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DIGITAL TWIN SOLUTIONS TO SETUP SUSTAINABLE DECISION SUPPORT SYSTEMS AND BUSINESS INTELLIGENCE



UNIVERSITÀ
DEGLI STUDI
FIRENZE

DINFO
DIPARTIMENTO DI
INGEGNERIA
DELL'INFORMAZIONE

DISIT
DISTRIBUTED SYSTEMS
AND INTERNET
TECHNOLOGIES LAB

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INTRODUCTION

Cities are rapidly transforming their services to address societal, environmental and economic challenges: SDG, DUT, 15MinCityIndex, etc. Verticals are progressively replaced by solutions capable of exploiting a huge range of data channels, getting smarter, and cross exploiting data. Cities/areas require tailored solutions, exploiting legacy solutions and pushing to the future and innovation. A Digital Twin, flexible, dynamic and highly interoperable platform leads to increase sustainability and control assets and operational objectives, fully integrated with the territory and stakeholders. Cities are evolving exploiting a plethora of data channels to get and provide hints and controls with respect to the Digital Twins of the single services, building and of the whole city.

With **Snap4City**, multiple domains are enforced into the city/area operating system enabling operation, management, plan and strategic views for **mobility and transport, energy, environment, government, tourism, security, safety, civil engineering, asset management for waste, lighting, parking, traffic, building, people flow, etc.** As it is on more than 40 cities/areas in countries as Italy, Spain, France, Bosnia-Herzegovina, Finland, Belgium, Greece, Croatia, Israel, Sweden, Australia, Brazil, Romania, Cina, Romania, etc., for data, services or third-party operators.

Snap4City provides real-time and offline solutions to support decision makers in cities to their daily operational actions on Digital Twin, grounded on ethical and explainable artificial intelligent, XAI/AI, solutions, deductions and assessments. It provides a complete understanding of the city conditions, producing early warning, providing suggestions, enabling simulations and plans as what-if analysis. It is used to suggest strategic and real time interventions to improve city services and general quality of life also providing living lab support.

Snap4City is a 100% open-source platform used in many cities and areas, includes Km4City ontological and semantic model (<https://www.km4city.org>) to guarantee the data interoperability. It is an official FIWARE Platform (<https://www.snap4city.org/467> , <https://www.fiware.org/>) compliant with with FIWARE Smart Data Models, IoT Data Models, and a large range of High Level Types., official EOSC Platform, official Node-RED Library, official E015 API, etc. Snap4City is provided “as a Service” or installed in your location (from yourself, as well as using a number of Snap4City certified companies), no licence fee is needed. The platform facilitates a wide range of application in the smart cities and IoT/IoE (Internet of Things/Web of Everything) integrated domains: defining city strategies, implementing control rooms, realizing ethics and explainable artificial intelligent solutions, computing key performance indicators (SUMI, SUM, IEEE, EC kpi, etc.), setting up solutions, harmonizing any legacy solution in place.

From security and privacy aspects, Snap4City is GDPR compliant, and passed PENTest. With Snap4City you can create your certified entities, and sequences of events using the provided Blockchain support. End-3-end secure connections are established from devices to dashboards. Snap4City is compliant with OpenID Connect, SSO, European Identity Card, SPID, EU Login, etc.

THE SOLUTION

Snap4City platform can cope with any data and information covering multiple domains / scenarios (<https://www.snap4city.org/4>) in integrated Digital Twins, for management, simulation, what if analysis, and strategic planning:

- **Mobility and transport:** smart parking, traffic flow reconstruction, traffic flow prediction, offer vs demand of transportation analysis, vehicle tracking, dynamic routing, multimodal routing, smart biking, reducing traffic congestion, people classification and counting, people flow tracking, etc. For example, in the REPLICATE H2020 project for Florence (Italy), and in the cities of Pisa, Livorno, Modena, Santiago de Compostela, on TRAFAIR CEF action; Pisa and Siena for smart biking with Sii-Mobility national mobility and transport smart city actions; Antwerp, Dubrovnik and Pont du Gard for people counting and tracking.
- **Energy:** smart light, control room on energy production and recovering, charging stations, electric vehicles fleet control, monitoring energy production and consumption; For example, in REPLICATE for recharging stations, for CAPELON partner in Sweden for Smart Light, for data centers, for single and groups of houses with PV panels and CER, in Merano for smart light.
- **Environment:** monitoring pollutant and weather, pollutant predictions, landslides 24H predictions, NOx predictions, NO2 very long-term predictions of annual average KPI, alerting, CO2 reduction, CO2 estimation from traffic, CO2 estimation for the city, smart waste management, decarbonization, collection of RAEE, satellite data. For example, in Florence, Pisa, Livorno for NOx/NO2 predictions, and general pollutant monitoring in Tuscany, Antwerp, Helsinki.
- **Governance control and KPI:** assets control, utilities, quality of life assessment and control, computing 15MinCityIndex, building automation, building energy management vs usage, digital twin, sustainability, smart decision support, city management KPI, etc. For example: in REPLICATE H2020 for Smart City Control Room of Florence; in the Firenze and Bologna for the 15 Min City Index; 15Min City Index model adopted a national level.
- **Tourism:** reputation assessment and control, tourists city usage monitoring, POI, For example:, in Antwerp for monitoring people flows with PAXCounters, and in Dubrovnik, Pont du Gard, and Valencia for monitoring people flow (via PAXCounters and/or TV Cams) and tourism aspects with HERITDATA (<https://herit-data.interreg-med.eu/>).

- **Safety & Security:** data and evolution certification with Blockchain; thermal cameras for critical condition monitoring, people counting, people tracking, automated moving object tracking with branded cameras, etc.; integration with VMS of Milestone, integration and plugin for AXIS cameras.
- **Industry 4.0:** ddepuration plants, production plants (monitoring industry plant, control and optimization, digital twin), production plant, predictive maintenance, integrated life cycles among different industry plant, such as on ALTAIR chemical plant, marketing analysis, production of suggestions and engagements; <https://www.snap4city.org/369>.

Interoperability: In this large range of solutions, Snap4City is compliant with more than 180 protocols and formats, and it capable to fully interoperate and/or integrate legacy systems. It is highly interoperable with any GIS, BIM, CKAN, Satellite Services, OSM, GTFS/NeTex, transport protocols, and IoT Networks protocols (IoT protocols), WoT, smart data models, data spaces, services and databases: <https://www.snap4city.org/283>, <https://www.snap4city.org/65>. Snap4City is an official FIWARE platform, exploits FIWARE multi-tenant Context Broker, NGSI-V2/LD protocols, Smart Data Models, automated broker deploy, protected communications and multiple broker connections. The interoperability, flexibility and modularity of Snap4City together enable the creation of business intelligence applications in a wide range of scenarios and domains. Snap4City enables the creation of federations of Smart solutions via Smart City API. All Snap4City APIs are accessible and well documented for developers, allowing customization and online development.

