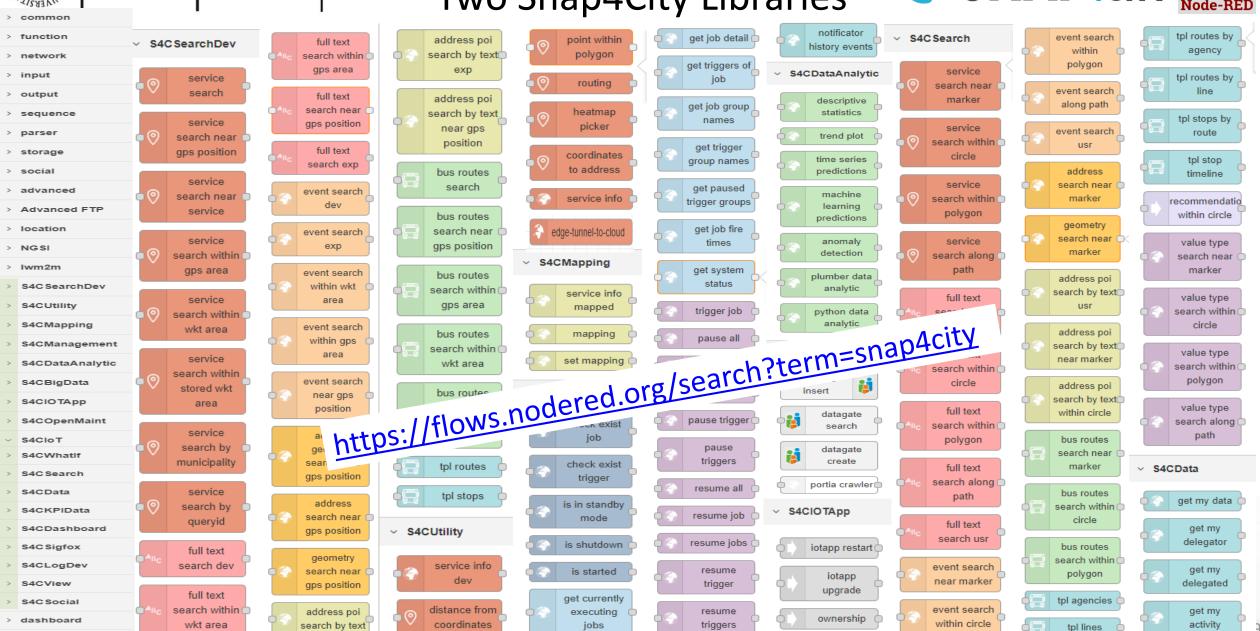
DELL'INFORMAZIONE

DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

Sept 2023 collection
Two Snap4City Libraries









DELL'INFORMAZIONE

series

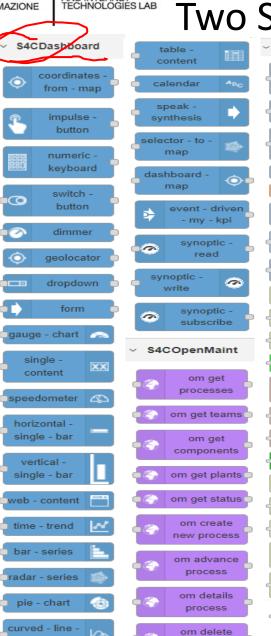
Sept 2023 collection Two Snap4City Libraries



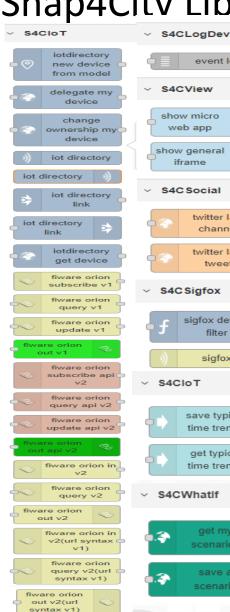




> time



process



snap4all



https://flows.nodered.or g/search?term=snap4city We suggest also to install:

AND: From Resource Manager

Data

Data

Search

Sci Hub



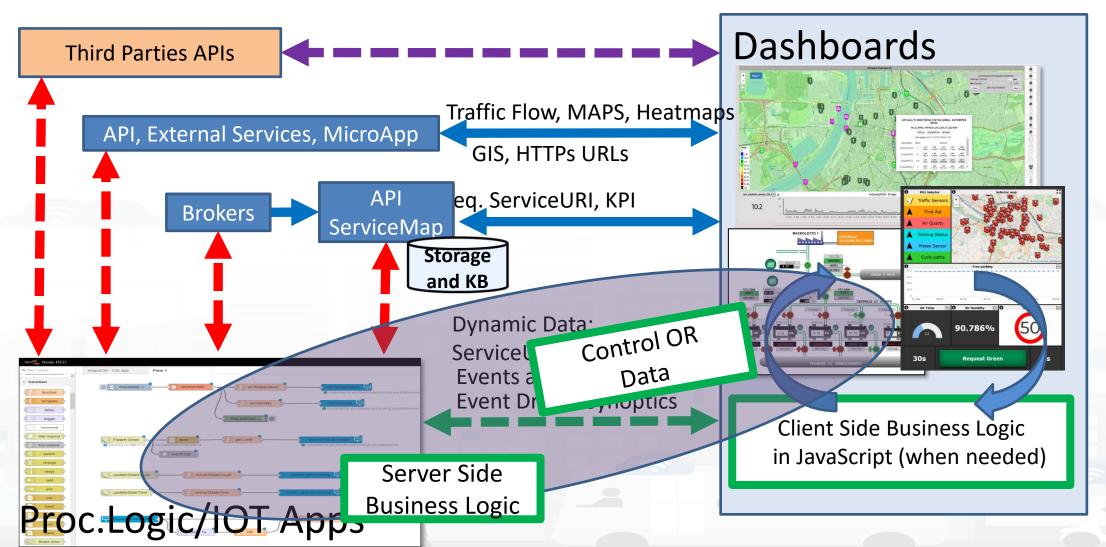
Snap4City (C), February 2024







How the Dashboards exchange data









S4CSearch









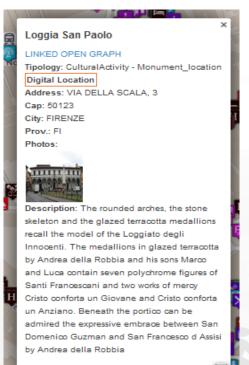
ANY kind of sensors

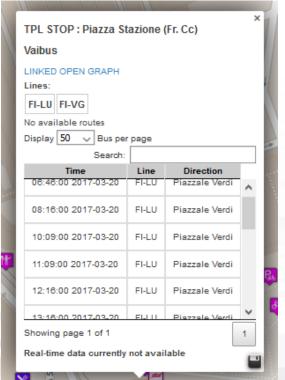
- To Get DATA of a Service / POI /sensor
 - Historical and real time
 - Real Time

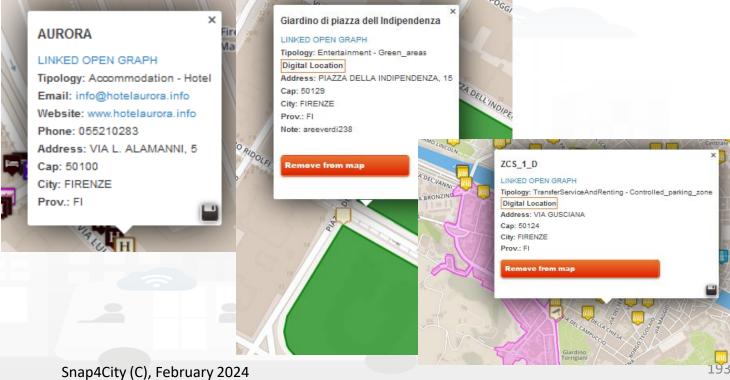




















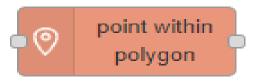




Distance from GPS point

distance from coordinates

- Point $\mathbf{\hat{V}}$ is in Polygon?
 - Polyline as WKT











Nature

numeric keyboard

switch button

dimmer

geolocator

dropdown

form

coordinates

from map

event driven

my kpi

synoptic read

synoptic

subscribe

0

100







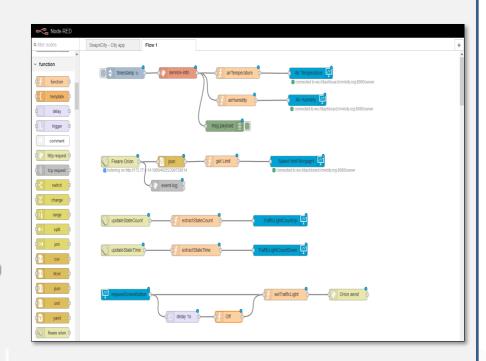






MapClick
MyKPI variable onchange
Synoptics

From Dashboard to IOT App



IOT Application









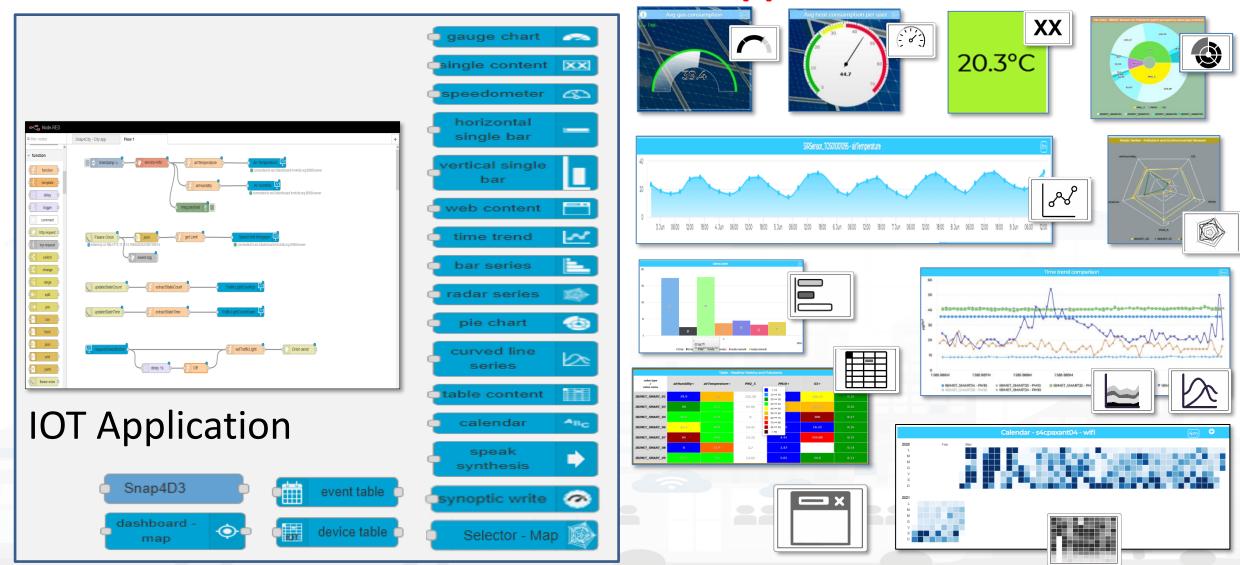
Nature





Dashboard-IOT App

From IoT App to Dashboard









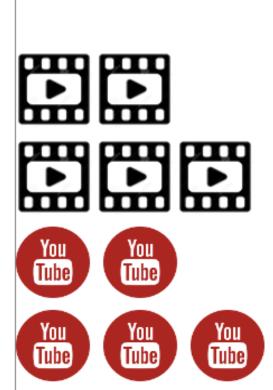


Part 5: Data Ingestion and Interoperability

Part 5: Data Ingestion and Interoperability

SLIDES

Interactive Slides



- When Solutions and tools for Data Ingestion and Interoperability are needed
- Overview of Snap4City Data Storage and Stack
- Knowledge Base: Modelling and Setting Up
- High Level Types vs Ingestion Process
- Data Ingestion Strategy and Orientation
- Ingestion of Points of Interest with POI Loader
- Models vs Devices/Entities and Registration
- Verification of Data Ingestion
 - Digital Twin Data Inspector vs Data Processes Details
 - My Data Dashboard Dev to assess data on Open Search Storage
- An Integrated Example for Time Series
- Entities Ingestion with Data Table Loader
- High Performance Ingestion via Python
- FIWARE Smart Data Models on Snap4City
- Ingestion of MyKPI with Proc.Logic / IoT App

