



SCALABLE SMART ANALYTIC APPLICATION BUILDER FOR SENTIENT CITIES









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www.snap4city.org





Cities are rapidly transforming their services to address current societal, environmental and economic challenges. Vertical smart solutions are being progressively replaced by solutions capable of exploiting a huge range of data channels, getting smarter, and cross exploiting data. Cities/areas require highly tailored solutions, exploiting the legacy and pushing to the future and innovation. A flexible, dynamic and highly interoperable platform is needed to increase sustainability, profit and full control of operational objectives, fully integrated with the territory and all the stakeholders. Cities are abandoning an approach based on single data sources and becoming aware of actual data channels where information and actions flow in multiple directions and Digital Twins and creating living labs with all stakeholders. Multi-directional flows are key services in implementing the city/area operating system enabling daily tuning to deal with current challenges, mobility as a service, smart waste, smart lighting, smart parking.

Snap4City is a 100% open-source platform used in many cities and areas. It is an official FIWARE Platform and Solution (https://www.snap4city.org/467, https://www.fiware.org) developed under the coordination of DISIT Lab of the University of Florence, Italy. Snap4City is GDPR compliant, passed PENTest, and it is an EOSC platform, an official Node-RED Library, official E015 API, etc. The platform is provided as "as a Service" basis, or installed in your location (from your self, as well as using a number of companies), no licence fee is needed. The platform has at present a wide range of activities in the smart city and IoT/IoE (Internet of Things/Internet of Everything) integrated domains: defining city strategies, implementing control room, realizing ethics and explainable artificial intelligent solutions and computing key performance indicators which are used daily in both city and industry management.

Snap4City has incorporated Km4City (<u>https://www.km4city.org</u>) ontological and semantic model to guarantee the data interoperability with any kind of IoT Devices, device models, data entities, physical structures ranging from the city, industry, and home. And thus, also with **FIWARE Smart Data Models**, providing a number of real-time open-source solutions to support decision makers in cities and large industries to ground their daily operational actions on solid explainable artificial intelligent predictions, deductions and assessments. It provides a complete understanding of the context and its trends, receiving early warning, anomaly detections, and performing simulation and what-if analysis. This information is used to suggest strategic interventions to improve city services and general quality of life, in multiple domains (e.g., Smart Cities and Smart Industry).



Snap4City platform can manage your data, on-cloud, on-premise and hybrid solutions. As it currently performs on more than 40 cities/areas in countries as: Italy, Spain, France, Bosnia-Herzegovina, Finland, Belgium, Greece, Croatia, Israel, Sweden, Australia, Brazil, Romania, etc. also with data and services or third-party operators. An easy tool for Docker based installations is provided: <u>https://www.snap4city.org/738</u>.

Snap4City covers **multiple domains / scenarios** (<u>https://www.snap4city.org/4</u>) in integrated or vertical manner:

- Mobility and transport: smart parking, traffic flow reconstruction, traffic flow prediction, offer vs demand of transportation analysis, vehicle tracking, routing, multimodal routing, smart biking, reducing traffic congestion, people counting, people flow tracking, etc. For example in the REPLICATE H2020 project for Florence, and in the cities of Pisa, Livorno, Modena, Santiago de Compostela, on TRAFAIR CEF; Pisa and Siena for smart biking with Sii-Mobility national smart city actions; Antwerp, Dubrovnik and Pont Du Gard for people counting;
- **Energy:** smart light, control room on energy production and recovering, charging stations, electric vehicles fleet control; For example, in REPLICATE for recharging stations, for CAPELON partner in Sweden for Smart Light;
- **Environment:** monitoring, pollutant predictions, landslides predictions, NOx prediction, NO2 very long-term predictions of annual average KPI, alerting, CO2 reduction, CO2 estimation from traffic, smart waste and management, decarbonization. For example, in Florence, Pisa, Livorno for NOX/NO2 predictions, and general pollutant monitoring in Tuscany, Antwerp, Helsinki;
- **Industry 4.0:** depuration 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; https://www.snap4city.org/369
- Governance control and KPI: people flow, tourists city usage monitoring, POI, utilities, quality of life assessment and control, 15MinCityIndex, building automation, digital twin, sustainability, smart decision support, city management KPI, etc. For example: in REPLICATE H2020 for Smart City Control Room of Florence, 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 Herit-Data; in the Firenze and Bologna for the 15 Min City Index;
- Interoperability: In this large range of solutions, Snap4City is compliant with more than 140 protocols and it is interoperable with GIS (Geographical Information Systems), BIM (local Digital Twin), CKAN (open data networks) and IoT Networks protocols (IOT protocols) https://www.snap4city.org/283, https://www.snap4city.org/65.