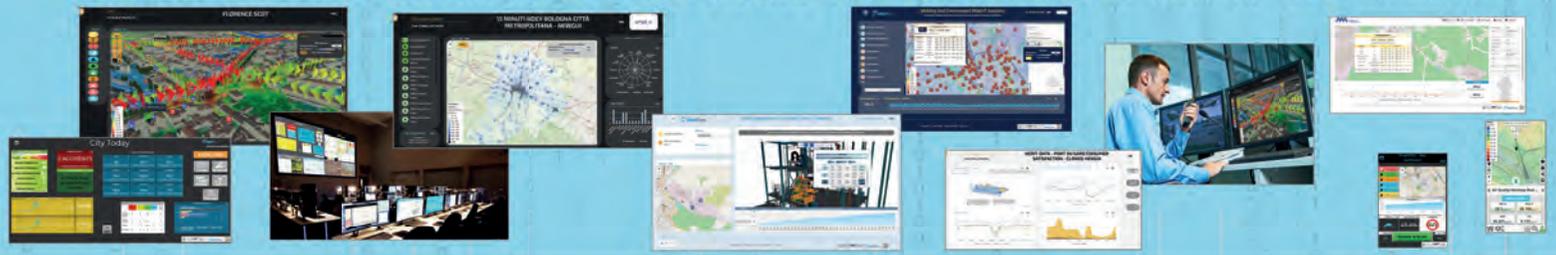
Data Integration, ingestion and distribution: Snap4City provides effective and simple tools and solutions for immediate data ingestion and data aggregation exploiting a large range of protocols and standards. Snap4City provides a range of tools (event driven, real time, push/pull) for shortening the processes for manipulating simple and complex data such as POI, KPI, IoT Devices, Satellite, Digital Twins, BIM, OD Matrices, Traffic Flows, Heatmaps, 3D Shapes/patterns, Typical Time trends, Color Maps, Trajectories, Flows, Video Streams, User profiles, Terrains, Maps, Orthomaps, SVG graphics; etc.

Security and Privacy: Snap4City platform passed the penetration and vulnerability tests and has been proven to be GDPR compliant. Snap4City provides end-2-end event-driven secure applications with real time connections from devices to dashboards and vice versa, including data processing, storage and data analytics. <https://www.snap4city.org/549>.



Smart Solutions and Decision Support Systems

CONTROL ROOMS - DECISION SUPPORT SYSTEMS - WHAT-IF ANALYSIS - BUSINESS INTELLIGENCE - SIMULATIONS - SMART APPLICATIONS



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DASHBOARDS - VISUAL ANALYTICS - SYNOPTICS - DIGITAL TWIN - GRAPHICAL WIDGETS - ANALYTICS - GUI CUSTOM STYLES - VISUAL PROGRAMMING



DASHBOARDS, WIDGETS
TEMPLATES

PREDICTION - ANOMALY DETECTION - CLUSTERING - ROUTING - SENTIMENT NLP - TRAFFIC FLOW
PEOPLE FLOWS - SDG - 15 MIN CITY INDEX - KPI - HEATMAPS - ORIGIN DESTINATION - ETC...

API - MICROSERVICES - GIS - BPM
VIDEO - REPORTS - MAPS - 3D ...



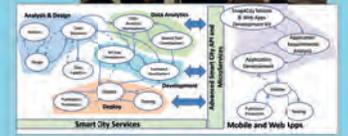
ANY: DATA, BROKER, NETWORK AND VERTICAL

EXPERT SYSTEM, KNOWLEDGE BASE
SEMANTIC REASONING
SMART DATA MODEL
IOT DEVICE MODELS, STORAGE

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

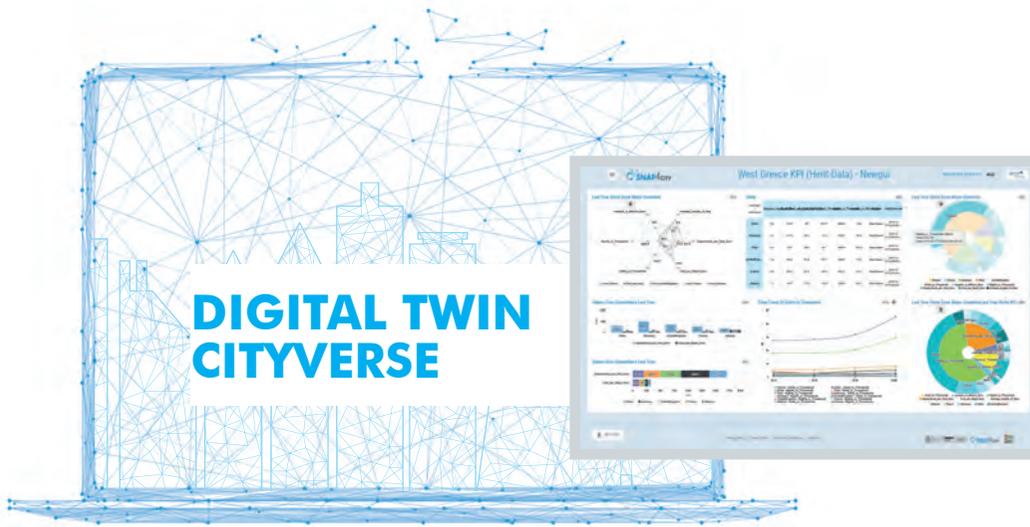
VISUAL PROGRAMMING, ADAPTERS
DATA FLOWS, WORKFLOWS
PARALLEL DISTRIBUTED PROCESSING
DATA DRIVEN

- Native and External Applications**
- Smart Parking
 - Smart Light
 - Smart Waste
 - Smart Energy
 - Smart Building
 - Smart Tourism
 - Social Media Analysis