High Level Types

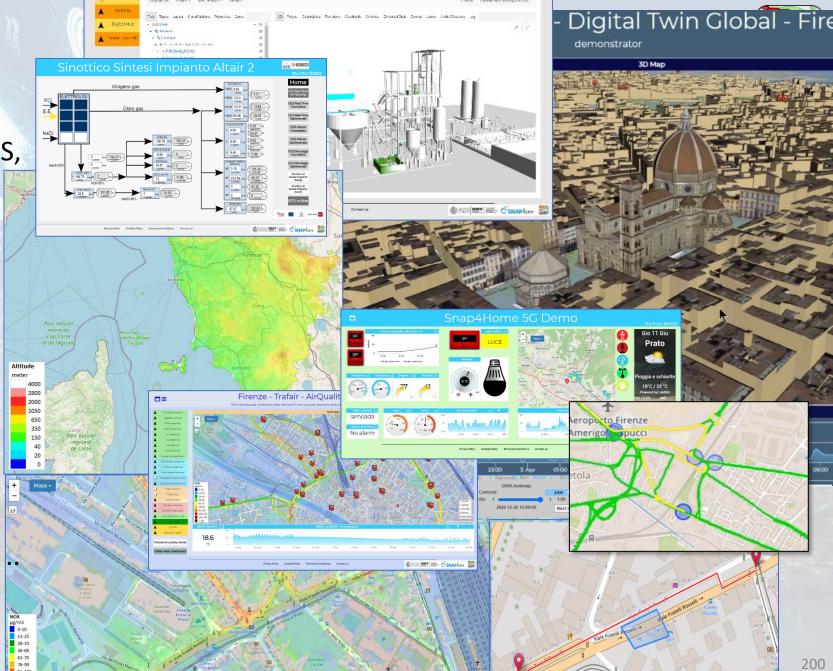
Snap4City (C), February 2024

- POI, IOT Devices, shapes,...
 - FIWARE Smart Data Models,
 - IoT Device Models
- GIS, maps, orthomaps, WFS/WMS, GeoTiff, calibrated heatmaps, ...
- Satellite data, ..
- traffic flow, typical trends, ...
- trajectories, events, Workflow, ...
- 3D Models, BIM, Digital Twins, ...
- OD Matrices of several kinds, ..
- Dynamic icons/pins, ...
- Synoptics, animations, ..
- KPI, personal KPI,...
- social media data, TV Stream,
- routing, multimodal, constraints,
- decision scenarios,









BIM Integration Dashboard

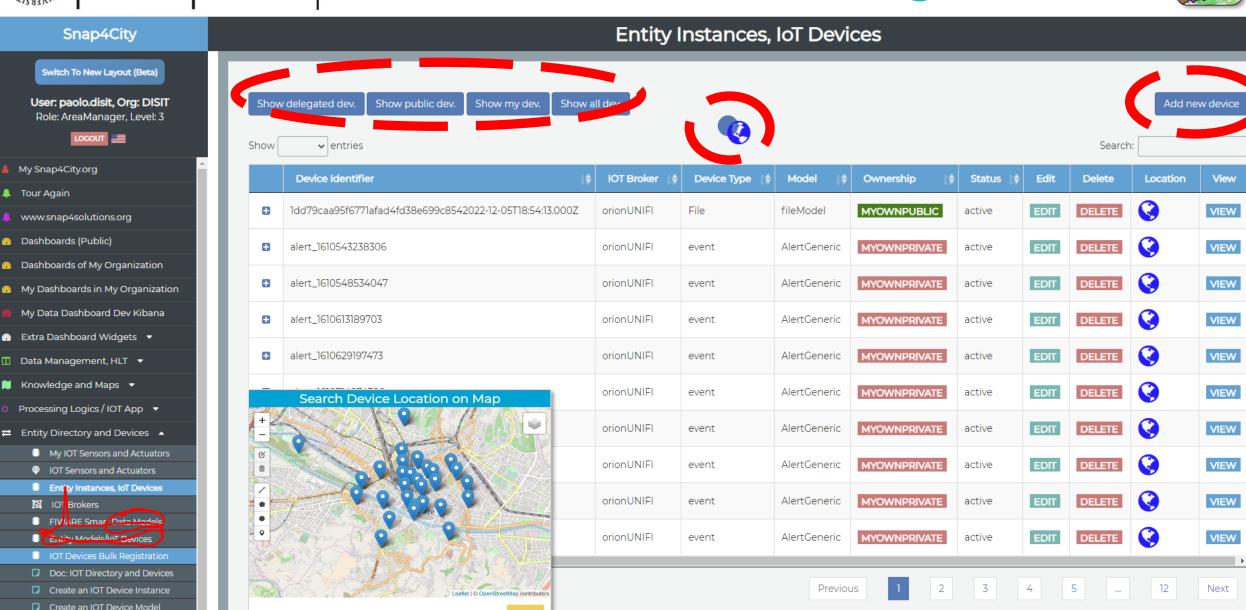
























Checking data/Entity ingestion results

Knowledge base

Semantic reasoners

- All searches
- Metata
- Structure
- Last values of IoT Dev
- **GTFS**
- Only public IoT Dev

- ServiceMap, SCAPI, SuperSM
 - LOG / LOD viewer
 - Super Service Map
 - SCAPI: Swagger
 - Last data
- **Data Inspector (last data)**
- IoT/Entity Directory
 - IoT Brokers
- **ServiceMap**, SCAPI (last data), SuperSM
- My Data Dashboard, OpenSearchDash
- **Data Inspector (last data)**

ServiceMap or Super ServiceMap



My Data Dashboard

DevDash

Indexing and aggregating NIFI, OpenSearch

- Faceted search
- Geo search
- Time Series
- Private and Public

Some functionalities are limited to certain roles

Data Inspector

Digital Twin view









Part 4: Data Analytics

- Why and Where use DA, AI and XAI --> General Life Cycle
- Data Processing
- What is Data Analytics, DA and Artificial Intelligence, Al
- List of the most relevant available DA and Al Solutions
- Predictions and Anomaly detections
- Computing: Higher Level Types Data and their representations
- How AI/XAI, and Life Cycle
- Using DA, AI, XAI in Snap4City infrastructure
 - Data Analytics <--> IoT App / Proc.Logic
- Decision Support Systems and What-If Analysis
- Routing, Multimodal Routing, Dynamic Routing
- Business Intelligence and Visual Analytics

Part 4: Data Analytics and Artificial Intelligence



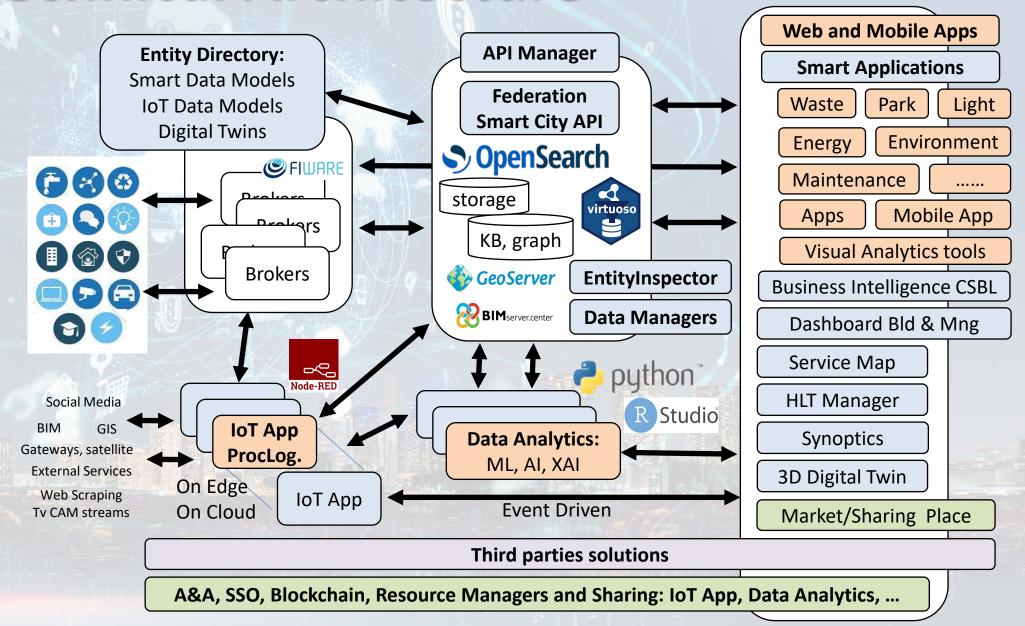
Interactive Slides



Technical Architecture









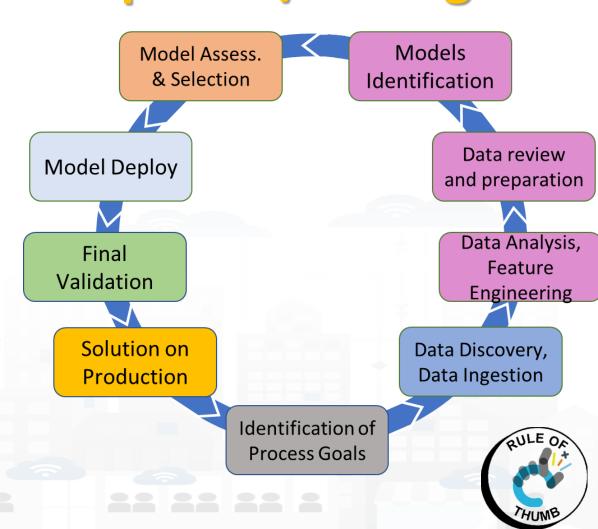








- Identification of Process goals and Planning (problem definition)
 - Which goals
 - How to compute, which language
 - Which environment, which libraries
- Data Discovery and Ingestion (from the general life cycle)
 - Data Collection, Data Preprocessing if needed
- Data Analysis: feature engineering, feature selection
 - Data ethics assessment
- Data review and preparation for the model, splitting, encoding
- Model Identification and building: ML, AI, etc....
 - Model Training
 - Tuning hyperparameters when possible
- Model Assessment and Selection (Evaluation)
 - Validation in testing
 - Assessment on a set of metrics depending on the goals: global relevant and feature assessment
 - Assessing computational costs
 - Impact Assessment, Ethic Assessment and incidental findings
 - Global and Local Explanation via Explainable AI techniques
- Model Deploy and Final Validation
 - Optimisation of computation cost for features, if needed reiterate
 - Solution on Production (security, scalability, etc.)
- Monitoring and Maintenance on production
- Documentation, incremental documentation