Snap4City supports cities and businesses to **improve sustainability** and reduce costs by connecting all management and control domains. To this end, Snap4City platform can rely on FIWARE Compliance and exploits FIWARE Context Broker with its NGSI-V2/LD protocols, supporting: Smart Data Models, automated deploy, protected communications and multiple broker connections. The interoperability, flexibility and modularity of Snap4City together enable the creation of applications in a wide range of scenarios such as those mentioned above. 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. Thanks to FIWARE's approach, the operating multi-tenant FIWARE Context Broker can feed data into Snap4City platform. To further support developers, Snap4City is supporting the concepts of living lab development and environment. https://www.snap4city.org/download/video/course2020/sys/

**Data Integration, ingestion and distribution:** Snap4City provides effective and simple tools and solutions for immediate data ingestion and data aggregation exploiting FIWARE as well a large range of protocols and standards. Snap4City provides a range of tools for shortening the processes for manipulating simple and complex data such as: POI, KPI, IoT Devices, Satellite, OD Matrices, Traffic Flows, Heatmaps, 3D Shapes/patterns, Trajectories, Flows, Video Streams, User profiles, Terrains, etc. https://www.snap4city.org/download/video/course2020/di/.

**Security and Privacy**: The Snap4City solution passed the penetration and vulnerability tests and has been proven to be GDPR compliant. With Snap4City, it is possible to create end-2-end event-driven secure applications with connections from devices to dashboards and vice versa, including data processing, storage and data analytics. https://www.snap4city.org/549

**Deploy and Platform Management:** The solution is distributed entirely open source including the application layer, multitenancy aspects, assessment and auditing, resource management, etc.

The Snap4City solution can be installed on private and public clouds (e.g., AWS, MS Azure) starting from an open-source virtual machine, as well as from docker compose - all modules being licence free. It provides a number of configurations from small standalone to very large installations. 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, smart application management, dashboard control and usage, etc. https://www.snap4city.org/471

**Training and Hackathons:** Snap4Industry/City provides an open, free of charge and compressive training course and on-line development open platform for testing and using the solution. The Course is based on slides, videos and examples from its portal: <u>https://www.snap4city.org/577</u> In most cases, Hackathons have been launched, for example with Sii-Mobility, Select4Cities, IEEE Intelligent Transportations Systems societies.

# **Tools for rapid implementation of sustainable Smart Solutions and Decision Support Systems**

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DISIT CONTRACTOR



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

PREDICTION - ANOMALY DETECTION - ENVIRONMENTAL MODEL - 3D MODEL KPI - SIMULATION - EARLY WARNING - SYNOPTIC - DIGITAL TWIN - VIRTUAL REALITY



**EXPERT SYSTEM KNOWLEDGE BASE** STORAGE



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



DATA FLOWS, DATA DRIVEN WORKFLOWS, MICROSERVICES PARALLEL DISTRIBUTED PROCESSING



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







For privacy reasons, numbers shown in this dashboard are not those of Florence

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Snap4City solution can work with data channels of any kind. Once data channels are established, city entities are modelled in a Knowledge Base (grounded on Km4City ontology and LD, linked data) and become ready for semantic queries exploiting relationships as: spatial, temporal and relational. Multiple brokers, devices and edge devices can be connected and managed via the IoT Directory which also performs automated discovery of devices on legacy brokers. Remote lot Edge Devices can be maintained, also updating the logic of control and data processing based on Node-RED. Snap4Čity can manage open and private data for each domain and organization. Snap4City also supports the most recent solutions for:

- Global Digital Twin: representing and navigating the city in 3D, • with shapes of the building, heatmaps and animations, traffic flows, pins, devices, POI, KPI, etc. <u>https://w</u>ww.snap4city.org/716
- Local Digital Twin: representing 3D shapes of building, internal and • external navigation, association of 3D elements to devices, real time data, etc. https://www.snap4city.org/716
- IoT Edge: supporting the installation of Snap4City processes and • interfaced in embedded systems, such as Linux based, windows based, Arm, AXIS cameras, Raspberry Pi, Android, etc.