METHODOLOGIES
LIVING LABS
COURSES AND COMMUNITY
DEVELOPMENT TOOLS

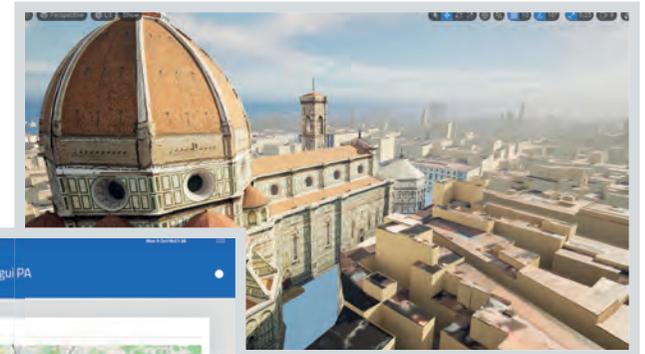
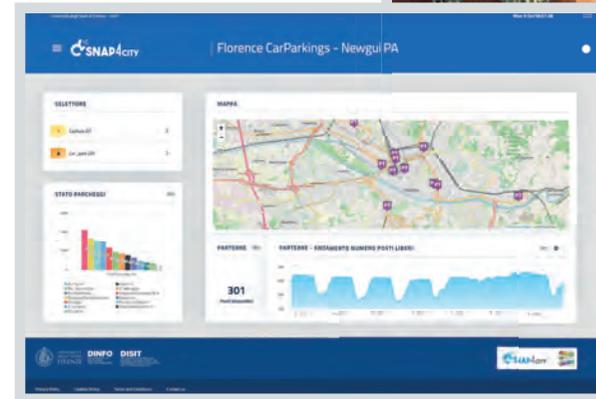
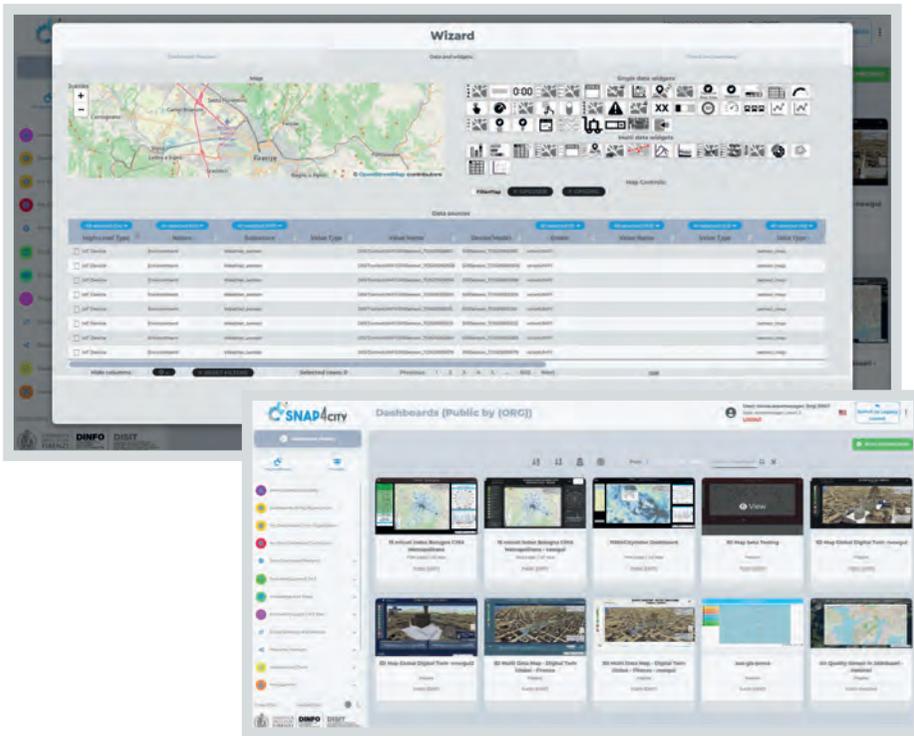




Snap4City solution models entities as city Digital Twins, including: spatial, temporal and relational aspects of any city element, 2D/3D geometries and patterns, data of any kind, behavioral aspects associated to the entities including dynamic, simulations, predictions, etc.; actionable on ActionURI; KPI/metrics of any sort, business models and business intelligence tools. Data analytic can be used for predictions, providing suggestions, supporting decision on plans and what if analysis. Snap4City can manage open and private data, static and real time event driven data of any domain and organization. Snap4City supports all the advanced solutions for:

- **Global Digital Twin:** representing and navigating the city in 3D on Web Browser (a version for Oculus), with shapes of the building, facades, roofs, high value buildings, BIM details for buildings, heatmaps and animations, traffic flows, pins, devices, POI, KPI, furniture (trees, luminaries, busses, aircraft, cars, benches, etc.) etc. <https://digitaltwin.snap4city.org>

- **Local Digital Twin:** representing 3D shapes of building, BIM, internal and external navigation, association of 3D elements to devices, IoT real time data, etc. <https://www.snap4city.org/716>
- **CityVerse** with walkable 3D representations and tools on Ureal and Oculus, exploiting the same real time data of Local and Global Digital Twins.
- **Dashboards, web and mobile applications** with business intelligence and logic.
- **Edge solutions:** supporting the installation of Snap4City processes and interfaced in embedded systems, such as Linux based, Windows based, Arm, AXIS cameras, Raspberry Pi, Android, etc. They can be on Node-RED as well as other formats for logic.