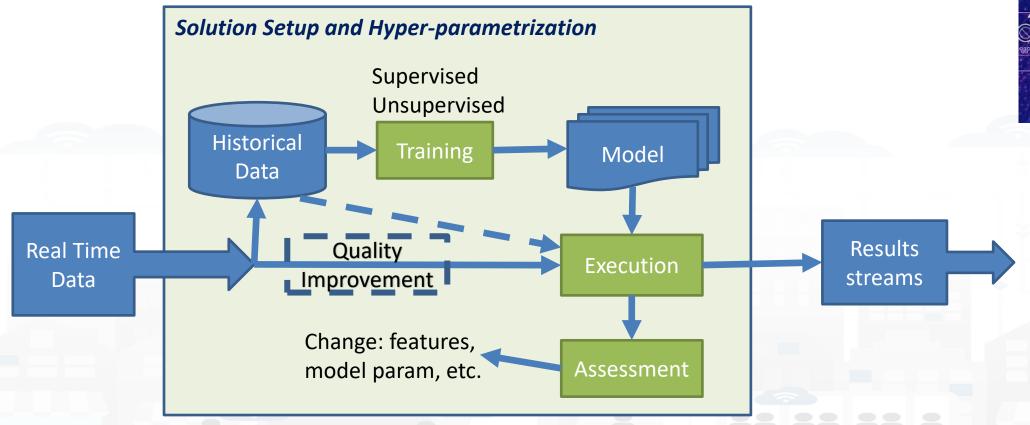








Simplified Training and Deploy process





Prediction
Prescriptions
Anomalies
Classifcation
Detection
Etc.









Evaluation Metrics

Root Mean Squared Error (RMSE)

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(obs_i - pred_i)^2}{n}}$$

Mean Absolute Scaled Error (MASE)

$$\begin{aligned} q_t &= \frac{obs_t - pred_t}{\frac{1}{n-1}\sum_{i=2}^{n}|obs_i - obs_{i-1}|} \\ MASE &= mean\left(|q_t|\right), \qquad t = 1, \dots, n \end{aligned}$$

R-Squared(R2)

•
$$\overline{y} = \frac{1}{n} \sum_{i=1}^{n} \text{obs}_i$$

•
$$R^2 = 1 - \left(\frac{\sum_{i=1}^{n} (obs_i - pred_i)^2}{\sum_{i=1}^{n} (obs_i - \overline{y})^2} \right)$$

Mean Absolute Error (MAE)

$$MAE = \frac{\sum_{i=1}^{n} |obs_i - pred_i|^2}{n^{211}}$$

Data Analytics on Snap4City platform



Studio









Ontology Schema



LOG.disit.org

Big Data

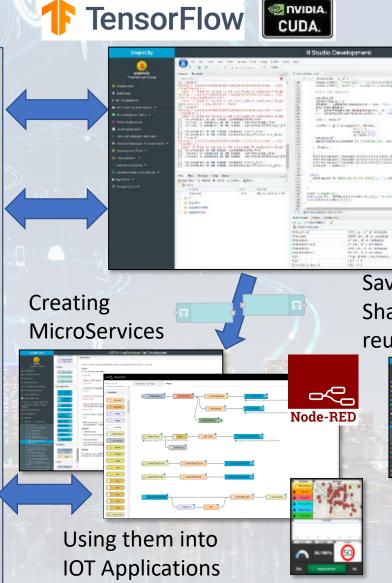
Store

Facility



tools

other



Saving / Sharing reusing



Resource Manager







Development



bdocker Data Analy

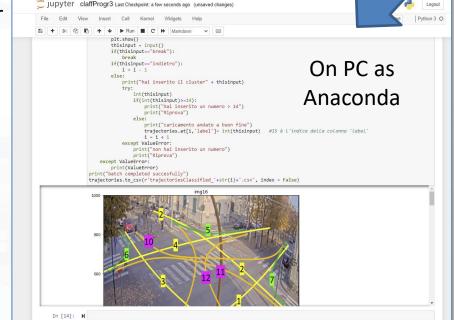
HeatmapDem







On Server Or On PC



Once File.py
Al Model
Mapping
Data..

Load File.py Al Model Mapping Oata..

Python data
analytic

eploy

To make the .PY usable as MicroService you need to adapt it to get and send data in/out with Node-RED from a Container.

If you provide a .zip file the main .py inside has to be called doScript.py



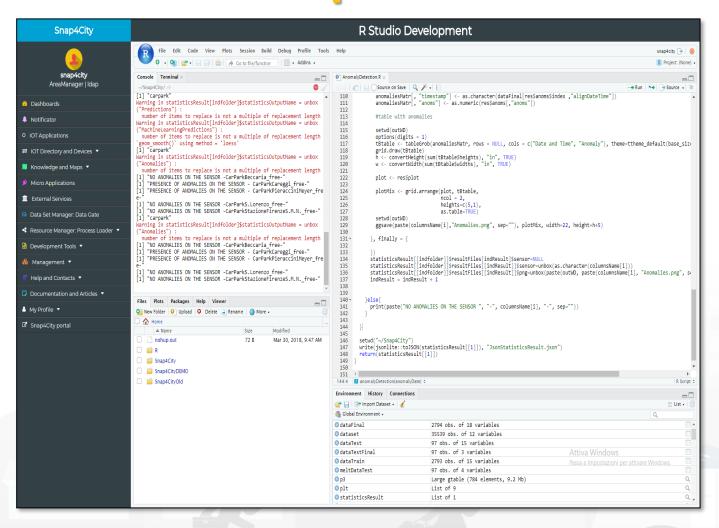


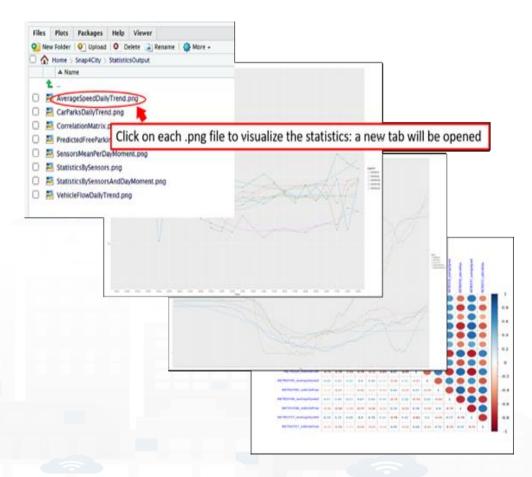




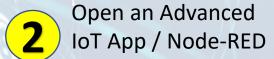


Developer in R Studio + Tensor Flow





Data Analytic Container









docker

S4CDataAnalytic plumber data analytic python data

analytic

Use Snap4City Data Analytic Node, and load in the code you developed.

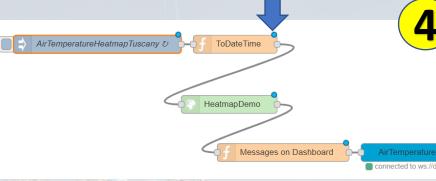


Develop .py or .r program on (i) Snap4City platform online, or (ii) your Development Machine.

The code has to respect the guidelines provided for creating API.

The API are called as a MicroService For example see:

https://www.snap4city.org/641 https://www.snap4city.org/645

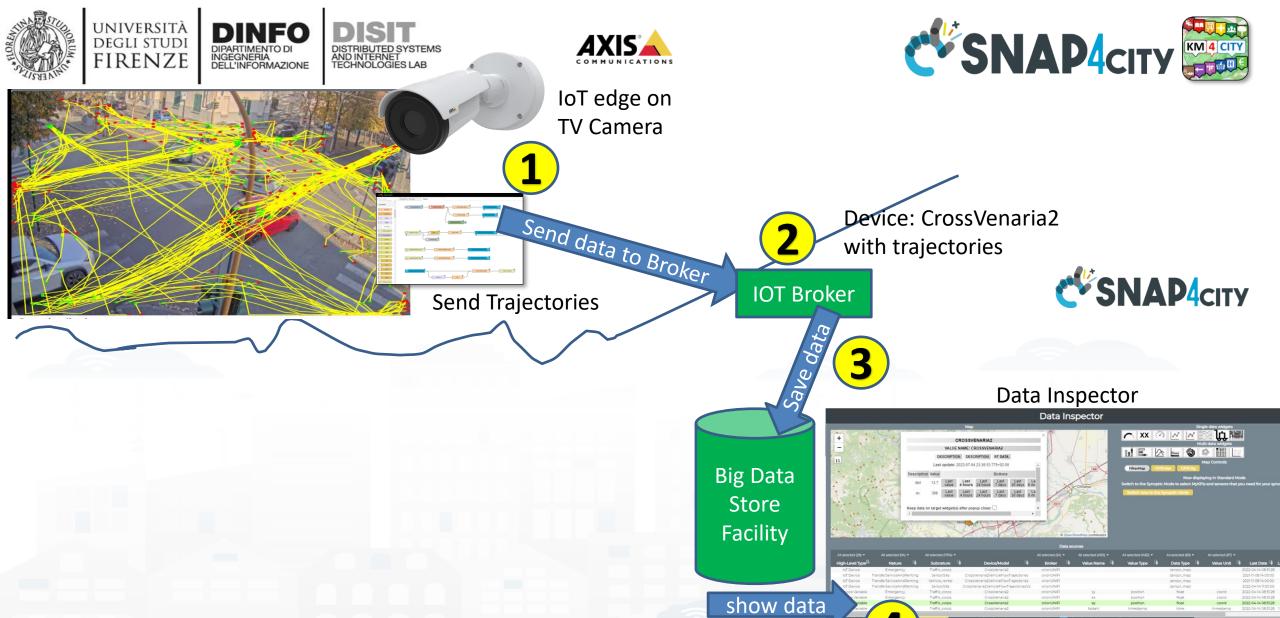


Deploy the IoT App → Snap4City Container Manager based on Marathon/Mesos is creating a Container for your Data Analytic code











Periodically









IoT edge on TV Camera



Devices:

- CrossVenaria2VehicleFlowTrajectoriesV2
- VenariaConteggio



IOT Broker

Save Counting per Cluster

Send data to Broke Send Trajectories

Activate

send data to Broken

From Trajectories to clusters. Counting in/out and flows

Get data

Device:

CrossVenaria2 with trajectories

Big Data Store **Facility**

show data

Monitoring Cross Road Venaria - (AXIS Camera)

python data

analytic

Create and use a Dashboard

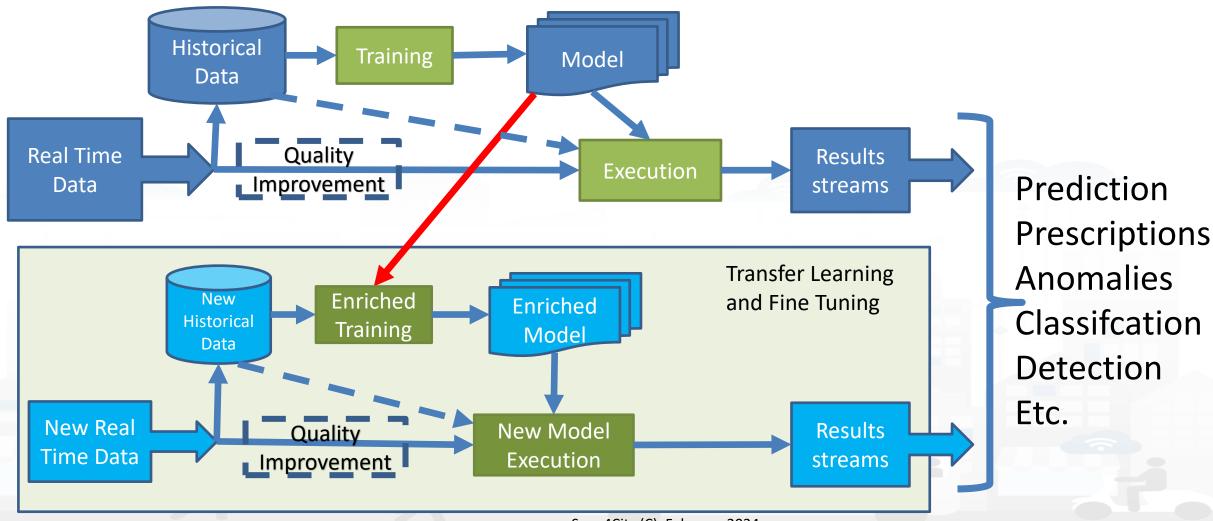








Simplified Deploy of Transfer Learning Model













Parts 7 & 8: API, Mobil, Business Intelligence

Part 7: Exploiting Snap4City API, and Web/Mobile Applications SDK

SLIDES

Interactive Slides



Part 8: Developing Smart Applications & Business Intelligence Solutions

SLIDES

<u>Interactive Slides</u>









- Smart City API: Internal and External
- Concepts and tools for using Knowledge Base, ServiceMap, API
- Federated Knowledge Bases and Smart City APIs
- Advanced Smart City API
- Access to Protected data
- Forging and managing: Mobile and Web Apps, MicroApplications
- Web and Mobile App Development Kit
- •
- Developing in the smart city IoT/WoT context
- Smart Solutions Development Life Cycle
- Analysis for Innovation (Co-Creation and Co-Working)
- Design: Data, Data Models, Data Relationships
- Design & Develop: Data Processes Proc.Logic / IoT App
- Design & Develop of Data Analytics
- Design & Develop: user interfaces, visual tools
- Visual Analytic vs Data Analytics: Client Side Business Logic
 Intelligence
- Design and Control of Smart Applications
 Snap4City (C), February 2024









Development

https://www.snap4city.org/d ownload/video/Snap4Tech-**Development-Life-Cycle.pdf**









Development Life-Cycle

https://www.snap4city.org/download/video/Snap4Tech-Development-Life-Cycle-v1-1.pdf

From Snap4City:

- We suggest you to read the TECHNICAL OVERVIEW:
 - https://www.snap4citv.org/download/video/Snap4Citv-
- https://www.snap4city.org

- https://www.snap4industrv.org
- https://twitter.com/snap4city
- https://www.facebook.com/snap4city
- https://www.youtube.com/channel/UC3tAO09EbNba8f2-u4vandg

Coordinator: Paolo Nesi, Paolo.nesi@unifi.it

DISIT Lab, https://www.disit.org DINFO dept of University of Florence, Via S. Marta 3, 50139, Firenze, Italy Phone: +39-335-5668674





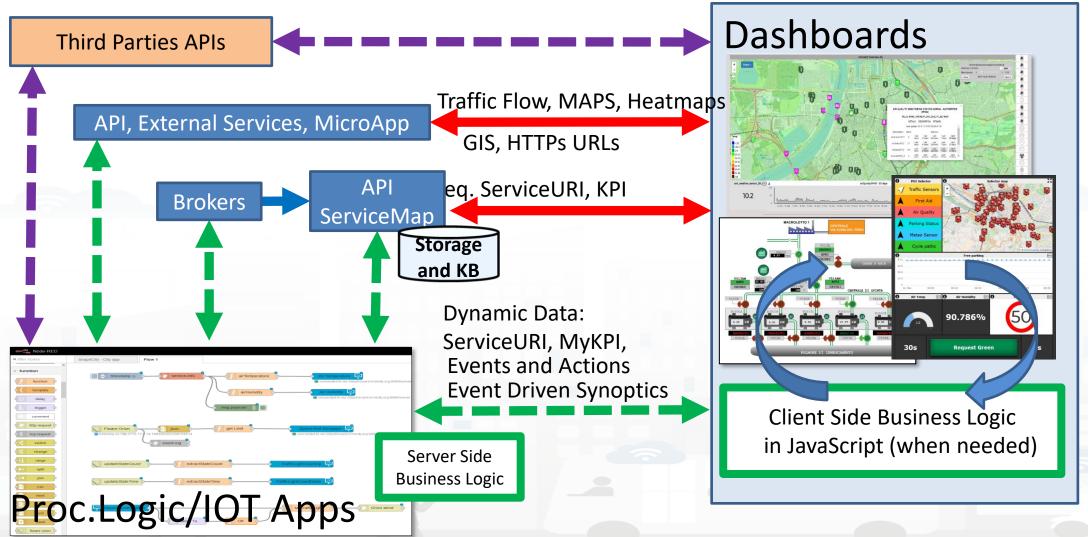








How the Dashboards exchange data

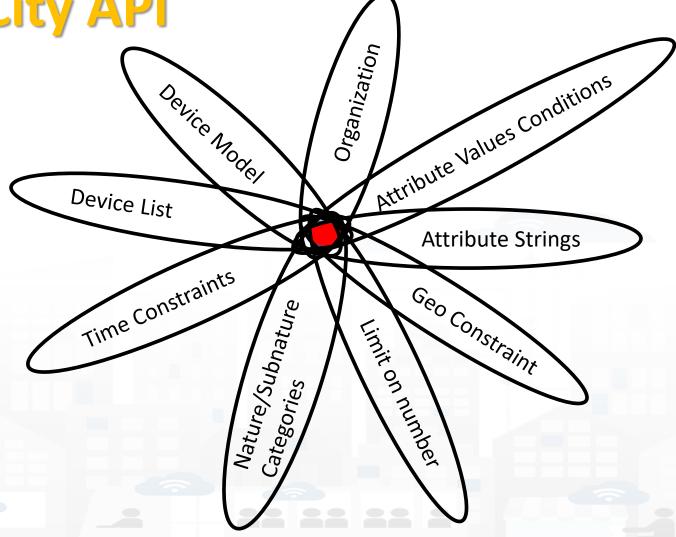






Selection on Smart City API

- Combining different filters for selecting entities from Smart City APIs
- Be care: filtering too much may lead to empty set ☺

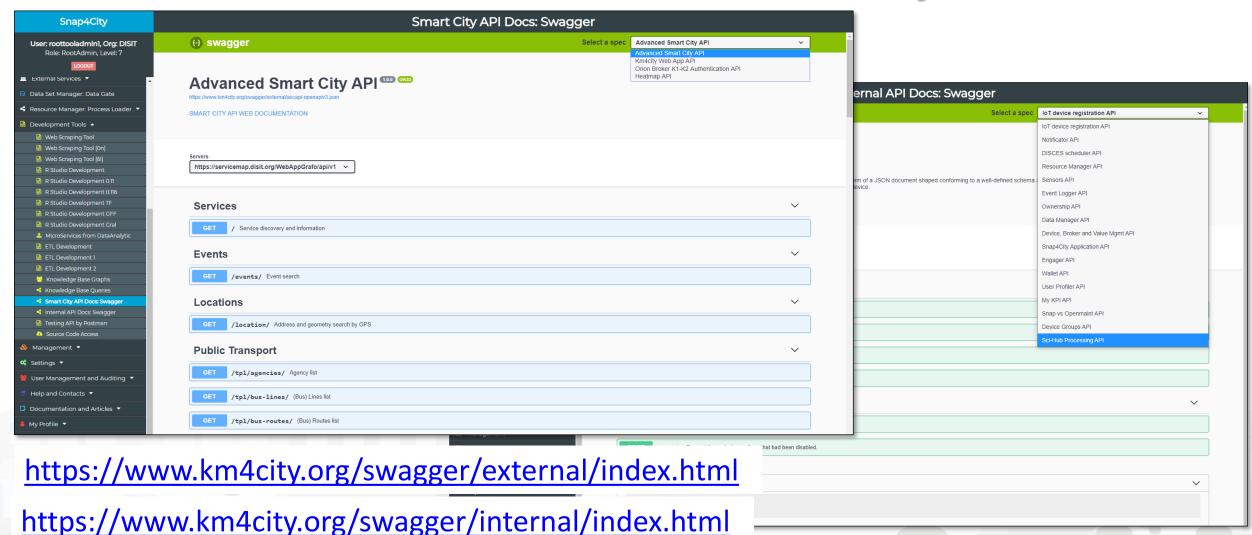








Internal and External Smart City API

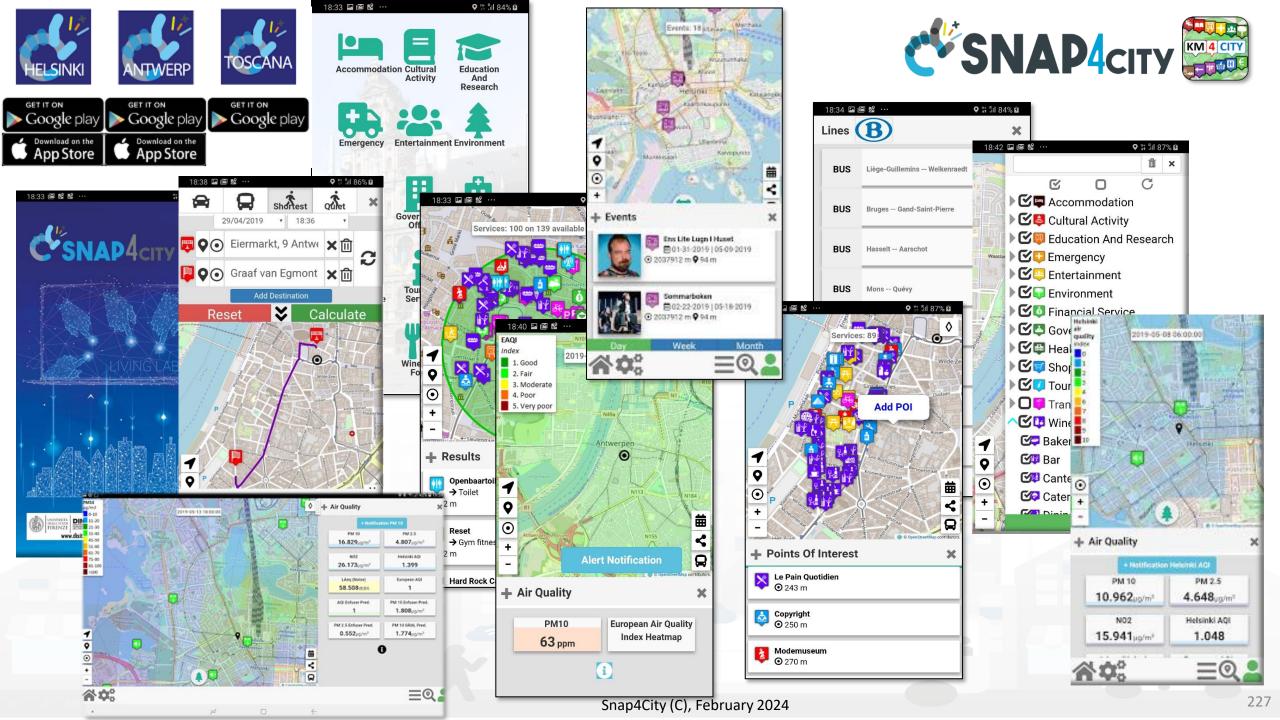






How to Get the «Query» used in More Options (2a)