The **Snap4City Dashboard Builder** provides 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, origin destination matrices and animations, traffic flow sequences/animations, typical trends, calendar heatmaps, Kiviat, barseries, custom widgets, animations, scenarios, routing, multimodal routing, public transport time line, weather

Monitoring Cross Road Venaria - (AXIS Camera) Gill Will Charle

forecast, BIMs, buttons, 3D shapes on local (building) and global Digital Twins (for the whole city), synoptics of any kind, dynamic PIN on maps, trajectories, etc. https://www.snap4city.org/download/video/course2020/das/ They are composed by means of the **Wizard** in an extremely easy manner to create solutions, along with complex applications with multiple dashboards and tools, up to complex control rooms, e.g., in Florence for Smart City, in ALTAIR for Industry Plant. 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. Snap4City is fully integrated with **data processing tools** such as Node-RED of JS Foundation in which the open Node-RED Snap4City Library is providing a large set of MicroServices for creating data adapters, integration, business logic and data transformations. They can be easily used to compute any kind of indicators and follow the KPIs needed by cities such as the EC indicator on pollutants (ISO37120, 37122); city indexes and so on https://www.snap4city.org/download/video/course2020/iot/



In addition, Snap4City fully supports the development of **real time data** analytic processes through machine learning, artificial intelligence, ethic explainable artificial intelligent (XAI) and statistical languages such as Python, Java, R-Studio, also exploiting Tensor Flow, Keras, and any kind of library for data analysis, machine learning and deep learning. Snap4City is distributing a number of Open Source data analytics tools and algorithms for: prediction, anomaly detection, heatmap production, clustering, classification, demand vs offer of transportation, and many others have been published on international top level journals for Smart Parking, Smart Biking, traffic flow reconstruction, traffic flow prediction, NOX prediction, NO2 prediction, people flow analysis, public transportation analysis, routing, etc. Data Analytics can be fully integrated into **What-IF analysis** tools in control rooms and for operators.

Traffic Flow Predictions, in/out of the city, Traffic Flow Reconstruction,

- from Traffic Sensors Data Covid-19 vs other data: traffic and environmental .
- Quality of Public Transport Service
- Origin Destination Matrices (from: Wi-Fi, Mobile Apps, etc.)
- Modal and Multimodal Routing for Navigation and Travel Planning
- Predicting Land Sliding .
- Demand of Mobility vs Offer of Transportation
- Environmental Data Analysis and Predictions, early Warning, Long . Term Prediction of Annual Mean of NO2 index of EC
- Anomaly Detection, .
- Decision support systems, What-IF Analysis....
- 15MinCityIndex Assessment of Cities
- . Predictive Maintenance on Plant
- User engagements, suggestion, nagging, recommendations .
- Social media analysis via twitter vigilance.
- See details on https://www.snap4city.org/download/video/course2020/da/





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. The very low costs for the adoption and implementation of changes, since they can be performed directly by city operators, has impressed many users. Snap4City can be freely installed on premise with its full solution components. 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, reduction of pollutant, smart parking, etc.

- **Environment**: ppredicting NOX and long term NO2, monitoring pollutants of any kind and alerting, informing city users, waste management, landslide predictions;
- **Energy**: recharging stations monitoring, smart light control;
- **Strategic planning**: performing what-if analysis with respect to critical conditions, planning production, system thinking on smart decision support systems;
- **City management:** predicting maintenance interventions, multichannel alerting, anomaly detection as early warning, etc., for resilience and control room;
- **People flow**: monitoring, measuring, and alerting on critical cases.



The possibility of establishing bi-directional connections with data/service channels in the above-mentioned domains, enabled higher levels of integration and exploitation, thus allowing the generation of unexpected hints and deduction, thanks to the support of the tools for data analytics, artificial intelligence, and what-if analysis.

Snap4City is an official FIWARE Platform and Solution. Thanks to FIWARE's openness, interoperability and spread, it has enabled a faster integration and exploitation of the IoT aspects in the Smart City model of Km4City. The first usage of FIWARE technology by Snap4City was in the fields of Smart Industry and Smart Cities.

number of integrations and particular in the cities of Firenze, Antwerp, Pisa, Livorno, Modena, Santiago de Compostela, Pont du Gard, Bologna, 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, SmartAmbulance, Italmatic, DIDA, and PC4City.

In 2019, DISIT Lab turned out to be the winner of the Select4Cities PCP of EC 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 (University of Florence) is proud to be a Gold Member of FIWARE and an official FIWARE Platform and Solution, certified Consultant, certified Trainer, and provides two certified FIWARE Experts.





• NOTES	
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## • SCENARIOUS -

https://www.snap4city.org/4

### • ORGANIZATIONS

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

#### • INTEROPERABILITY

https://www.snap4city.org/283

• IOT APPLICATIONS

https://www.snap4city.org/22

• TUTORIAL https://www.snap4city.org/577

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

MOBILE APPS
<u>https://www.snap4city.org/489</u>

DATA ANALYTICS
<u>https://www.snap4city.org/524</u>

## • INSTALLATIONS

https://www.snap4city.org/471

• ARTICLES -

https://www.snap4city.org/78

#### • 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

www.snap4city.org







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