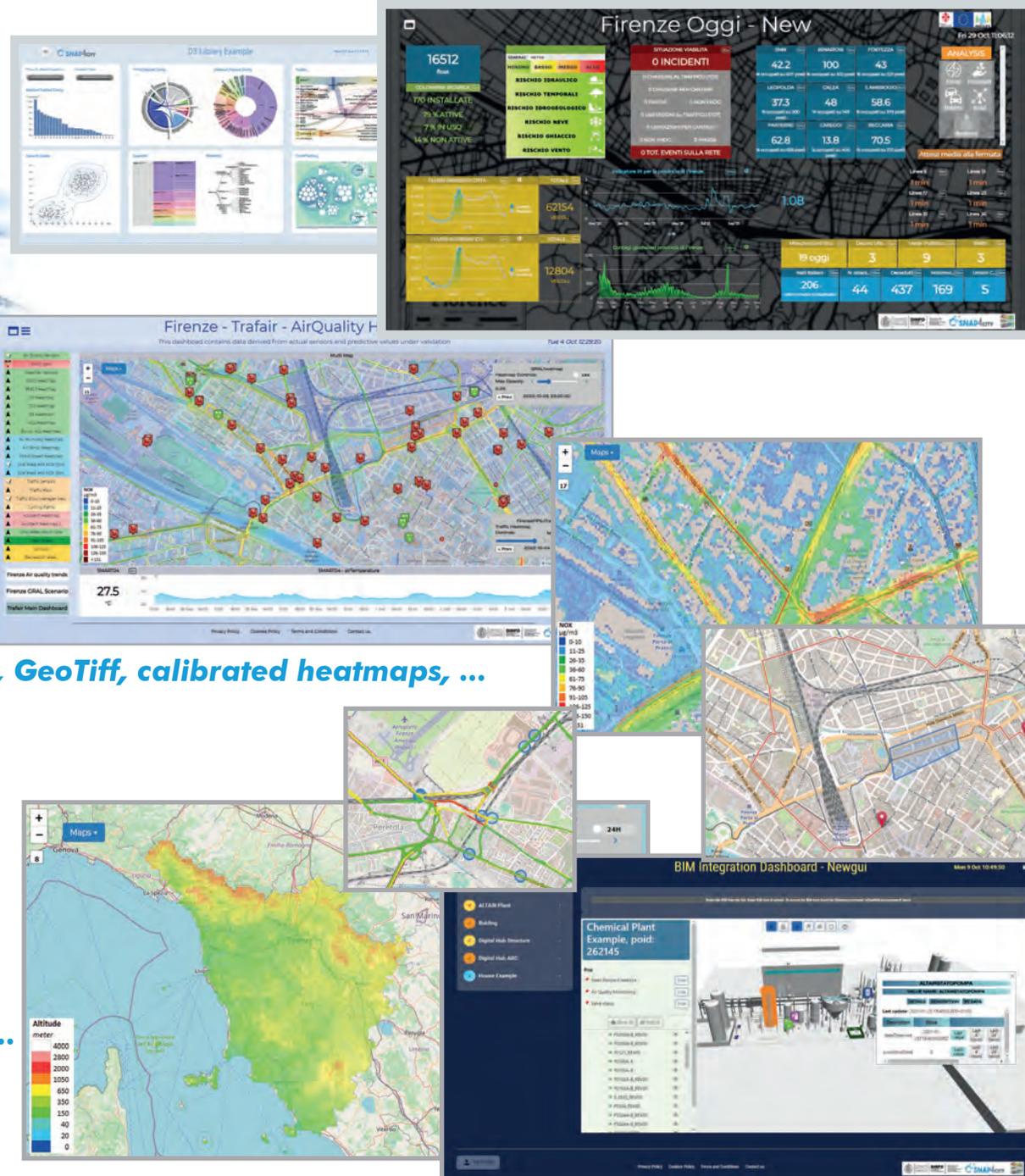


The **Snap4City Dashboard Builder** with its **Business Intelligence engine** provide a wide range of graphic rendering tools to show and play with a variety of complex interactive data and graphic representations: maps, orthomaps, tables, time trends, heatmaps, heatmap sequences/animations, traffic flows and animations, origin destination matrices and animations, typical trends, calendar heatmaps, Kiviat / spider, hierarchies, sunburst, bubbles, scatterplot, treemaps, ven circle packing, chords, stream graphs, radial, barseries, custom widgets, SVG animations, scenarios, routing, multimodal routing, public transport time line, weather forecast, BIMs, buttons, 3D shapes on local (building) and global Digital Twins (for the whole city),

synoptics of any kind, dynamic / graphics PIN on maps, trajectories, etc. They realize event-driven solutions working in real time and provide interactive web tools and mobile Apps, for operators and final users. The Snap4City Dashboard Builder provides an enormous range of interactive features, joining 3D representations, Digital Twin representations and navigations, integration with workflow management systems, BMP, for ticketing and management; synoptics panels for industrial monitoring and animations, etc., guaranteeing security, privacy and GDPR. The Knowledge Base (Km4City ontology and LD, linked data) provides support for semantic and real time queries. Multiple brokers, gateways, devices and edge devices can be connected and managed via the IoT/Entity Directory. The focus can be only multiple scenarios.

DATA TYPE COVERAGE

- **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, ...**
- **etc.**



- **SCENARIOS**

<https://www.snap4city.org/4>



- **ORGANIZATIONS**

<https://www.snap4city.org/download/video/cov/>



- **INTEROPERABILITY**

<https://www.snap4city.org/283>



- **APPLICATIONS / PROCESSING**

<https://www.snap4city.org/22>



- **INSTALLATIONS**

<https://www.snap4city.org/471>



- **CLIENT SIDE BUSINESS LOGIC**

<https://www.snap4city.org/911>



- **DEVELOPMENT LIFE CYCLE**

<https://www.snap4city.org/download/video/Snap4Tech-Development-Life-Cycle.pdf>



- **TECHNICAL OVERVIEW**

<https://www.snap4city.org/download/video/Snap4City-PlatformOverview.pdf>



- **SNAP4CITY FIWARE IMPACT STORY**

https://www.snap4city.org/drupal/sites/default/files/files/FF_ImpactStories_Snap4City.pdf



- **INNOVATIONS**

<https://www.snap4city.org/343>



- **MOBILE APPS**

<https://www.snap4city.org/489>



- **ARTIFICIAL INTELLIGENCE**

<https://www.snap4city.org/524>



- **ARTICLES**

<https://www.snap4city.org/78>

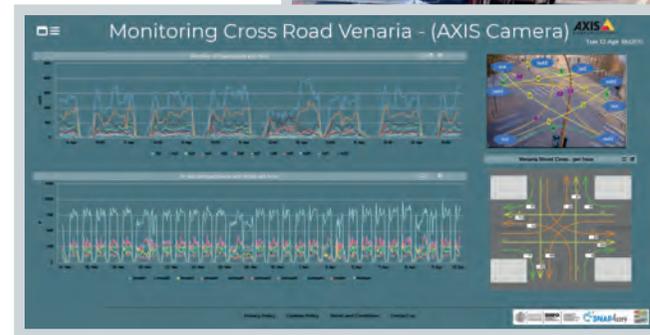
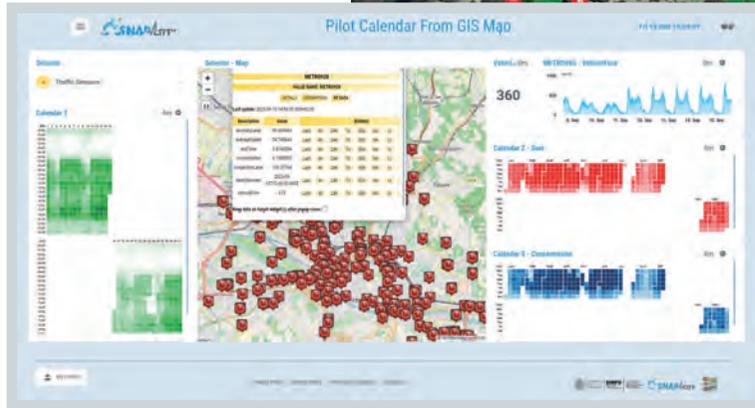
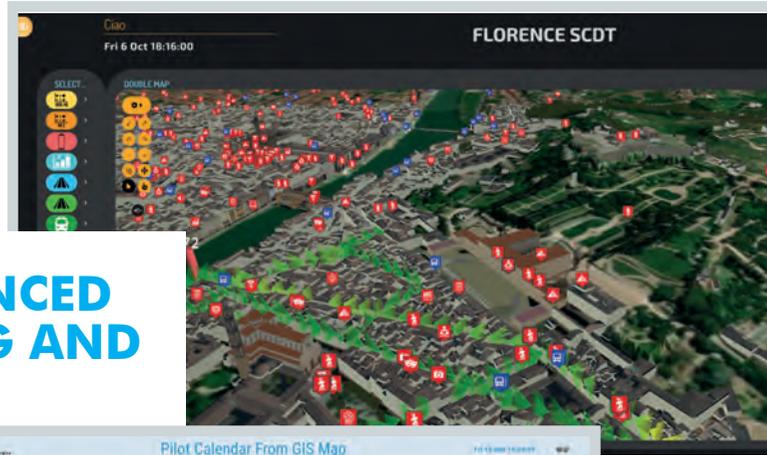