- REST CALL by category → JSON (Options in RED), they are REST ASCAPI calls
 - Requesting a category, so that to see all Services of the same category (subNature)
 - http://svealand.snap4city.org/ServiceMap/api/v1/?selection=59.581458578537955;16.71183586120606;59.62
 http://svealand.snap4city.org/ServiceMap/api/v1/?selection=59.581458578537955;16.71183586120606;59.62
 http://svealand.snap4city.org/ServiceMap/api/v1/?selection=59.581458578537955;16.71183586120606;59.62
 - Please note that in the MoreOption dashboard the GPS area is neglected
 - https://servicemap.disit.org/WebAppGrafo/api/v1/?selection=43.64471;11.005751;43.89471;11.505751&cate gories=Green areas&maxResults=200&format=json
 - Please note that in the MoreOption dashboard the GPS area is neglected
 - Custom PINS note: "selection" coordinates are used for collecting attributes in custom PINS. Other options such as "maxDists" cannot be used in custom PIN. All parameters can be used in other cases.
 - Different KB links are identified by their ASCAPI links: svealand.snap4city.org, servicemap.disit.org,
 - Requests to SuperServiceMap for the network of Federated KBs by using /api/.....
 Without prefixed KB to obtain merged results from more KBs. For example as:
 - /api/v1/?categories=Air_quality_monitoring_station&format=json
 - Please note that the direct links to the superservicemap can be of the form:
 - https://www.disit.org/superservicemap/api/v1/?



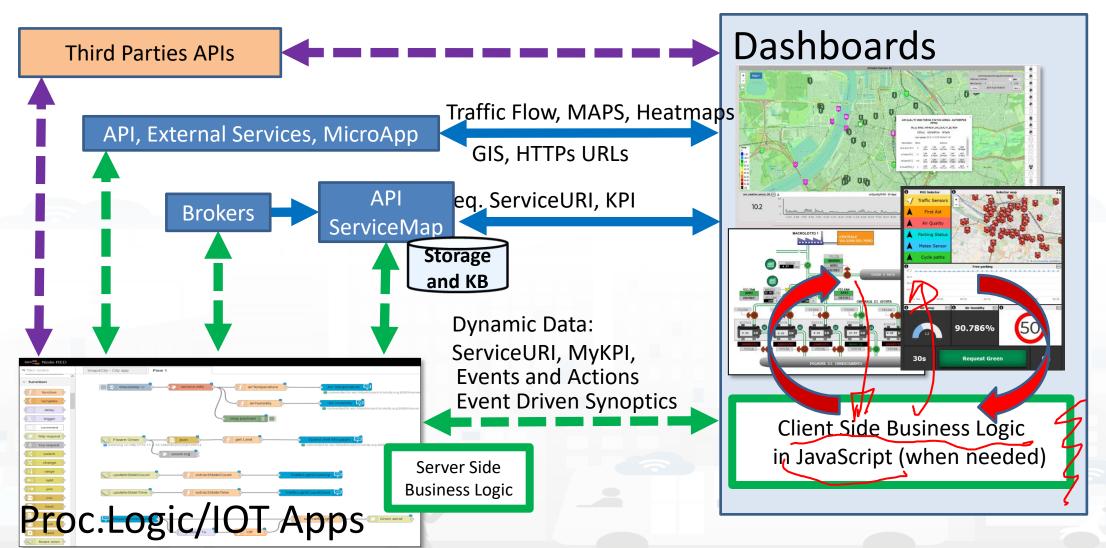








How the Dashboards exchange data





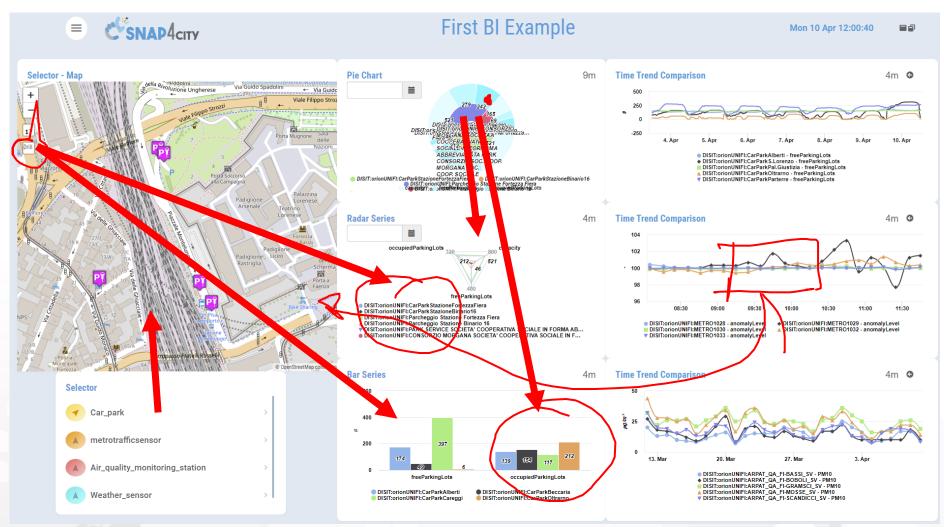






Example: From Map to Graphs (spatial drill down)

- 1) Select the area of interest on map
- 2) Select the sensors kind of interest
- 3) Drill down on map
- 4) The JavaScript CSBL on Map will send data to the programmed Widgets. In this case, arrowed in **RED**













Client Side Business Logic











Client-Side Business Logic Widget Manual

From Snap4City:

- We suggest you read https://www.snap4city.org/download/video/Snap4Tech- Development-Life-Cycle.pdf
- We suggest you read the TECHNICAL OVERVIEW
 - https://www.snap4city.org/download/video/Snap4City-

Coordinator: Paolo Nesi, Paolo.nesi@unifi.it

DISIT Lab, https://www.disit.org DINFO dept of University of Florence, Via S. Marta 3, 50139, Firenze, Italy







https://www.snap4city.org/do wnload/video/ClientSideBusin essLogic-WidgetManual.pdf



SCALABLE SMART ANALYTIC APPLICATION BUILDER FOR SENTIENT CITIES













Note on Training Material

- Course 2023: https://www.snap4city.org/944
 - Introductionary course to Snap4City technology
- Course https://www.snap4city.org/577
 - Full training course with much more details on mechanisms and a wider set of cases/solutions of the Snap4City Technology
- Documentation includes a deeper round of details
 - Snap4City Platform Overview:
 - https://www.snap4city.org/drupal/sites/default/files/files/Snap4City-PlatformOverview.pdf
 - Development Life Cycle:
 - https://www.snap4city.org/download/video/Snap4Tech-Development-Life-Cycle.pdf
 - Client Side Business Logic:
 - https://www.snap4city.org/download/video/ClientSideBusinessLogic-WidgetManual.pdf
- On line cases and documentation:
 - https://www.snap4city.org/108
 - https://www.snap4city.org/78
 - https://www.snap4city.org/426





Snap4City Training vs Targets

- Estimate Indicators: P1, P2, P3, P4, P5
 - IoT App/Proc.Logic JavaScript, Data Analytics, Dashboards to see data and results
 - Load additional data: P1, P2, P3, P5
 - IoT App/Proc.Logic JavaScript, IoT Directory, ServiceMap, advanced interoperability, Dashboards to see them
 - Performing AI/XAI on accessible data: P1, P2, P3, P4, P5 (P8)
 - IoT App/Proc.Logic JavaScript, ServiceMap, ASCAPI, Python, Dashboards to see data/results
 - Developing Business intelligence: P1, P2, P3, P7, P8
 - IoT App/Proc.Logic JavaScript, Dashboards to see them, ASCAPI, CSBL for making them intelligent, JavaScript
 - Developing Web and Mobile Apps: P1, P2, P3, P7, P8
 - ServiceMap, ASCAPI, Dashboards
 - Deploy, install, test and management: P1, P2, P3, P6
 - IoT App/Proc.Logic JavaScript, ServiceMap, Dashboards to see them

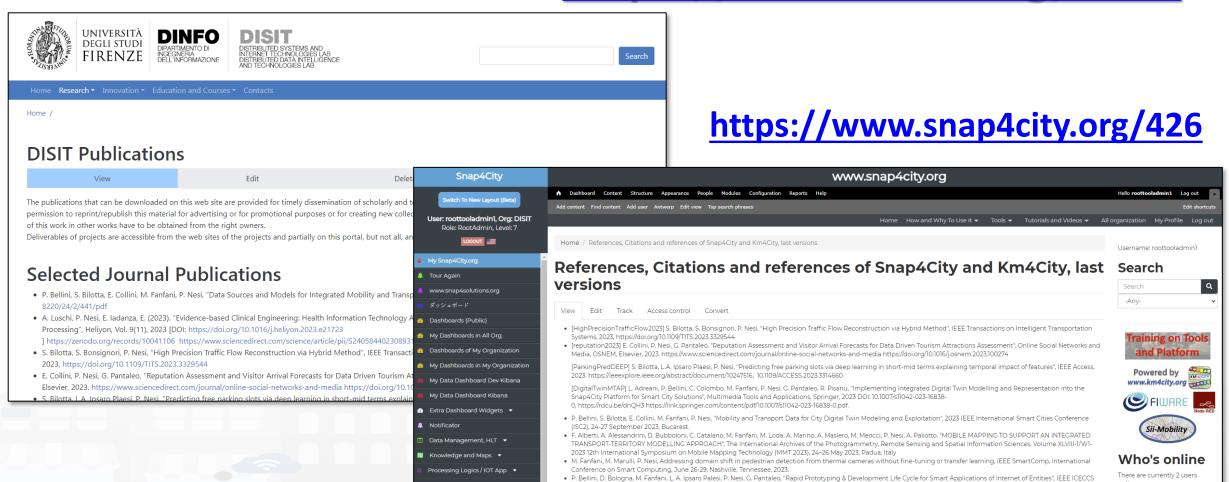








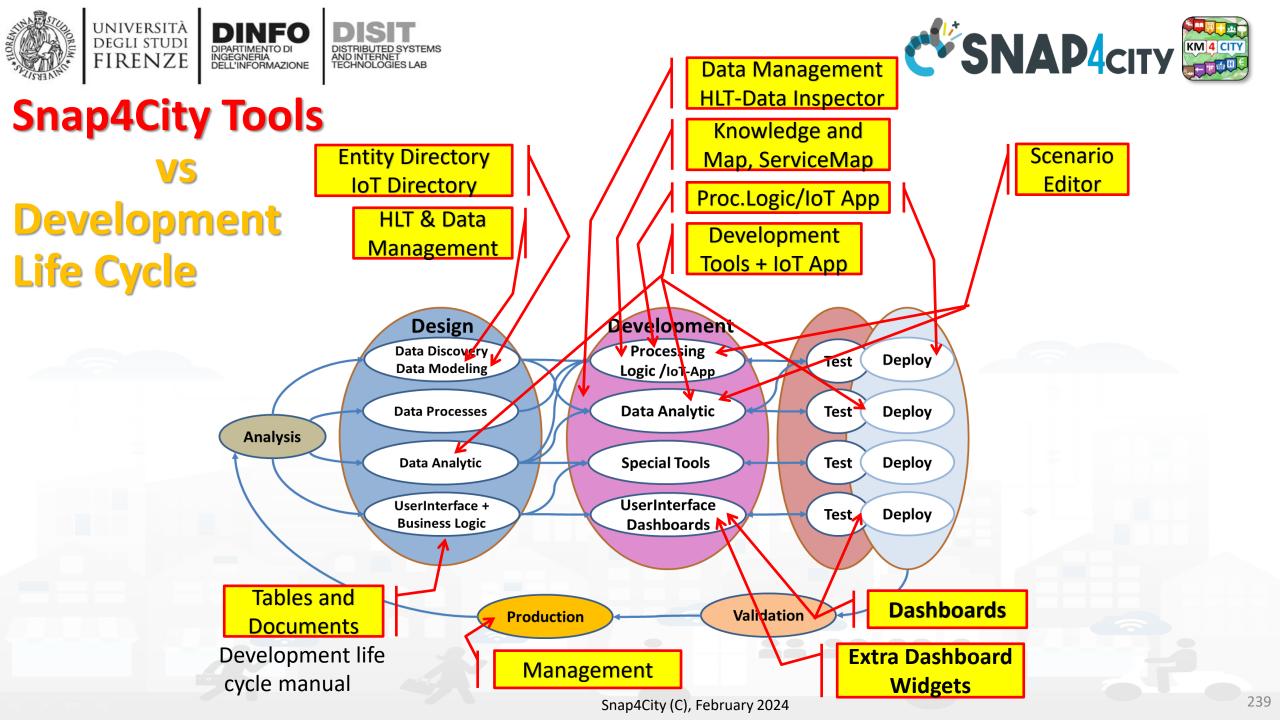
DISIT lab Publications: https://www.disit.org/5487



SCALABLE SMART ANALYTIC APPLICATION BUILDER FOR SENTIENT CITIES









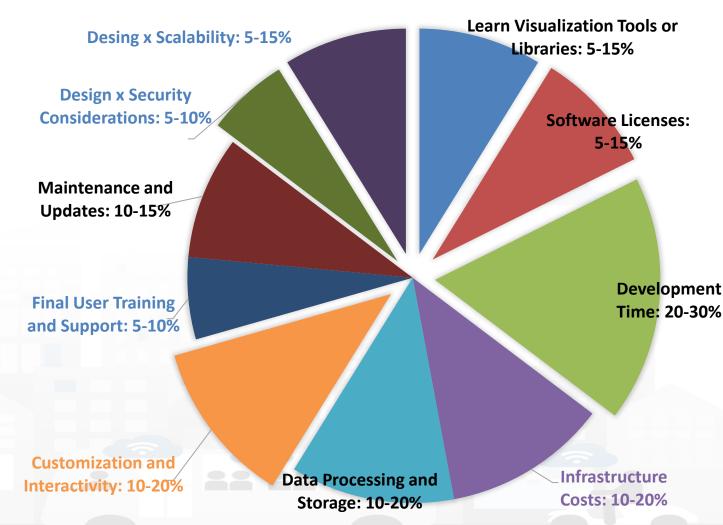






Typical costs to setup operative conditions

- Learn Visualization Tools or Libraries: 5-15%
- Software Licenses: 5-15%
- Development Time: 20-30%
- Infrastructure Costs: 10-20%
- Data Processing and Storage: 10-20%
- Customization and Interactivity: 10-20%
- Final Users Training and Support: 5-10%
- Maintenance and Updates: 10-15%
- Design for Security/privacy: 5-10%
- Design for Scalability: 5-15%
- In yellow, what is not impacted











Snap4City strongly reduces the effort/costs for

- Learn Visualization Tools or Libraries: 5-15% → 10%
 - Visual tools, visual programming, training course, dev. Manuals, etc.
- Software Licenses: 5-15% → 0%
 - Development environment fully open source
- **Development Time**: 20-30% → **5%**
 - Dashboard builder, synoptics, widget exchange, dashboard exchange, clone, delegations, etc.
 - Reused cloned and shared solutions, artefacts
- Customization and Interactivity: 10-20% → 10%
 - Dashboards with Business Logic: CSBL, Node-red SSBL
 - Direct development of Business Intelligence without coding all details
- Design for Security/privacy: 5-10% → only respect the guidelines
 - Snap4City is end-to-end secure and GDPR compliant, all is already in place
- Design for Scalability: 5-15% → only respect the guidelines
 - Snap4City is scalable from Back-End to Front-End, all is already in place
- Reduction of: 45% for development effort of smart city solutions



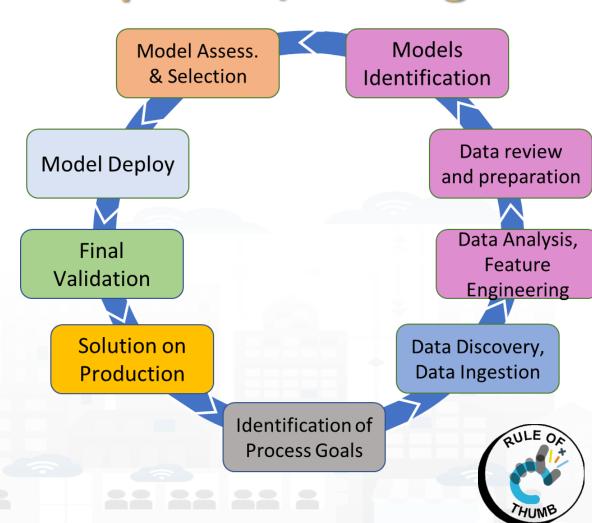








- Identification of Process goals and Planning (problem definition)
 - Which goals
 - How to compute, which language
 - Which environment, which libraries
- Data Discovery and Ingestion (from the general life cycle)
 - Data Collection, Data Preprocessing if needed
- Data Analysis: feature engineering, feature selection
 - Data ethics assessment
- Data review and preparation for the model, splitting, encoding
- Model Identification and building: ML, AI, etc....
 - Model Training
 - Tuning hyperparameters when possible
- Model Assessment and Selection (Evaluation)
 - Validation in testing
 - Assessment on a set of metrics depending on the goals: global relevant and feature assessment
 - Assessing computational costs
 - Impact Assessment, Ethic Assessment and incidental findings
 - Global and Local Explanation via Explainable AI techniques
- Model Deploy and Final Validation
 - Optimisation of computation cost for features, if needed reiterate
 - Solution on Production (security, scalability, etc.)
- Monitoring and Maintenance on production
- Documentation, incremental documentation





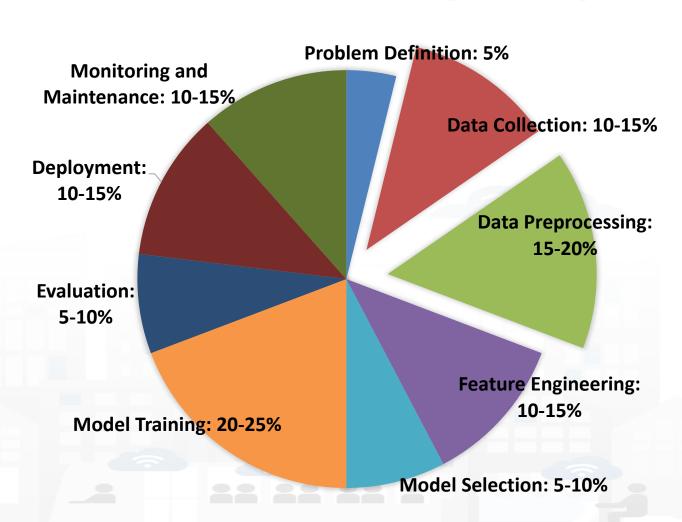






Typical Effort of Phases without Snap4City

- Please note the effort for Data Preprocessing and Data Collection
 - 25-35%
- Please note that the pie has not taken into account the effort for creating
 - an actual applications or
 - simple web results rendering on dashboard











Snap4City on Data Collection and PreProcess

- Effort reduction from 25-35% to 10-15%, >55% reduction of effort for
 - Data Collection via
 - Direct collection access with Brokers, harvesting of external brokers and data models
 - Usage of library of data models, more than 1700 models: saving analysis
 - Custom data models, massive automated construction of entities
 - Automated enrichment of Km4City Ontology and knowledge base: saving time analysis
 - IoT App / Node-red development of data collection processes: fast development

Data PreProcess via

- Node-red visual programming (node.js) for preprocessing, transcoding, thousands of microservices and libraries, reuse of blocks and data flows, etc.
- Semantic recovering of data relationships via semantic graph DB with Km4City models
- Eventually usage of Python or R-studio or others when needed
- Reuse and share of Node-RED solutions, large number of cases

SCALABLE SMART ANALYTIC APPLICATION BUILDER FOR SENTIENT CITIES











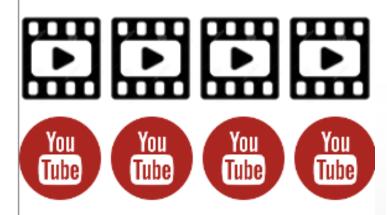


Part 6: Platform Architecture, interop and Deploy

Part 6: Snap4City Platform Architecture, Interoperability, Management and Deploy

SLIDES

Interactive Slides



- Snap4City Architecture
- Interoperability of Snap4City Platform
- Interoperability with respect to Hardware staff
- Adding Features and Modules to Snap4City
- FIWARE and Snap4City
- Snap4City vs State of the Art Solutions
- Smart City planning with Snap4City Team Support
- The Role of the Living Lab Support
- Snap4City Platform: Administration Overview
- Snap4Tech: Smart Solutions as a Service
- Deploy Snap4Tech solutions: Docker Based





















Technical Overview

From: DINFO dept of University of Florence, with its

DISIT Lab, Https://www.disit.org with its Snap4City solution

Snap4City:

- Web page: <u>Https://www.snap4city.org</u>
- https://twitter.com/snap4city
- https://www.facebook.com/snap4city