- **SNAP4INDUSTRY**

<https://www.snap4industry.org>



SNAP4CITY ADVANCED DATA PROCESSING AND DEVELOPMENT



Snap4City provides full solutions, and in all cases also the development environment for your platform evolution, being an almost no-coding platform. You can register entity models, create devices, create Dashboards, create data analytics and business intelligence tools by using visual programming in most cases; using Node-RED, wizard, visual Dashboard builder. **Snap4City provides** easy to use tools for customizing and creating solutions, any kind of complex applications with multiple dashboards and tools, up to complex control rooms set up with business intelligence.

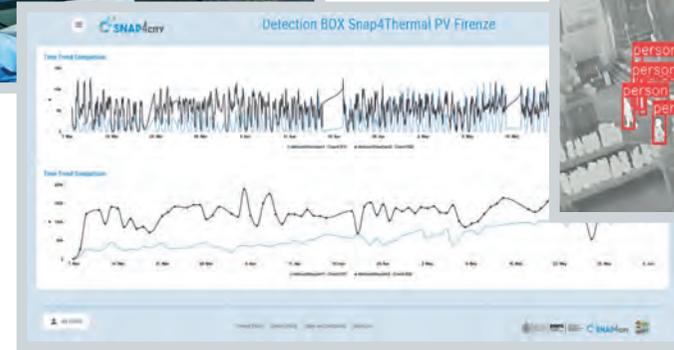
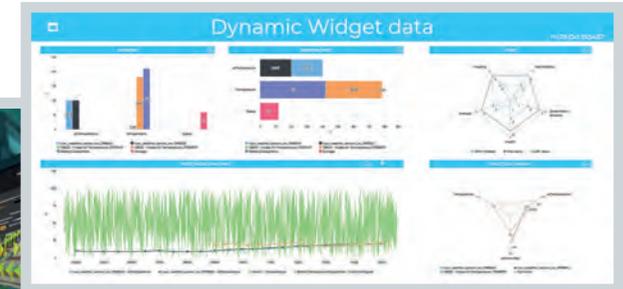
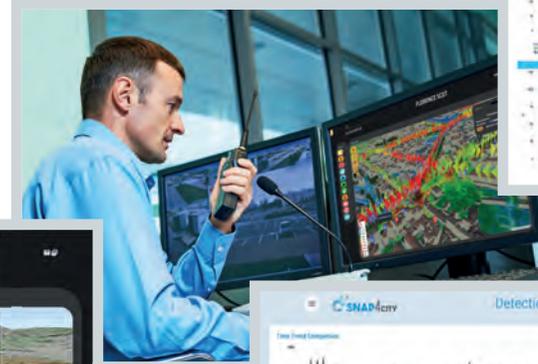
Snap4City is fully integrated with **data processing tools** such as Node-RED of JS Foundation in which the open **Node-RED Snap4City Libraries** provide a large set of MicroServices for creating data adapters, integration, business logic and data transformations. They can be easily used to compute in real time any kind of indicators and follow the KPIs needed by cities such as, SDG indexes, EC indicator on pollutants (ISO37120, 37122); 15MinCityIndex; SUMI; SUMP; etc.



In addition, Snap4City fully supports the development of **real time data analytic processes** through machine learning, artificial intelligence, ethic explainable artificial intelligent (XAI) and languages such as Python, Java, R-Studio, also exploiting Tensor Flow, Pandas, Keras, and any kind of library for data analysis, machine learning, deep learning, fine tuning, transfer learning. Snap4City is distributing Open-Source data analytics tools and algorithms for: prediction, anomaly detection, heatmap production, clustering, classification, demand vs offer of transportation, and many others for implementing: Smart Parking, Smart Biking, traffic flow reconstruction,

traffic flow prediction, land slide predictions, retail suggestions, NOX prediction, NO2 prediction, CO2 computing, people flow analysis, public transportation analysis, routing, etc. Data Analytics is fully integrated into **What-IF analysis tools** in control rooms and for operators, defining scenarios and solutions. Snap4City is integrated with **SUMO** for micro scale simulation, while simulations at meso e macro scales are provided by Snap4City. Other tools are also integrated with Snap4City such as OSM, VMS Milestone, Graphhopper, CKAN, Orion Broker, Node-RED, Cultron Node-RED, Python, ArcGIS, QGIS, Copernico, D3 lib, NeTex, LOGraph, etc.

BENEFITS AND IMPACT



The usage of Snap4City has brought about improvements and has been of great benefit to a wide range of situations where it has been adopted for management, prediction and plans. The very low costs for its adoption and implementation of changes, has impressed many users, which may contributed directly performing changes exploiting the visual tools, and may take the full control of the platform in short time. Snap4City can be installed on premise with its full solution components: VM, Docker and Kubernetes. Its impact has been demonstrated in a wide range of solutions, pilots, and trials, including:

- **Mobility and transport:** reducing people congestion, traffic congestion, monitoring and controlling traffic flow, simulating and analysing mobility and transport, reducing time for parking cars and bike, routing and dynamic routing, reduction of pollutant,

smart parking, sending alarms, providing suggestions, computing indicators, performing what-if analysis;

- **Energy:** recharging stations monitoring, smart light control, monitoring energy production and consumption in real time, computing indicators, sending alarms, performing simulation and what-if analysis, data certification;
- **Environment:** predicting NOX and long term NO2, monitoring pollutants of any kind and alerting, informing city users, waste management, landslide predictions, computing indicators, CO2 computation, and what-if analysis, data certification;
- **Strategic planning:** performing what-if analysis with respect to critical conditions and planned scenarios of any kind, planning production, system thinking on smart decision support systems, 15MinCityIndex, SDG, SUMI, etc.;



- **Tourism:** predicting reputation, assessing people flow, monitoring critical conditions with thermal cameras, controlling 360 cameras, counting and tracking, measuring, and alerting on critical cases;
- **Management:** predicting maintenance interventions, multichannel alerting, anomaly detection as early warning, service reputation, etc., for resilience and control room;
- **People flow:** predicting maintenance interventions, multichannel alerting, anomaly detection as early warning, service reputation, etc., for resilience and control room.