Contact Person: Paolo Nesi, Paolo.nesi@unifi.it

- o Phone: +39-335-5668674
- o Linkedin: https://www.linkedin.com/in/paolo-nesi-849ba51/
- Twitter: https://twitter.com/paolonesi
- o FaceBook: https://www.facebook.com/paolo.nesi2



Tech Overview

 https://www.snap4city.o rg/drupal/sites/default/f iles/files/Snap4City-PlatformOverview.pdf







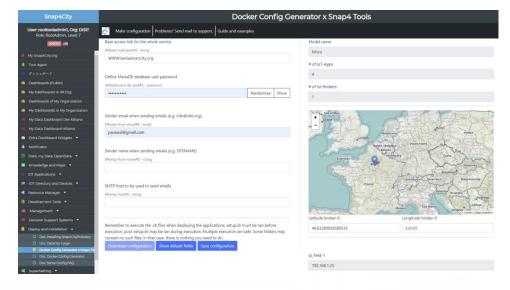


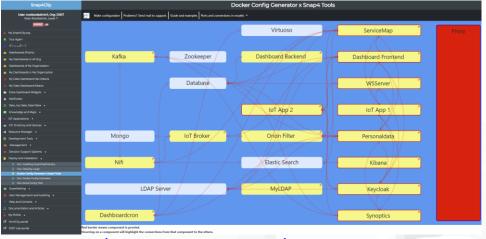


Installations, different models a TOOL to get them

- Micro X:
 - 1 VM of dockers
- Normal X,Y:
 - 2 VM of dockers
- Small X,Y: scalable
 - 4 VM of dockers
- DataCitySmall X,Y,Z: scalable
 - 6 VM of dockers
- DataCityMid X,Y,Z,T: scalable
 - # VM + X/70 VM + Y/3 VM + Z VM + T VM of dockers
- DataCityLarge: scalable
 - · depending on your needs







How to adopt Snap4City



Powered by





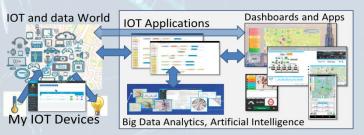


Smart City as a Service

- Supporting Org
- 100% Open Source Platform: Github
- Further developments
- **Publishing Appliances and Dockers**
- Training courses, docs
- Consulting
- **Forums**
- Etc.



On your premise



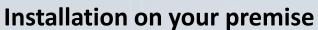




- Different configurations
 - From small to scalable
 - Exploiting your legacy tools
 - Interoperable with any tool
- No vendor lock-in, No tech lock-in

Mixed solutions! For example:

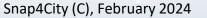
- Start on Cloud as Smart City as a Service
 - Migrate on premise on the fly
- Start on Cloud into a sand box
 - Pass to install on premise what you need





Download

and deploy











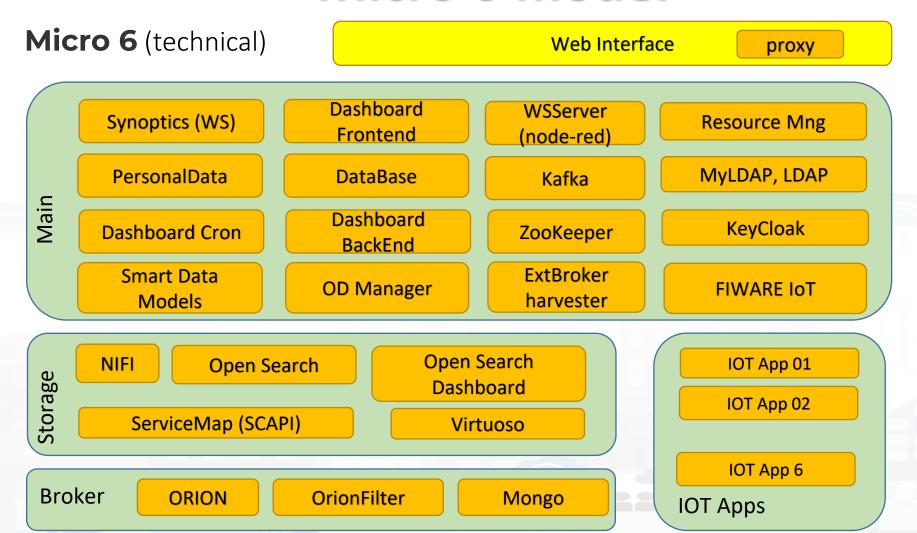
1Hour

and

installation

ready to use

Micro 6 model













• SLA:

- Including: Direct Contact, POC; Help Desk
 - may be an Organization on our cloud to test new tools, and work with the community, this is typically 5-12Keuro first 2years and 1-2keuro for each successive year depending on the feature and number of users you are placing.
- Similar to: https://www.snap4city.org/497 with some adaptation on the basis of your deploy and critical conditions, if any
 - Updates, help desk, etc.

Our support can be valued on:

- The basis of the complexity of your solution: 10% of the cost
 - Or
- Block of: 16 hours, for 3000 euro / 50 hours, for 6000 euro
 - larger packages can be negotiated
- Support can be provided by: Snap4, DISIT Lab, and other companies
- Customizations can be assessed separately







Using from Cloud or Installing on Premise

- Cloud «as a service»: a number of installations are in place
 - The largest https://www.snap4city.org
 - 20 tenants/organizations, Billions of data
 - 1 hour deploy new organization, devices, data, dashboards

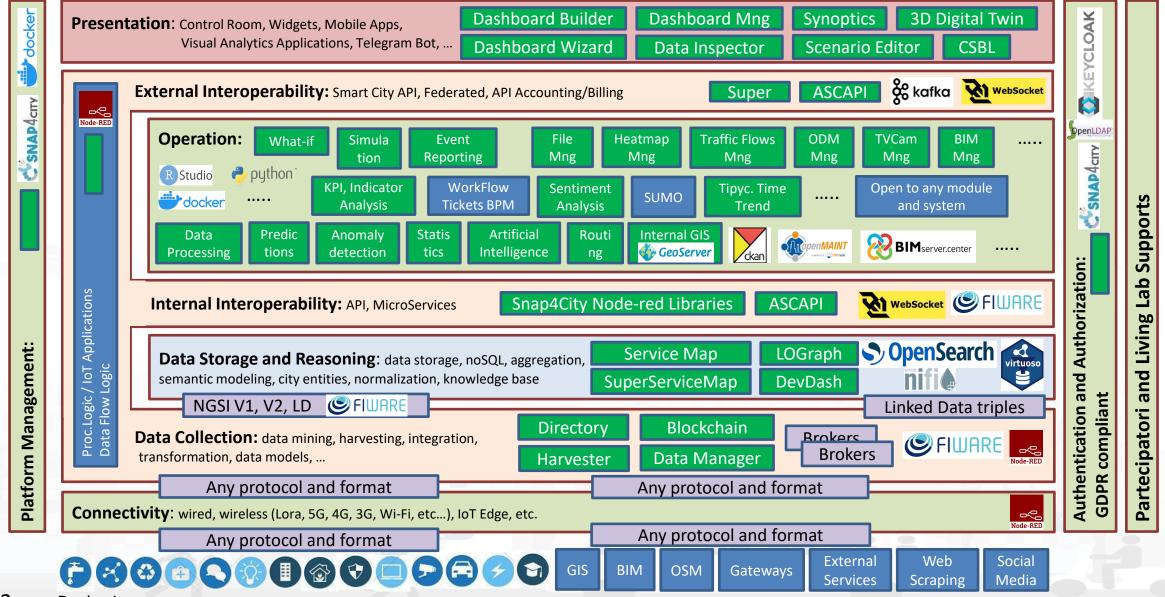


- Installations on public or private cloud, or on private servers
 - A number of ready to use configurations from 1VM to multiple scalable solutions: https://www.snap4city.org/471
 - VM: Appliances ready to use
 - Docker compose, Tool for generating and downloading the docker compose files
 - Micro X version can be installed and tested in 4 hours. https://www.snap4city.org/738



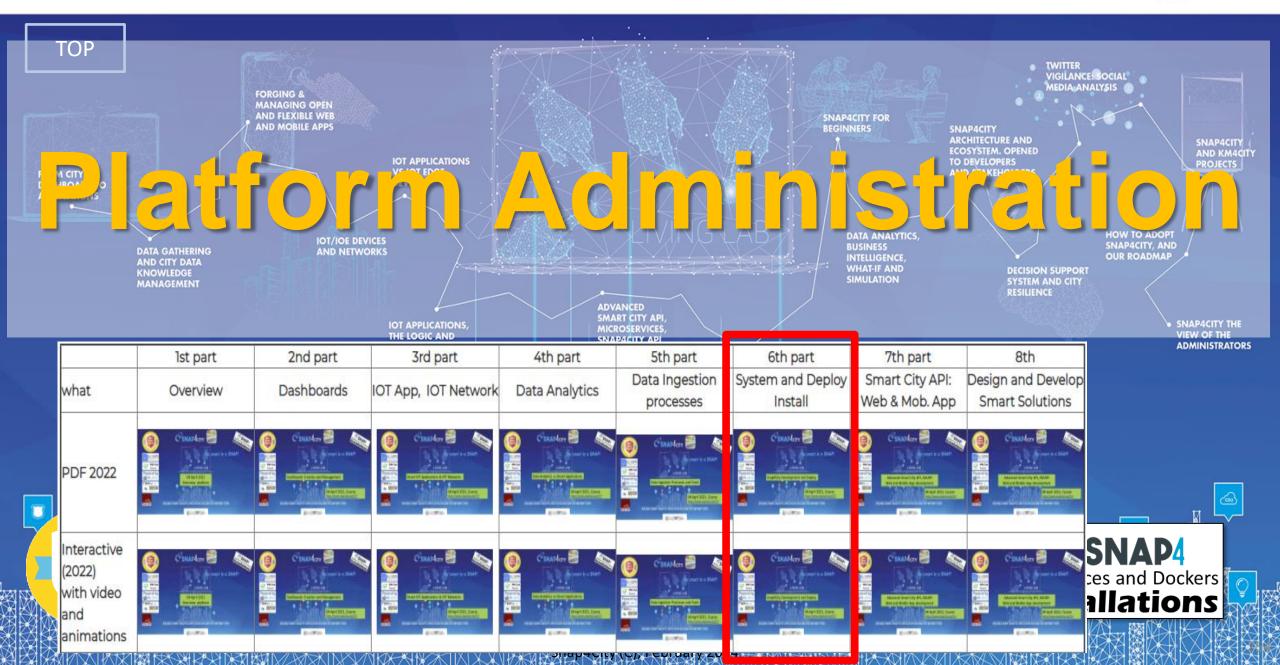






SCALABLE SMART ANALYTIC APPLICATION BUILDER FOR SENTIENT CITIES













Roles in Snap4City/Industry solutions

RootAdmin

 The gods of the specific installation, access to all tools for all Organizations

ToolAdmin

 The administrators of an Organization with some capabilities on single tools

AreaManager (developers)

 access to development tools, access to a wider number of resources, IOT with both basic and advanced, IOT Models, etc.

Manager (final users)

 limited access to development, IOT App development with Basic library.

- Users of any Role have full control on their own resources: data, devices, dashboards, IOT App, etc., which may control according to GDPR rules,
 - providing access, revoking, etc.

All users start as Manager roles

 All users have also a Level (numeric). A score about what they have exploited in the platform. Higher scores correspond to wider exploitation of capabilities.

RootAdmin users may

- pass Users to higher roles. Ask to <u>snap4city@disit.org</u> to become an AreaManager for testing
- Provide/grant specific authorizations to data access on Tool usage
- In the Installation on Premise, you become the Root Admin of it, you decide ALL.

Platform Management and control



Platform Management tools

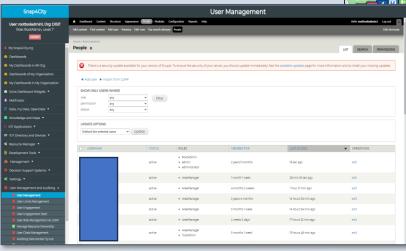
- Installation procedures
- monitoring and control tools
- Quality control
- Help desk and SLA

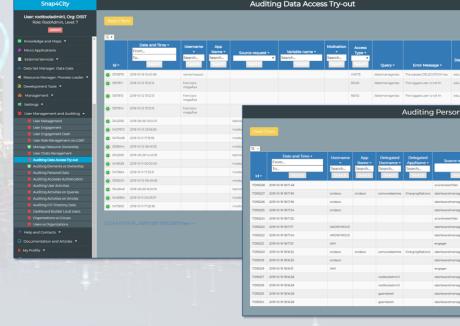
User management tools

- User profiling, limiting
- Auditing tools according to GDPR
- Menu profiling
- CRM
- Training and tutoring tools
 - Develop. Life Cycle
 - · Develop. tools
 - · Manual, courses, etc.
 - Community
- etc.



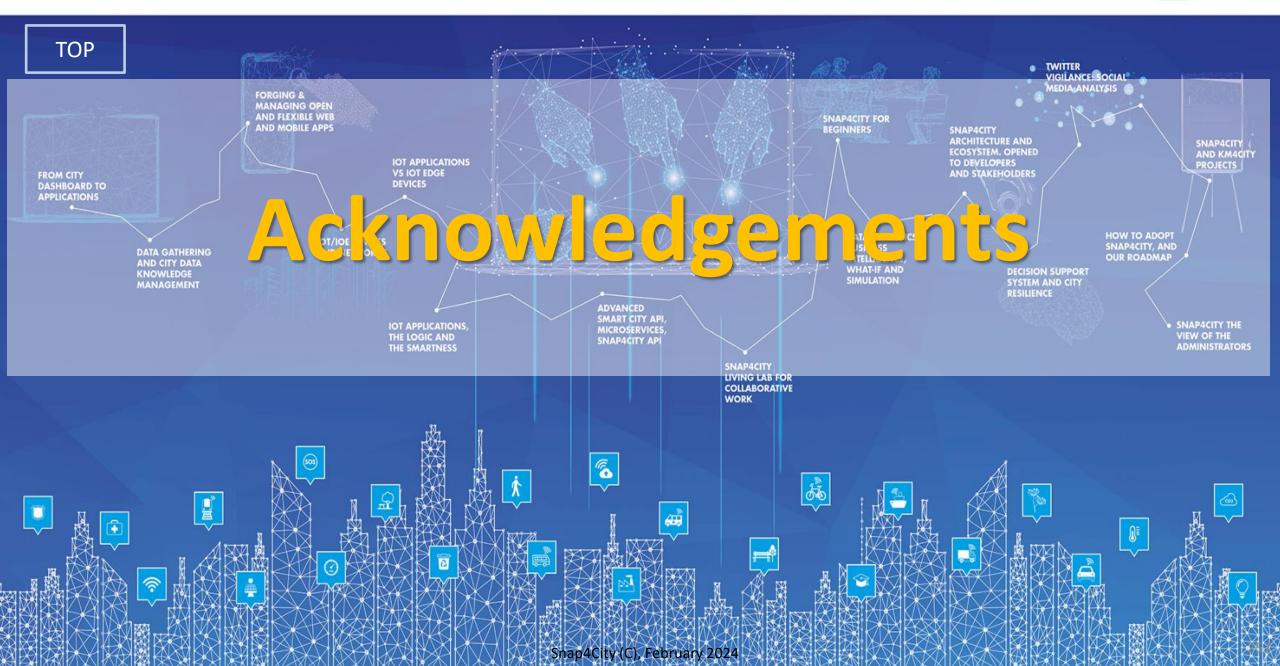






SCALABLE SMART ANALYTIC APPLICATION BUILDER FOR SENTIENT CITIES











Overview





SMART CITIES AND SMART INDUSTRY

Snap4City: FIWARE powered smart app builder for sentient cities

ith the contribution of









- https://fiwarefoundation.medium.com/sna p4city-fiware-poweredsmart-app-builder-forsentient-cities-acfe24df49d5
- https://www.snap4city.org/drupal/sites/default/files/files/FF ImpactStories Snap4City.pdf

2023 booklets

Smart City





https://www.snap4city.org /download/video/DPL SN AP4CITY.pdf Industry





https://www.snap4city.org/download/video/DPL SNAP4INDUSTRY.pdf

Artificial Intelligence





https://www.snap4city.o rg/download/video/DPL SNAP4SOLU.pdf







https://www.snap4city.org/4

- <u>Scenario: SnapBot: Real Time Smart City services via Telegram</u>
- <u>Scenario: Copernicus Satellite Data</u>
- Scenario: SmartBed, Materasso Intelligente
- MicroServices Suite for Smart City Applications
- Scenario: MODBUS for Snap4Industry Snap4City Applications
- Scenario: MOBIMART Interreg: MOBilità Intelligente MARe Terra
- Scenario: City of Roma case, mobility and environmental data
- Scenario: Herit-Data video and aims
- Scenario: Control Room vs Video Wall
- Scenario: Snap4Home the case of: Alexa, Philips, Sonoff, TP-link, etc. (Italiano)
- Scenario: how to manage maintenance and accidents workflows
- Scenario: Snap4Home, how to exploit Snap4City solution on home automation
- Scenario: Energy Monitoring
- Scenario: Multipurpose User Engagement Tools
- Scenario: 5G Enabled Water Cleaning Control (smart city, industry 4.0)
- Scenario: High Level Control of Industrial Plant (industry 4.0)
- Scenario: Vehicle Monitoring via OBD2
- Scenario: Events and Museums Monitoring in Antwerp
- Scenario: High Resolution Prediction of Environmental Data
- Scenario: Mobility and Transport Analyses in multiple cities
- Scenario: People Flow Analysis via Wi-Fi
- Scenario: Antwerp Pilot on Environmental Data
- Scenario: Helsinki Pilot on Environmental Data
- Scenario: Firenze Smart City Control Room
- Scenario: Mobile & Web App: Toscana Where What ... Km4City, Toscana in a Snap
- Scenario: Helsinki Pilot on User Behaviour
- Scenario: Antwerp Pilot on User Behaviour

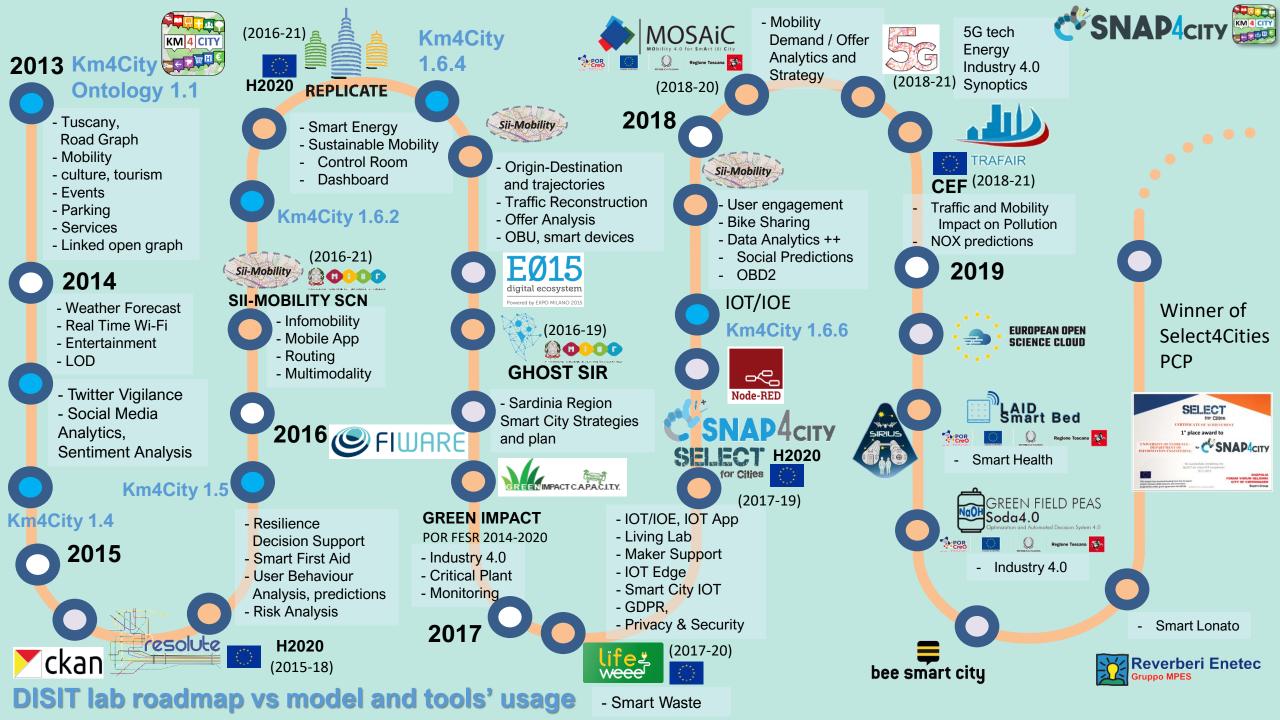




Scenarious

- Data Analytic: Origin Destination Matrices, Algorithms and tools
- Data Analytic: Traffic Flow Reconstruction
- Data Analytic: in general, and the cases of Antwerp and Helsinki
- Data Analytic: Predicting Air Quality
- <u>Data Analytic: Analyzing Public</u>
 <u>Transportation Offer wrt Mobility Demand</u>









smartGARDAlake

Smart **Ambulance** (2021-22)

Enterprise (2021-22)Industry 4.0

enel X

Almafluida Industry 4.0 (2021-22)



Contract

Contract

2021

JRC

AMPERE (2021-22) Industry 4.0

SYN-RG-AI

Industry 4.0

2022

GRUPPO **PRETTO**

uni systems

SmartCity, 2021-23

SmartCity



2023

EI THE, 2022-26

Contract, 2022-23

enel x

Contract, 15min



G. Agile, 2021-23

CN MOST, 2022-26



EDIM

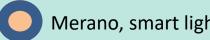




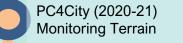


Contract, 2022-23

Merano, smart light



2024



Winner of Open

Data Challenge of

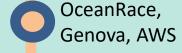
enel X

AXIS

AXIS collab SmartCity

IMPETUS

Security and Risk



Cuneo, smart city Rhodes, smart city



















- Smart Light
- Sweden



Asymmetrica Smart City, 2022-23



Italferr, Smart City





TOP













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