Its capability and compliance at European level allowed to perform a huge number of integrations and particular in the cities of Firenze, Antwerp, Pisa, Livorno, Modena, Santiago de Compostela, Pont du Gard, Bologna, Merano, Cuneo, Valencia, Dubrovnik, Helsinki, Lonato del Garda, and in a number of projects: REPLICATE H2020, RESOLUTE H2020, TRAFAIR CEF, Sii-Mobility MIUR, SODA4.0 of ALTAIR, 5G MIUR, MOBIMART Interreg, HERITDATA Interreg, Life Weee, AMPERE, Enterprise, Italmatic, DIDA, and PC4City.

In 2019, DISIT Lab (University of Florence) turned out to be the winner of the Select4Cities PCP of EU and one year later won the ENEL-X open data challenge in 2020. Currently, Snap4City is one of the platforms of the EOSC (European Open Science Cloud), library of Node-RED, and DISIT Lab is proud to be a Gold Member of FIWARE and an official FIWARE Platform and Solution, certified Consultant, certified Trainer, provides two certified FIWARE Experts; and awards from DMS, ICCSA. DISIT Lab and other partners participated providing Snap4City solutions and a strong number of innovations in a number of EC projects (RESOLUTE, REPLICATE, TRAFAIR, MOBIMART, Select4Cities, Snap4City, WEEE, Panacea, Impetus, Tuscany X.0 EDIH, etc.), and national/regional (Sii-Mobility, MOSAIC, ALMAFLUIDA, SODA, Pretto, Enterprise, ES THE, CN MOST, etc.), and in many direct contracts.

ADOPTION OF SNAP4CITY FOR CITIES AND INTEGRATORS

Trial for single users is open on Snap4City.org portal via direct registration.

Snap4City multitenant multidomain platform can be adopted by requesting the installation on your premise or on public cloud, or requesting smart city services from our cloud. We can customize your Snap4City instance, integrate your legacies or preferred third party modules of any kind (they can be open source or proprietary). We provide H24 help-desk, maintenance according to consolidated SLA. Training for the adoption and usage of the Snap4City tools is provided and freely accessible on web.

Integrators can access to the catalogue of modules and services to compose their preferred version of Snap4City platforms. **Snap4City multitenant multidomain modular platform based on microservices** which can be installed on-cloud, on-premises and on hybrid solutions; via VM, dockers and Kubernetes, on AWS, Ms Azure, etc. - all modules are licence free. An easy tool for container-based installations is provided: <https://www.snap4city.org/738>. The solution is entirely distributed open source including the application layer, multitenancy aspects, assessment and auditing, resource management, user management, auditing, reporting, etc. Snap4City provides a number of configurations from small standalone solutions to very large scalable installations. If you start small the platform can be extended with simple procedures. Snap4City provides all needed management

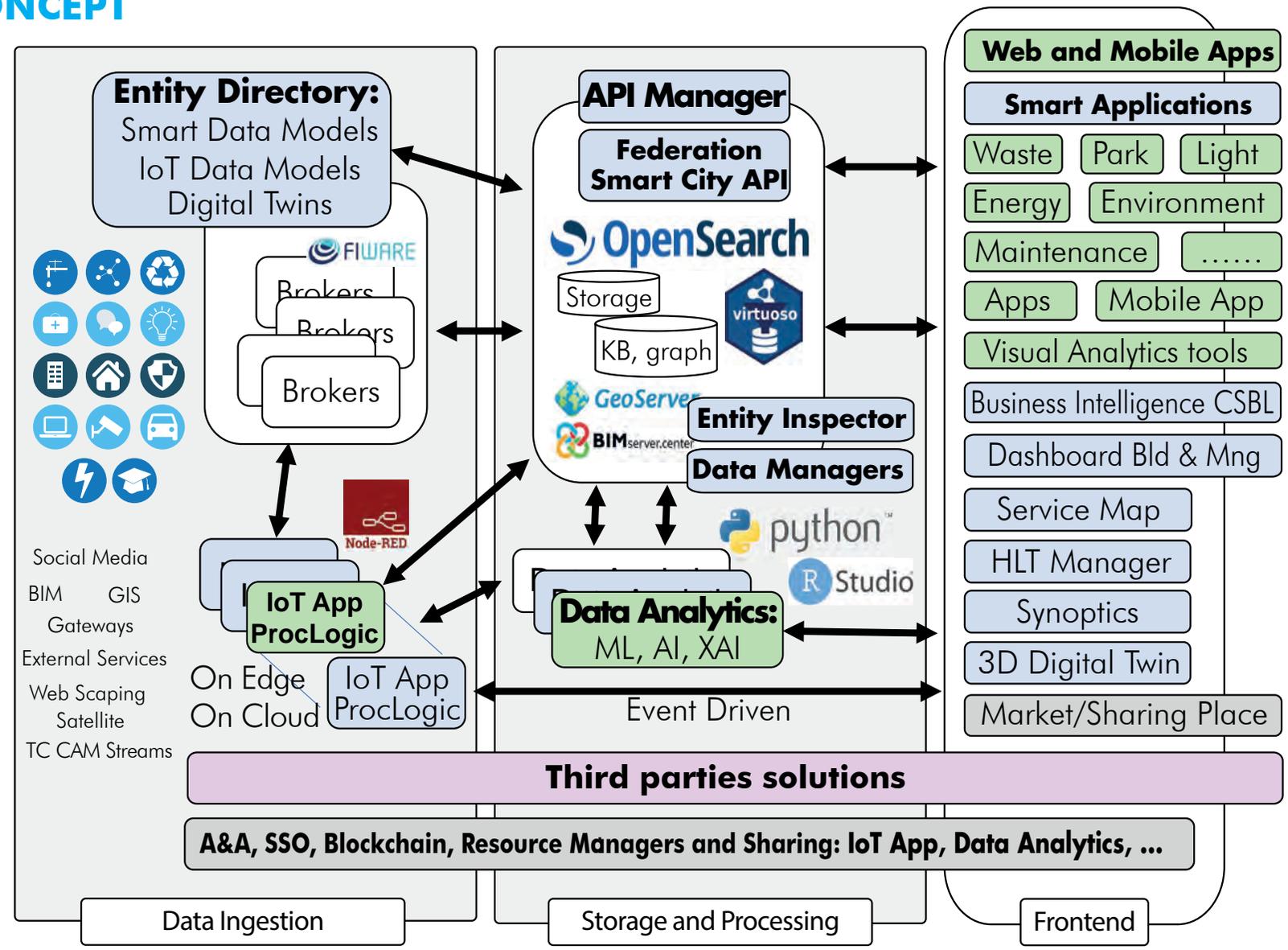
tools for user management, organization management, resource accounting, process management, high level type management, reporting, multilingual support, multitenant support, scheduling, alerting, quality control, data inspection management, Digital Twin support, smart application management, dashboard control and usage, business intelligence, etc. <https://www.snap4city.org/471>. For the list of installed platforms see: <https://www.snap4city.org/661> which use the Powered by Snap4Tech logo in their installations. We provide H24 help-desk, maintenance and second level maintenance for distributors and integrators worldwide. All the installed versions of Snap4City includes also the development environment which allows you to develop data processes, data analytics and dashboards.

Training and Hackathons: The Snap4City community of developers and users is a source of stimulus and innovations. Snap4City provides an open, free of charge and comprehensive training course and on-line development open platform for testing and using the solution. The course is provided on slides, interactive slides and videos, and includes case studies from: <https://www.snap4city.org/577>. See also the 2023 course. In most cases, for stimulating a larger local collaboration of stakeholder, Hackathons have been launched, for example with Sii-Mobility, Select4Cities, and IEEE Intelligent Transportations Systems societies.

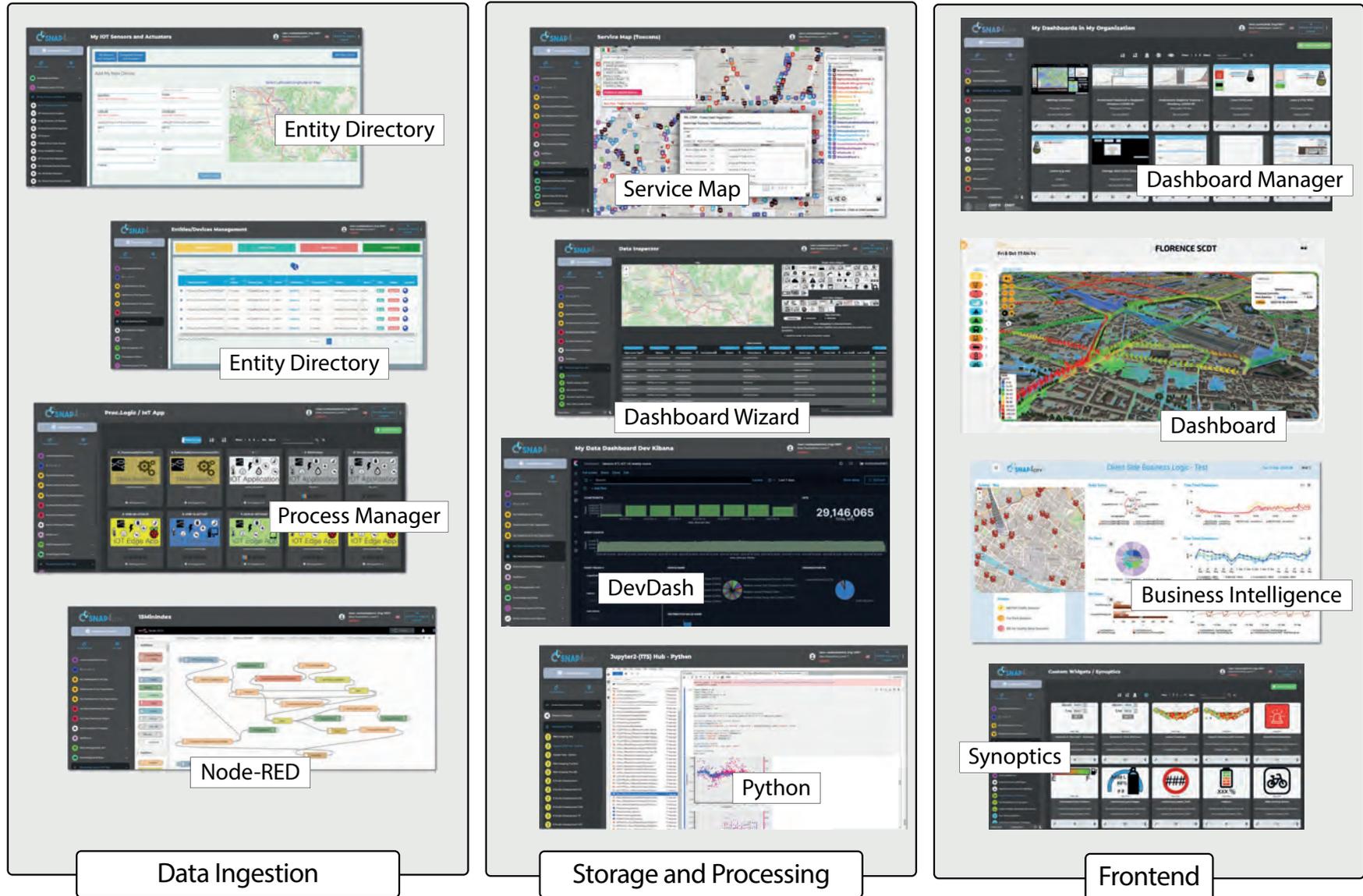
Special program for research institutions: Research non-profit institutions or foundations can set up agreement with DISIT Lab for exchanging researchers and/or becoming experts lab of Snap4City in your area. A setup support is provided free of charge to help them starting using the platform. The results produced are promoted by Snap4City according to different channels including the Snap4City users' network and mailing lists.

Living Lab and working support with stakeholders
Snap4City provide a support for setting up Living Labs. The largest is on Snap4City.org portal. A consolidated methodology based on quadruple helix helps you setting up your smart city engaging stakeholders and final users.

CONCEPT



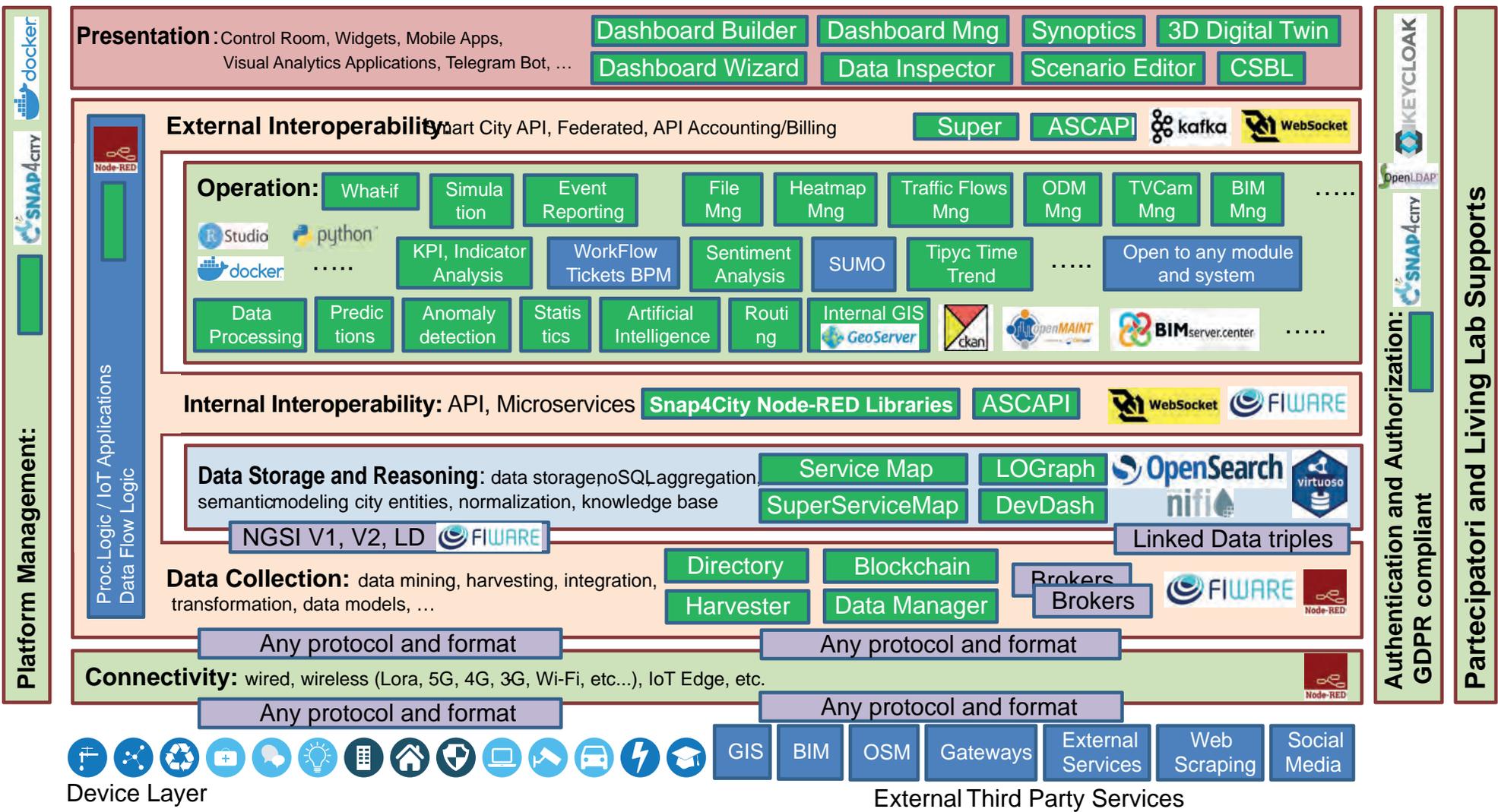
DEVELOPMENT ENVIRONMENT



TECHNICAL ARCHITECTURE



Snap4City components are represented with green blocks



ONLINE TRAINING MATERIAL OVERVIEW

<https://www.snap4city.org/944>



The training course is open to everybody free of charge and includes frontal slides, full access to the platform and development tools, and exercises during the courses.

Participants should be registered on <https://www.snap4city.org> performing the free registration as free *DISIT Organization* or on their own Organization if they have one on Snap4City.

- **Overview:**

- Needs of the Operators vs platform
- Platform Overview: from data to interactive tools
- Data Analytics, Artificial Intelligence
- Some Cases by Domains: solutions vs analytics
- Other Cases and scenarios
- Overview of the next parts of the Course
- References to other training material

- **Dashboard production and management**

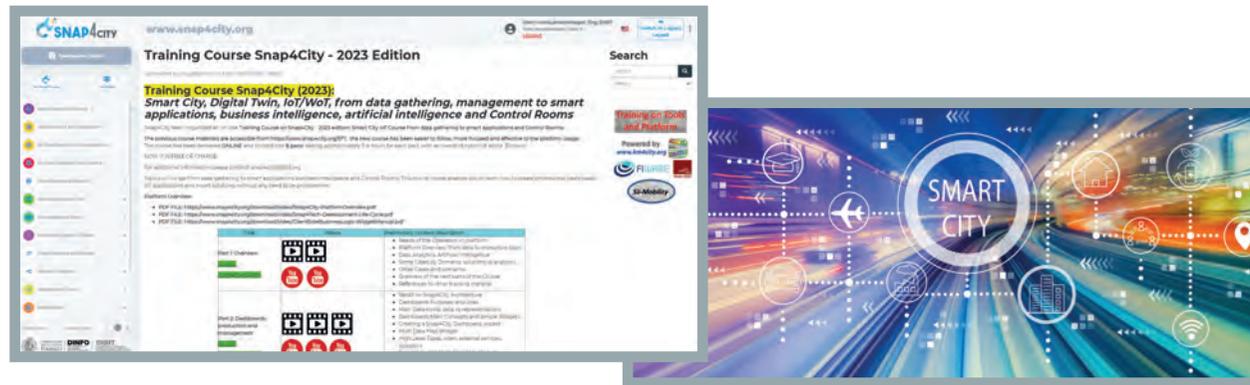
- Recall on Snap4City Architecture
- Dashboards Purposes and Uses
- Main Data Kinds: data vs representations
- Dashboards Main Concepts and simple Widgets
- Creating a Snap4City Dashboard, wizard
- Multi Data Map Widget
- High Level Types, video, external services, synoptics
- Selector for the Multi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

- **IOT App, Process Logic, Server Side Business Logic**

- 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

- **Data Analytics and Artificial Intelligence**

- Why and Where use DA, AI and XAI --> General Life Cycle
- Data Processing
- What is Data Analytics, DA and Artificial Intelligence, AI
- List of the most relevant available DA and AI 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
- training material



- **Data Ingestion and Interoperability**
 - 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
 - training material
- **Snap4City Platform Architecture, Interoperability, Management and Deploy**
 - 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
- training material
- **Exploiting Snap4City API, and Web/Mobile Applications SDK**
 - 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
 - training material
- **Developing Smart Applications & Business Intelligence Solutions**
 - 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
 - What is missing here and you can get from former course
 - training material

The course includes slides, full access to the platform and development tools.



CITY



INDUSTRY



ARTIFICIAL INTELLIGENCE

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